Stefan Marinov was born in Sofia on the 1 February 1931 in a family of intellectual communists. In 1948 he finished a Soviet College in Prague and began to study physics at the universities of Prague and Sofia.
In 1951 he went to the Varna High Navy School as a volunteer and after graduating sailed as a deck officer on Bulgarian, Czechoslovak-Chinese and West-German cargoes. In 1958 he came back to Sofia to complete his studies in physics. Then he graduated also in the radio-engineering faculty of the Sofia Polytechnic.
From 1960 to 1974 he worked as Assistent Professor in the Physical Faculty of the Sofia University and as scientific researcher in the Physical Institute of the Bulgarian Academy of Sciences, from where he was expelled and pensioned as a paranoic in 1974. From 1974 to 1977 Marinov managed his own Laboratory for Fundamental Physical Problems. In 1966/67, 1974 and 1977 he got compulsory treatment in the Sofia psychiatries because of his political dissent.
In September 1977 he received a passport und transferred to Brussels. In 1978 he lived in Washington. In the years 1979—1981 he lived in Genoa in the house of the prominent Italian paraphysicist Count Lelio Galateri. Since 1981 he lives in Graz and earned his bread as a groom in a stable for riding horses. Marinov has published the following books on physics: Eppur si muove (1977), Classical Physics (1981), The Thorny Way of Truth (1982—1991). He is editor of the journal Deutsche Physik and director of the Institute for Fundamental Physics, Graz, where he is the only researcher.

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MARINOV DIVINE ELECTROMAGNETISM

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ELECTRO-MAGNETISM

EAST - WEST
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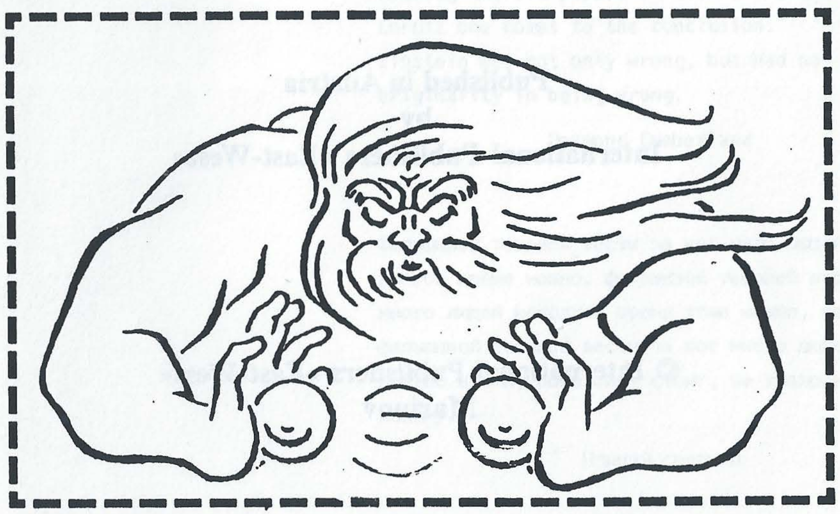

ELECTRO-MAGNETISM

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Суди спокойней, беспристрастней -
и ты поймешь в конце концов:
просчеты мудрецов опасней,
чем заблуждения глупцов.

Вадим Шефнер (НЕВА, 3/1991, стр. 3)

Reading the old papers of Poincaré and Lorntz one comes to the conclusion: Einstein was not only wrong, but had no originality in being wrong.

Desmond Cumberland

Фальшивой теорией вести за нос мало людей долгое время можно, фальшивой теорией вести много людей недолгое время тоже можно, но фальшивой теорией вести за нос много людей долгое время, пока свет стоит, не удалось никому.

Плиний средний

Отыщи всему начало и ты многое поймешь.

Козьма Прутков

Relativity has vanished through the window...

John Maddox, Nature, **346**, 103.

The drawing on the cover is by Prof. J. P. Wesley

P R E F A C E

Electromagnetism is a science which is to be learned by everybody who knows some mathematics in ten days. Eleven days are too many.

Why then the students in the universities study it for years and nevertheless all of them, as well as the professors who teach it in the class-rooms, look with desperation at the electromagnetic phenomena, without being able to explain what is really going on there and why? A clear example for the "puzzleness" of the electromagnetic phenomena are the numerous papers in the AMERICAN and EUROPEAN JOURNAL OF PHYSICS. Such a paper is also that of John Maddox cited quite the whole in Sect. 21.

When reading this book the reader will give the answer readily: Official electromagnetism is simply wrong. The theory of relativity is wrong, the "closed current lines", "flux" and "propagation of interaction" Faraday-Maxwell concepts are wrong.

In electromagnetism there are only a couple of simple and clear formulas (as a matter of fact, there is only one fundamental formula, the Newton-Lorentz equation), deduced logically from a couple of simple axioms (see them is Sect. 2), and any electromagnetic phenomenon is then to be calculated by the help of these simple formulas if one knows differential, integral and vector calculus.

And the fundamental Newton-Lorentz equation leads logically to the violation of the laws of angular momentum and energy conservation, i.e., to the construction of machines which rotate under the action of internal forces and which produce energy from nothing.

Official physics works with a wrong fundamental formula, namely with the Lorentz equation, consequently without the scalar magnetic field and assumes that the electromagnetic effects depend only on the relative velocities of the bodies.

One may wonder: how was it possible that until the end of the XXth century humanity has not noticed the scalar magnetic intensity and the existence of the motional-transformer induction. I point out at the reasons for this "blindness": 1) the scalar magnetic intensity is equal to zero (with some very rare exceptions) when it is generated by a closed current, and 2) the induced motional and motional-transformer electric tensions in a closed loop are equal. And in low-acceleration electromagnetism official physics works predominantly with closed currents and closed loops.

But why to narrate in the preface in a hurry that what is written calmly and in all detail in the book?!

DIVINE ELECTROMAGNETISM can be read, grasped and mastered in ten days. At this reading the reader has to jump over some complicated calculations. One will lose nothing if one will not verify all steps of the mathematical speculations. All other "theoretical" deductions are of the most simple kind which every sophomore student can follow with easiness.

If the reader would have under hand the first part of my encyclopaedic book CLASSICAL PHYSICS, entitled MATHEMATICAL APPARATUS, the reading of this book can proceed more quickly and calmly, as there can be found all relevant formulas from algebra, trigonometry, analytical geometry, differential calculus, integral calculus, infinite series, differential equations, vector and tensor analysis. For this reason I do not attach to the present book a part dedicated to the mathematical apparatus used in it.

I wish to note only the following.

Every student in a technical university knows what are the differential operators grad, div, rot, however few of them know the fourth differential operator ($\mathbf{v}$.grad), called "vector-gradient". I won from a friend of me 1000 AS by asserting that if we take five university textbooks on electromagnetism, then with surety in four of them we will not find the operator ($\mathbf{v}$.grad). In case that in more than in one of the five books the operator would be found, I had to pay to the friend 5000 AS. We ordered the books on the library computer. The operator ($\mathbf{v}$.grad) couldnot be found even a single time in all of them. (A similar bet can be won with Grassmann's formula, namely I shall pay to everyone 5000 AS if by choosing arbitrarily five university text-books on electromagnetism, Grassmann's formula would be found written explicitly in more than in one.)

Thus if one wonders why the motional-transformer induction was not revealed by humanity, I always retort: And if some student occasionally has observed it, how would he write it, if the professor has not told him that besides grad, div and rot there is also ($\mathbf{v}$.grad).

It is very useful to have under hand the formulas for grad, div, rot and ($\mathbf{v}$.grad) of a product of two functions, as to deduce the relevant formula any time when one needs it is tedious. As I use some of these formulas often in the book, I give them here:

If Φ, Φ_1, Φ_2, are scalar funcions and $\mathbf{A}$, $\mathbf{A}_1$, $\mathbf{A}_2$ are vector functions of the coordinates of the reference point, then

$$\mathrm{grad}(\Phi_1\Phi_2) = \Phi_1 \mathrm{grad}\Phi_2 + \Phi_2 \mathrm{grad}\Phi_1,$$

$$\mathrm{grad}(\mathbf{A}_1.\mathbf{A}_2) = (\mathbf{A}_1.\mathrm{grad})\mathbf{A}_2 + (\mathbf{A}_2.\mathrm{grad})\mathbf{A}_1 + \mathbf{A}_1\times\mathrm{rot}\mathbf{A}_2 + \mathbf{A}_2\times\mathrm{rot}\mathbf{A}_1,$$

$$\mathrm{div}(\Phi\mathbf{A}) = \Phi\mathrm{div}\mathbf{A} + \mathbf{A}.\mathrm{grad}\Phi,$$

$$\mathrm{div}(\mathbf{A}_1\times\mathbf{A}_2) = \mathbf{A}_2.\mathrm{rot}\mathbf{A}_1 - \mathbf{A}_1.\mathrm{rot}\mathbf{A}_2,$$

$$\mathrm{rot}(\Phi\mathbf{A}) = \Phi\mathrm{rot}\mathbf{A} - \mathbf{A}\times\mathrm{grad}\Phi,$$

$$\mathrm{rot}(\mathbf{A}_1\times\mathbf{A}_2) = (\mathbf{A}_2.\mathrm{grad})\mathbf{A}_1 - (\mathbf{A}_1.\mathrm{grad})\mathbf{A}_2 + \mathbf{A}_1\mathrm{div}\mathbf{A}_2 - \mathbf{A}_2\mathrm{div}\mathbf{A}_1,$$

$$(\mathbf{v}.\mathrm{grad})(\Phi\mathbf{A}) = \mathbf{A}(\mathbf{v}.\mathrm{grad}\Phi) + \Phi(\mathbf{v}.\mathrm{grad})\mathbf{A},$$

$$(\mathbf{v}.\mathrm{grad})(\mathbf{A}_1\times\mathbf{A}_2) = \mathbf{A}_1\times(\mathbf{v}.\mathrm{grad})\mathbf{A}_2 - \mathbf{A}_2\times(\mathbf{v}.\mathrm{grad})\mathbf{A}_1.$$

The book is dedicated primarily to low-acceleration electromagnetism. Only Chapter IV is dedicated to high-acceleration electromagnetism (radiation of electromagnetic waves). This Chapter can be simply omitted by the persons who are not interested to learn how I solve the problems about the radiation of energy.

Well. Now read the book. Without fear - you are in paradise under the shadow of a beautiful cherry-tree. When opening your mouth, the cherries fall exactly in and the Divinity combs his long white beard on the medow next to yours solving the cross-words in the last day English press.

And after ten days you will know electromagnetism much better than any other professor in the world.

Let me make at the end an important remark concerning the nasty and disgusting problem about the measuring systems. In my address "Marinov to the world's scientific conscience"[45] I wrote: "In the damned system SI **B** and **H** are, my God!, two quantities with different dimensions, so that even the grandchildren of our grandchildren will curse and swear at us when studying electromagnetism." One of the most important reasons that electromagnetism cannot be understood by the students is the damned measuring system SI. If the electromagnetic units of measurement (ampere, volt, etc.) had been introduced on the basis of the Gauss system, the mental disorders between the students (and the professors!) of the high technical schools would be with 35% less.

But we have this damned system SI and cursing and swearing we must live with it, as every European who comes to the Island with his own car has to drive on the left and curse and swear...

I dedicated a whole Chapter (Chapter V) to the measuring systems to save my readers from mental disorders, as such a chapter cannot be found in the current text-books (I can make the same bet as above!). Read this chapter attentively, and then have always under hand Table 43.2 jumping from the Gauss system to the SI system (and vice versa) without thinking too much. Think then theoretically in the Gauss system, as I do in Chapters I-IV, and make the numerical calculations for the experiments in the SI system, as I do in Chapter VI.

Italians say: *Guadagna a Milano e spendi a Napoli.*

Graz, July 1993

Stefan MARINOV

Hoferfinder,

Oberstallknecht von Niederschöckl

Il Signor GENIO TEORICO e la Signorina ESPERIMENTALINA

C O N T E N T S :

I. AXIOMATICS

1. INTRODUCTION

As a result of my experimental and theoretical work in the last twenty years, I firmly established that space and time are absolute categories, such as defined by Newton and conceived intuitively by everybody during one's childhood and student life. The crucial experiments supporting this viewpoint are my "rotating axle" experiments(1-6), by means of which for the first time in history I succeeded in measuring the Earth's absolute velocity in a laboratory.

Proceeding from the absolute space-time concepts, I tried to build all of CLASSICAL (i.e., non-quantum and non-statistical) PHYSICS on a firm and clearly defined axiomatical basis. I established that this axiomatical basis can by chosen in a very simple, intuitively comprehensible manner, and that all fundamental equations in classical physics can be then obtained by plain and rigorous mathematical speculations.

The internal logic of the theory impelled me to introduce axiomatically, by analogy with the magnetic energy, a companion to the gravitational energy which I called MAGRETIC ENERGY (Heaviside first has done this). Until now human experience has not established the existence of such a type of energy, but neither has it shown whether such an energy should not exist. Thus the magretic energy is a hypothetical notion. Nevertheless, I hope that in future, when experimental techniques will offer the necessary possibilities, the existence of magretic energy might be revealed.

I propose an aether-type model for light propagation, i.e., I assume that light propagates with a constant velocity along any direction only in absolute space. However, the "aether" is not some medium at rest in absolute space in which light propagates like sound in air. I firmly defend the corpuscular (Newton) model of light propagation, rejecting the wave (Huyghens-Fresnel) model, so that I call my model for light propagation NEWTON-AETHER MODEL.

Within effects of first order in V/c (V is the absolute velocity of the reference frame considered, c is the velocity of light in absolute space or the to-and-fro velocity in any inertial frame), all physical and light propagation phenomena can be rightly described by the traditional "Newtonian" mathematical apparatus, and thus within this accuracy the Galilean transformation is adequate to physical reality. I call this the low-velocity mathematical approach (LOW-VELOCITY PHYSICS).

The low-velocity mathematical apparatus wrongly describes the effects of second (and higher) order in V/c. For a correct explanation of these effects, the Newton-aether model of light propagation must be replaced by the MARINOV-AETHER MODEL.

The high-velocity mathematical approach (HIGH-VELOCITY PHYSICS) based on the Lorentz transformation and on its companion the Marinov transformation (both of which can be considered as mathematical presentation of the Marinov-aether character of light propagation), as well as on the 4-dimensional mathematical formalism of Minkowski, rightly describes the effects of any order in V/c. [3,5,7] However, the Lorentz transformation and the 4-dimensional mathematical apparatus must be treated from an absolute point of view, as is done in my absolute space-time thepry.[5] If they are treated and manipulated from a "relativistic" point of view, as is done in the Einstein approach to the theory of relativity, results inadequate in regard to physical reality are obtained. The errors to which the theory of relativity leads are within effects of first order in V/c.

In my approach I assume axiomatically (see the second axiom in Sect. 2) that the velocity of light, propagating along the direction **n** in absolute space and along the direction **n'** in a frame moving with a velocity **V** is absolute space, is equal not to

$$c' = c\{1 - (\mathbf{n}'\times\mathbf{V}/c)^2\}^{1/2} - \mathbf{n}'.\mathbf{V} = c(1 - 2\mathbf{n}.\mathbf{V}/c + V^2/c^2)^{1/2}, \qquad (1.1)$$

as it must be according to the traditional Newtonian concepts but to

$$c' = \frac{c(1 - V^2/c^2)^{1/2}}{1 + \mathbf{n}'.\mathbf{V}/c} = \frac{c(1 - \mathbf{n}.\mathbf{V}/c)}{(1 - V^2/c^2)^{1/2}}. \qquad (1.2)$$

These formulas differ one from another only within terms of second order in V/c. In this book I shall not present motivations for the substitution of formulas (1.1) by the formulas (1.2) and the reader can find such motivations in Refs. 3,5,7,8. Accepting axiomatically the validity of formulas (1.2), I remove from the way to the scientific truth a terribly heavy stone which has for about a century tormented humanity. I showed[3,5,7,8] that either one has to introduce the peculiar Marinov-aether character of light propagation into the theory, or one should be unable to bring all effects observed in space-time physics under one hat.

Formula (1.1) shows that the time which a light pulse needs to cover a distance d in the moving frame is equal to $\Delta t_{\parallel} = 2d/(1 - V^2/c^2)$ when this distance is parallel to the frame's motion and to $\Delta t_{\perp} = 2d/(1 - V^2/c^2)^{1/2}$ when it is perpendicular to the frame's motion. Formula (1.2) shows that in both these cases the time should be the same $\Delta t_{\parallel} = \Delta t_{\perp} = 2d/(1 - V^2/c^2)^{1/2}$ and with the factor $(1 - V^2/c^2)^{-1/2}$ larger than the time needed to cover the same distance d when it is at rest in absolute space. (Take into account that when d is parallel to the frame's motion $\mathbf{n}'.\mathbf{V} = \mathbf{n}.\mathbf{V} = V$, $(\mathbf{n}'\times\mathbf{V})^2 = 0$, and when d is perpendicular to the frame's motion $\mathbf{n}'.\mathbf{V} = 0$, $\mathbf{n}.\mathbf{V} = V^2/c$, $(\mathbf{n}'\times\mathbf{V})^2 = V^2$. A LIGHT CLOCK sends successively light pulses to and fro.

If we define the time unit in the ABSOLUTE (attached to absolute space) FRAME and in the RELATIVE (moving) FRAME by the time which light needs to cover a certain distance d to and fro, we obtain that the time unit in the moving frame (which I call PROPER TIME UNIT) is larger by the factor $(1 - V^2/c^2)^{-1/2}$ than the time unit in the rest frame (which I call UNIVERSAL TIME UNIT). Thus the Marinov-aether character of light propagation automatically introduces the CLOCK RETARDATION which I consider (and I show this[3,5]) to be a physical effect; thus I do not use the notion "TIME DILATION".

One may add that formulas (1.2) can be considered as introducing also automatically the "LENGTH CONTRACTION", but I firmly defend the opinion that the "length contraction" is not a physical effect and appears in the mathematical apparatus only because of the peculiar Marinov-aether character of light propagation.

I showed[3,5,7,8] that if the isotropy of the to-and-fro light velocity in the moving frame will be coupled with the principle of relativity, the Lorentz transformation should be obtained, while if it will be coupled with the existence of absolute space, the Marinov transformation formulas should be obtained. My experiments[1-6] demonstrated that the Marinov transformation is adequate to physical reality and I showed[3,5,7,8] how the Lorentz transformation is to be reconciled with physical reality, i.e., with the space-time absoluteness. I showed also[3,5,7,8] the fundamental difference between the LORENTZ and MARINOV INVARIANCES which can be briefly delineated as follows:

If there is an isolated material system of several interacting particles, the most natural and simple approach is to consider the motion of these particles in a frame attached to absolute space. Then we can make the following two transformations:

1) To move the whole system with a velocity **V** in absolute space and to consider the appearing in the system physical phenomena further in absolute space.

2) To leave the system untouched and to consider the appearing in the system phenomena in another (relative) frame which moves with a velocity **V** in absolute space.

According to the principle of relativity, these two transformations must lead to identical results for all phenomena which can be observed in the system, as according to this principle an absolute space does not exist and if there is a system and observer, it is immaterial whether the observer moves with respect to the system or the system moves with respect to the observer.

According to my absolute space-time theory, the two mentioned transformations do not lead to identical results, although many of the observed phenomena remain identical, first of all the low-velocity mechanical phenomena, but not the electromagnetic and high-velocity mechanical phenomena.

When we wish to obtain results adequate to physical reality, we have to use the Lorentz transformation only when making the first of the above transformations. In such a case the "moving frame" K' in which we first consider the material system (usually if the system represents a single particle, it is at rest in K', and if the system has many particles, its center of mass is at rest in K') and the "rest frame" K in which we then consider the system (and in which the single particle or the center of mass of the system move with a velocity **V**) is one and the same physical frame attached to absolute space. Thus it is not the observer who has changed his velocity with respect to absolute space, but the system has changed its velocity from zero to **V** with respect to absolute space. As the velocity of light in absolute space is c along any direction, then in the "moving frame" K' and in the "rest frame" K it will preserve its constant value along all directions because, I repeat, K and K' are, as a matter of fact, one and the same physical frame. When making such a kind of transformation we must always replace the 4-dimensional scalars observed in K' by their 4-dimensional analogues in K, i.e., we have to work with the Lorentz invariant quantities.

When making the second of the above transformations, we have to use the Marinov transformation. In such a case the frame K is attached to absolute space and the moving frame K' moves with a velocity **V** in absolute space, i.e., those are two different physical frames, whilst the observed system has always the same character of motion with respect to absolute space. Now the velocity of light will be c in the rest frame K, but it will be direction dependent in the moving frame K'. When making such a kind of transformation we have to replace the 3-dimensional scalars observed in K by their 3-dimensional analogues in K', keeping in mind that the Marinov invariant quantities as the space and time energies have the same values in K and K'.

When K and K' are two inertial frames, it is not easy to find experiments revealing the difference between the above two transformations and I was the first man constructing such experiments (such successful experiments!). However when K' is a rotating frame, then it is of cardinal importance whether the observed system rotates with respect to the observer or the observer rotates with respect to the system. Being unable to understand the difference between the first and second transformations for inertial frames, the relativists were unable to understand many substantial differences for the case where K and K' rotate one with respect to the other. Moreover ideal inertial frames do not exist because for any frame moving with an enough constant velocity in absolute space always a far enough center can be found, so that the motion of the frame can be considered as rotation about this center. This theorem is similar to Archimedes' theorem that for any big enough number always a number which is bigger can be found.

2. THE AXIOMS OF CLASSICAL PHYSICS

The fundamental undefinable notions (concepts) in physics are:

a) space,

b) time,

c) energy (matter).

I consider the notions "MATTER" and "MATERIAL SYSTEM" as synonyms of the notions ENERGY and ENERGY SYSTEM.

An IMAGE (MODEL) OF A MATERIAL SYSTEM is any totality of imprints (symbols) with the help of which, if corresponding possibilities and abilities are at our disposal, we can construct another system IDENTICAL with the given one. We call two material systems identical if their influence on our sense-organs (directly, or by means of other material systems) is the same. We call two images of a given material system EQUIVALENT if with their help identical systems can be constructed. An image is ADEQUATE TO PHYSICAL REALITY if the impact of the considered system on our sense-

organs, as predicted from this image, is the same as the actual impact.

A material system is called ISOLATED if it can be represented by a model independent of other material systems.

We imagine space as a continuous, limitless, three-dimensional totality of space points. The different Cartesian frames of reference (these are geometrical, i.e., mathematical concepts) with which we represent space may have various relations with respect to each other. Depending on their relationship to each other, any pair of Cartesian frames of reference will belong to one or more of the following three classes:

1. Frames with different origins.
2. Frames whose axes are mutually rotated.
3. Frames with differently oriented (or reflected) axes (right or left orientation).

The fundamental properties of space may be defined as:

1. HOMOGENEITY. Space is called homogeneous if considering any material system in any pair of space frames of the first class, we always obtain equivalent images.

2. ISOTROPY. Space is called isotropic if considering any material system in any pair of space frames of the second class, we always obtain equivalent images.

3. REFLECTIVITY. Space is called reflective if considering any material system in any pair of space frames of the third class, we always obtain equivalent images.

We imagine time as continuous, limitless, one-dimensional totality of moments (time points). Here frames of reference for time of the first and third class only can be constructed, i.e., time frames with different origins and oppositely directed axes. The fundamental properties of time may be defined as:

1. HOMOGENEITY. Time is called homogeneous if considering any material system in any pair of time frames of the first class, we always obtain equivalent images.

2. REVERSIBILITY. Time is called reversible if considering any material system in any pair of time frames of the third class, we always obtain equivalent images.

The assertions of my first (for space), second (for time), third (for energy), fourth (for the first type of space energy), fifth (for the second type of space energy), sixth (for time energy), seventh (for the first type of space-time energy), eighth (for the second type of space-time energy) and ninth (for conservation of energy) axioms are the following:

AXIOM I. SPACE is homogeneous, isotropic and reflective. The unit of measurement L for distances (i.e., space intervals along one of the three dimensions in space) has the property of length and may be chosen arbitrarily. ABSOLUTE SPACE is the reference frame in which the world as a whole is at rest.

AXIOM II. TIME is homogeneous. The unit of measurement T for time intervals has the property of time and is to be established from the following symbolical relation

$$L/T = c, \qquad (2.1)$$

where c is a universal constant which has the property of velocity (length divided by time). Light propagates in absolute space with this velocity which is called UNIVERSAL LIGHT VELOCITY. In a frame moving with a velocity **V** in absolute space the two-way light velocity along any arbitrary direction, called PROPER LIGHT VELOCITY, is

$$c_o = c/(1 - V^2/c^2)^{1/2}, \qquad (2.2)$$

while the one-way light velocity along a direction concluding an angle θ' with **V**, called PROPER RELATIVE LIGHT VELOCITY, is

$$c_o' = c/(1 + V\cos\theta'/c). \qquad (2.3)$$

Thus $c' = c_o'(1 - V^2/c^2)^{1/2}$ must be called UNIVERSAL RELATIVE LIGHT VELOCITY. The time unit in any frame is defined by the period for which light covers a half-length unit to and fro. Hence the universal time intervals are measured on light clocks which are at rest in absolute space, while the proper time intervals are measured on light clocks which are at rest in the moving frame.

AXIOM III. All individually different material systems can be characterized by a uniform (i.e., having the same qualitative character) quantity which is called ENERGY and which can only have different numerical value for different material systems. The unit of measurement E for energy has the property of energy and is to be established from the following symbolical relation

$$ET = h, \qquad (2.4)$$

where h is a universal constant which has the property of ACTION (energy multiplied by time) and is called PLANCK CONSTANT. If we assume the numerical values of c and h to be unity, then the corresponding units for length, time and energy are called NATURAL UNITS OF MEASUREMENT. MATERIAL POINTS (or PARTICLES) are those points in space whose energy is different from zero. Every particle is characterized by a parameter m, called UNIVERSAL MASS, whose dimensions and numerical value are to be established from the relation

$$e = mc^2, \qquad (2.5)$$

where e is the energy of the material point when it is at rest in absolute space and is called UNIVERSAL (TIME) ENERGY. When a particle moves in absolute space its energy is called PROPER (TIME) ENERGY and has two forms: the MARINOV TIME ENERGY (or SECOND PROPER TIME ENERGY) and the HAMILTON TIME ENERGY (or FIRST PROPER TIME ENERGY)

$$e_{oo} = mc_o^2/2 = mc^2/2(1 - v^2/c^2), \quad e_o = mcc_o = mc^2/(1 - v^2/c^2)^{1/2} = m_oc^2, \qquad (2.6)$$

where the quantity m_o is called PROPER MASS. Other important characteristics of a material point are the quantities

$$\mathbf{p} = m\mathbf{v} \quad (\mathbf{p}_o = m_o\mathbf{v}) \quad \text{and} \quad \bar{p} = mc \quad (\bar{p}_o = m_oc), \qquad (2.7)$$

called, respectively, the UNIVERSAL (PROPER) SPACE MOMENTUM and the UNIVERSAL (PROPER) TIME MOMENTUM. Furthermore every particle is also characterized by the quantities

$$\mathbf{k} = \mathbf{p}/h = m\mathbf{v}/h \quad (\mathbf{k}_o = \mathbf{p}_o/h = m_o\mathbf{v}/h) \quad \text{and} \quad \bar{k} = \bar{p}/h = mc/h \quad (\bar{k}_o = \bar{p}_o/h = m_oc/h), \qquad (2.8)$$

called, respectively, the UNIVERSAL (PROPER) WAVE VECTOR and the UNIVERSAL (PROPER) WAVE SCALAR. Two material points can be discerned one from another if the space distance between them (at a given moment) is more than their PROPER WAVE LENGTH $\lambda_o = 1/\bar{k}_o$, or the time interval between their passages through a given space point is more than their PROPER PERIOD $\tau_o = 1/c\bar{k}_o$. If these conditions are not fulfilled, the particles interfere (the phenomenon "interference" will be not considered in this book).*

AXIOM IV (NEWTON'S LAW). The individual image of a material system in space is given by the value of its PROPER GRAVITATIONAL ENERGY U_g. The energy U_g of two particles is proportional to their proper time momenta $\bar{p}_{o1}$, $\bar{p}_{o2}$ divided by c and inversely proportional to the distance r between them

$$U_g = -\gamma\bar{p}_{o1}\bar{p}_{o2}/c^2r = -\gamma m_{o1}m_{o2}/r. \qquad (2.9)$$

The coupling constant γ, called the GRAVITATIONAL CONSTANT, shows what part of the energy unit represents the gravitational energy of two unit masses separated by a unit distance. The mass m_e of an important class of elementary (non-divisible) particles, called electrons, is a universal constant called the MASS OF ELECTRON. If one works with natural units and assumes the numerical value of the electron mass to be unity, i.e., $m_e = 1\,EL^{-2}T^4$, then the gravitational constant has the value $\gamma = 2.78\times10^{-46}\,E^{-1}L^5T^{-4}$. If taking in (2.9) not the proper but the universal masses, U_g is called UNIVERSAL GRAVITATIONAL ENERGY.

AXIOM V (COULOMB'S LAW). In addition to the mass parameter, every particle is characterized by a parameter q, called the ELECTRIC CHARGE. The quantities

$$\mathbf{j} = q\mathbf{v}, \qquad \bar{j} = qc \qquad (2.10)$$

are called, respectively, the SPACE CURRENT and the TIME CURRENT. The individual image of a material system in space, in addition to its gravitational energy U_g, is also given by the value of its ELECTRIC ENERGY U_e. The energy U_e of two particles is proportional to their time currents $\bar{j}_1$, $\bar{j}_2$ divided by c and inversely proportional to the distance r between them

$$U_e = \bar{j}_1\bar{j}_2/\varepsilon_oc^2r = q_1q_2/\varepsilon_or. \qquad (2.11)$$

The coupling constant $1/\varepsilon_o$ is called the INVERSE ELECTRIC CONSTANT and ε_o - the ELECTRIC CONSTANT; the inverse electric constant shows what part of the energy unit represents the electric energy of two unit charges separated by a unit distance. The

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* The recent experiments of F. Louradour et al. (Am. J. Phys., **61**, 242 (1993)) have shown that two extremely short light waves, practically photons concentrated in a single space-time point, can interfere when these photons are radiated from different sources and have different frequencies, i.e., periods, the only condition being that at a given moment they cross the same space point. Thus the conclusion of certain physicists that a photon can interfere with itself is an absurdity. Any particle interferes with any other particle, but only at certain conditions this interference can be observed.

dimensions of the electric charge q and of the electric constant ε_o are to be established from (2.11), thus the dimensions of one of them are to be chosen arbitrarily. The electric charge of every elementary particle is equal to q_e, $-q_e$, or 0, where q_e is a universal constant called THE CHARGE OF ELECTRON. If we work with natural units and assume the numerical value of the electron charge to be unity, i.e., q_e^2 = 1 EL, then the electric constant is dimensionless and has the numerical value ε_o = 861.

AXIOM VI. The individual image of a material system in time is given by the value of its proper time energy E_o. The proper time energy of one particle e_o depends on its absolute velocity **v**, i.e., on its velocity with respect to absolute space; the change (the differential) of the proper time energy is proportional to the scalar product of the velocity and the differential of the velocity, the mass of the particle being the coupling constant,

$$de_o = m\mathbf{v}.d\mathbf{v}. \tag{2.12}$$

AXIOM VII (MARINOV'S LAW). The individual image of a material system in space and time is given by the value of its PROPER MAGRETIC ENERGY W_g. The energy W_g of two particles is proportional to the scalar product of their proper space momenta $\mathbf{p}_{o1}$, $\mathbf{p}_{o2}$ divided by c and inversely proportional to the distance r between them

$$W_g = \gamma\mathbf{p}_{o1}.\mathbf{p}_{o2}/c^2r = \gamma m_{o1}m_{o2}\mathbf{v}_1.\mathbf{v}_2/c^2r. \tag{2.13}$$

The coupling constant γ, called the MAGRETIC CONSTANT, is equal to the gravitational constant. If taking in (2.13) not the proper but the universal masses, W_g is called UNIVERSAL MAGRETIC ENERGY.

AXIOM VIII (NEUMANN'S LAW). The individual image of a material system in space and time, in addition to its magretic energy W_g, is also given by the value of its MAGNETIC ENERGY W_e. The energy W_e of two particles is proportional to the scalar product of their space currents $\mathbf{j}_1$, $\mathbf{j}_2$ divided by c and inversely proportional to the distance r between them

$$W_e = -\mu_o\mathbf{j}_1.\mathbf{j}_2/c^2r = -\mu_o q_1 q_2\mathbf{v}_1.\mathbf{v}_2/c^2r. \tag{2.14}$$

The coupling constant μ_o, called the MAGNETIC CONSTANT, is equal to the inverse electric constant.

AXIOM IX. FULL ENERGY H of a material system is called the sum of the time energy E_o and the space energy U. TOTAL ENERGY $\tilde{H}$ is the full energy minus the space-time energy W. The numerical value of the total energy of an isolated material system remains constant in time, that is

$$d\tilde{H} = 0, \quad \text{i.e.,} \quad dE_o + dU - dW = 0. \tag{2.15}$$

NOTE. If we take a general look at equations (2.9), (2.11), (2.13) and (2.14), we see that it is more reasonable to choose as parameters of the space and space-time energies in gravimagretism and electromagnetism not the masses and the electric charges of the particles but their MARINOV MASSES and MARINOV ELECTRIC CHARGES

$$m^* = m/c, \qquad q^* = q/c. \tag{2.16}$$

With the Marinov masses and charges the space and space-time energies of two particles will be written

$$U_g = -\gamma m^*_{o1}m^*_{o2}c^2/r, \qquad W_g = \gamma m^*_{o1}m^*_{o2}\mathbf{v}_1.\mathbf{v}_2/r, \tag{2.17}$$

$$U_e = q^*_1 q^*_2 c^2/\varepsilon_o r, \qquad W_e = -\mu_o q^*_1 q^*_2\mathbf{v}_1.\mathbf{v}_2/r. \tag{2.18}$$

In the CGS-system of units - see Chapter V - we take $\varepsilon_o = 1/\mu_o = 1$.

3. TRANSFORMATION OF COORDINATES

For the sake of simplicity, the space geometry in this section will be one-dimensional.

If in the frame K', moving with the velocity V with respect to frame K, the radius vector of a certain point, which is at rest in K', is x', then its radius vector with respect to frame K will be

$$x = x' + Vt, \tag{3.1}$$

where t is the (absolute) time interval between the initial moment when the origins of both frames have coincided and the moment of observation. This is the DIRECT GALILEAN TRANSFORMATION. The INVERSE GALILEAN TRANSFORMATION will be

$$x' = x - Vt. \tag{3.2}$$

The Galilean transformation seems to be in conformity with the PRINCIPLE OF RELATIVITY as by considering either frame K or frame K' attached to absolute space nothing changes in the transformation formulas. I shall, however, add that since the time of Copernicus humanity does not make the error, when considering an object moving with respect to the fixed stars, to consider the object at rest and the stars moving. The Galilean transformation under this Copernican insight is, obviously, in conformity with the Newton-aether character of light propagation.

The Marinov-aether character of light propagation introduces changes into the Galilean transformation formulas. Taking into account the Marinov-aether character of light propagation, I showed[3,5,7] that:

1) By assuming the principle of relativity as valid, one obtains the Lorentz transformation formulas.

2) By assuming the principle of relativity as not valid, one obtains the Marinov transformation formulas.

As these demonstrations are time and space consuming, I shall not give them here (see Refs. 3, 5 or 7), and I shall only give the formulas for the:

1. DIRECT AND INVERSE LORENTZ TRANSFORMATIONS

$$x' = (x - Vt)/(1 - V^2/c^2)^{1/2}, \qquad t' = (t - xV/c^2)/(1 - V^2/c^2)^{1/2}, \tag{3.3}$$

$$x = (x' + Vt')/(1 - V^2/c^2)^{1/2}, \qquad t = (t' + x'V/c^2)/(1 - V^2/c^2)^{1/2}. \tag{3.4}$$

2. DIRECT AND INVERSE MARINOV TRANSFORMATIONS

$$x' = (x - Vt)/(1 - V^2/c^2)^{1/2}, \qquad t_o = t(1 - V^2/c^2)^{1/2}, \tag{3.5}$$

$$x = x'(1 - V^2/c^2)^{1/2} + Vt_o/(1 - V^2/c^2)^{1/2}, \qquad t = t_o/(1 - V^2/c^2)^{1/2}. \tag{3.6}$$

One sees that the Lorentz transformation formulas are entirely symmetric and thus one can attach either frame K to absolute space (in this case light velocity will be isotropic in K and anisotropic in K') or frame K' (in this case light velocity will be isotropic in K' and anisotropic in K), while the Marinov transformation formulas are not symmetric, so that frame K is to be considered attached to absolute space and the velocity of light is isotropic in K and anisotropic in K'.

The time "coordinates" in the Lorentz transformation do not present real physical time, as in their transformation formulas space coordinates do appear. I call such time RELATIVE (or LORENTZ TIME). The time in the Marinov transformation is real measurable physical time. There is only the stipulation that the time units used in frames moving with different velocities with respect to absolute space are different, as in my second axiom I chose the time unit in any frame to be equal to the duration which a light pulse takes to cover a half-unit distance to and fro. I showed[3,5] that, as in any periodic phenomenon, independent of its character, light velocity plays an important role, the clock retardation appears not only in "light clocks" but in any other "clock".

The Marinov transformation is adequate to physical reality. The Lorentz transformation can be kept adequate to physical reality only if it will be considered from an absolute point of view, thus if the relative time will be considered not adequate to real time and the relative (or Lorentz) velocity[3,5] appearing in the Lorentz transformation formulas for velocities will be considered not as real velocity. In Refs. 3 and 5 I show the way in which the Lorentz transformation can be saved from the pernicious Einstein's relativistic claws. In Einstein's claws the Lorentz transformation contradicts physical reality and the errors to which it leads are of first order in V/c. Let me remember that the errors to which the Galilean transformation formulas lead are of second order in V/c. Thus the Lorentz transformation in Einstein's claws is a worse mathematical apparatus than the Galilean transformation.

In the Lorentz transformation, it is assumed that the velocity of light has an absolute constant value in any inertial frame; however, as the space coordinates enter into the transformation formulas for time, time is assumed "relative". In the Marinov transformation, time is assumed absolute (consequently the space coordinates are not present in the transformation formulas for time) and the velocity of light appears to be relative, i.e., direction dependent in any moving frame. My approach is straightforwardly adequate to physical reality, while in the Lorentz transformation the absoluteness of time is transferred to light velocity and the relativity of light velocity is transferred to time. Nevertheless the Lorentz transformation is very useful in theretical physics because it allows the introduction of the powerful mathematical apparatus of the 4-dimensional formalism which gives extreme simplicity and elegance to electromagnetism and, according to my concepts, to gravimagretism, too. In my absolute space-time theory[5] I work intensively with the 4-dimensional mathematical formalism and I introduced the following very convenient notations:

$$\overset{\mapsto}{a} = (\vec{a}, i\bar{a}) = (\mathbf{a}, i\bar{a}) \tag{3.7}$$

is a 4-VECTOR where $\vec{a} = \mathbf{a}$ is its space part and $\bar{a}$ is its time part,

$$\overset{\leftrightarrow\!\!\mapsto}{a} = \begin{vmatrix} \overset{\leftrightarrow}{a} & i\vec{a} \\ i\tilde{\vec{a}} & -\bar{a} \end{vmatrix} \tag{3.8}$$

is a 4-TENSOR where $\overset{\leftrightarrow}{a}$ is its space-space part, $\vec{a} = \mathbf{a}$ is its space-time part, $\tilde{\vec{a}} = \tilde{\mathbf{a}}$ is its time-space part and $\bar{a}$ is its time-time part,

$$\overline{\nabla} = (\partial/\partial x, \partial/\partial y, \partial/\partial z, -i\partial/c\partial t) = (\partial/\partial x)\hat{\mathbf{x}} + (\partial/\partial y)\hat{\mathbf{y}} + (\partial/\partial z)\hat{\mathbf{z}} - (i\partial/c\partial t)\hat{\boldsymbol{\tau}}, \tag{3.9}$$

where $\hat{\mathbf{x}}, \hat{\mathbf{y}}, \hat{\mathbf{z}}$ are the unit vectors along the three space axes and $\hat{\boldsymbol{\tau}}$ is the unit vector along the time axis, is a symbolical 4-vector calle by me the ERMA OPERATOR (in honour of my girl-friend, the Bulgarian physicist Erma Gerova), the square of which is the symbolical 4-dimensional scalar, called the d'ALEMBERT OPERATOR (the symbol is proposed by me)

$$\underline{\Delta} = \overline{\nabla}.\overline{\nabla} = \partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2 - \partial^2/c^2\partial t^2. \tag{3.10}$$

The four-dimensional Erma and d'Alembert operators correspond to the three-dimensional HAMILTON OPERATOR and LAPLACE OPERATOR

$$\nabla = (\partial/\partial x, \partial/\partial y, \partial/\partial z) = (\partial/\partial x)\hat{\mathbf{x}} + (\partial/\partial y)\hat{\mathbf{y}} + (\partial/\partial z)\hat{\mathbf{z}}, \tag{3.11}$$

$$\Delta = \partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2.$$

4. VELOCITY, ACCELERATION, SUPER-ACCELERATION

I introduce two kinds of velocity of a particle (by analogy with the universal and proper light velocities):

The UNIVERSAL VELOCITY

$$\mathbf{v} = d\mathbf{r}/dt, \tag{4.1}$$

where dr is the distance covered by the particle (which is absolute and does not depend on the frame in which we are working) for a time interval dt registered on a UNIVERSAL CLOCK (i.e., a clock attached to absolute space).

The PROPER VELOCITY

$$\mathbf{v}_o = d\mathbf{r}/dt_o = d\mathbf{r}/dt(1 - v^2/c^2)^{1/2} = \mathbf{v}/(1 - v^2/c^2)^{1/2}, \tag{4.2}$$

where the time interval dt_o is read on a PROPER CLOCK (i.e., a clock attached to the particle).

It is logical to introduce three kinds of acceleration:

The UNIVERSAL ACCELERATION

$$\mathbf{u} = d\mathbf{v}/dt = d^2\mathbf{r}/dt^2. \quad (4.3)$$

The FIRST PROPER ACCELERATION

$$\mathbf{u}_o = \frac{d\mathbf{v}_o}{dt} = \frac{d}{dt}\left(\frac{d\mathbf{r}}{dt_o}\right) = \frac{\mathbf{u}}{(1 - v^2/c^2)^{1/2}} + \frac{\mathbf{v}}{c^2}\frac{\mathbf{v}.\mathbf{u}}{(1 - v^2/c^2)^{3/2}}. \quad (4.4)$$

The SECOND PROPER ACCELERATION

$$\mathbf{u}_{oo} = \frac{d\mathbf{v}_o}{dt_o} = \frac{d}{dt_o}\left(\frac{d\mathbf{r}}{dt_o}\right) = \frac{\mathbf{u}}{1 - v^2/c^2} + \frac{\mathbf{v}}{c^2}\frac{\mathbf{v}.\mathbf{u}}{(1 - v^2/c^2)^2}. \quad (4.5)$$

Further it is logical to introduce four kinds of super-acceleration:

The UNIVERSAL SUPER-ACCELERATION: $\mathbf{w} = d\mathbf{u}/dt$.

The FIRST PROPER SUPER-ACCELERATION: $\mathbf{w}_o = d\mathbf{u}_o/dt$.

The SECOND PROPER SUPER-ACCELERATION: $\mathbf{w}_{oo} = d\mathbf{u}_{oo}/dt$.

The THIRD PROPER SUPER-ACCELERATION: $\mathbf{w}_{ooo} = d\mathbf{u}_{oo}/dt_o$.

5. TIME ENERGY

5.1. THE LOW-VELOCITY CONSIDERATION.

From the axiomatical relation (2.12), immediately after integration, the form of the TIME ENERGY of a particle with mass m in low-velocity physics can be obtained

$$e_o = mv^2/2 + \text{Const}. \quad (5.1)$$

If we assume Const = 0, we obtain the form of the KINETIC ENERGY

$$e_k = mv^2/2. \quad (5.2)$$

If we assume Const = mc^2 (see the third axiom), we obtain the form of the time energy in low-velocity physics, called LOW-VELOCITY TIME ENERGY

$$e_1 = mc^2 + mv^2/2. \quad (5.3)$$

5.2. THE HIGH-VELOCITY CONSIDERATION.

To obtain the TIME ENERGY of a particle in high-velocity physics, we have to put in the axiomatical relation (2.12) the proper velocity $\mathbf{v}_o$ instead of the universal velocity $\mathbf{v}$. There are three possibilities

$$de^o = m\mathbf{v}_o.d\mathbf{v}, \qquad de_o = m\mathbf{v}.d\mathbf{v}_o, \qquad de_{oo} = m\mathbf{v}_o.d\mathbf{v}_o, \quad (5.4)$$

and after integration we obtain three different expressions for the time energy in high-velocity physics

$$e^o = - mc^2(1 - v^2/c^2)^{1/2} = - mc^2 + mv^2/2 = - e + e_k, \quad (5.5)$$

$$e_o = mc^2/(1 - v^2/c^2)^{1/2} = mc^2 + mv^2/2 = e + e_k, \quad (5.6)$$

$$e_{oo} = mc^2/2(1 - v^2/c^2) = mc^2/2 + mv^2/2 = e/2 + e_k, \quad (5.7)$$

where all constants of integration are taken equal to zero. I call these three forms, respectively, LAGRANGE TIME ENERGY, HAMILTON TIME ENERGY and MARINOV TIME ENERGY.

All these three forms of time energy are used in theoretical physics, however the Hamilton energy is the most convenient as the proper time momentum, $\bar{p}_o$, is proportional to it

$$\bar{p}_o = e_o/c = m_o c = mc/(1 - v^2/c^2)^{1/2}. \quad (5.8)$$

From here again (see the second formula (2.6)) we obtain the relation between proper mass and universal mass

$$m_o = m/(1 - v^2/c^2)^{1/2} = m^* c_o, \quad (5.9)$$

where $c_o = c/(1 - v^2/c^2)^{1/2}$ is the proper light velocity in a frame attached to the particle, which I call PROPER TIME VELOCITY <u>of the particle</u>. According to my concepts one has to work <u>always</u> with the universal mass and its velocity dependence is to be transferred to the time velocity of the particle. Thus I use the notion "proper mass" only for certain convenience and the reader has never to forget that in the Newton's gravitational law (see the fourth axiom) the mass appears coupled with light velocity. Or to say even more clear: the notion "mass" does not exist; only the notion "energy" ("time momentum") does exist.

The product of the mass of the particle by its acceleration is called KINETIC FORCE. Thus

$$\mathbf{f} = m\mathbf{u}, \qquad \mathbf{f}_o = m\mathbf{u}_o, \qquad \mathbf{f}_{oo} = m\mathbf{u}_{oo} \quad (5.10)$$

are, respectively, the UNIVERSAL KINETIC FORCE, the FIRST PROPER KINETIC FORCE and the SECOND PROPER KINETIC FORCE of the particle. I denote always the kinetic force <u>of</u> the particle (of the system of particles) by small letter "f" and the potential force (see later) acting <u>on</u> the particle (on the system of particles) by capital letter "F". As we shall see in the next chapter,the kinetic force of a particle is always equal to the potential force acting on the particle. This equality is the fundamental equation in physics.

II. THE FUNDAMENTAL EQUATIONS OF CLASSICAL PHYSICS

6. THE LAGRANGE EQUATIONS

6.1. THE LOW-VELOCITY CONSIDERATION.

The space energy U and the space-time energy W are called by the common name POTENTIAL ENERGIES. As can be seen easily, the space-time energy is to be considered only in high-velocity physics as its presence leads to effects of the order v/c; in low-velocity physics, when speaking about potential energy, we take into account only the space energy. In low-velocity physics I write time energy E without the subscript "o" and I usually mean only the kinetic energy.

Let us assume that in a time dt the space (potential) energy U and the time (i.e., kinetic) energy E of an isolated system of n particles have changed their values by dU and dE. Denote by $\mathbf{r}_i$, $\mathbf{v}_i$, $\mathbf{u}_i$, e_i, respectively, the radius vector, velocity, acceleration and energy (i.e., kinetic energy) of the i-th particle. As space energy depends only on the distances between the particles (I repeat, the velocity dependence of the gravitational space energy is a high-velocity phenomenon), we shall have

$$dU = \sum_{i=1}^{n} \frac{\partial U}{\partial \mathbf{r}_i}.d\mathbf{r}_i. \tag{6.1}$$

The kinetic energy depends only on the velocities of the particles, and thus

$$dE = \sum_{i=1}^{n} \frac{\partial E}{\partial \mathbf{v}_i}.d\mathbf{v}_i = \sum_{i=1}^{n} \frac{\partial e_i}{\partial \mathbf{v}_i}.d\mathbf{v}_i = \sum_{i=1}^{n} \frac{d}{dt}\left(\frac{\partial e_i}{\partial \mathbf{v}_i}\right).d\mathbf{r}_i, \tag{6.2}$$

where we have taken into account (5.2) and the relation

$$\mathbf{u}_i.d\mathbf{r}_i = \mathbf{v}_i.d\mathbf{v}_i, \tag{6.3}$$

which can be proved right by dividing both sides by dt.

Substituting (6.1) and (6.2) into the fundamental axiomatical equation (2.15), and dividing by dt, we obtain

$$\sum_{i=1}^{n} \left\{\frac{d}{dt}\left(\frac{\partial e_i}{\partial \mathbf{v}_i}\right) + \frac{\partial U}{\partial \mathbf{r}_i}\right\}.\mathbf{v}_i = 0. \tag{6.4}$$

In this equation all n (as a matter of fact, 3n) expressions in the brackets must be identically equal to zero because otherwise a dependence would exist between the components of the velocities of the different particles, and this would contradict our sixth axiom that the time energy of a particle of a system of particles depends only on its own velocity. Thus from (6.4) we obtain the following system of n vector equations

$$\frac{d}{dt}\left(\frac{\partial e_i}{\partial \mathbf{v}_i}\right) = -\frac{\partial U}{\partial \mathbf{r}_i}, \qquad i = 1, 2, \ldots, n, \tag{6.5}$$

which are called the LAGRANGE EQUATIONS and represent the fundamental equations in low-velocity physics.

Taking into account (5.2), (4.3) and the first relation (5.10), we see that the left side of (6.5) represents the kinetic force $\mathbf{f}_i$ of the i-th particle. Introducing the notation

$$\mathbf{F}_i = -\partial U/\partial \mathbf{r}_i \tag{6.6}$$

and calling $\mathbf{F}_i$ the POTENTIAL FORCE which all n-1 particles exert on the i-th particle, we can write equations (6.5) in the form

$$\mathbf{f}_i = \mathbf{F}_i, \qquad i = 1,2,\ldots,n, \tag{6.7}$$

in which form they are called the NEWTON EQUATIONS (or NEWTON'S SECOND LAW).

The potential force with which the j-th particle acts on the i-th particle is $\mathbf{F}_i^j = -\partial U_{ij}/\partial \mathbf{r}_i$, and the potential force with which the i-th particle acts on the j-th particle is $\mathbf{F}_j^i = -\partial U_{ij}/\partial \mathbf{r}_j$, where U_{ij} is the space energy of these two particles. Since U_{ij} depends on the distance between the particles, we shall have

$$\partial U_{ij}/\partial \mathbf{r}_i = -\partial U_{ij}/\partial \mathbf{r}_j, \quad \text{i.e.,} \quad \mathbf{F}_i^j = -\mathbf{F}_j^i. \tag{6.8}$$

Thus the potential forces with which two particles of a system of particles (in general, two parts of the system) act on each other are always equal and oppositely directed along the line connecting them. Consequently also the kinetic forces of two interacting particles will be equal and oppositely directed along the line connecting them. This result is called NEWTON'S THIRD LAW.

6.2. THE HIGH-VELOCITY CONSIDERATION.

As the high-velocity forms of the space and space-time energies in gravimagretism and electromagnetism are different, the Lagrange equations in these two physical domains will be slightly different. I shall deduce the more complicated equations in gravimagretism, from which the equations in electromagnetism can immediately be obtained.

A. Gravimagretism.

In high-velocity gravimagretism the space energy U depends also on the velocities of the particles and equation (6.1) is to be replaced by the following one (see formulas (2.9), (5.9) and (4.4))

$$dU = \sum_{i=1}^{n}\left(\frac{\partial U}{\partial \mathbf{r}_i}.d\mathbf{r}_i + \frac{\partial U}{\partial \mathbf{v}_i}.d\mathbf{v}_i\right) = \sum_{i=1}^{n}\left\{\frac{\partial U}{\partial \mathbf{r}_i}.d\mathbf{r}_i + \frac{U_i\mathbf{v}_i.d\mathbf{v}_i}{c^2(1-v^2/c^2)^{3/2}}\right\} = \sum_{i=1}^{n}\left(\frac{\partial U}{\partial \mathbf{r}_i}.d\mathbf{r}_i + \frac{U_i}{c^2}\mathbf{v}_i.d\mathbf{v}_{oi}\right), \tag{6.9}$$

where U_i is the part of the space energy in which the i-th particle takes part which is universal with respect to m_i.

In high-velocity physics equation (6.2) is to be replaced by the following one (see formulas (5.6), (5.5) and (4.4))

$$dE_0 = \sum_{i=1}^{n} \frac{\partial E_0}{\partial \mathbf{v}_i}.d\mathbf{v}_i = \sum_{i=1}^{n} \frac{\partial e_{oi}}{\partial \mathbf{v}_i}.d\mathbf{v}_i = \sum_{i=1}^{n} \frac{d}{dt}\{(1 - \frac{v_i^2}{c^2})\frac{\partial e_{oi}}{\partial \mathbf{v}_i}\}.d\mathbf{r}_i = \sum_{i=1}^{n} \frac{d}{dt}(\frac{\partial e_i^o}{\partial \mathbf{v}_i}).d\mathbf{r}_i =$$

$$\sum_{i=1}^{n} m\mathbf{u}_{oi}.d\mathbf{r}_i, \qquad (6.10)$$

where e_{oi} and e_i^o are the Hamilton and Lagrange time energy of the i-th particle.

In high-velocity gravimagretism we have to take into account also the space-time energy W. However, taking into account that the magretic energy of two particles moving with velocities $\mathbf{v}_1$ and $\mathbf{v}_2$ is $\mathbf{v}_1.\mathbf{v}_2/c^2$ times less than their gravitational energy, we have to work not with the proper magretic energy of the system of masses but with its universal magretic energy.

In Ref. 5 when deducing the Lagrange equations in gravimagretism, I worked with the proper magretic energy of the system. This more complicated calculation was needless. Indeed, to discuss the problem whether we have to work with the proper or universal magretic energy is senseless, as we do not know whether a magretic energy does exist at all. Thus we shall consider W as the universal magretic energy

$$dW = \sum_{i=1}^{n} (\frac{\partial W}{\partial \mathbf{r}_i}.d\mathbf{r}_i + \frac{\partial W}{\partial \mathbf{v}_i}.d\mathbf{v}_i) = \sum_{i=1}^{n} \{\frac{\partial W}{\partial \mathbf{r}_i}.d\mathbf{r}_i + d(\frac{\partial W}{\partial \mathbf{v}_i}.\mathbf{v}_i) - d(\frac{\partial W}{\partial \mathbf{v}_i}).\mathbf{v}_i\}, \qquad (6.11)$$

We have

$$\sum_{i=1}^{n} d(\frac{\partial W}{\partial \mathbf{v}_i}.\mathbf{v}_i) = \sum_{i=1}^{n} dW_i = d\sum_{i=1}^{n} W_i = 2dW, \qquad (6.12)$$

where W_i is the part of the space-time energy in which the i-th particle takes part and there is

$$W = (1/2)\sum_{i=1}^{n} W_i, \qquad (6.13)$$

so that formula (6.11) can be written as follows

$$dW = \sum_{i=1}^{n} \{-\frac{\partial W}{\partial \mathbf{r}_i}.d\mathbf{r}_i + d(\frac{\partial W}{\partial \mathbf{v}_i}).\mathbf{v}_i\}. \qquad (6.14)$$

Substituting equations (6.9), (6.10) and (6.14) into the fundamental equation (2.15) and dividing by dt, we obtain by the same reasoning as in Sect. 6.1 the fundamental equations of motion in high-velocity gravimagretism

$$\frac{d}{dt}\{\frac{\partial(E^o - W)}{\partial \mathbf{v}_i}\} + (U_i/c^2)\mathbf{u}_{oi} = -\frac{\partial(U + W)}{\partial \mathbf{r}_i}, \qquad i = 1,2,\ldots,n, \qquad (6.15)$$

which I call the FULL LAGRANGE EQUATIONS IN GRAVIMAGRETISM. If there is no magretic energy, we have to put W = 0. But if the gravitational energy will depend on the proper masses of the particles, there still will be a difference between the low-velocity equations (6.5) and the high-velocity equations (6.15).

The quantity

$$\tilde{\mathbf{F}}_i = -\partial(U + W)/\partial \mathbf{r}_i \qquad (6.16)$$

is called FULL POTENTIAL FORCE. The quantity (6.6), as already said, is called potential force and if more precision is needed NEWTONIAN POTENTIAL FORCE.

The quantity

$$\tilde{\mathbf{f}}_{oi} = (m + U_i/c^2)\,\mathbf{u}_{oi} - \frac{d}{dt}(\frac{\partial W}{\partial \mathbf{v}_i}) = \tilde{m}\mathbf{u}_{oi} - \frac{d}{dt}(\frac{\partial W}{\partial \mathbf{v}_i}) = \mathbf{f}_{oi} - \frac{d}{dt}(\frac{\partial W}{\partial \mathbf{v}_i}) \qquad (6.17)$$

is called PROPER FULL KINETIC FORCE. The quantity $\mathbf{f}_{oi}$ is called PROPER KINETIC FORCE and if more precision is needed PROPER NEWTONIAN KINETIC FORCE.

The quantity

$$\tilde{m} = m + U_i/c^2 \qquad (6.18)$$

is called FULL MASS and the mass m can be called with more precision NEWTONIAN MASS. As however $mc^2 \gg |U_i|$, a distinction between m and $\tilde{m}$ will be not made further.

The FULL NEWTON EQUATIONS are

$$\mathbf{f}_{oi} = \tilde{\mathbf{F}}_i, \qquad i = 1,2,\ldots,n. \qquad (6.19)$$

The FULL NEWTON'S THIRD LAW for the full potential forces with which two particles act one on another

$$\partial(U_{ij} + W_{ij})/\partial \mathbf{r}_i = -\partial(U_{ij} + W_{ij})/\partial \mathbf{r}_j, \quad \text{i.e.,} \quad \tilde{\mathbf{F}}_i^j = -\tilde{\mathbf{F}}_j^i, \qquad (6.20)$$

shows that these forces are equal and oppositely directed along the line joining them.

The FULL NEWTON'S THIRD LAW for the full kinetic forces of two interacting particles

$$\mathbf{f}_{oi} - (d/dt)(\partial W_{ij}/\partial \mathbf{v}_i) = -\{\mathbf{f}_{oj} - (d/dt)(\partial W_{ij}/\partial \mathbf{v}_j\}, \quad \text{i.e.,} \quad \tilde{\mathbf{f}}_{oi} = -\tilde{\mathbf{f}}_{oj} \qquad (6.21)$$

shows that these forces are also equal and oppositely directed. However it may be

$$\mathbf{f}_{oi} \neq -\mathbf{f}_{oj}, \qquad (6.22)$$

i.e., the Newtonian kinetic forces of two interacting particles in high-velocity physics may be not equal and oppositely directed. Hence at the availability of space-time energy the "Newtonian" Newton's third law might be violated.

B. Electromagnetism.

In electrimagnetism the space energy is not velocity dependent and the space-time energy has not "velocity dependent denominators". Thus, it is easy to see that the the FULL LAGRANGE EQUATIONS IN ELECTROMAGNETISM will have the form

$$\frac{d}{dt}\frac{\partial(E^o - W)}{\partial \mathbf{v}_i} = -\frac{\partial(U + W)}{\partial \mathbf{r}_i}, \qquad i = 1,2,\ldots,n. \qquad (6.23)$$

Correspondingly the PROPER FULL KINETIC FORCE will have the form

$$\tilde{\mathbf{f}}_{oi} = m\mathbf{u}_{oi} - \frac{d}{dt}\frac{\partial W}{\partial \mathbf{v}_i} = \mathbf{f}_{oi} - \frac{d}{dt}\frac{\partial W}{\partial \mathbf{v}_i}, \qquad (6.24)$$

and here the notion "full mass" cannot be introduced, i.e., only the gravitational energy leads to a change of the Newtonian mass to a full mass but the electric energy does not. Pay attention in making the distinction: If there are two particles with masses m_1, m_2 and electric charges q_1, q_2 (let them be at rest), whose gravitational and electric energies are U_g and U_e, there will be a difference in the masses of the particles when they will be separated and when they will stay near one to another: the decreased mass of every particle will be given by formula (6.18), where U_i (< 0) is their gravitational energy. However, if we consider the two particles as a single particle, the mass of the composed particle will be, neglecting their mutual gravitationla energy as small with respect to their mutual electric energy,

$$m_{system} = 2m + U_e/c^2. \qquad (6.25)$$

There is nothing strange in this effect, as mass and energy are two names of the same thing and to pass from the masses to the energies we have only to multiply (6.25) by c^2.

As also in electromagnetism only the full kinetic forces are equal, oppositely directed and acting along the line joining the interacting particles, but the Newtonian kinetic forces are not, the "Newtonian" Newton's thid law in electromagnetism might become violated and only the full Newton's third law holds good (see Sect. 63). In electromagnetism also the energy conservation law may become violated (see Chapter VI).

One will perhaps pose the question: How have I come to a violation of the energy conservation law when this law is a fundamental axiom in my electromagnetic theory (axiom IX)? The answer is the following: My axiomatics concerns only the physics of particles. As in the physics of particles I assume the energy conservation law as a fundamental axiom, one can, of course, not violate this law for a system of single particles. But my experiments are done with solid bodies (pieces of metal), i.e., media, in which currents flow. Here the kinetic forces of the particles are "transferred" to the whole body (it can be also liquid) and this is the reason that leads to a violation of the energy conservation law in such experiments.

Of course, we are at the beginning of a new chapter in physics (the physics of the violation of the laws of conservation) and the mathematical and logical analysis of the appearing phenomena needs a much more profound experimental and theoretical research.

7. THE NEWTON-MARINOV EQUATION

Now I shall give another form of the full Lagrange equations in gravimagretism, called in this form also the Newton-Marinov equations.

Let us have a system of n masses m_i moving with velocities $\mathbf{v}_i$, whose distances from a given REFERENCE POINT are r_i. The quantities

$$\Phi = -\gamma \sum_{i=1}^{n} m_{oi}/r_i, \qquad \mathbf{A} = -\gamma \sum_{i=1}^{n} m_{oi}\mathbf{v}_i/cr_i \qquad (7.1)$$

are called GRAVITATIONAL POTENTIAL and MAGRETIC POTENTIAL generated by the system

of masses at this reference point.

If a material point (a particle) with mass m, called TEST MASS, crosses the reference point with a velocity $\mathbf{v}$, the gravitational and magretic energies of the whole system of n+1 masses in which mass m takes part will be

$$U = m_o\Phi, \qquad W = -m_o\mathbf{v}.\mathbf{A}/c = -m\mathbf{v}.\mathbf{A}/c \qquad (7.2)$$

In equations (6.15) we can write U_i instead of U and e_i^o instead of E^o. Choosing then our test mass as the i-th particle of the system of n+1 particles, we can suppress the index "i" and so we obtain the equation of motion of our test particle in the form

$$\frac{m}{c^2}(c^2 + \Phi)\mathbf{u}_o + \frac{m}{c}\frac{d\mathbf{A}}{dt} = -m_o \mathrm{grad}(\Phi - \mathbf{v}.\mathbf{A}/c). \qquad (7.3)$$

This equation can be written also in the form

$$(1 + \Phi/c^2)\mathbf{u}_o + (1/c)d\mathbf{A}/dt = -\mathrm{grad}(\Phi - \mathbf{v}.\mathbf{A}/c)/(1 - v^2/c^2)^{1/2}, \qquad (7.4)$$

which is the equation of motion of a particle surrounded by a gravimagretic system of particles in which the mass of the particle does not take place at all.

Equation (7.3) represents the full Newton (Lagrange) equation in gravimagretism written with the help of the potentials and I call it the NEWTON-MARINOV EQUATION.

When deducing the Newton-Marinov equation I have supposed that the considered material system is isolated. But it is impossible to construct a gravitationally isolated system, as one cannot suppress the gravitational action of the celestial bodies. Looking at formula (7.3), it is logically to assume that the term c^2 in the brackets on the left side represents the gravitational potential generated by all celestial bodies at the reference point taken with a negative sign, i.e.,

$$c^2 = \Phi_w = \gamma \sum_{i=1}^{n} m_i/r_i, \qquad (7.5)$$

where n is the number of the particles in the world, or the number of the celestial bodies (in the last case m_i is the mass of the i-th celestial body). From this point of view the mystery of time energy disappears, as time energy represents nothing else than the negative gravitational energy of the particle with the mass of the whole world

$$m_o c^2 = -m_o\Phi_w. \qquad (7.6)$$

So we reduce the energy forms to two kinds - space energy and space-time energy, and it becomes clear that never the "volume" and the "materiality" of the particles can be established, as such "material points", i.e., drops of energy, do not exist. The time energy of any particle is its gravitational energy dispersed in the whole world. Thus, accepting the undefinable notions "space" and "time" as intuitively clear, the only enigmatic notion in physics remains the notion "space energy". (N.B. May be in this link of every particle with the whole universe is to be searched for the explanation of the paraphysical phenomena.)

Embracing this point of view, we can cancel the notion "time energy" in our axiomatics and operate only with the notions "space energy" and "space-time energy" (let me again emphasize that in the same manner we can cancel the notion "mass" and operate only with the notion "energy").

The notion "time energy" can be canceled from the axiomatics if we replace the sixth and ninth axioms by the follwoing ones:

AXIOM VI. The energy e_0 of any particle is its gravitational energy with the mass of the whole world, which we call WORLD ENERGY and denote by U_w, taken with a negative sign. The world energy of a unit mass which rests in absolute space is equal to $- c^2$ energy units. Thus the world energy of a mass m moving in absolute space is

$$U_w = - m_o c^2. \qquad (7.7)$$

AXIOM IX. The change in time of the difference of the space and space-time energies of an isolated material system is equal to the change in time of its world energy, that is

$$dU - dW = dU_w. \qquad (7.8)$$

So we see that the discussion of the problem about the equality of "inertial" and "gravitational" masses <u>loses its sense</u>, as "inertial mass" does not exist. The mass is only gravitational. Thus all costly experiments with which one searches to establish whether there is a difference between the "inertial" and "gravitational" masses have been and continue to be a waste of time, efforts and money.

In the light of these conclusions the PRINCIPLE OF EQUIVALENCE in the formulation that the gravitational field in a small space domain can be replaced by a suitable non-inertially moving frame of reference also loses its flavour. Let me note, however, that the principle of equivalence in its "relativistic" formulation, according to which a gravitational acceleration cannot be experimentally distinguished from a kinematic acceleration is <u>not true</u>, as I have demonstrated by the help of my accelerated "coupled mirrors" experiment.[3,5,9]

Let us now present the Newton-Marinov equation in another more convenient for calculations form.

The full time change of **A** can be presented as a sum of its partial time change (direct dependence of **A** on time, because the n charges generating **A** change their positions and velocities) and the time change of **A** caused by the change of the radius vector of the particle, because of its motion with velocity **v**. Thus we can write

$$\frac{d\mathbf{A}}{dt} = \frac{\partial \mathbf{A}}{\partial t} + \frac{\partial \mathbf{A}}{\partial \mathbf{r}}\frac{d\mathbf{r}}{\partial t} + \frac{\partial \mathbf{A}}{\partial r}\frac{\partial r}{\partial x}\frac{dx}{dt} + \frac{\partial \mathbf{A}}{\partial r}\frac{\partial r}{\partial y}\frac{dy}{dt} + \frac{\partial \mathbf{A}}{\partial \mathbf{r}}\frac{\partial r}{\partial z}\frac{dz}{dt} = \frac{\partial \mathbf{A}}{\partial t} + \mathbf{v}\frac{\partial \mathbf{A}}{\partial \mathbf{r}} + v_x\frac{\partial \mathbf{A}}{\partial x} + v_y\frac{\partial \mathbf{A}}{\partial y} + v_z\frac{\partial \mathbf{A}}{\partial z} =$$

$$\frac{\partial \mathbf{A}}{\partial t} + \mathbf{v}\,\mathrm{div}\mathbf{A} + (\mathbf{v}.\mathrm{grad})\mathbf{A}. \qquad (7.9)$$

Note that I consider the time change of **A** due to the time change of the radius vector of the test particle, first, because of a direct change in time of the radius vector of the test particle, **v**div**A**, and then because of a direct change in time of its components, (**v**.grad)**A**. My critics of the above interpretation of the full time derivative of A raise the objection that I take <u>twice</u> the same "partial" derivative. They do not take into account that in physics there is <u>only one</u> independent variable, the time t, and thus we are not at all allowed, from a rigorous mathematical point of view,to introduce partial time derivatives (there are always people who assert that the Maxwell-Lorentz equations are to be written not with partial but with full derivatives). Indeed, the partial derivatives in physics have <u>another aspect</u> which is rather physical and <u>not</u> mathematical: We look first at the change of the potential when the particles generating it change velocities and positions for a time dt and second when the test particle changes its position for a time dt. In the second case we have to take both **v**div**A** and (**v**.grad)**A**, otherwise (i.e., by taking only (**v**.grad)**A**) we shall obtain a <u>wrong</u> physical equation. The mathematical reliability of equation (7.9) is proven by the fact that the obtained equation of motion is <u>physically right</u>.

However, we shall later see (Sect. 24) that in electromagnetism the term $(\partial \mathbf{A}/\partial \mathbf{r})(d\mathbf{r}/dt)$ is to be slightly changed, as the experiment <u>impels us</u> to introduce this change. Thus if we shall not write now in (7.9) the term $(\partial \mathbf{A}/\partial \mathbf{r})(d\mathbf{r}/dt)$, nevertheless we have to introduce it later in a slightly changed form, as otherwise our equation will enter into a conflict with the experiments. Thus there is no need now to discuss at great length the problem whether equation (7.9) is to be written with or without this term. I repeat, we are impelled to introduce *ad hoc* such a term (in a <u>slightly modified form</u>) to be able to obtain an equation which will be adequate to physical reality. Thus the conclusion is to be drawn that the fundamental equation in electromagnetism can be not deduced only by a rigorous mathematical logic from the Coulomb and Neumann laws. Nevertless the simplicity with which I obtain from these two laws <u>almost the right</u> fundamental equation is <u>amazing</u>.

Taking now into account the **mathematical relation** (see p. 6)

$$\mathrm{grad}(\mathbf{v}.\mathbf{A}) = (\mathbf{v}.\mathrm{grad})\mathbf{A} + (\mathbf{A}.\mathrm{grad})\mathbf{v} + \mathbf{v}\times\mathrm{rot}\mathbf{A} + \mathbf{A}\times\mathrm{rot}\mathbf{v}, \qquad (7.10)$$

which, in our case, must be written at the condition **v** = Const, and putting (7.9) and (7.10) into (7.3), making no difference between full and Newtonian mass, we obtain the Newton-Marinov equation in its most convenient form

$$\mathbf{f}_o \equiv d\mathbf{p}_o/dt = - m_o(\mathrm{grad}\Phi + \partial \mathbf{A}/c\partial t) + (m_o/c)\mathbf{v}\times\mathrm{rot}\mathbf{A} - (m_o/c)\mathbf{v}\mathrm{div}\mathbf{A}. \qquad (7.11)$$

To this equation we always attach its scalar supplement which can be obtained after the multiplication of both its sides by the velocity of the test mass

$$\mathbf{v}.\mathbf{f}_o \equiv de_o/dt = - m_o\mathbf{v}.(\mathrm{grad}\Phi + \partial \mathbf{A}/c\partial t + v\,\mathrm{div}\mathbf{A}/c). \qquad (7.12)$$

Introducing the quantities

$$\mathbf{G} = - \mathrm{grad}\Phi - \partial \mathbf{A}/c\partial t, \qquad \mathbf{B} = \mathrm{rot}\mathbf{A}, \qquad S = - \mathrm{div}\mathbf{A}, \qquad (7.13)$$

called GRAVITATIONAL INTENSITY, (VECTOR) MAGRETIC INTENSITY and SCALAR MAGRETIC IN-

TENSITY, we can write the Newton-Marinov equation in the form

$$dp_o/dt = m_o\mathbf{G} + (m_o/c)\mathbf{v}\times\mathbf{B} + (m_o/c)\mathbf{v}S. \quad (7.14)$$

Denoting $(1/m_o)d\mathbf{p}_o/dt = \mathbf{G}_{glob}$ and calling it GLOBAL GRAVITATIONAL INTENSITY, we can write (7.11) and (7.14) in the form

$$\mathbf{G}_{glob} = - \text{grad}\Phi - \partial\mathbf{A}/c\partial t + (\mathbf{v}/c)\times\text{rot}\mathbf{A} - (\mathbf{v}/c)\text{div}A = G + (\mathbf{v}/c)\times B + (\mathbf{v}/c)S. \quad (7.15)$$

When clarity needs it, G is to be called RESTRICTED GRAVITATIONAL INTENSITY.

Taking partial derivative with respect to time from the gravitational potential Φ (consider the distances r_i in the first expression (7.1) as functions of time) and divergence from the magretic potential **A** (see the second expression (7.1)), we obtain the EQUATION OF POTENTIAL CONNECTION

$$\text{div}\mathbf{A} = - \partial\Phi/c\partial t, \quad (7.16)$$

which in official electromagnetism is <u>wrongly</u> called the "LORENTZ GAUGE CONDITION". Equation (7.16) is a <u>lawful</u> physical equation and <u>not</u> a "condition" which one can impose at will.

8. THE NEWTON-LORENTZ EQUATION

In electromagnetism the formulas analogical to formulas (7.1) and (7.2) for the ELECTRIC and MAGNATIC POTENTIALS are

$$\Phi = \sum_{i=1}^{n} q_i/r_i, \qquad \mathbf{A} = \sum_{i=1}^{n} q_i\mathbf{v}_i/cr_i, \quad (8.1)$$

$$U = q\Phi, \qquad W = - q\mathbf{v}.\mathbf{A}/c. \quad (8.2)$$

The equation analogical to the Newton-Marinov equation is called in electromagnetism the NEWTON-LORENTZ EQUATION and I shall write it in a form analogical to (7.3)

$$m\mathbf{u}_o + (q/c)d\mathbf{A}/dt = - q\,\text{grad}(\Phi - \mathbf{v}.\mathbf{A}/c), \quad (8.3)$$

in a form analogical to (7.11)

$$\mathbf{f}_o \equiv d\mathbf{p}_o/dt = - q(\text{grad}\Phi + \partial\mathbf{A}/c\partial t) + (q/c)\mathbf{v}\times\text{rot}\mathbf{A} - (q/c)\mathbf{v}\text{div}\mathbf{A}, \quad (8.4)$$

and in a form analogical to (7.15), calling $\mathbf{E}_{glob} = (1/q)d\mathbf{p}_o/dt$ GLOBAL ELECTRIC INTENSITY,

$$\mathbf{E}_{glob} = - \text{grad}\Phi - \partial\mathbf{A}/c\partial t + (\mathbf{v}/c)\times\text{rot}\mathbf{A} - (\mathbf{v}/c)\text{div}\mathbf{A} = E + (\mathbf{v}/c)\times B + (\mathbf{v}/c)S, \quad (8.5)$$

where

$$\mathbf{E} = - \text{grad}\Phi - \partial\mathbf{A}/c\partial t, \qquad B = \text{rot}\mathbf{A}, \qquad S = - \text{div}\mathbf{A} \quad (8.6)$$

are the (RESTRICTED) ELECTRIC INTENSITY, the (VECTOR) MAGNETIC INTENSITY and the SCALAR MAGNETIC INTENSITY, q is the electric charge of a test mass m moving with velocity **v** and Φ, **A** are the electric and magnetic potentials of the surrounding system at the reference point crossed by the test mass.

The scalar supplement to the Newton-Lorentz equation is (see (7.12))

$$\mathbf{v}.\mathbf{f}_o \equiv de_o/dt = - q\mathbf{v}.(\text{grad}\Phi + \partial\mathbf{A}/c\partial t + \mathbf{v}\text{div}\mathbf{A}/c). \quad (8.7)$$

The EQUATION OF POTENTIAL CONNECTION in electromagnetism will have exactly the same form as in gravimagretism (see (7.16))

$$\text{div}\mathbf{A} = - \partial\Phi/c\partial t. \quad (8.8)$$

Substituting (8.8) into (8.5), we obtain the Newton-Lorentz equation in a very symmetric form showing that E_{glob} is determined by the time and space derivatives of Φ and **A**

$$E_{glob} = (\mathbf{v}/c^2)\partial\Phi/\partial t - \text{grad}\Phi - (1/c)\partial\mathbf{A}/\partial t + (\mathbf{v}/c)\times\text{rot}\mathbf{A}. \quad (8.9)$$

Thus the scalar magnetic intensity can be calculated either by the third formula (8.6) or by the formula

$$S = (1/c)\partial\Phi/\partial t. \quad (8.10)$$

If we have a system of two particles with masses m_1, m_2 and charges q_1, q_2 moving with velocities $\mathbf{v}_1$, $\mathbf{v}_2$, we can write

$$U + W = q_1\Phi_1 - q_1\mathbf{v}_1.\mathbf{A}_1/c = q_2\Phi_2 - q_2\mathbf{v}_2.\mathbf{A}_2/c. \quad (8.11)$$

Thus the following equality must be valid

$$m_1\mathbf{u}_{o1} + (q_1/c)d\mathbf{A}_1/dt = - \{m_2\mathbf{u}_{o2} + (q_2/c)d\mathbf{A}_2/dt\}, \quad (8.12)$$

as grad(U + W) in equation (8.3) can be taken once for the reference point where m_1 is placed and once for the reference point where m_2 is placed.

Equation (8.12) can be written in the form

$$\sum_{i=1}^{2} \{m_i\mathbf{u}_{oi} + (q_i/c)d\mathbf{A}_i/dt\} = 0, \quad (8.13)$$

or

$$\sum_{i=1}^{2} (\mathbf{p}_{oi} + q_i\mathbf{A}_i/c) = \mathbf{Const}. \quad (8.14)$$

The quantity in the bracket called FULL MOMENTUM of the particle m is denoted by $\tilde{\mathbf{p}}_o$ and (8.14) is called LAW OF THE CONSERVATION OF THE FULL MOMENTUM.

If W = 0, we obtain

$$\sum_{i=1}^{2} \mathbf{p}_{oi} = \mathbf{P}_o = \mathbf{Const}. \quad (8.15)$$

This is called LAW OF CONSERVATION OF THE (SPACE) MOMENTUM and $\mathbf{P}_o$ is called proper momentum of the whole system.

The law (8.14) can be easily generalized for a system of n particles, as any two particles of the system interact <u>independently</u> of the existence of the other particles.

If **r** is the radius vector of a particle m, the quantity

$$\mathbf{l}_o = \mathbf{r}\times\mathbf{p}_o \quad (8.16)$$

is called PROPER ANGULAR MOMENTUM of the particle m with respect to the frame's origin.

If

$$\sum_{i=1}^{n} \mathbf{l}_{oi} = \mathbf{L}_o = \mathbf{Const}, \qquad (8.17)$$

we say that the angular momentum of the system of n particles with respect to the frame's origin is conserved. Equation (8.17) is called LAW OF CONSERVATION OF THE ANGULAR MOMENTUM and L_o is called proper angular momentum of the system. The deduction of this law in gravitation and electricity is straightforward but there are problems in gravimagretism and electromagnetism. As I have shown above, one can deduce <u>logically</u> only the law of conservation of the full momentum.

If $\mathbf{r}$ is the radius vector of a particle with a kinetic force $\mathbf{f}$, i.e., on which a potential force F acts, then

$$\mathbf{M} = r\times F \qquad (8.18)$$

is called MOMENT OF FORCE (or TORQUE) of this potential force with respect to the frame's origin. The vector distance $\mathbf{r}$ in (8.18), as well as in (8.16), can be taken with respect to any point of space.

In this book the four-dimensional aspects of electromagnetism are not considered (my electromagnetism in 4-dimensional interpretation is considered in Ref. 5). I should like only to note that the axiomatical assertion (see equations (2.11) and (2.14)) that the electric and magnetic energies of two positive charges moving with parallel velocities have <u>opposite</u> signs finds its more profound explanation when considering the sum of the electric and magnetic energies of two charges (see equation (8.11)) as a scalar product (taken with a negative sign) of the 4-current of the one particle

$$\overleftrightarrow{j}_1 = q_1\overleftrightarrow{v}_1 = (q_1\mathbf{v}_1, iq_1c) \qquad (8.19)$$

with the 4-potential generated by the other particle

$$\overleftrightarrow{A}_1 = (\mathbf{A}_1, i\Phi_1) = (\mathbf{j}_2/cr, i\bar{j}_2/cr) = (q_2\mathbf{v}_2/cr, iq_2/r). \qquad (8.20)$$

Calling this product electromagnetic energy of the two particles and denoting it by W + U, we shall have

$$W + U = -\overleftrightarrow{j}_1.\overleftrightarrow{A}_1 = -\mathbf{j}_1.\mathbf{A}_1 + \bar{j}_1\bar{A}_1 = -q_1q_2\mathbf{v}_1.\mathbf{v}_2/c^2r + q_1q_2/r. \qquad (8.21)$$

9. DIFFERENTIAL RELATIONS BETWEEN DENSITIES AND POTENTIALS

A STATIC SYSTEM of particles is this one in which the particles do not move. The QUASI-STATIC SYSTEM is this one in which the particles can move but at any moment at any differentially small volume the same number of particles moving with the same velocity can be found. A DYNAMIC SYSTEM of particles is this one in which the particles can have arbitrary velocities.

The MASS and MOMENTUM DENSITIES of a system of particles at a reference point with

radius vector $\mathbf{r}$ are the following quantities (these are the so-called δ-DENSITIES)

$$\mu(\mathbf{r}) = \sum_{i=1}^{n} m_i\delta(\mathbf{r}-\mathbf{r}_i), \qquad \boldsymbol{\pi}(\mathbf{r}) = \sum_{i=1}^{n} \mathbf{p}_i\delta(\mathbf{r}-\mathbf{r}_i), \qquad (9.1)$$

where $\mathbf{r}_i$ are the radius vectors of the single masses m_i, $\mathbf{p}_i$ are their momenta and $\delta(\mathbf{r}) = \delta(x)\delta(y)\delta(z)$ is the three-dimensional δ-function of Dirac.

9.1. THE STATIC AND QUASI-STATIC CASES.

First I shall prove the validity of the following mathematical relation

$$\Delta(1/r) = -4\pi\delta(\mathbf{r}), \qquad (9.2)$$

where Δ is the Laplace operator and r is the distance between the origin of the frame and the reference point.

Indeed, putting into (9.2)

$$r = |\mathbf{r} - 0| = (x^2 + y^2 + z^2)^{1/2}, \qquad (9.3)$$

we obtain an identity. Only for r = 0 the left-hand side gives the uncertainty 0/0 and the right-hand side gives the uncertainty δ(0).

To establish whether relation (9.2) is valid also for r = 0, let us integrate (9.2) over an arbitrary sphere with radius R which has its center at the frame's origin. Using the Gauss theorem, we shall obtain for the integral on the left-hand side

$$\int_V \Delta(1/r)dV = \int_V \mathrm{div}\{\mathrm{grad}(1/r)\}dV = \oint_S \mathrm{grad}(1/r).d\mathbf{S} = -\oint_S (1/r^2)dS = -(1/R^2)\oint_S dS = -4\pi, \qquad (9.4)$$

where S is the surface of the sphere of integration whose volume is V and $d\mathbf{S}$ is the elementary area (taken as a vector) of the integration surface with a direction pointing outside of the volume enclosed. The integral of the right of (9.2) taken over the same arbitrary surface, on the grounds of the fundamental property of the δ-function, gives the same result. Since the integrals of both sides of (9.2) are equal and the domains of integration represent spheres with arbitrary radii, both integrands must be also equal. Thus the relation (9.2) is valid also for r = 0.

In the same way, or on the grounds of the first axiom for homogeneity and isotropy of space, we can prove the validity of the following relations

$$\Delta(1/|\mathbf{r}-\mathbf{r}_i|) = -4\pi\delta(\mathbf{r}-\mathbf{r}_i), \qquad i=1,2,\ldots,n, \qquad (9.5)$$

where $\mathbf{r}_i$ are the radius vectors of n different space points.

Let us assume that $\mathbf{r}_i$ is the radius vector of a space point where a mass m_i is placed (static case) or where at any moment a mass m_i moving with a velocity $\mathbf{v}_i$ can be found (quasi-static case). Multiplying every of the equalities (9.5) by the corresponding mass m_i or momentum divided by c, $\mathbf{p}_i/c$, and summing, we obtain, after having taken into account (7.1) and (9.1), the following differential equations for the potentials in terms of the mass and momentum densities

$$\Delta\Phi = 4\pi\gamma\mu, \qquad \Delta\mathbf{A} = (4\pi/c)\gamma\boldsymbol{\pi}. \qquad (9.6)$$

9.2 THE DYNAMIC CASE.

Let us consider a point (calling it i-point) which moves with a velocity v along the x-axis of a rest frame K and at the initial zero moment crosses the origin of the frame. Let a moving frame K' be attached to this i-point, and let the transformation between K and K' be a special one (as are the transformations considered in Sect. 3). In such a case the radius vector of the i-point in K' will be $\mathbf{r}'_i = (0,0,0)$. If the radius vector of the reference point in frame K is $\mathbf{r} = (x,y,z)$, according to the Marinov transformation (3.5), the radius vector $\mathbf{r}'$ of the same reference point in the moving frame K' is given by

$$\mathbf{r}' = (x',y',z') = \left(\frac{x - vt}{(1 - v^2/c^2)^{1/2}}, y, z\right). \tag{9.7}$$

The distance between the i-point and the reference point considered in frame K' but expressed by the coordinates in frame K will be

$$r_o = |\mathbf{r}' - \mathbf{r}'_i| = |\mathbf{r} - \mathbf{r}_i|_o = \left\{\frac{(x - vt)^2 + (1 - v^2/c^2)(y^2 + z^2)}{1 - v^2/c^2)}\right\}^{1/2}. \tag{9.8}$$

This distance considered in frame K and expressed by the coordinates in frame K will be

$$r = |\mathbf{r} - \mathbf{r}_i| = \{(x - vt)^2 + y^2 + z^2\}^{1/2}. \tag{9.9}$$

I call r the UNIVERSAL DISTANCE and r_o the PROPER DISTANCE.[3,5,8] The difference between these two distances is due to the Marinov-aether character of light propagation. I repeat, this has nothing to do with a physical "length contraction" ("Lorentz length contraction"). As a matter of fact, here we are considering the distance between two points moving with respect to one another which cannot be connected by a rigid rod, and thus it is meaningless to speak about a contraction of such a "rod". On the other hand, the situation in the frames K and K' is entirely symmetric: in frame K the i-point is moving and the reference point is at rest, while in frame K' the i-point is at rest and the reference point is moving. I wish that the reader understands once and for ever that the Marinov transformation (as well as the Lorentz transformation) serve only for the introduction of the Marinov-aether character of light propagation into the mathematical apparatus of high-velocity physics. The Marinov-aether character of light propagation is incompatible with the classical conceptions for motion of a particle which, I repeat, lead to the Newton-aether character of light propagation (cf. formulas (1.1) and (1.2) once more!). The Marinov-aether "abnormality" in the motion of the photons (this "abnormality" exists also at the motion of the particles with non-zero rest mass[5]) leads to the mathematically contradicting equations (9.8) and (9.9) which describe the same physical distance.

Now easily can be established the validity of the following mathematical relation

$$\square(1/r_{oo}) = - 4\pi\delta(\mathbf{r} - \mathbf{r}_i), \tag{9.10}$$

where $\square$ is the d'Alembert operator and

$$r_{oo} = r_o(1 - v^2/c^2)^{1/2} = \{(x - vt)^2 + (1 - v^2/c^2)(y^2 + z^2)\}^{1/2} \tag{9.11}$$

is called the SECOND PROPER DISTANCE.

Indeed, using in (9.10) the expression (9.11), we obtain an identity. Only for $r_{oo} = 0$, i.e., for $x - vt = y = z = 0$, the left-hand side gives the uncertainty 0/0 and the right-hand side gives the uncertainty $\delta(0)$.

To establish whether relation (9.10) is valid also for $r_{oo} = 0$, let us integrate (9.10) over an arbitrary sphere with radius R which has its center at the i-point (thus this sphere is moving along the x-axis of frame K with the velocity v)

$$\int_V \square(1/r_{oo})dV = - 4\pi\int_V \delta(\mathbf{r} - \mathbf{r}_i)dV. \tag{9.12}$$

For all points of volume V the integrand on the left-hand side is equal to zero. Thus we can spread the integral over a small domain around the point with coordinates given by $x - vt = y = z = 0$, i.e., about the i-point which is also the origin of frame K'. But as $r_{oo} \to 0$, we obtain $1/r_{oo} \to \infty$, and the derivatives with respect to x,y,z will increase much faster than the derivative with respect to t. Hence the latter can be neglected with respect to the former. So we reduce the integral on the left-hand side of (9.12) to the integral (9.4). The integral on the right-hand side of (9.12), on the grounds of the fundamental property of the δ-function, gives the same result, and, as in Sect. 9.1, we conclude that the integrands must be equal. Thus relation (9.10) is valid also for the i-point.

In the same manner as in Sect. 9.1, we can obtain from (9.10) the following relations between potentials and densities for the most general dynamic case

$$\square\Phi = 4\pi\gamma\mu(t), \qquad \square\mathbf{A} = (4\pi/c)\gamma\boldsymbol{\pi}(t), \tag{9.13}$$

where the mass and momentum densities can be functions of time.

In electromagnetism the δ-DENSITIES of the CHARGE and the CURRENT are defined by the following formulas similar to formulas (9.1)

$$Q(\mathbf{r}) = \sum_{i=1}^{n} q_i\delta(\mathbf{r} - \mathbf{r}_i), \qquad \mathbf{J}(\mathbf{r}) = \sum_{i=1}^{n} \mathbf{j}_i\delta(\mathbf{r} - \mathbf{r}_i). \tag{9.14}$$

In electromagnetism the formulas analogical to (9.6) and (9.14) will be

$$\Delta\Phi = - 4\pi Q, \qquad \Delta\mathbf{A} = - (4\pi/c)\mathbf{J}, \tag{9.15}$$

$$\square\Phi = - 4\pi Q(t), \qquad \square\mathbf{A} = - (4\pi/c)\mathbf{J}(t). \tag{9.16}$$

10. INTEGRAL RELATIONS BETWEEN DENSITIES AND POTENTIALS

10.1. THE STATIC AND QUASI-STATIC CASES.

Substituting formulas (9.1) into the definition equalities for the potentials (7.1), we obtain the integral relation between the gravitational and magretic potentials and the mass and momentum densities for a static and quasi-static system of particles

$$\Phi = -\gamma\int_V (\mu/r)dV, \qquad \mathbf{A} = -\gamma\int_V (\pi/cr)dV, \qquad (10.1)$$

where μ and π are the mass and momentum densities in the volume dV which are equal to the sums of the δ-densities in dV divided by dV. These equations are to be considered also as solutions of the differential equations (9.6).

10.2. THE DYNAMIC CASE.

The integral relations between densities and potentials for the general dynamic system are to be obtained by solving equations (9.13). I showed[5] that the solution of equations (9.13) leads to the following integral relations between densities and potentials

$$\Phi(\mathbf{r}_0,t) = -\frac{\gamma}{2}\int_V \frac{1}{r}\{\mu(\mathbf{r},t-\frac{r}{c}) + \mu(\mathbf{r},t+\frac{r}{c})\}dV,$$

$$\mathbf{A}(\mathbf{r}_0,t) = -\frac{\gamma}{2}\int_V \frac{1}{r}\{\pi(\mathbf{r},t-\frac{r}{c}) + \pi(\mathbf{r},t+\frac{r}{c})\}dV, \qquad (10.2)$$

where $\Phi(\mathbf{r}_0,t)$ and $\mathbf{A}(\mathbf{r}_0,t)$ are the potentials at the reference point with radius vector $\mathbf{r}_0$ at the moment t and the integral is spread over the whole space or over the volume V in which there are particles of the system.

I call the potentials (giving for brevity only the formulas for the gravitational potential)

$$\Phi' = -\gamma\int_V \frac{\mu(t-r/c)}{r}\,dV, \qquad \Phi'' = -\gamma\int_V \frac{\mu(t+r/c)}{r}\,dV, \qquad (10.3)$$

respectively, ADVANCED and RETARDED POTENTIALS. Official physics calls wrongly Φ' "retarded" and Φ'' "advanced" potential. Indeed Φ' is the potential at the moment $t' = t - r/c$ which is before the OBSERVATION MOMENT t and thus it is an ADVANCED MOMENT, while Φ'' is the potential at the moment $t'' = t + r/c$ which follows after the observation moment t and thus it is a RETARDED MOMENT. Conventional physics mixes up the notions as it supposes that the "interaction" propagates with the velocity c and it assumes that Φ' is the potential at the moment of observation t, i.e., that the potential "appears" with a certain "retardation" at the reference point and leaves absolutely without attention the other solution Φ'' of the equations (9.13).

The potentials must be given as half-sums of their advanced and retarded values as an observer at the reference point can obtain information only about the advanced and retarded values in the following two ways: 1) either messengers will start from any volune dV_i at the respective advanced moments $t_i' = t - r_i/c$ and, moving with the highest possible velocity c, will bring the information about the mass and momentum densities in dV_i to the observer at the reference point, or 2) messengers will start from the reference point at the observation moment t and moving with velocity c will reach every of the volumes dV_i at the respective retarded moments $t_i'' = t + r_i/c$ to see which are there the mass and momentum densities. Obviously the densities at the moment of observation will be the half-sums of the advanced and retarded densities.

If in the volume dV_i the charges move with accelerations, they will radiate energy in the form of gravimagretic waves which will propagate in space with the velocity of light. In Chapter IV I show that a mass moving with acceleration generates, besides the "momentary" gravitational and magretic intensities, two other intensities: the one propagates with the velocity c away from the mass carrying with itself momentum and energy and the other acts directly on the radiating mass. I call the "momentary" intensity due to the masses and their velocities the POTENTIAL INTENSITY, the intensity field due to the masses and their accelerations which carry away energy and momentum the RADIATION INTENSITY, and the intensity acting on the radiating mass braking its motion, so that the lost kinetic energy should compensate the radiated energy the RADIATION REACTION INTENSITY. The mathematical logic leads to all these three substantially different intensities. And all these three intensities have been observed in electromagnetism ex as the mathematics applied to the Newton-Lorentz equation predicts them.

If we wish to know what gravimagretic energy reaches the reference point at the moment of observation t in the form of gravimagretic waves, we have to use for the calculation not the observation potential (with whose help the potential intensity can be calculated) but the advanced potential because the radiated energy needs the time r_i/c to come from the volume dV_i to the reference point.

Official physics, or, better to say, the majority of the conventional physicists think that not only the radiated energy propagates with the velocity c but also the potentials "propagate" with the same velocity and introduce the notion "propagation of interaction". Following this trend, they calculate also the potential intensities by the help of the advanced (in their language, retarded) potentials. This is wrong, as one is able to observe only the propagation of energy, i.e., the transfer of mass. An immaterial "interaction" cannot be observed and it is senseless to narrate that such an "interaction", like a ghost, can propagate.

The potentials are not really existing physical quantities, they exist only in our heads. Also the intensities exist only in our heads. The only physical quantity which really does exist is the energy (the mass). And only energy can be transferred from one space domain to another.

The wrong treatment of the potentials of dynamic systems leads to the result that the official physicists are unable to calculate the radiation reaction intensity proceeding directly from the potentials. Their wrong calculations lead to the phantasmagoric self-accelerating solutions.(5) In Chapter IV I give my theoretical solution of the problem about the radiation of electromagnetic waves. And I propose two very simple experiments (see Sect. 37) with whose help one can see whether the potential electric intensity appears momentarily in whole space, as I assert, and that only the radiation electric intensity has a wave character of propagation with a velocity equal to c.

11. LIENARD-WIECHERT FORMS OF THE POTENTIALS

Let us consider (fig. 1) a system consisting of only one electric charge q which moves in absolute space with the constant velocity **v**. Let us take the reference point at the origin, P, of the rest frame K.

Let us assume that at the advanced moment t' the charge q sends a photon from its advanced position Q' which, covering for the time $\Delta t' = r'/c$ the ADVANCED DISTANCE r' arrives at the observation moment $t = t' + r'/c$ at the reference point when the distance to q is the OBSERVATION DISTANCE r. Then this photon is sent back to q along the RETARDED DISTANCE r" and after time $\Delta t'' = r''/c$ it reaches the charge q at the retarded moment $t'' = t + r''/c$ when it is at its retarded position Q".

If the photon has a Newton-aether character of propagation, taking into account that $Q'Q = v(r'/c)$ and $QQ'' = v(r''/c)$, we can easily find the relation between the observation distance, on one side, and the advanced and retarded distances, on the other side,

$$r = r'(1 - 2\mathbf{n}'.\mathbf{v}/c + v^2/c^2)^{1/2}, \qquad r = r''(1 + 2\mathbf{n}''.\mathbf{v}/c + v^2/c^2)^{1/2}. \qquad (11.1)$$

These formulas can be obtained also if putting into the second formula (1.1) $c' = r/\Delta t'$, $c = r'/\Delta t'$, $\mathbf{n}.\mathbf{V} = \mathbf{n}'\mathbf{v}$, for the first case, and $c' = r/\Delta t''$, $c = r''/\Delta t''$, $\mathbf{n}.\mathbf{V} = - \mathbf{n}''.\mathbf{v}$, for the second case.

However when the photon has a Marinov-aether character of propagation, we have to find the relation between observation, advanced and retarded distances by putting into the second formula (1.2), in which the factor $(1 - V^2/c^2)^{1/2}$ related to the clock retardation is to be omitted, $c' = r/\Delta t'$, $c = r'/\Delta t'$, $\mathbf{n}.\mathbf{V} = \mathbf{n}'.\mathbf{v}$, for the first case, and $c' = r/\Delta t''$, $c = r''/\Delta t''$, $\mathbf{n}.\mathbf{V} = - \mathbf{n}''.\mathbf{v}$, for the second case, thus obtaining

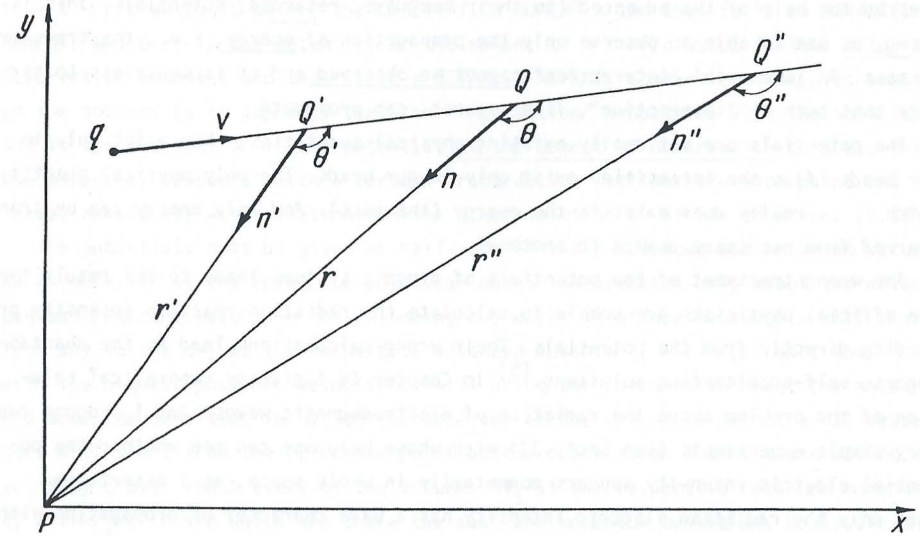

Fig. 1. Advanced, observation and retarded distance.

$$r = r'(1 - \mathbf{n}'.\mathbf{v}/c), \qquad r = r''(1 + \mathbf{n}''.\mathbf{v}/c), \qquad (11.2)$$

and here (as well as in formulas (11.1)) **n**' and **n**" are the unit vectors pointing, respectively, from the advanced and retarded position of q to the reference point.

As the Newton-aether and Marinov-aether characters of light propagation are mathematically contradicting, it is senseless to try to reconcile formulas (11.1) and (11.2).

By putting the expressions (11.2) into formulas (8.1), we obtain the so-called LIENARD-WIECHERT POTENTIALS in electromagnetism

$$\Phi = \frac{q}{r'(1 - \mathbf{n}'\mathbf{v}/c)} = \frac{q}{r''(1 + \mathbf{n}''.\mathbf{v}/c)}, \qquad \mathbf{A} = \frac{q\mathbf{v}}{cr'(1 - \mathbf{n}'.\mathbf{v}/c)} = \frac{q\mathbf{v}}{cr''(1 + \mathbf{n}''.\mathbf{v})}. \qquad (11.3)$$

It is extremely important to note that **v**, especially in the nominators of **A**, is the observation velocity of the charge q and not its advanced velocity **v**', as conventional physics assumes (for the case when **v** is not constant), considering only the left parts of these equations and calling them wrongly "retarded" potentials. It must be absolutely clear that Φ and **A** in formulas (11.3) are the observation potentials, as the distances in (11.3) are the observation distances.

Let me note that by considering in the nominators of **A** the observation velocity in the forms $\mathbf{v} = \mathbf{v}' + \mathbf{u}'(t - t') = \mathbf{v}''\ \ \mathbf{u}''(t'' - t)$, where **v**', **v**" and **u**', **u**" are the advanced and retarded velocities and accelerations, I could deduce the radiation reaction intensity directly from the potentials working with the most simple and rigorous mathematical logic (see Sect. 34).

12. THE MAXWELL-MARINOV EQUATIONS

Taking rotation from both sides of the first equation (7.13) and making use of the mathematical identities

$$\mathrm{rot}(\mathrm{grad}\Phi) = 0, \qquad \mathrm{div}(\mathrm{rot}\mathbf{A}) = 0, \qquad (12.1)$$

we obtain the FIRST PAIR OF THE MAXWELL-MARINOV EQUATIONS

$$\mathrm{rot}\mathbf{G} = - \partial\mathbf{B}/c\partial t, \qquad \mathrm{div}\mathbf{B} = 0. \qquad (12.2)$$

Let us now take partial derivatives with respect to time from both sides of the first equation (7.13), dividing it by c,

$$\partial\mathbf{G}/c\partial t = - (1/c)\mathrm{grad}(\partial\Phi/\partial t) - (1/c^2)\partial^2\mathbf{A}/\partial t^2. \qquad (12.3)$$

Write the second equation (9.13) in the form

$$- (1/c^2)\partial^2\mathbf{A}/\partial t^2 = - \Delta\mathbf{A} + (4\pi/c)\gamma\pi \qquad (12.4)$$

and put here the mathematical identity

$$\Delta\mathbf{A} = \mathrm{grad}(\mathrm{div}\mathbf{A}) - \mathrm{rot}(\mathrm{rot}\mathbf{A}). \qquad (12.5)$$

Substituting (12.4) into (12.3) and taking into account (7.16), we obtain

$$rot\mathbf{B} = (1/c)\partial\mathbf{G}/\partial t - (4\pi/c)\gamma\pi. \qquad (12.6)$$

Let us finally take divergence from both sides of the first equation (7.13)

$$div\mathbf{G} = -\Delta\Phi - (1/c)\partial(div\mathbf{A})/\partial t. \qquad (12.7)$$

Write the first equation (9.13) in the form

$$\Delta\Phi = (1/c^2)\partial^2\Phi/\partial t^2 + 4\pi\gamma\mu. \qquad (12.8)$$

Putting (12.8) into (12.7) and taking into account (7.16), we obtain

$$div\mathbf{G} = -4\pi\gamma\mu. \qquad (12.9)$$

Equations (12.6) and (12.9) are the SECOND PAIR OF THE MAXWELL-MARINOV EQUATIONS.

13. THE MAXWELL-LORENTZ EQUATIONS

The analogues to the Maxwell-Marinov equations in electromagnetism are the famous Maxwell-Lorentz equations. Here are the FIRST and SECOND PAIR OF THE MAXWELL-LORENTZ EQUATIONS (see formulas (12.2), (12.6) and (12.9))

$$rot\mathbf{E} = -(1/c)\partial\mathbf{B}/\partial t, \qquad div\mathbf{B} = 0, \qquad (13.1)$$

$$rot\mathbf{B} = (1/c)\partial\mathbf{E}/\partial t + (4\pi/c)\mathbf{J}, \qquad div\mathbf{E} = 4\pi Q. \qquad (13.2)$$

Now I shall present the Maxwell-Lorentz equations in an integral form.

According to Gauss theorem we have

$$\oint_S \mathbf{B}.d\mathbf{S} = \int_V div\mathbf{B}\, dV, \qquad (13.3)$$

where the integral on the left side is taken over the closed surface S bounding the volume V, over which we take the integral on the right side. Using here the second equation (13.1), we obtain

$$\oint \mathbf{B}.d\mathbf{S} = 0. \qquad (13.4)$$

This integral equation, which corresponds to the differential equation (13.1), asserts that the scalar flux of the magnetic intensity through any closed surface is equal to zero.

According to Stokes theorem we have

$$\oint_L \mathbf{E}.d\mathbf{r} = \int_S rot\mathbf{E}.d\mathbf{S}, \qquad (13.5)$$

where the integral on the left side is taken along the closed line L bounding the surface S, over which we take the surface integral on the right side. Using here the first equation (13.1), we obtain

$$\oint_L \mathbf{E}.d\mathbf{r} = -(1/c)(\partial/\partial t)\int_S \mathbf{B}.d\mathbf{S}. \qquad (13.6)$$

This integral equation, which corresponds to the first differential equation (13.1), asserts that the circulation of the electric intensity along any closed line L is equal to the time derivative, taken with an opposite sign, from the scalar flux of the magnetic intensity through any surface bounded by this line.

The circulation of the electric intensity is also called ELECTRIC TENSION along the respective line and is denoted by U (do not confound this symbol with the symbol for the electric energy). For the differential part $d\mathbf{r}$ of the line L we shall have

$$dU = \mathbf{E}.d\mathbf{r}. \qquad (13.7)$$

Let us turn now our attention to the second pair of the Maxwell-Lorentz equations.

According to Gauss theorem we have

$$\oint_S \mathbf{E}.d\mathbf{S} = \int_V div\mathbf{E}\, dV. \qquad (13.8)$$

Using here the second equation (13.2), we obtain

$$\oint_S \mathbf{E}.d\mathbf{S} = 4\pi\int_V Q dV. \qquad (13.9)$$

This integral equation which corresponds to the second differential equation (13.2), asserts that the scalar flux of the electric intensity through any closed surface S is equal to the sum of the charges in the volume V bounded by this surface and multiplied by 4π.

According to Stokes theorem we have

$$\oint_L \mathbf{B}.d\mathbf{r} = \int_S rot\mathbf{B}.d\mathbf{S}. \qquad (13.10)$$

Using here the first equation (13.2), we obtain

$$\oint_L \mathbf{B}.d\mathbf{r} = (1/c)(\partial/\partial t)\int_S \mathbf{E}.d\mathbf{S} + (4\pi/c)\int_S \mathbf{J}.d\mathbf{S}. \qquad (13.11)$$

The quantity

$$\mathbf{J}_{dis} = (1/4\pi)\,\partial\mathbf{E}/\partial t \qquad (13.12)$$

is called DISPLACEMENT CURRENT DENSITY. Using this quantity (whose physical essence will be explained in Sect. 30), we can write (13.11) in the form

$$\oint_L \mathbf{B}.d\mathbf{r} = (4\pi/c)\int_S (\mathbf{J} + \mathbf{J}_{dis}).d\mathbf{S}. \qquad (13.13)$$

This integral equation, which corresponds to the first differential equation (13.2), asserts that the circulation of the magnetic intensity along any closed line L is equal to the scalar flux of the current and displacement current through any surface S bounded by this line.

14. ENERGY DENSITY AND ENERGY FLUX DENSITY

Let us multiply the first equation (13.1) by $\mathbf{B}$, the first equation (13.2) by $\mathbf{E}$, and then subtract the first from the second

$$\frac{\mathbf{E}}{c}\cdot\frac{\partial\mathbf{E}}{\partial t} + \frac{\mathbf{B}}{c}\cdot\frac{\partial\mathbf{B}}{\partial t} + \frac{4\pi}{c}\mathbf{J}.\mathbf{E} + \mathbf{B}.rot\mathbf{E} - \mathbf{E}.rot\mathbf{B} = 0. \qquad (14.1)$$

Using the mathematical relation (see p. 6)

$$\mathrm{div}(\mathbf{E}\times\mathbf{B}) = \mathbf{B}.\mathrm{rot}\mathbf{E} - \mathbf{E}.\mathrm{rot}\mathbf{B}, \qquad (14.2)$$

we can write (14.1) in the form

$$\frac{\partial}{\partial t}\frac{E^2+B^2}{8\pi} + \mathbf{J}.\mathbf{E} + \frac{c}{4\pi}\,\mathrm{div}(\mathbf{E}\times\mathbf{B}) = 0. \qquad (14.3)$$

Let us now integrate this equation over an arbitrary volume V containing our electromagnetic system and use the Gauss teorem for the last term

$$\frac{\partial}{\partial t}\int_V \frac{E^2+B^2}{8\pi}\,dV + \int_V \mathbf{J}.\mathbf{E}\,dV + \oint_S c\frac{\mathbf{E}\times\mathbf{B}}{4\pi}.d\mathbf{S} = 0, \qquad (14.4)$$

where the last integral is spread over the surface S of the volume V.

Taking into account the second equation (9.14), we can write

$$\int_V \mathbf{J}.\mathbf{E}\,dV = \sum_{i=1}^{n} q_i\mathbf{v}_i.\mathbf{E}, \qquad (14.5)$$

where n is the number of the charges in the system.

Putting this into (14.4) and taking into account equation (8.7), assuming there $S = -\,\mathrm{div}\mathbf{A} = 0$, as this is a rather ad hoc introduced term, we obtain

$$\frac{\partial}{\partial t}\int_V \frac{E^2+B^2}{8\pi}\,dV + \frac{d}{dt}\sum_{i=1}^{n} e_{oi} + \frac{c}{4\pi}\oint_S (\mathbf{E}\times\mathbf{B}).d\mathbf{S} = 0. \qquad (14.6)$$

If we consider the integral on the right side as time (kinetic) energy, then, having in mind the energy conservation law (2.15), we have to assume that the corresponding "particles" move with the velocity c away from the volume V and that in a unit of time the energy

$$\mathbf{I} = \frac{c}{4\pi}\,\mathbf{E}\times\mathbf{B} \qquad (14.7)$$

crosses a unit surface placed at right angles to **I**, which is called (ELECTROMAGNETIC) ENERGY FLUX DENSITY. The quantity

$$\mathbf{S} = \frac{1}{4\pi}\,\mathbf{E}\times\mathbf{B} \qquad (14.8)$$

is the density of this energy (at a snap shot) and is called the POYNTING VECTOR.

It turns out (see Chapter IV) that **E** and **B** in the last term of (14.6) are to be considered as the electric and magnetic intensities radiated by the charges of the system and thus are to be denoted by $\mathbf{E}_{rad}$ and $\mathbf{B}_{rad}$. Then E and B in the first term of (14.6) are to be considered as the radiation electric and magnetic intensities radiated by the charges of the system which still have not left the volume V and thus are also to be denoted by E_{rad} and B_{rad}. The middle term in (14.6) is the change of the time energy of the system which, according to formulas (14.5) and (8.7), is equal to the change of the potential electric energy of the system. Thus, for a given short time interval, the change of electric (or time) energy of the system is equal to the change of the radiated energy in the volume V (given by the first term in (14.6)) plus the energy radiated outside the volume V (given by the third term in (14.6)). Thus E and **B** in formula (14.6) do not represent the potential electric and magnetic intensities, $\mathbf{E}_{pot}$, $\mathbf{B}_{pot}$, but only the radiation electric and magnetic intensities $\mathbf{E}_{rad}$, $\mathbf{B}_{rad}$. In Chapter IV we shall see that $E_{rad} = B_{rad}$ and $\mathbf{E}_{rad}.\mathbf{B}_{rad} = 0$.

Considering the potential electric and magnetic fields as physical realities, official physics brought into the theory a big mess. I repeat, the potential electric and magnetic intensities are mathematical quantities which exist only in our heads. They have neither energy density (the energy density near the charges will be infinitely big and thus incalculable!) nor momentum density. Meanwhile the radiated electric and magnetic intensities are physically existing quantities with the energy density

$$\bar{S} = (E^2 + B^2)/8\pi \qquad (14.9)$$

and momentum density **I** given by formula (14.7).

Concluding this chapter, let me say that the Maxwell-Lorentz equations are not some "physical" equations invented by somebody. They are the most trivial mathematical deductions from the Newton-Lorentz equation (which in its official form can be found in Maxwell's "Treatise" and thus it is unjustified to call it "Lorentz equation") and the equations (9.16) connecting densities and potentials, which, from their part, are the most obvious results of the definition equations (8.1) for the potentials and the definition equations (9.14) for the densities.

But neither the Newton-Lorentz equation is some "physical" equation, as it is a trivial mathematical result from the Coulomb law (axiom V), the Neumann law (axiom VIII), the form of the time energy of mass m moving with velocity **v** (axiom VI) and the energy conservation law (axiom IX). I have, however, to emphasize that I spent 3 years in Sofia of intensive mental work some 20 years ago to arrive at the deduction of the Lorentz equation from the mentioned four axioms, and my last 10 years in Graz to understand that at this deduction I had to take $d\mathbf{A}/dt$ in the form(7.9) and not without the term $\mathbf{v}\mathrm{div}\mathbf{A}$, as I did in Sofia, and to write it thus in the Newton-Lorentz form. Nicolaev's experiments, however, impelled me to introduce some changes in this term (see Sect. 24).

Thus, according to me, in classical physics there are only four discoveries:

1) Coulomb's law in electromagnetism and Newton's law in gravitation.

2) Neumann's law (as a matter if fact, the coronation of Neumann's law as a fundamental physical axiom was done by me).

3) The form of the time energy of a particle.

4) The energy conservation law.

As my own physical discovery, I consider the revelation of the Marinov-aether character of light propagation. In my CLASSICAL PHYSICS[5] the Marinov-aether character of light propagation is introduced in the theory as an axiom (the tenth axiom). I did not follow this way in the present book, as the volume of Sect. 2 had to be substantially increased, meanwhile I wish to explain with this book what electromagnetism is in the most laconic way.

As another physical discovery is to be considered the introduction, rather *ad hoc*, of the scalar magnetic intensity in its Whittaker's and Nicolaev's forms (see Sect. 24), noting, however, that the form of the scalar magnetic intensity is still not established definitely. The "discovery" of the motional-transformer induction and the "invention" of the perpetua mobilia MAMIN COLIU, VENETIN COLIU and SIBEREAN COLIU (see Chapter VI) are simple logical results to which all logically thinking children have to come alone when analyzing the Newton-Lorentz equation. Thus, according to me, discovery is the creation of an axiomatical assertion (which is right!). The mathematical deductions from the axiomatical assertions cannot be discoveries.

I do not consider the coronation of the potentials as the primary physical quantities and the decoronation of the intensities as an achievemnt of some value, as those are obvious things and every logically thinking child has to come alone to these conclusions. Indeed, if **A** is given, then every ordinary child is able the calculate quickly E_{tr}, B and S, but if E_{tr}, **B** and S are given neither the most extraordinary professor is able to calculate **A**.

Neither the establishment of space and time as absolute categories nor the rejection of the principles of relativity and equivalence can be considered as achievements of some value, as every normally thinking child accepts these assertions as true and not the oposite.

III. LOW-ACCELERATION ELECTROMAGNETISM

15. INTRODUCTION

Further I shall no more pay attention to gravimagretism and only some "neuralgic" aspects of electromagnetism will be treated.

In Chapter III the acceleration of the electric charges of the system considered will be supposed low and thus their radiation will be neglected (it will be shown in Chapter IV that the energy radiated by the electric charges is proportional to their accelerations).

The electromagetic equations obtained in Chapter II are for a system of single particles. But the electromagnetic systems with which we experiment only rarely consist of single particles. The predominant part of the material systems are MEDIA which are built in a very complicated manner of single charged and uncharged particles. We shall disregard the way in which the media are built and we shall accept very simple models elaborated by humanity after centuries of experimental work and observations. It turns out that by accepting these genuine models of the media, we can calculate a large quantity of the electromagnetic phenomena by the help of the simple equations deduced in Chapter II for a system of single particles. This simple approach to the problems of electromagnetism is called PHENOMENOLOGICAL APPROACH.

I shall work in this book with the most simple media: current conducting wires, condensers filled by air (vacuum) or by dielectrics and coils filled by air or by magnetics, appealing to the most general and elementary knowledges of the reader, elaborated in the secondary schools or by reading some popular booklets.

16. RESISTANCE

The ELECTRIC CURRENT I which flows in a metal wire (which will be called also CONDUCTOR) is the quantity of electric charge dq which crosses its cross-section for the time dt

$$I = dq/dt. \qquad (16.1)$$

The electric tension dU along a length d**r** of the conductor will be given by formula (13.7), where E will be the acting electric intensity which I call also DRIVING ELECTRIC INTENSITY. Consequently the tension U along the whole or a part of the conductor will be called DRIVING ELECTRIC TENSION.

It was experimentally established (by Ohm in 1826) that the current flowing in a conductor is proportional to the electric tension between its end points

$$I = GU, \qquad (16.2)$$

where the coefficient G which depends on the material substance of the conductor and on its geometry is called CONDUCTANCE. Equation (16.2) is called OHM'S LAW.

of the scalar magnetic intensity in its Whittaker's and Nicolaev's forms (see Sect. 24), noting, however, that the form of the scalar magnetic intensity is still not established definitely. The "discovery" of the motional-transformer induction and the "invention" of the perpetua mobilia MAMIN COLIU, VENETIN COLIU and SIBEREAN COLIU (see Chapter VI) are simple logical results to which all logically thinking children have to come alone when analyzing the Newton-Lorentz equation. Thus, according to me, discovery is the creation of an axiomatical assertion (which is right!). The mathematical deductions from the axiomatical assertions cannot be discoveries.

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The conductance of a wire with a unit length and unit cross-section is called CONDUCTIVITY and is denoted by γ. Thus the conductance of a wire with length L and cross-section S will be

$$G = \gamma S/L. \quad (16.3)$$

RESISTANCE R, which is much more used in practice, is the quantity inverse to conductance

$$R = 1/G = L/\gamma S = \rho L/S, \quad (16.4)$$

where ρ is called RESISTIVITY and this is the resistance of wire with unit length and unit cross-section. Thus we can write

$$I = U/R. \quad (16.5)$$

If the resistance of a wire is zero, it is called SUPER-CONDUCTOR.

Let us suppose that dq charges have been transferred along a conductor for a time dt, the tension between whose end points is $U = \Delta\Phi$, where $\Delta\Phi$ is the difference between the electric potentials at the end points. According to the first formula (8.2), in which we have to write U_e, dq and $\Delta\Phi$ instead of U, q and Φ, the electric energy of the system will change with

$$dU_e = dq\Delta\Phi = dqU = IUdt, \quad (16.6)$$

where equation (16.1) was taken into account.

The change of the energy in a time unit

$$P = dU_e/dt \quad (16.7)$$

is called POWER, and from (16.6) and (16.7) we obtain

$$P = IU = RI^2 = U^2/R. \quad (16.8)$$

This power is liberated as heat in the conductor and is lost by the source supplying the driving tension. HEAT is a physical phenomenon outside the domain of electromagnetism and for this reason Ohm's law cannot be obtained from my axiomatics. In "pure" electromagnetism, which is to be thoroughly explained by logical deductions from the axiomatics, the conductors must be super-conductors.

Until the present time it is not clear how electric current propagates along metal wires. The phenomenological model proposed by me[6] is the following:

The so-called valence electrons, which are the current conducting electrons, are loosely connected with the ions of the metal lattice, jumping continuously from one atom to another and forming a kind of "electron gas" throughout the solid ions' lattice. If there is no electric tension applied to the wire, the motion of the valence electrons is chaotic and their average velocity is zero. When an electric tension is applied to the wire (imagine, for simplicity, that an electric pulse is applied to the left end of the wire by supplying a surplus of electrons), the chaotically moving electrons from the left end, where the concentration exeeds the concentration of the valence electrons, begin to move with a preferred average velocity to the right, where the electron concentration is less. The average "DRIFT

VELOCITY" of the electrons, v_{dr}, is of the order of mm/sec. This velocity can be easily calculated if assuming that all valence electrons in the wire are current conducting electrons. However the velocity, v_{en}, with which the "electrons' concentration" propagates through the wire, and which I call the ENERGY VELOCITY, is of the order of c, as can be established by measuring the velocity with which the current pulse propagates. Thus, after a second the exceeding electrons which were supplied to the left wire's end will be transferred to 1 mm, but the electrons' concentration will be exceeding at a distance of 300,000 km. If the wire is not closed, the electrons' concentration will be reflected from the right end and returning back will be reflected from the left end, and so on, until the surplus electrons will be distributed uniformly troughout the wire and its surface will become equipotential.

As the electrons are absolutely identical and indistingushable one from another, we must conclude that in a second the exceeding electrons were transferred at a distance of 300,000 km. (Indeed, if 100 electrons in file move on 1 cm each in a second or the first electron moves on 100 cm, while the other 99 remain at rest, the physical result is the same.)

If there is a consumer at the right end of the wire and the supply of surplus electrons at the left end is continuous, the electric energy from the supplier to the consumer will proceed along the wire with the velocity $v_{en} = c$.

It must be clear that the velocity of the single electrons is neither the drift velocity, v_{dr}, nor the energy velocity, v_{en}. Every electron moves chaotically. It is possible that some of the supplied surplus electrons may cover the whole wire with a velocity c and be always in the "electrons' surplus concentration". The probability for such a case is v_{dr}/v_{en}. Even in a wire without electric tension there is a possibility that some electron will cross it from one end to the other with a velocity c, however the probability for such a case is zero. Although the electric energy transferred along a wire is something material and can be measured in energy units transferred in a time unit along a length unit, official physics speaks about a foggy "propagation of interactoon", being unable to explain what a physical quantity "interaction" is and with which measuring instruments and in which measuring units is to be measured. For certain official physicists the "interaction" propagates through the metal, for other it surrounds the conductor similarly to the aura which surrounds the human body according to the assertions of the Indian yogas.

My friends Milnes[10] and Pappas[11] have done experiments for measuring the velocity of propagation of current pulses along copper wires and have established that it is much higher than c, at least 10 or even 100 times higher than c.

It turns out that only the directed motion of the electrons liberates heat but the chaotic motion does not. This result makes the hypothesis about the "electron gas" shaky. Thus after so many years of experimentation with currents in metal wires, one can make the conclusion: we still do not know the mechanism of propagation of the current.

17. CAPACITANCE

It is obvious that the potential difference (tension) between a charged conductor and other uncharged conductors in its neighbourhood (the latter usually are connected to earth) will be proportinal to the electric charge q on the conductor

$$U = (1/C)q, \qquad (17.1)$$

where the coefficient 1/C depends on the geometry of the whole system and C is called CAPACITANCE. The number C shows the quantity of electric charge with which the conductor is to be charged to increase its potential with unity respectively to the uncharged conductors. A material system which has capacitance is called CONDENSER (one can use also the word CAPACITOR).

Let us have a condenser consisting of two parallel plates of surface S, the distance between which is d. One can use equation (13.8) and the second equation (13.2) to find its capacitance. The volume of integration V will be chosen so that it contains one of the plates, the charge density on which is Q. Designating the surface of the volume V by S', we shall have

$$\oint_{S'} \mathbf{E}.d\mathbf{S} \;\; 4\pi\int_V Q dV = 4\pi q, \qquad (17.2)$$

where q is the whole charge on the plate (the charge on the other plate is -q if the latter is not earthed). If d is small with respect to $\sqrt{S}$, we can assume that the electric intensity is different from zero only between the plates, being there constant and perpendicular to the plates. Thus we shall have

$$ES = 4\pi q. \qquad (17.3)$$

As E = U/d, we obtain from here

$$q = (S/4\pi d)U. \qquad (17.4)$$

Comparing this with (17.1), we obtain for the capacitance of the parallel plate condenser

$$C = S/4\pi d. \qquad (17.5)$$

We see from equation (17.4), if denoting the surface charge density by $\Sigma = q/S$, that the electric intensity between two nearly placed parallel plates charged homogeneously with surface charge density Σ is

$$E = 4\pi\Sigma. \qquad (17.6)$$

Let us find now the capacitance of a cylindrical condenser with coaxial plates with radii R_i and R_e of the internal and external plates and length L, supposing $R_e - R_i \ll L$.

We use again formula (13.8) and choose the volume of integration V to contain only the internal cylindrical plate. Assuming again that E is different from zero only in the space between the plates where it is constant and perpendicular to the condenser's axis, we shall obtain from (13.8), if choosing the integration surface

crossing the space between the plates to be cylindrical with a radius r,

$$E(2\pi rL) = 4\pi q. \qquad (17.7)$$

Thus the tension between the plates will be

$$U = \int_{R_i}^{R_e} \mathbf{E}.d\mathbf{r} = (2q/L)\int_{R_i}^{R_e} dr/r = 2q\ln(R_e/R_i)/L. \qquad (17.8)$$

Comparing this with (17.1), we obtain for the capacitance of the cylindrical condenser

$$C = L/2\ln(R_e/R_i). \qquad (17.9)$$

Denoting the surface charge density on the internal cylindrical plate by $\Sigma = q/2\pi R_i L$, we see from equation (17.7) that the electric intensity between two nearly placed coaxial cylindrical plates charged homogeneously with surface charge density Σ, at a distance r from the cylindrical axis, is

$$E = 4\pi\Sigma R_i/r. \qquad (17.10)$$

From here, at $r = R_i$, we obtain formula (17.6).

18. INDUCTANCE

18.1. INDUCTANCE OF A LOOP.

Let us have a circuit in which current I flows. This current will generate the magnetic potential A(r) at a reference point with radius vector **r**. Let us take the line integral of **A** along a certain closed loop L. According to Stokes theorem, taking into account the second formula (8.6), we shall have

$$\oint \mathbf{A}.d\mathbf{r} = \int_S \text{rot}\mathbf{A}.d\mathbf{S} = \int_S \mathbf{B}.d\mathbf{S} = \Phi, \qquad (18.1)$$

where S is an arbitrary surface spanned on the closed line and Φ is called MAGNETIC FLUX (electric potential and magnetic flux are designated by the same symbol and be attentive to not confound them!) crossing the surface S.

If denoting by $\mathbf{A}_o$ the magnetic potential generated by a unit current flowing in the circuit, and if taking the line L to be the circuit itself, we shall have

$$\Phi = I\oint_L \mathbf{A}_o.d\mathbf{r} = LI, \qquad (18.2)$$

where

$$L = \oint_L \mathbf{A}_o.d\mathbf{r} = \int_S \mathbf{B}_o.d\mathbf{S} \qquad (18.3)$$

is called INDUCTANCE of the circuit and $\mathbf{B}_o$ is the magnetic intensity generated by a unit current flowing in the circuit on the arbitrary surface S spanned on the circuit. Thus L is the magnetic flux generated by a unit current flowing in the circuit through any surface S spanned on the circuit.

18.2. INDUCTANCE OF A CIRCULAR LOOP.

Let us calculate the inductance of the most simple circular circuit (fig.2).

We take the reference framewith origin at the center of the loop and we shall calculate first the magnetic potential generated by an arbitrary current element at an internal (in the loop) and at an external (outside the loop) reference point, both lying on the positive x-axis. Let us denote the distance from the frame's origin to both reference points by ρ_{int} and ρ_{ext}, and from the loop's element by r_{int} and r_{ext}. The radius of the circular loop is denoted by R and the angle between the x-axis and the radius vector to the loop's element (which, for definiteness, let us consider in the first quadrant) by ϕ. The flow of the current will be taken in the positive direction (i.e., counter-clockwise).

If dq is the quantity of electric charge which for a time dt is transferred through the cross-section of the wire, we can write $dq\mathbf{v} = dq\,d\mathbf{r}/dt = Id\mathbf{r}$, where $I = dq/dt$ is the flowing current, $d\mathbf{r}$ is the line element of the loop taken along the current, and the expression $Id\mathbf{r}$ is called CURRENT ELEMENT. Resolving the vector of the current element into a horizontal and vertical components, we see that the actions of the horizontal components of two symmetric current elements in the first and fourth quadrants will annihilate one another, so that only the action of the vertical component will remain. Thus we concude that the magnetic potential at the internal and external reference points originated by both symmetric current elements in the first and fourth quadrants will be parallel to the y-axis. For the absolute value, according to the definition formula for **A** (8.1), we obtain

$$dA = 2\frac{I\,dr\cos\phi}{cr} = \frac{2IR\cos\phi\,d\phi}{c(\rho^2 - 2\rho R\cos + R^2)^{1/2}}, \qquad (18.4)$$

where by r and ρ either the internal or external distances are denoted, and we put $dr = Rd\phi$.

To obtain the magnetic potential originated by the current in the whole loop, we have to integrate formula (18.4) for ϕ changing from 0 to π, thus obtaining

$$A = \int dA = \frac{2IR}{c}\int_0^{\pi}\frac{\cos\phi\,d\phi}{(\rho^2 - 2\rho R\cos\phi + R^2)^{1/2}} = \begin{cases} \dfrac{\pi I}{c}\dfrac{\rho}{(R^2-\rho^2)^{1/2}} & (\text{for } \rho < R), \\[2ex] \dfrac{\pi I}{c}\dfrac{R^2}{(\rho^2-R^2)^{1/2}} & (\text{for } \rho > R). \end{cases} \qquad (18.5)$$

The value of the elliptical integral in (18.5) can be found in a standard table of integrals. This formula shows that the magnetic potential increases rapidly from 0 at the center of the loop to infinity at the loop, and then it decreases slowly to 0 at infinity.

As the magnetic potential of a circular loop has rotational symmetry, the magnetic intensity produced by it can be calculated immediately, using the expression for rotation in cylindrical coordinates, taking $\mathbf{A} = (A_\rho, A_\phi, A_z) = (0, A, 0)$, where for

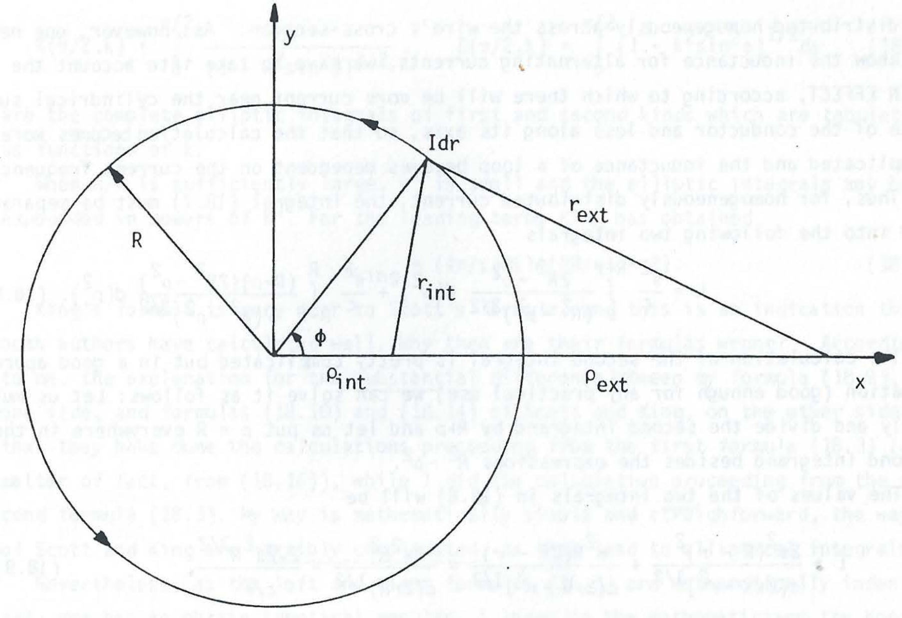

Fig. 2. Circular loop in which current flows.

A the expressions (18.5) are to be taken,

$$B = \text{rot}A = \frac{1}{\rho}\frac{\partial(\rho A)}{\partial\rho}\hat{z} = \begin{cases} \dfrac{\pi I}{c}\dfrac{2R^2-\rho^2}{(R^2-\rho^2)^{3/2}}\hat{z} & (\text{for } \rho < R), \\[2ex] -\dfrac{\pi I}{c}\dfrac{R^2}{(\rho^2-R^2)^{3/2}}\hat{z} & (\text{for } \rho > R). \end{cases} \qquad (18.6)$$

This formula shows that the magnetic intensity increases from $(2\pi I/cR)\hat{z}$ at the center of the loop to $\infty\hat{z}$ at the loop inside and then decreases from $-\infty\hat{z}$ at the loop outside to 0 at infinity.

Let us calculate the inductance of the circular circuit according to the second formula (18.3) for $\rho < R$

$$L = \int_S \mathbf{B}_0 . d\mathbf{S} = \frac{\pi}{c}\int_0^R \frac{2R^2-\rho^2}{(R^2-\rho^2)^{3/2}}2\pi\rho\,d\rho = \frac{2\pi^2}{c}R + \frac{2\pi^2}{c}\left.\frac{R^2}{(R^2-\rho^2)^{1/2}}\right|_0^R = \infty. \qquad (18.7)$$

We see that by substituting the limit "R" in the solution on the right side, we obtain infinity. Thus the inductance of a circular infinitely thin loop is infinitely large.

If the radius of the circular wire is r, we have to divide the integral (18.7) into two integrals: one in the limits from 0 to R - r, in which the magnetic intensity in the circle of radius R-r is generated by the whole current (in our case I = 1), and one in the limits from R-r to R, in which the current is a function of the integration variable. In our case we have to take I = (R-ρ)/r, if the current is distributed homogeneously across the wire's cross-section. As, however, one needs to know the inductance for alternating currents, we have to take into account the SKIN EFFECT, according to which there will be more current near the cylindrical surface of the conductor and less along its axis, so that the calculation becomes more complicated and the inductance of a loop becomes dependent on the current frequency.

Thus, for homogeneously distributed current, the integral (18.7) must be separated into the following two integrals

$$L = \frac{\pi^2}{c}\int_0^{R-r} \frac{2R^2 - \rho^2}{(R^2 - \rho^2)^{3/2}}\, d(\rho^2) + \frac{\pi^2}{c}\int_{R-r}^{R} \frac{(R-\rho)(2R^2 - \rho^2)}{r(R^2 - \rho^2)^{3/2}}\, d(\rho^2). \quad (18.8)$$

The calculation of the second integral is pretty complicated but in a good approximation (good enough for any practical use) we can solve it as follows: Let us multiply and divide the second integrand by $R+\rho$ and let us put $\rho = R$ everywhere in the second integrand besides the expressions $R^2 - \rho^2$.

The values of the <u>two</u> integrals in (18.8) will be

$$L = \frac{2\pi^2(R - r)^2}{c(2rR - r^2)^{1/2}} + \frac{\pi^2 R(2R - r)}{c(2rR - r^2)^{1/2}} \cong \frac{4\pi^2R^2}{c(2rR)^{1/2}} = \frac{2\sqrt{2}\pi^2R^{3/2}}{c\sqrt{r}}, \quad (18.9)$$

where the result on the right is obtained by neglecting r with respect to R.

Thus the first integral in (18.8) gives only the <u>half</u> of the right value.

Scott[12] also tried to find the inductance of a circular wire and after <u>horrible</u> calculations, where the physical substance of the problem was completely lost, obtained the following result

$$L_{Scott} = (4\pi/c)R\{\ln(8R/r) - 7/4\}. \quad (18.10)$$

Scott's formula is <u>definitely wrong</u>, as the <u>truncated</u> first integral (18.8), which I shall denote by L_{trunc} and which gives a value definitely lower than the true inductance L_{true}, is always <u>larger</u> than L_{Scott}. Here are the relations L_{trunc}/L_{Scott} for R/r = 10; 100; 1000: L_{trunc}/L_{Scott} = 1.11; 2.21; 4.84. The relations of the true enough inductance L given by the value on the right of (18.9) to Scott's value for the same ratios R/r are: L/L_{Scott} = 2.74; 4.51; 9.71.

There are also two aesthetical reasons showing that Scott's formula is wrong: 1) His theretical demonstration is too complicated and MARINOV'S RAZOR says: *Ogni teoria complicata è sbagliata.* 2) The number 7/4 indicates that something is rotten in the formula: the Divinity cannot put this number in a formula describing such a symmetric effect.

King[13] gives in *Handbuch der Physik*, the most authoritative source of physics knowledge, the following formula for the inductance of a circular loop

$$L_{king} = (4\pi/c)\{R(R+r)\}^{1/2}\{(2/k - k)K(\pi/2,k) - (2/k)E(\pi/2,k)\}, \quad (18.11)$$

where

$$k = (1 - k'^2)^{1/2}, \qquad k' = r/(2R+r), \quad (18.12)$$

and

$$K(\pi/2,k) = \int_0^{\pi/2} \frac{d\phi}{(1 - k^2\sin^2\phi)^{1/2}}, \qquad E(\pi/2,k) = \int_0^{\pi/2} (1 - k^2\sin^2\phi)^{1/2}\, d\phi \quad (18.13)$$

are the complete elliptic integrals of first and second kinds which are tabulated as functions of k.

When R/r is sufficiently large, k' is small and the elliptic integrals may be expounded in powers of K'. For the leading terms King has obtained

$$L_{king} = (4\pi/c)R\{\ln(8R/r) - 2\}. \quad (18.14)$$

King's formula is very near to Scott's formula, and this is an indication that both authors have calculated well. Why then are their formulas wrong? - According to me, the explanation for the <u>substantial</u> difference between my formula (18.9), on one side, and formulas (18.10) and (18.14) of Scott and King, on the other side, is that they have done the calculations proceeding from the first formula (18.3) (as a matter of fact, from (18.16)), while I did the calculation proceeding from the second formula (18.3). My way is mathematically simple and straighforward, the ways of Scott and King are <u>horribly complicated</u>, as they lead to elliptical integrals.

Nevertheless, as the left and right formulas (18.3) are mathematically indentical, one has to obtain <u>identical results</u>. I leave to the mathematicians the honour to find why the calculations of Scott and King have led to a wrong result.

18.3. NEUMANN'S FORMULA.

Returning to formula (18.3) and taking into account that

$$\mathbf{A} = \oint_L I\mathbf{dr}/cr, \qquad \mathbf{A}_o = \oint_L \mathbf{dr}/cr, \quad (18.15)$$

we can write the left side of formula (18.3) in the form

$$L = \oint_L \oint_L \mathbf{dr}.\mathbf{dr}'/cr. \quad (18.16)$$

Let us have now two circuits L_1 and L_2. Let us take the line integral of the magnetic potential $\mathbf{A}_1$ generated by the current I_1 in the first circuit along the contour L_2 of the second circuit. Using again Stokes theorem, as in formula (18.1), we shall have

$$\oint_{L_2} \mathbf{A}_1.\mathbf{dr}_2 = \int_{S_2} \mathrm{rot}\mathbf{A}_1.\mathbf{dS}_2 = \int_{S_2} \mathbf{B}_{12}.\mathbf{dS}_2 = \Phi_{12}, \quad (18.17)$$

where S_2 is an arbitrary surface spanned on the closed line L_2 and Φ_{12} is the magnetic flux generated by the current in the loop L_1 which crosses the surface of the loop L_2. If $\mathbf{A}_1$ is generated by a unit current and if taking into account formula (18.15), we can write for the MUTUAL INDUCTANCE of L_2 due to the unit current in L_1

$$L_{12} = \oint_{L_2} \mathbf{A}_{o1}.\mathbf{dr}_2 = \oint_{L_1}\oint_{L_2} \mathbf{dr}_1.\mathbf{dr}_2/cr_{12}. \quad (18.18)$$

This is called the FORMULA OF NEUMANN and obviously $L_{12} = L_{21}$.

Now the inductance (18.16) can be called SELF-INDUCTANCE and denoted by L_{11}.

If we have N circular loops with the same radius overlapping one another and if the common radius of their filaments is much less than the loop's radius, we can make the following conclusion: The self-inductance of every loop will be L (see (18.9)) and the mutual inductance of every loop caused by the other N-1 loops will be (N-1)L. Thus the inductance of all N loops will be N^2L.

If the distances between the loops are considerable and their positions one with respect to another arbitrary, every single mutual inductance will be less than L, and thus the inductance of the whole system will be less than N^2L.

Let me note that if the currents I_1 and I_2 are flowing, respectively, in the coils L_1 and L_2, the mutual inductance of whom is L_{12}, then the mutual magnetic energy of the currents in these two coils will be (see (2.14) and (18.18))

$$W_{12} = - \oint_{L_1}\oint_{L_2} q_1\mathbf{v}_1.q_2\mathbf{v}_2/c^2r_{12} = - \oint_{L_1}\oint_{L_2} I_1d\mathbf{r}_1.I_2d\mathbf{r}_2/c^2r_{12} = - I_1I_2L_{12}, \tag{18.19}$$

where the relations $I_1d\mathbf{r}_1 = q_1\mathbf{v}_1$, $I_2d\mathbf{r}_2 = q_2\mathbf{v}_2$ have been taken into account.

As a matter of fact, I called equation (2.14) Neumann's law when proceeding from formula (18.19).

For the magnetic energy of the current elements in a single coil with self-inductance L we shall have

$$W = - (1/2)LI^2 \tag{18.20}$$

and it is a negative quantity, meanwhile in any official text-book on electromagnetism this energy is taken wrongly as a positive quantity.

It is easy to see that on the right side of (18.20) the coefficient 1/2 is to be taken, as at the integration in (18.16) we take once the product of $d\mathbf{r}_i$ with $d\mathbf{r}_j'$ and once the product of $d\mathbf{r}_j$ with $d\mathbf{r}_i'$, so that we shall obtain twice their magnetic energy. Of course, we can write (18.20) without the factor 1/2 but then this factor is to be put in formula (18.16).

I have, however, to emphasize that the calculation of the self-inductance according to formula (18.16) inevitably leads to improper integrals, as the distance r_{ii} between the element $d\mathbf{r}_i$ at the one integration along L and the element $d\mathbf{r}_i' = d\mathbf{r}_i$ at the other integration along the same contour L is zero. Perhaps here is to be searched for the wrong calculations of Scott and King.

18.4. INDUCTANCE OF AN INFINITELY LONG SOLENOID.

Let us consider N circular loops of radius R with a common axis and having the same distance one from another, in which current I flows. We can assume, for mathematical rigorosity, that the N circular loops are independent and any has its own source of electric tension, but, of course, we shall have in mind that all loops are connected, building thus a COIL, and that there is only one source of electric tension. Such a cylindrical coil is called also SOLENOID. If the length of the solenoid is l, there will be n = N/l TURNS (of WINDINGS) on a unit of its length. When l tends to infinity, the solenoid is called INFINITE.

The magnetic potential in the plane of any circular loop generated by its own current is given by formula (18.5). The magnetic potential generated in a plane whose distance from the loop's plane is z will be

$$A = \frac{2IR}{c}\int_0^{\pi} \frac{\cos\phi\, d\phi}{(\rho^2 - 2\rho R\cos\phi + R^2 + z^2)^{1/2}}. \tag{18.21}$$

The magnetic potential generated by all windings of an infinite solenoid at a point with cylindrical coordinates ρ, ϕ, z will be

$$A = \sum_{i=1}^{N=\infty} A_i = \frac{2IR}{c}\int_0^{\infty} ndz \int_0^{\pi} \frac{\cos\phi\, d\phi}{(\rho^2 - 2\rho R\cos\phi + R^2 + z^2)^{1/2}}. \tag{18.22}$$

This integral can be evaluated by dividing it in two parts, from 0 to π/2 and from π/2 to π, writing in the second integral π - ϕ for ϕ and interchanging its limits. Denoting then $a_1 = \rho^2 - 2\rho R\cos\phi + R^2$, and $a_2 = \rho^2 + 2\rho R\cos\phi + R^2$, we shall have

$$A = \frac{2nIR}{c}\int_0^{\infty} dz \int_0^{\pi/2} \cos\phi\, d\phi\{\frac{1}{(a_1^2 + z^2)^{1/2}} - \frac{1}{(a_2^2 + z^2)^{1/2}}\}. \tag{18.23}$$

Interchanging now the order of integration, we can easily take the integral on z

$$A = \frac{2nIR}{c}\int_0^{\pi/2} \cos\phi\, d\phi \ln\{\frac{a_2}{a_1}\frac{z + (z^2 + a_1^2)^{1/2}}{z + (z^2 + a_2^2)^{1/2}}\}\Big|_0^{\infty} = \frac{2nIR}{c}\int_0^{\pi/2} \cos\phi\, d\phi \ln(a_2/a_1) =$$

$$\frac{2nIR}{c}\int_0^{\pi/2} \cos\phi\, d\phi \ln\{\frac{\rho^2 + 2\rho R\cos\phi + R^2}{\rho^2 - 2\rho R\cos\phi + R^2}\}. \tag{18.24}$$

Let us denote $\alpha = 2\rho R/(\rho^2 + R^2)$ and use integration by parts, the one part being $\cos\phi d\phi$ and the other the logarithm. The integrated part vanishes and the integral, except for the factor 2nIR/c, becomes

$$2\alpha\int_0^{\pi/2} \frac{\sin^2\phi\, d\phi}{1 - \alpha^2\cos^2\phi} = \frac{2}{\alpha}\{\phi - (1 - \alpha^2)^{1/2}\arctan\frac{\tan\phi}{(1 - \alpha^2)^{1/2}}\}\Big|_0^{\pi/2}, \tag{18.25}$$

as the reader can readily verify by differentiation.

The expression $\arctan\{\tan\phi/(1 - \alpha^2)^{1/2}\}$ approaches π/2 as ϕ → π/2. Using

$$(1 - \alpha^2)^{1/2} = (\rho^4 - 2\rho^2R^2 + \rho^4)^{1/2}/(\rho^2 + R^2) = |\rho^2 - R^2|/(\rho^2 + R^2), \tag{18.26}$$

we obtain

$$A = \frac{2nIR}{c}\frac{\rho^2 + R^2}{\rho R}\frac{\pi}{2}(1 - \frac{|\rho^2 - R^2|}{\rho^2 + R^2}). \tag{18.27}$$

Thus

$$A = \begin{cases} 2\pi nI\rho/c, \\ 2\pi nIR^2/c\rho, \end{cases} \qquad B = \frac{1}{\rho}\frac{\partial(\rho A)}{\partial\rho} = \begin{cases} 4\pi nI/c, & (\text{for } \rho < R), \\ 0, & (\text{for } \rho > R). \end{cases} \tag{18.28}$$

The inductance of one loop of this infinite solenoid, according to both formulas (18.3), will have the value

$$L = 4\pi^2 nR^2/c = 4\pi nS/c = 4\pi NS/cl, \qquad (18.29)$$

where $S = \pi R^2$ is the cross-section of the solenoid.

The inductance of all $N = nl$ loops of the solenoid will be

$$L = 4\pi^2 n^2 lR^2/c = 4\pi n^2 lS/c = 4\pi N^2 S/cl. \qquad (18.30)$$

This formula remains valid for a final solenoid if l is big enough with respect to R. Otherwise the inductance of the solenoid will be less than (18.30).

19. RESISTORS, CAPACITORS AND INDUCTORS

Every conductor has a certain resistance, capacitance and inductance. Conductors for which only one of these qualities is predominant are called, respectively, RESISTORS, CAPACITORS (condensers) and INDUCTORS. An IDEAL RESISTOR is this one whose capacitance and inductance are (or can be accepted) zeros. An IDEAL CAPACITOR is this one whose resistance and inductance are zeros. An IDEAL INDUCTOR is this one whose resistance and capacitance are zeros.

In Sect. 16 the energetic aspects of the resistors have been already considered.

Let us now consider the energetic aspects of capacitors and inductors.

To charge a condenser having capacitance C with total charge q_o, we have to spent the following energy (see the first formula (8.2) in which we have to exchange the potential difference $\Delta\Phi$ by the tension U)

$$U_e = \int_0^{q_o} U dq = \int_0^{q_o} (q/C) dq = q_o^2/2C = CU_o^2/2, \qquad (19.1)$$

where U and q are the variable tension and electric charge of the condenser during the charging and U_o is the tension of the charged condenser. This energy will be invested as MECHANICAL ENERGY ("mechanical energy" is another name of kinetic energy) because always when we add a new portion of charge dq the repulsion from the side of the charges on the condenser q becomes greater and gretaer. The electric energy U_e stored in the condenser can then be liberated when discharging it.

Usually a condenser is charged by a SOURCE OF ELECTRIC TENSION. The sources of electric tension can be chemical (a CELL, called also a BATTERY), thermal (thermocouple), mechanical (friction of two solid bodies), piezoelectric (appearing at an increased pressure on a solid body), induced (see Sect. 21). Every source of electric tension has its own resistance, called internal resistance and denoted by R_i. If $R_i = 0$, the source is called IDEAL.

The tension produced by a source of electric tension is called usually DRIVING (ELECTRIC) TENSION and is denoted by U_{dr}. For U_{dr} official physics uses the very bad term ELECTROMOTIVE FORCE. Also the very bad term VOLTAGE is used for electric tension.

A charged condenser is also a source of electric tension. If we connect its

plates by a conductor with zero resistance, it will discharge momentarily with an infinitely large current.

Let now discharge a condenser with capacitance C through a resistor with resistance R. The sum of the tensions on the condenser and on the resistor must be zero and thus we can write

$$RI + q/C = 0 \quad \text{or} \quad Rdq/dt = -q/C, \qquad (19.2)$$

where q is the charge on the condenser at the moment t. The differential equation (19.2) can be solved directly and its integral is

$$\int_{q_o}^{q} dq/q = -(1/RC)\int_0^t dt. \qquad (19.3)$$

Taking the integral, we obtain

$$\ln(q/q_o) = -t/RC \quad \text{or} \quad q = q_o e^{-t/RC}, \qquad (19.4)$$

and we have further

$$I = (q_o/RC)e^{-t/RC} = (U_o/R)e^{-t/RC} = I_o e^{-t/RC}, \quad U = U_o e^{-t/RC}. \qquad (19.5)$$

The value RC is now seen to be the time it takes the charge, current and potential to drop to 1/e = 0.368 of its initial value and is called the TIME CONSTANT of the circuit containing the capacitance C and the resistance R.

Now if we charge up a condenser with a cell of driving tension U_{dr} and wires of total resistance R (including the eventual internal resistance R_i of the cell), the driving tension must be equal to the sum of the tensions on the resistor and on the condenser

$$U_{dr} = RI + q/C \quad \text{or} \quad CU_{dr} = RCdq/dt + q. \qquad (19.6)$$

To solve this differential equation in the form of the indefinite integral as above, let us define the charge $Q = CU_{dr} - q$ as the difference between the final charge CU_{dr} on the condenser and its value q at any time t. Then $q = CU_{dr} - Q$ and $dq/dt = -dQ/dt$, so that equation (19.6) reads

$$CU_{dr} = -RCdQ/dt + CU_{dr} - Q, \qquad (19.7)$$

or

$$dQ/Q = -(1/RC)dt. \qquad (19.8)$$

Thus we obtain as above

$$Q = Q_o e^{-t/RC}, \qquad (19.9)$$

and as for q = 0 there is $Q_o = CU_{dr}$, we have

$$CU_{dr} - q = CU_{dr}e^{-t/RC}, \qquad (19.10)$$

which rearranges to

$$q = CU_{dr}(1 - e^{-t/RC}), \qquad (19.11)$$

from which we derive

$$I = U_{dr}e^{-t/RC}/R, \qquad U = U_{dr}(1 - e^{-t/RC}). \qquad (19.12)$$

Let us consider now an ideal inductor with inductance L.

If the current in the inductor changes, an electric tension will appear in the inductor directed oppositely to the driving tension producing the current. The value of this electric tension can be found proceeding from the Newton-Lorentz equation (8.5). Putting in this equation $\Phi = 0$, $v = 0$, as the inductor is not charged electrically and is at rest, we shall find for the global electric intensity which in this case I shall call INDUCED ELECTRIC INTENSITY

$$E_{ind} = -\partial \mathbf{A}/c\partial t, \qquad (19.13)$$

where **A** is the magnetic potential along the inductor.

For the INDUCED ELECTRIC TENSION which will appear along the whole length of the inductor L (do not confound the length of the inductor with its inductance) we shall have (see (18.2))

$$U_{ind} = \oint_L E_{ind}.dr = -(\partial/c\partial t)\oint_L A.dr = -(\partial/c\partial t)\int_S B.dS = -\partial\Phi/c\partial t = -L\partial I/c\partial t, \qquad (19.14)$$

where **B** is the magnetic intensity through the surface S spanned over the contour L of the inductor (or the sum of the surfaces spanned on its single windings), Φ is the <u>common</u> magnetic flux and I is the current flowing in the inductor. Equation (19.14) is called FARADAY'S LAW, although it is the <u>most trivial</u> result from the Newton-Lorentz equation.

Equation (19.14) shows that only when the magnetic potential along the inductor's wires changes in time, an induced electric intensity and thus also induced electric tension do appear. And the magnetic potential changes in time only when the current changes in time.

I repeat here the statement presented in many of my articles: Electromagnetism can (and has to) be explained operating only with the potentials. One introduces the notion "intensities" (and "fluxes") only for mathematical or mnemonic conveniences. So, for example, working with the intensity and not with the potentials, I "calculated" in Sect. 18 the inductance of a circular loop much more easily than it can be done if working with the potential. On the other hand, however, the calculation with the intensities may lead to wrong results (see Sect. 22), as the intensities are <u>derivatives</u> of the potentials and contain <u>less</u> mathematical information.

Let us now make a circuit of an ideal inductor with inductance L, a resistor of resistance R and a cell with driving tension U_{dr}. The driving tension plus the induced tension must be equal to the tension on the resistor, called also OHMIC (ELECTRIC) TENSION,

$$U_{dr} + U_{ind} = U \quad \text{or} \quad U_{dr} = RI + LdI/cdt. \qquad (19.15)$$

Let us multiply this equation by the charge $dq = Idt$ which has passed for a time dt along the circuit, i.e., from the positive electrode of the source to its negative source, and integrate then the equation for the time from 0 to t

$$\int_0^t U_{dr} Idt = \int_0^t RI^2 dt + \int_0^{I_0} LIdI/c, \qquad (19.16)$$

where $I = 0$ is the current at the initial zero moment and $I_0 = U_{dr}/R$ is the current when $dI/dt = 0$.

The integral on the left gives the energy lost by the source, the first integral on the right gives the energy liberated as heat in the resistor and the second integral on the right gives the magnetic energy

$$W = -LI_0^2/2c \qquad (19.17)$$

<u>taken with an opposite sign</u>, as according to equation (2.15) the electromagnetic energy of a system is equal to the <u>difference</u> of its electric and magnetic energies. The magnetic energy (19.17) is stored in the inductor which can be then liberated when shortcircuiting the driving tension.

At such a short-circuiting of the external driving tension U_{dr}, the driving tension in the circuit will be the induced tension and it must be equal to the ohmic tension

$$U_{ind} = U \quad \text{or} \quad -LdI/cdt = RI. \qquad (19.18)$$

This is a differential equation of the form of the equation (19.3) and the solution, by analogy with the solution (19.4), will be

$$I = I_0 e^{-cRt/L}, \qquad (19.19)$$

where $t = 0$ now refers to the time of the short-circuiting of the source.

Let us find the amount of heat liberated in the resistor. From the equation (19.18), after the multiplication by Idt and integration for the time from $t = 0$ to $t = \infty$, we obtain

$$\int_0^\infty RI^2 dt = -L\int_{I_0}^0 IdI/c = LI_0^2/2c, \qquad (19.20)$$

which is just the extra amount of energy originally provided by the cell and "pumped" in the inductor. Now, at the short-circuiting of the external driving tension, this energy will transform in heat in the resistor.

If there is a circuit with a source of driving tension, resistor, capacitor and inductor connected in series, U_{dr} and $U_{ind} = -LdI/cdt$ must be equal to the sum of the tensions on the resistor, RI, and on the condenser, q/C, and rearranging we have

$$U_{dr} = RI + q/C + LdI/cdt \quad \text{with} \quad q = \int_0^t Idt. \qquad (19.21)$$

The solution of this differential equation for a harmonic driving tension is given in Sect. 54.2 and I show then that it <u>obviously</u> violates the energy conservation.

At the end of this section let me give the formulas for the resistance, capacitance and inductance of two resistors, capacitors and inductors connected:

In series: $R = R_1 + R_2$, $\quad 1/C = 1/C_1 + 1/C_2$, $\quad L = L_1 + L_2$, (19.22)

In parallel: $1/R = 1/R_1 + 1/R_2$, $\quad C = C_1 + C_2$, $\quad 1/L = 1/L_1 + 1/L_2$. (19.23)

Indeed:

1) For two resistances in series we have $U = U_1 + U_2$, i.e., $RI = R_1 I + R_2 I$, and

for two resistance in parallel we have $I = I_1 + I_2$, i.e., $U/R = U/R_1 + U/R_2$.

2) For two condensers in series we have $U = U_1 + U_2$, i.e., $U/C = U/C_1 + U/C_2$, as the charges on condensers in series are equal, and for two condensers in parallel we have $q = q_1 + q_2$, i.e., $CU = C_1U + C_2U$, as the tensions on two condensers in parallel are equal.

3) For two inductors in series we have $U = U_1 + U_2$, i.e., $-LdI/dt = - L_1dI/dt - L_2dI/dt$, and for two inductors in parallel we have $I = I_1 + I_2$, i.e., $U/\omega L = U/\omega L_1 + U/\omega L_2$, where ω is the frequency of the alternating current (see Sect. 54.2).

20. DIELECTRICS AND MAGNETICS

20.1. DIELECTRICS.

Any medium is current conducting but the differences in the conductivities of the different media may be very large. The media with high conductivity are called CONDUCTORS, with low conductivity INSULATORS (or DIELECTRICS) and with medium conductivity SEMI-CONDUCTORS.

If a conductor is placed in an electric field, its side which points along the field will become charged positively and the opposite side, pointing against the field, negatively. This effect is called ELECTRIC POLARIZATION BY INDUCTION (shortly INDUCTION POLARIZATION) or ELECTROSTATIC INDUCTION.

If a dielectric is placed in an electric field, it becomes also polarized. We call this kind of electrostatic induction DIELECTRIC (or MOLECULAR) POLARIZATION. The difference between these two kinds of polarization is that the positive (resp., negative) charges provoking the induction polarization can be taken away and the conductor will then remain charged as a whole negatively (resp., positively), while the "polarization charges" of a dielectric cannot be taken away, and we call them BOUND CHARGES. The induction polarization appears because the FREE CHARGES (electrons) of the conductor increase their concentration at one side of the body and decrease it at the opposite side in an external electric field, while the dielectric polarization appears because the molecules of the dielectric become polarized, i.e., the one end of the molecule becomes positive and the other end negative (the molecules of certain media can always be polarized but they arrange themselves along a definite direction only in an external electric field.

The physical essence of the molecular polarization as well as the physical essence of the conduction of current are not clear enough.

Further only the dielectric polarization will be considered.

Let us have a parallel plate condenser between whose plates a dielectric is placed. When applying to the condenser a certain external tension U, on the left of its plates N positive charges will appear and on the right N negative charges. After the polarization of the dielectric (which appears with a certain very short retardation), on the left side of the dielectric $N - \Delta N$ negative charges will appear

and on its right side $N - \Delta N$ positive charges. The negative bound charges on the left dielectric's surface will attract by induction other positive charges from the positive electrode of the source of driving tension and the charge on the left condenser's plate will increase, causing further increase of the bound charges on the left dielectric's surface. This process will go on until an equilibrium will be installed (the same appears on the right plate of the condenser). At the equilibrium state there will be $4\pi\chi N$ negative charges on the left dielectric's surface and $N + 4\pi\chi N = N(1 + 4\pi\chi)$ positive charges on the left condenser's plate, where χ is called ELECTRIC SUSCEPTIBILITY of the dielectric and

$$\varepsilon = 1 + 4\pi\chi \tag{20.1}$$

is called PERMITTIVITY of the dielectric (in the system SI one writes $\varepsilon = 1 + \chi$).

Now the electric intensity generated by the charges on the condenser's plates, called ELECTRIC DISPLACEMENT, will be

$$\mathbf{D} = \varepsilon\mathbf{E} = (1 + 4\pi\chi)\mathbf{E} = \mathbf{E} + 4\pi\mathbf{P}, \tag{20.2}$$

where

$$\mathbf{P} = \chi\mathbf{E} \tag{20.3}$$

is called ELECTRIC POLARIZATION of the dielectric and it is $1/4\pi$ part of the electric intensity generated by the bound electric charges on the right and left surfaces of the dielectric.

The tension acting on the condenser $U = \mathbf{E}.d$ (d is the distance between the condenser's plates) before putting the dielectric and after putting it is the same, thus the electric intensity between the plates also remains the same, **E**, and it is the sum of the electric intensity **D** produced by the charges on the condenser's plates and the electric intensity $- 4\pi\chi\mathbf{E} = - 4\pi\mathbf{P}$ produced by the bound charges on the left and right surfaces of the dielectric. Thus the physically right equation is not equation (20.2) but the following one

$$\mathbf{E} = \mathbf{D} - 4\pi\chi\mathbf{E} = \mathbf{D} - 4\pi\mathbf{P}. \tag{20.4}$$

The electric displacement **D** cannot be measured. One can measure only the electric intensity E by making, for example, a narrow cut in the dielectric of the condenser and by putting there the measuring instrument.

20.2 MAGNETICS.

An inductor along which current flows is called ELECTROMAGNET (or shortly MAGNET). A solenoid is the most simple magnet. The centers of the solenoid's end windings are called POLES. NORTH POLE is the one from which one sees the current in the windings flowing counter-clockwise, and SOUTH POLE is the one from which one sees the current flowing clockwise. A small magnet is called also MAGNETIC DIPOLE.

According to the older concepts, the molecules of the media are magnetic dipoles. Usually these dipoles are pointing chaotically in all space directions. When put in an external magnetic field B, the magnetic dipoles arrange themselves along the field and the medium becomes magnet as a whole. The molecules may be not magnetic dipoles but they can become such only when the medium is put in an external magnetic field. This effect is called MAGNETIZATION and magnetizable medium is called MAGNETIC.

According to the now-a-day concepts not the whole molecule is a magnetic dipole but only the electrons are such magnetic dipoles with a strictly determined dipole moment and a strictly defined angular momentum, called SPIN, which is parallel to the magnetic dipole moment. When a magnetic is put in an external magnetic field those are the magnetic dipole moments of the electrons which arrange themselves along the field and so the magnetic becomes a magnet.

Let us put a magnetic in a long solenoid whose magnetic intensity is $\mathbf{B} = (4\pi nI/c)\hat{\mathbf{z}}$ (see formula (18.28)). The magnetic field produced by the magnetic after its magnetization in the solenoid (which appears with a certain time retardation, especially when the magnetic goes out of the solenoid - see the Ewing effect in Sect. 54.5) is

$$4\pi\mathbf{M} = 4\pi\chi_m\mathbf{B}, \tag{20.5}$$

where $\mathbf{M}$ is called MAGNETIZATION of the magnetic (it is equal to $1/4\pi$ part of the magnetic intensity produced by the magnetic) and χ_m is called MAGNETIC SUSCEPTIBILITY.

The resultant magnetic intensity in the solenoid will be

$$\mathbf{B}_\mu = \mathbf{B} + 4\pi\mathbf{M} = (1 + 4\pi\chi_m)\mathbf{B} = \mu\mathbf{B} \tag{20.6}$$

and

$$\mu = 1 + 4\pi\chi_m \tag{20.7}$$

is called PERMEABILITY of the magnetic (in the system SI one writes $\mu = 1 + \chi_m$).

Thus the resultant magnetic intensity is the sum of the initial magnetic intensity B and the magnetic intensity (20.5) produced by the magnetized magnetic, so that (20.6) is the physically right equation.

Usually one denotes the initial magnetic intensity by $\mathbf{H}$ and the symbol $\mathbf{B}$ is preserved for the final magnetic intensity when the magnetic is put in the electromagnet, calling it in this case MAGNETIC INDUCTION (or MAGNETIC FLUX DENSITY). With these notations equation (20.6) is to be written as follows

$$\mathbf{B} = \mathbf{H} + 4\pi\mathbf{M} = \mu\mathbf{H}. \tag{20.8}$$

I am definitely against this separation. The magnetic intensity H and the "magnetic induction" B are not two different physical quantities. Whether in the solenoid there is a magnetic or another solenoid generating the same additional intensity $4\pi\mathbf{M} = 4\pi\chi_m\mathbf{B}$, there are absolutely no differences in the physical effects produced by these two systems. For this reason I shall very often use the word "magnetic intensity" both for $\mathbf{H}$ and $\mathbf{B}$, and often I shall use the symbol $\mathbf{B}$ for $\mathbf{H}$ and the symbol $\mathbf{B}_\mu$ for the "magnetic induction" B, trying to emphasize in this way that between B and

H there is no principal physical difference.

The most tragic thing is that in the measuring system SI $\mathbf{H}$ and $\mathbf{B}$ are measured in different measuring units. For this reason this system must never be used in theoretical considerations when one wishes to understand the physical essence of the effects in electromagnetism.

And I should like to note that there is a substantial difference between dielectrics and magnetics. The dielectrics make only a new distribution of the available electric intensity, while the magnetics generate new magnetic intensity. As I already said, if one will cut a narrow slot in the dielectric of a parallel plate condenser, one will measure exactly the same electric intensity $\mathbf{E}$ which one will measure at the same point if there is no dielectric. However if one will cut a narrow slot in the magnetic of a solenoid, one will measure a μ times higher magnetic intensity than in the case where there is no magnetic. Thus the characters of dielectrics and magnetics are totally different and those who try to present electric polarization and magnetization as two similar phenomena do a big harm.

If $\chi_m < 0$, the MEDIUM is called DIAMAGNETIC, if $\chi_m = 0$, the medium is called NON-MAGNETIC, if $\chi_m > 0$, the medium is called PARAMAGNETIC and if $\chi_m \gg 0$, the medium is called FERROMAGNETIC.

The magnetic induction $\mathbf{B}$ in ferromagnetic materials depends not only on $\mathbf{H}$ but also on the "hystory", i.e., on the magnetic intensities which have acted on the material before putting it in the field of the magnetic intensity $\mathbf{H}$. The dependence of $\mathbf{B}$ on the "hystorical" $\mathbf{H}$ (fig. 3) is called HYSTERESIS.

Let at the intial moment the ferromagnetic material be not magnetized. Thus if

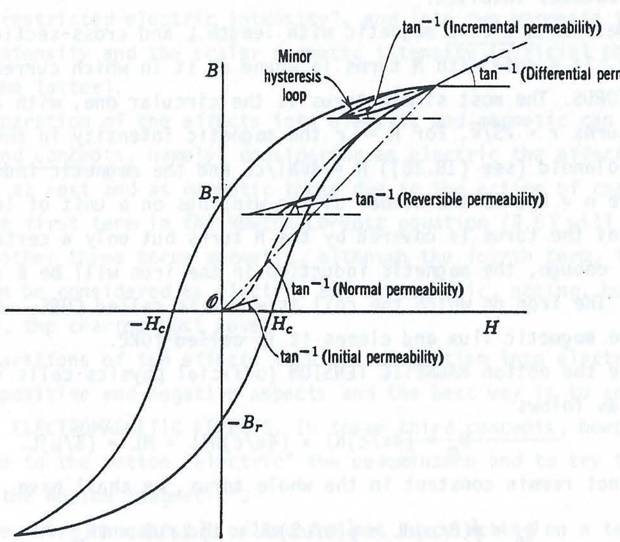

Fig. 3. The hysteresis loop.

the external magnetic intensity H is zero, the magnetic induction B produced by the magnetic will be zero. If H will begin to increase positively, B will also begin to increase positively and the dependence B = f(H) will be presented by the dashed line which begins from point O. After coming to some maximum magnetic intensity H_{max}, let begin to diminish H. When coming at H = 0, the magnetic induction produced by the magnetic will be B_r and is called RESIDUAL (or REMANENT) MAGNETIC INDUCTION. After changing the direction of the magnetic intensity and letting it increase negatively, we shall arrive at the intensity $-H_c$ when the magnetic induction produced by the magnetic will be zero. $|-H_c|$ is called COERCIVE MAGNETIC INTENSITY (one says wrongly "COERCIVE FORCE"). After coming to $-H_{max}$ and returning again to H_{max}, we shall describe the closed loop in fig. 3 which is called the HYSTERESIS LOOP.

Let me note that there is "hysteresis" also at the polarization of dielectrics. Magnetics with large residual magnetic induction are called PERMANENT MAGNETS (shortly MAGNETS) and dielectrics with large residual electric displacement are called ELECTRETS.

In fig. 3 there are shown different kinds of permeabilities defined by the relation

$$\mu = \arctan(B/H), \tag{20.9}$$

noting that in the figure the "arctan" is designated by "$\tan^{-1}$".

It can be shown that the area of the hysteresis loop in fig. 3 is equal to the energy which is lost in the form of heat for magnetizing, demagnatizing, anti-magnetizing, demagnetizing and again magnetizing of unity volume of the magnetic. This energy is called HYSTERESIS LOSSES. The effect is no more a pure electromagnetic effect as heat becomes involved.

Let consider now a closed magnetic with length L and cross-section S, whose permeability is μ. If a coil with N turns is wound on it in which current I flows, this is called a TORUS. The most simple torus is the circular one, with radius R and radius of the turns $r = \sqrt{S/\pi}$. For R >> r the magnetic intensity in the torus is as in a very long solenoid (see (18.28)) $H = 4\pi NI/cL$ and the magnetic induction is $B = 4\pi\mu nI/c$, where n = N/L is the number of the windings on a unit of length. If not the whole length of the torus is covered by the N turns but only a certain part ΔL of it and μ is high enough, the magnetic induction in the iron will be $B = 4\pi\mu nI/c$, where now $n = N/\Delta L$. The iron on which the coil is wound is called CORE, and the iron which "conducts" the magnetic flux and closes it is called YOKE.

I introduce the notion MAGNETIC TENSION (official physics calls it "MAGNETOMOVING FORCE"), U_m, as folows

$$U_m = (4\pi/c)NI = (4\pi/c)nIL = HL = (B/\mu)L. \tag{20.10}$$

If μ does not remain constant in the whole torus, we shall have

$$U_m = \oint_L (B/\mu)dL = \oint_L (\Phi/\mu S)dL = \Phi\oint_L dL/\mu S = \Phi R_m \tag{20.11}$$

This equation has a form similar to that of Ohm's law (16.5). Here the magnetic

tension U_m stays for the electric tension U, the magnetic flux Φ stays for the electric current I and the "magnetic resistance" R_m, called RELUCTANCE, stays for the electric resistance R. The analogy between Ohm's law in electricity (16.5) and "Ohm's law in magnetism" (20.11) is purely formal and has no certain physical background.

The quantity reciprocal to R_m

$$G_m = 1/R_m = \mu S/L \tag{20.12}$$

is called PERMEANCE. Thus permeability μ corresponds to the conductivity γ (see (16.3)).

Let have a slot of small length in the iron ring, and let us assume that the magnetic flux remains constant along the whole length of the torus, i.e., let us assume that there is no dispersion of magnetic flux in the slot.

Now we shall have for the reluctance, according to the last part of equation (20.11),

$$R_m = (L - l)/\mu S + l/S = \{L + l(\mu-1)\}/\mu S \cong (L + \mu l)/\mu S. \tag{20.13}$$

Thus an air slot of length l increases the reluctance as an additional iron part of length $L' = \mu l$.

21. THE DIFFERENT KINDS OF ELECTRIC INTENSITY

According to the concepts of official physics, which I shall call the first concepts, the EFFECTS on charges at rest are called ELECTRIC and the effects on charges in motion are called MAGNETIC. I also followed these concepts when separating the terms in the Newton-Lorentz equation (8.5) into two electric terms, presented under the common name "restricted electric intensity", and into two magnetic terms, the vector magnetic intensity and the scalar magnetic intensity (official physics, of course, ignores the latter).

However the separation of the effects into electric and magnetic can be done following other second concepts, namely, considering as electric the effects due to the action of charges at rest and as magnetic those due to the action of charges in motion. Now only the first term in the Newton-Lorentz equation (8.5) will be called electric and the other three terms magnetic, although the fourth term, in view of equation (8.8) can be considered as electric and as magnetic, noting, however, that to have $\partial\Phi/\partial t \neq 0$, the charges must move.

Both these separations of the effects in electromagnetism into electric and magnetic have their positive and negative aspects and the best way is to consider all effects as common ELECTROMAGNETIC EFFECTS. In these third concepts, however, it is convenient to give to the notion "electric" the pedominance and to try to evade as much as possible the notion "magnetic".

Following these third concepts, I called the net force acting on a test charge "global electric intensity". I give to the different parts of this force

$$E_{coul} = -\,\mathrm{grad}\Phi, \quad E_{tr} = -\,\partial\mathbf{A}/c\partial t, \quad E_{mot} = (\mathbf{v}/c)\times\mathrm{rot}\mathbf{A}, \quad E_{whit} = -\,(\mathbf{v}/c)\mathrm{div}\mathbf{A} \quad (21.1)$$

the names: COULOMB ELECTRIC INTENSITY, TRANSFORMER ELECTRIC INTENSITY, MOTIONAL ELECTRIC INTENSITY and WHITTAKER ELECTRIC INTENSITY.

The transformer electric intensity can have two substantially different aspects:

a) REST-TRANSFORMER ELECTRIC INTENSITY (in case where the wires of the surrounding system are at rest and only the flowing currents change)

$$E_{rest\text{-}tr} = -\,(1/c)\partial\mathbf{A}/\partial t. \quad (21.2)$$

b) MOTIONAL-TRANSFORMER ELECTRIC INTENSITY (in case where the currents flowing in the wires of the surrounding system are constant but the wires move, and the magnetic potential becomes a composite function of time through the radius vectors $\mathbf{r}_i$ connecting the different current elements with the reference point)

$$E_{mot\text{-}tr} = -\frac{1}{c}\sum_{i=1}^{n}\frac{\partial\mathbf{A}_i\{\mathbf{r}_i(t)\}}{\partial t} = -\frac{1}{c}\sum_{i=1}^{n}\left(\frac{\partial\mathbf{A}_i}{\partial x}\frac{\partial x_i}{\partial t} + \frac{\partial\mathbf{A}_i}{\partial y}\frac{\partial y_i}{\partial t} + \frac{\partial\mathbf{A}_i}{\partial z}\frac{\partial z_i}{\partial t}\right) = \frac{1}{c}\sum_{i=1}^{n}(\mathbf{v}_i.\mathrm{grad})\mathbf{A}_i \quad (21.3)$$

where $v_i = -\,\partial\mathbf{r}_i/\partial t$ is the velocity of the i-th current element of the surrounding system which generates the magnetic potential A_i at the reference point. The time derivative of the radius vector $\mathbf{r}_i$ is taken with a negative sign, as $\mathbf{r}_i$ points from the i-th current element to the reference point. If the surrounding system, i.e., the magnet, moves translatory, we shall have $\mathbf{v}_i = \mathbf{v}$ and thus

$$E_{mot\text{-}tr} = (1/c)(\mathbf{v}.\mathrm{grad})\mathbf{A}. \quad (21.4)$$

The motional-transformer electric intensity and the formula describing it were discovered by me[6], although every child must come to this "discovery" following the elementary mathematical logic. I repeat once more (see Sect. 14) that in electromagnetism there are only three discoveries: the law of Coulomb, Neumann and Newton (i.e., Newton's law for gravitational energy of two masses leading to the world gravitational energy of mass m, U_w, which when taken with negative sing gives the time energy of m, e_o). All other electromagnetic "effects" are simple logical conclusions to which these three laws lead, after introducing the most simple models for conductors, dielectrics and magnetics.

Why then official physics does not know the motional-transformer electric intensity? The answer is: Because of the introduction in physics of the wrong PRINCIPLE OF RELATIVITY. Indeed, according to this principle, all physical effects must depend only on the relative velocities of the bodies. Thus, this principle asserts that if at a motion of a wire with velocity $\mathbf{v}$ respectively to a magnet at rest the induced in the wire electric intensity is given by the third formula (21.1), then the electric intensity induced in the wire at rest when the magnet moves with a velocity $\mathbf{v}$ will be

$$E_{relativistic} = -\,E_{mot} = (1/c)\mathbf{v}\times\mathrm{rot}\mathbf{A}. \quad (21.5)$$

How many papers and books have been written to show that the stupidity (21.5) must be true!

Let me present here the experiemnt of Kennard[14] which in my simplified variation (fig. 4) was labeled by J. Maddox[15] as "Stefan Marinov's puzzle". As a matter of fact, there is no puzzle at all, as Kennard's experiment is a trivial illustration of the difference between the motional and motional-transformer electric intensities and the "puzzle" is only in the heads of the poor relativists.

I shall present first the description of the puzzle by John Maddox' own words:[15]

... from time to time, in Marinov's copious writings, there are relatively simple arguments that appear accessible even to those still at high school. Here is one series of *gedanken* experiments presented as if it were a Christmas puzzle (the original intension), with some helpful (or misleading) hints for its solution.

The figure (fig. 4) shows a pair of circular conductors arranged as two concentric circles. Equal electric currents are circulated in each, but in opposite directions. The simplest way of creating this arrangement is to cut through the concentric pair at some point and to join the loose ends in pairs by short lengths of straight conductor. An electromotive force applied anywhere along the conductor will engender a current which must be everywhere uniform. At the bridged gap, there will be equal currents flowing in opposite directions, so their influence on the magnetic fields in the concentric gap will be zero.

The device is thus a means of arranging that there is a uniform magnetic field in the space between the concentric circles in a direction perpendicular to their plane (downwards into the plane of the paper when the current in the circuit flows in the direction indicated). The sensor in the experiment is a conductor long enough just to bridge the gap between the concentric circles and mounted on thin insulating support in such a way that it can be made to slide around the circle. The objective is to measure the voltage across the sliding conductor, either by a standard voltmeter or by a condenser whose accumulated charge will be a measure of the voltage in a steady state.

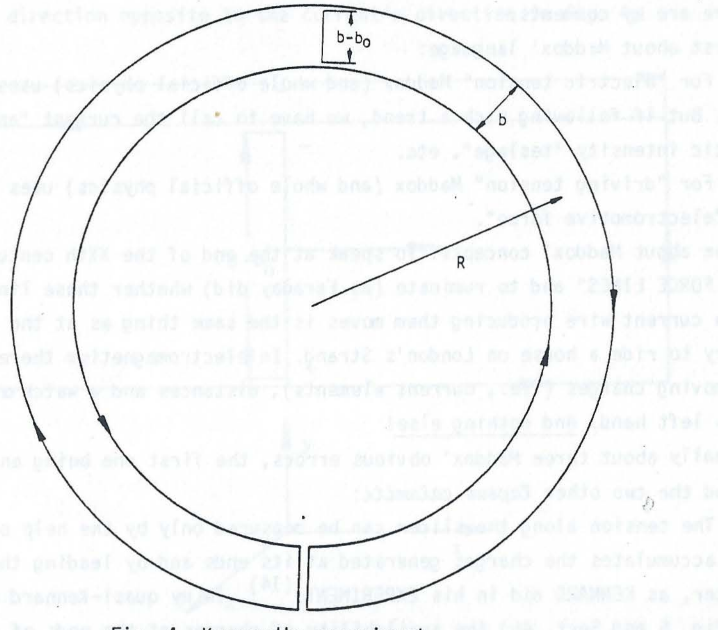

Fig. 4. Kennard's experiment.

The simplest case is when the sliding conductor is at rest. Then there is no voltage. Right? Next comes the case in which the sliding conductor moves at uniform speed around the concentric gap, always pointing along a radius of the concentric circles. As the slider moves, it will cut through magnetic lines of force at constant rate, so that there will be a constant voltage across the ends. The polarity of the slider will depend only on the direction of the current in the concentric circuit, and not on whether the slider moves clockwise or anticlockwise. Right again?

Now come the tricky part, at least so far as Marinov is concerned. What happens if the sliding conductor is fixed in space, but the undrlying concentric circuit is rotated about its center? Relativity theory naturally predicts that the voltage across the sliding conductor would be the same as in the first experiment, and with the same polarity. On the other hand, questions may be raised about the degree to which the pattern of magnetic forces generated by the current is dragged around the ring by its rotation. Maybe there is a smaller voltage, but with the same polarity. What, asks Marinov, is the answer?

The second conundrum is superficially simpler: simply rotate the apparatus in its own plane, about the center of the concentric circles. (There will be a small voltage due to Earth's magnetic field, but this may safely be neglected.) Is there now a voltage, and with what polarity? If the answer to the first question is "Yes" the answer to the second must be "No", and vice versa. Readers are invited to make up their minds before reading on.

Marinov's own answers are unambiguous. Vice versa wins the day. When the underlying concentrc circle is rotated and the slider is kept fixed, there is no voltage across the movable conductor. But when the whole apparatus is rotated about its centre, the voltage across the now-moving sliding conductor is identical with that obtained when the slider is moving relative to the concentric circuit.

The implications are evidently important. The null answer to Marinov's first question implies that relativity has vanished through the window, the affirmative answer to the second implies that an isolated apparatus carrying a circulating current will generate a voltage when rotated, which raises forbidden questions about absolute space.

Here are my comments:

First about Maddox' language:

1) For "electric tension" Maddox (and whole official physics) uses the word "voltage". But if following such a trend, we have to call the current "amperage", the magnetic intensity "teslage", etc.

2) For "driving tension" Maddox (and whole official physics) uses the very bad word "electromotive force".

Then about Maddox' concepts: To speak at the end of the XXth century about "MAGNETIC FORCE LINES" and to ruminate (as Faraday did) whether these lines will move when a current wire producing them moves is the same thing as at the end of XXth century to ride a horse on London's Strand. In electromagnetism there are only charges, moving charges (i.e., current elements), distances and a watch on the physicist's left hand. And nothing else!

Finally about three Maddox' obvious errors, the first one being an essential error and the two other *lapsus calamiti*:

1) The tension along the slider can be measured only by the help of a condenser which accumulates the charges generated at its ends and by leading them to an electrometer, as KENNARD did in his EXPERIMENT.[14]. In my quasi-Kennard experiment (see fig. 5 and Sect. 45) the availability of charges at the ends of the slider was

indicated electrometrically directly by "golden leaves". By the help of a "standard voltmeter" the difference between the motional and motional-transformer induced electric tensions cannot be demonstrated, as at the ends of the slider one must put sliding contacts and at motion of the voltmeter with its wires leading to the sliding contacts a tension will be induced in these wires exactly equal and opposite to the tension induced in the slider when it moves with the same velocity.

2) Maddox writes that the polarity on the slider will not depend on whether the slider moves clockwise or anti-clockwise. This is wrong. By changing the sense of the slider's rotation the polarity of the tension induced in the slider will also change.

3) Maddox writes that the two concentric current wires generate a "uniform" magnetic field. This is not true. The magnetic field is not uniform. It is the strongest near the concentric wires and the weakest along the middle circle between them.

Now I shall calculate the effects in Maddox' "puzzle" which is not at all a puzzle but, as already said, a trivial illustration of the third formula (21.1) and of formula (21.4).

To be able to make these calculations, let us find first the magnetic potential generated by two currents I flowing in two infinitely long parallel wires separated by a distance b. In fig. 5 two such wires are presented assuming that their lengths, d, tend to infinity. If the frame's origin is taken at the center of the rectangle, the ordinate of the upper wire will be b/2 and of the lower - b/2. The current in the rectangular loop in fig. 5 is flowing in positive, i.e., anti-clockwise direction, thus in a direction opposite to the current's direction in fig. 4.

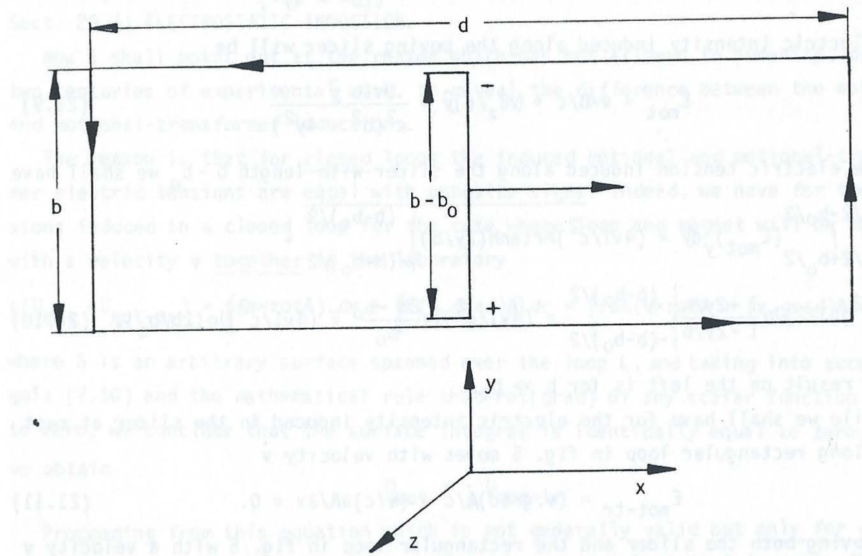

Fig. 5. The quasi-Kennard experiment.

According to formula (18.15) we shall have for the x-component of **A** generated by the upper wire at a reference point taken on the y-axis

$$A_x = -(I/c)\int_{-d/2}^{d/2}\{(b/2-y)^2+x^2\}^{-1/2}dx = -(2I/c)\ln\frac{d/2+\{(b/2-y)^2+d^2/4\}^{1/2}}{b/2-y}, \quad (21.6)$$

the components A_y and A_z being equal to zero. We see that for $d \to \infty$ the component A_x tends to infinity. However the magnetic potential generated by the upper and lower currents in fig. 5 is final also for infinitely long wires, namely

$$A_x = -\frac{2I}{c}\ln\frac{d/2+\{(b/2-y)^2+d^2/4\}^{1/2}}{b/2-y} + \frac{2I}{c}\ln\frac{d/2+\{(b/2+y)^2+d^2/4\}^{1/2}}{b/2+y} \cong \frac{2I}{c}\ln\frac{b/2-y}{b/2+y}, \quad (21.7)$$

where the result on the right side is written for d long enough and y can take any value except b/2 and - b/2.

These two long d-wires can be connected with the short b-wires and so we shall obtain a rectangular loop with $d \gg b$. As the two b-wires are far enough from the reference point, their contribution to the magnetic potential can be neglected.

I shall calculate the effects for the rectangular long loop in fig. 5. If the radius R in fig. 4 is large enough, i.e., if $R \gg b$, the same effects will be valid also for the concentric loops in fig. 4.

The magnetic intensity for reference points along the y-axis will be if using formula (21.7)

$$B = \text{rot}\mathbf{A} = -(\partial A_x/\partial y)\hat{z} = \frac{8Ib\hat{z}}{c(b^2-4y^2)} \quad (21.8)$$

and the electric intensity induced along the moving slider will be

$$E_{mot} = \mathbf{v}\times\mathbf{B}/c = (vB_z/c)\hat{y} = \frac{8vIb\,\hat{\mathbf{y}}}{c^2(b^2-4y^2)} \quad (21.9)$$

For the electric tension induced along the slider with length $b - b_o$ we shall have

$$U_{mot} = \int_{-b/2+b_o/2}^{b/2-b_o/2}(E_{mot})_y dy = (4vI/c^2)\text{Artanh}(2y/b)\Big|_{-(b-b_o)/2}^{(b-b_o)/2} =$$

$$(4vI/c^2)(1/2)\ln\frac{1+2y/b}{1-2y/b}\Big|_{-(b-b_o)/2}^{(b-b_o)/2} = (4vI/c^2)\ln\frac{2b-b_o}{b_o} \cong (4vI/c^2)\ln(2b/b_o), \quad (21.10)$$

where the result on the left side is for $b \gg b_o$.

Meanwhile we shall have for the electric intensity induced in the slider at rest when the long rectangular loop in fig. 5 moves with velocity **v**

$$E_{mot-tr} = (\mathbf{v}.\text{grad})\mathbf{A}/c = (\mathbf{v}/c)\partial\mathbf{A}/\partial x = 0. \quad (21.11)$$

When moving both the slider and the rectangular loop in fig. 5 with a velocity **v** the electric intensity induced in the slider will be the sum of the motional (21.9)

and motional-transformer (21.11) intensities, thus the tension induced will be given by formula (21.10). That's the whole "puzzle" of Dr. Maddox and the relativity blind.

Let me note that the magnetic intensity produced by a very long wire at a distance r, according to formula (21.8), in which we put b/2 = r, y = 0, will be

$$B_{single} = (1/2)B_{double} = 2I/cr. \quad (21.12)$$

The electric intensities (21.1) are the kinetic forces of the unit test charge. They can lead to the motion of the test charge in the conductor, and in such a case we call them ELECTROMOTIVE FORCES or they can be transferred from the charge on the metal lattice (ions' lattice) setting the whole conductor in motion, and in such a case we call them PONDEROMOTIVE FORCES. All four electric intensities (21.1) can lead to electromotive forces but only E_{mot} and E_{whit} can lead to ponderomotive forces. When **v** is the velocity of the test charge in the conductor, E_{mot} and E_{whit} generate ponderomotive forces, and when v is the velocity of the conductor, E_{mot} and E_{whit} generate electromotive forces. If E_{coul} and E_{tr} have pushed the charges to the extremities of the conductor and for them there is no more motional freedom, E_{coul} and E_{tr} can also generate ponderomotive forces.

The phenomenon of induction of electric intensity in conductors (and dielectrics) is called ELECTROMAGNETIC INDUCTION. The electromagnetic induction described by the third formula (21.1) is called MOTIONAL INDUCTION, by the fourth formula (21.1) WHITTAKER INDUCTION, by formula (21.7) REST-TRANSFORMER INDUCTION and by formula (21.3) MOTIONAL-TRANSFORMER INDUCTION. The induction of electric intensity in conductors (and dielectrics) according to the first formula (21.1) was called (see Sect. 20.1) ELECTROSTATIC INDUCTION.

Now I shall point out at the reason which has not allowed to humanity, during two centuries of experimental work, to reveal the difference between the motional and motional-transformer inductions.

The reason is that for closed loops the induced motional and motional-transformer electric tensions are equal with opposite signs. Indeed, we have for the tensions induced in a closed loop for the case where loop and magnet will be moved with a velocity **v** together in the laboratory

$$c(U_{mot}+U_{mot-tr}) = \oint_L(\mathbf{v}\times\text{rot}\mathbf{A}).d\mathbf{r} + \oint_L\{(\mathbf{v}.\text{grad})\mathbf{A}\}.d\mathbf{r} = \int_S \text{rot}\{\mathbf{v}\times\text{rot}\mathbf{A} + (\mathbf{v}.\text{grad})\mathbf{A}\}.d\mathbf{S} = 0, \quad (21.13)$$

where S is an arbitrary surface spanned over the loop L, and taking into account formula (7.10) and the mathematical rule that rot(grad) of any scalar function is equal to zero, we conclude that the surface integral is identically equal to zero. Thus we obtain

$$U_{mot} = -U_{mot-tr}. \quad (21.14)$$

Proceeding from this equation which is not generally valid but only for closed loops Einstein created the monster called "theory of relativity" (see his 1905-paper).

22. THE POTENTIALS, NOT THE INTENSITIES, DETERMINE THE ELECTROMAGNETIC EFFECTS

The childishly simple theory obtained when proceeding from the axiomatic Coulomb, Neumann and Newton laws asserts that the electromagnetic effects are determined by the electric and magnetic potentials. Official physics asserts that the electromagnetic effects are determined by the electric and magnetic intensities (of course ignoring the scalar magnetic intensity).

The intensities are space and time derivatives of the potentials and, of course, they will also determine the electromagnetic effects. But as any derivative carries less information than the function itself, so the intensities may not be able to explain all effects which are described in all details by the potentials.

In my theory, if a material system is given, then the electric and magnetic potentials are uniquely defined by the help of the definition equalities (8.1). Thus the potentials Φ and **A** are the primordial quantities which determine the motion of the test charge. According to official physics, the primordial quantities which determine the motion of the test charge are the restricted electric intensity **E** and the vector magnetic intensity **B**. Thus for official physics any two potentials Φ, **A** which, when put in the first two equations (8.6) give the right intensities **E**, **B**, have the whole right to be treated as potentials of the system in consideration.

Let us have two potentials Φ, **A** which give the right intensities **E**, **B**. Let us take an arbitrary function $f(\mathbf{r},t) = f(x,y,z,t)$ of the radius vector of the reference point and of time and write two "new" potentials

$$\Phi' = \Phi - \partial f/\partial t, \qquad \mathbf{A}' = \mathbf{A} + \mathrm{grad}f. \qquad (22.1)$$

If putting Φ' and $\mathbf{A}'$ in the first two equations (8.6), we shall obtain two new intensities

$$\mathbf{E}' = -\,\mathrm{grad}(\Phi - \partial f/\partial t) - (\partial/c\partial t)(\mathbf{A} + \mathrm{grad}f) = -\,\mathrm{grad}\Phi - \partial\mathbf{A}/c\partial t = \mathbf{E},$$

$$\mathbf{B}' = \mathrm{rot}(\mathbf{A} + \mathrm{grad}f) = \mathrm{rot}\mathbf{A} + \mathrm{rot}(\mathrm{grad}f) = \mathrm{rot}\mathbf{A} = \mathbf{B}. \qquad (22.2)$$

It turns thus out that the new intensities are identical with the old ones. And according to official physics the new potentials have the same right to be considered as potentials of the system in consideration. Official physics calls the transformation (22.1) GAUGE TRANSFORMATION and the function $f(\mathbf{r},t)$ GAUGE TRANSFORMATION FUNCTION.

So, according to official physics, one can take as a gauge transformation function the following one

$$\partial f/c\partial t = \Phi, \qquad (22.3)$$

obtaining thus the new electric potential equal to zero in whole space. Taking into account also the equation of potential connection (8.8), we shall thus have

$$\Phi' = 0, \qquad \mathrm{div}\mathbf{A}' = 0. \qquad (22.4)$$

Official physics considers thus as justified to erase the reality of the electric and scalar magnetic fields. Monstruous!

For my theory (and for the Divinity) the gauge transformation (22.1) is inadmissible and not the intensities but the potentials determine thoroughly the effects in electromagnetism.

Now I shall show with simple considerations how the gauge transformation (22.1) may lead to contradictions with the physical reality.

In Sect. 18 I have calculated **A** and **B** of a very long circular solenoid. Now I shall do this for a very long solenoid with rectangular cross-sectuon.

As the exact calculation is pretty complicated (I have not seen such a calculation in the literature!), I shall present here a very simple approximate calculation which also leads to the right result.

Formula (21.7) gives the magnetic potential generated by the rectangular loop shown in fig. 5 at the assumtion $d \gg b$. Let us now suppose that there are n such loops on a unit of length along the z-axis going from $z = -\infty$ to $z = \infty$. As in such a case there will be ndz turns along the differential length dz, the resultant magnetic potential is to be calculated according to the following formula, if we shall suppose $b \gg |y|$, i.e., if we shall suppose that the reference point is near to the x-axis,

$$A_x = \frac{2I}{c}\int_{-\infty}^{\infty}\ln\left\{\frac{(b/2-y)^2+z^2}{(b/2+y)^2+z^2}\right\}^{1/2} ndz = \frac{I}{c}\int_{-\infty}^{\infty}\left\{\ln\left(1-\frac{by}{b^2/4+z^2}\right)-\ln\left(1+\frac{by}{b^2/4+z^2}\right)\right\}ndz =$$

$$-\frac{nI}{c}\int_{-\infty}^{\infty}\frac{2by}{b^2/4+z^2}\,dz = -\frac{4nIy}{c}\arctan(2z/b)\Big|_{-\infty}^{\infty} = -\,4\pi nIy/c, \qquad (22.5)$$

where I neglected y^2 with respect to $b^2/4$ and then I presented the logarithm as a power series neglecting the powers higher than the first.

For the magnetic intensity we obtain

$$\mathbf{B} = \mathrm{rot}\mathbf{A} = -\,(\partial A_x/\partial y)\hat{\mathbf{z}} = (4\pi nI/c)\hat{\mathbf{z}}, \text{ i.e., i.e., } \quad B_z = 4\pi nI/c. \qquad (22.6)$$

Thus the vector of the magnetic intensity in the rectangular very long solenoid will have the following Cartesian components

$$\mathbf{A}_{rect} = (-4\pi nIy/c,\ 0,\ 0) = (-\,yB_z,\ 0,\ 0). \qquad (22.7)$$

According to formula (18.26), we shall have for **A** and **B** in a circular very long solenoid

$$A_\phi = 2\pi nI\rho/c, \qquad B_z = 4\pi nI/c. \qquad (22.8)$$

Thus the magnetic intensities in two very long solenoids with circular and rectangular cross-sections are equal. However the magnetic potentials are not. The magnetic potential in the long solenoid with prolongated rectangular cross-section is given by formula (22.7), while, taking into account that Cartesian components of the magnetic potential in the circular solenoid are $A_x = -\,A_\phi\sin\phi = -\,A_\phi y/\rho$, $A_y = A_\phi\cos\phi = A_\phi x/\rho$, we shall have

$$A_{circ} = (-2\pi nIy/c,\ 2\pi nIx/c,\ 0) = (-yB_z/2,\ xB_z/2,\ 0). \qquad (22.9)$$

The transformation from the potential (22.7) to the potential (22.9), or vice versa is, of course, a gauge transformation. Indeed, choosing the gauge transformation function in (22.1) in the form $f(x,y,z,t) = B_z xy/2$, we obtain the potential (22.9) if proceeding from the potential (22.7)

$$\mathbf{A}' = \mathbf{A} + \mathrm{grad} f = -yB_z\hat{x} + (yB_z/2)\hat{x} + (xB_z/2)\hat{y} = -(yB_z/2)\hat{x} + (xB_z/2)\hat{y}. \qquad (22.10)$$

Thus, according to official physics, for magnetic potentials in two very long solenoids with circular and rectangular cross-sections (with d >> b!) one can take both quantities (22.7) and (22.9) and all effects will be determined by the magnetic intensity B_z given in (22.6) and (22.8) which has the same value in both solenoids.

To show that this is not true, let us put an electric charge q at the centers of both solenoids. If moving this charge with a velocity v in both solenoids first along the x-axis and then along the y-axis, the acting force, of course, will be the same:

a) motion of the charge along the x-axis

$$f = qE_{mot} = (q/c)v\hat{x}\times B_z\hat{z} = -(qvB_z/c)\hat{y} = -(4\pi qvnI/c^2)\hat{y}, \qquad (22.11)$$

b) motion of the charge along the y-axis

$$f = qE_{mot} = (q/c)v\hat{y}\times B_z\hat{z} = (qvB_z/c)\hat{x} = (4\pi qvnI/c^2)\hat{x}. \qquad (22.12)$$

However if moving the solenoids with a velocity v, leaving the charge at rest, the acting force will be

a) motion of the solenoid with circular cross-section along the x-axis

$$f = (q/c)(v\hat{x}.\mathrm{grad})(-yB_z\hat{x}/2 + xB_z\hat{y}/2) = (qvB_z/2c)\hat{y} = (2\pi qvnI/c^2)\hat{y}, \qquad (22.13)$$

a') motion of the solenoid with rectangular cross-section along the x-axis

$$f = (q/c)(v\hat{x}.\mathrm{grad})(-yB_z\hat{x}) = 0, \qquad (22.14)$$

b) motion of the solenoid with circular cross-section along the y-axis

$$f = (q/c)(v\hat{y}.\mathrm{grad})(-yB_z\hat{x}/2 + xB_z\hat{y}/2) = -(qvB_z/2c)\hat{x} = -(2\pi qvnI/c^2)\hat{x}, \qquad (22.15)$$

b') motion of the solenoid with the rectangular cross-section along the y-axis

$$f = (q/c)(v\hat{y}.\mathrm{grad})(-yB_z\hat{x}) = -(qvB_z/c)\hat{x} = -(4\pi qvnI/c^2)\hat{x}. \qquad (22.16)$$

Thus the motion of the test charge in these two solenoid, at motion of the solenoids, will be completely different, although the magnetic intensities in the solenoids remain the same.

I should like to note that when calculating the integral (22.5) I integrated for z in the limits for $-\infty$ to ∞, while when calculating the integral (18.23) I integrated for z in the limits from 0 to ∞. Easily can be seen that if in (18.23) I had also calculated in the limits from $-\infty$ to ∞, a value for A two times than the right

one should be obtained. I could not found an explanation for this discrepancy, noting that when B. B. Dasgupta (Am. J. Phys., **52**, 258, (1984)) calculates directly the magnetic intensity in a long circular solenoid he integrates for z in the limits from $-\infty$ to ∞ and obtains the right result. Scott[12] (p.322) makes the calculation through the magnetic potential, exactly as I do; he takes z in the limits from $-\infty$ to ∞ but the result which he then writes is two times smaller than this one which is to be obtained at a right mathematical calculation. I turn the attention of the mathematicians to this strange discrepancy.

23. ABSOLUTE AND RELATIVE NEWTON-LORENTZ EQUATIONS

The Newton-Lorentz equation (8.4) is written in a frame attached to absolute space and I call it the ABSOLUTE NEWTON-LORENTZ EQUATION.

Let us now find the form of the Newton-Lorentz equation in a laboratory (frame) moving with a velocity **V** in absolute space, where it will be called the RELATIVE NEWTON-LORENTZ EQUATION, begging once more the reader to pay attention to the difference between the Lorentz and Marinov invariances considered in Sect. 1. Thus I shall look for the Newton-Lorentz equation not forthe system considered first with mass center at rest in absolute space and then with its mass center moving with velocity **V** in absolute space but if the observer would move with velocity **V** in absolute space and the system considered remains always with mass center at rest in absolute space.

Let the velocities of the test charge and of the charges of the system in consideration by v and v_i with respect to absolute space and v', v_i' with respect to the laboratory which moves with the velocity **V** in absolute space.

As the velocity of the moving laboratory can be not high (the velocity of a laboratory attached to the Earth is about 300 km/sec!), it is enough to use the Galilean formulas for the addition of velocites

$$\mathbf{v} = \mathbf{v}' + \mathbf{V}, \qquad \mathbf{v}_i = \mathbf{v}_i' + \mathbf{V}, \qquad (23.1)$$

which can be obtained when differentiating formula (3.1) with respect to time (of course written in three dimensions), and not the Marinov formulas for addition of velocities which can be obtained [3,5] at the differentiation of formula (3.5).

Let me note that in Ref. 5 I consider the effects which can be observed if the mass center of the system in consideration (usually a single particle) is considered first at rest in absolute space and then moving with a velocity v in absolute space. In this case the velocity v can be high (even approaching c) and the Marinov or the Lorentz transformation formulas are to be used (I repeat - see Sect. 3 - when considered from an absolute point of view these two transformations lead to identical results).

Thus using (23.1), we shall have for the argument of the gradient in formula (8.3), having in mind the definition formulas for the potentials (8.1),

$$\phi - \frac{\mathbf{v}.\mathbf{A}}{c} = \sum\frac{q_i}{r_i} - \frac{\mathbf{v}'+\mathbf{V}}{c}.\sum\frac{q_i(\mathbf{v}'_i+\mathbf{V})}{cr_i} = \Phi'(1 - \frac{\mathbf{v}'.\mathbf{V}}{c^2} - \frac{V^2}{c^2}) - \frac{\mathbf{v}'+\mathbf{V}}{c}.\mathbf{A}', \qquad (23.2)$$

where $\Phi' = \Phi$ is the relative electric potential which is equal to the absolute electric potential, as the electric potential is not velocity dependent, $\mathbf{A}' = \sum q_i\mathbf{v}'_i/cr_i$ is the relative magnetic potential, and the summations are taken over the n charges of the system in consideration.

The total time derivatives of the absolute and relative magnetic potentials must be equal

$$d\mathbf{A}/dt = d\mathbf{A}'/dt, \qquad (23.3)$$

because $d\mathbf{A}/dt$ depends only on the changes (for a time dt) of the absolute velocities of the charges and $d\mathbf{A}'/dt$ depends on changes of their relative velocities and these changes are equal, and on the changes of the distances between q_i and q which are equal, too.

Putting (23.2) and (23.3) into (8.3), we shall have, remembering the deduction of formula (7.11),

$$\frac{d}{dt}\frac{m(\mathbf{v}+\mathbf{V})}{\{1-(\mathbf{v}+\mathbf{V})^2/c^2\}^{1/2}} = -q(\mathrm{grad}\Phi + \frac{1}{c}\frac{\partial\mathbf{A}}{\partial t}) + \frac{q}{c}\,\mathbf{v}\times\mathrm{rot}\mathbf{A} - \frac{q}{c}\,\mathbf{v}\mathrm{div}\mathbf{A} +$$

$$\frac{q\mathbf{v}.\mathbf{V}}{c^2}\mathrm{grad}\Phi + \frac{qV^2}{c^2}\mathrm{grad}\Phi + \frac{q}{c}\,\mathbf{V}\times\mathrm{rot}\mathbf{A} + \frac{q}{c}(\mathbf{V}.\mathrm{grad})\mathbf{A}, \qquad (23.4)$$

where all laboratory quantities in (23.4) and further in this section are written without primes.

Comparing formulas (23.4) and (8.4), we see that their "potential" (right) parts differ with the last four terms in equation (23.4). The electric absolute effects are proportional to V/c and can be neglected with respect to the relative (laboratory) electric effects, however the magnetic absolute effects are not only comparable with the relative magnetic effects but, at V > v, are even bigger.

To demonstrate the validity and effectivity of the relative Newton-Lorentz equation (23.4), let us consider again the rectangular current loop in fig. 5. Let us suppose that the loop moves with a velocity $\mathbf{V}$ in absolute space and let us attach to it the moving frame K'.

The test charge (the vertical wire in fig. 5) is first at rest in the laboratory, i.e., at rest with respect to the loop, and then it is moved with the laboratory velocity v. The electric intensity induced in the wire as a result of this motion, which can be observed by the help of a voltmeter that is all the time at rest in the laboratory, can be calculated from the following two equations

$$c\mathbf{E} = \mathbf{V}\times\mathrm{rot}\mathbf{A} + (\mathbf{V}.\mathrm{grad})\mathbf{A}, \qquad c\mathbf{E}' = \mathbf{v}\times\mathrm{rot}\mathbf{A} + \mathbf{V}\times\mathrm{rot}\mathbf{A} + (\mathbf{V}.\mathrm{grad})\mathbf{A}, \qquad (23.5)$$

and for the difference E' - E we obtain

$$\mathbf{E}' - \mathbf{E} = \mathbf{E}_{mot} = (\mathbf{v}/c)\times\mathrm{rot}\mathbf{A}. \qquad (23.6)$$

Let us now suppose that the test charge (the vertical wire in fig. 5) is always at rest in the laboratory and the loop originating the magnetic potential first is at rest in the laboratory and then is moved with velocity $\mathbf{v}$. The electric intensity induced in the wire as a result of this motion cannot be observed by the help of a voltmeter but only by observing the change of the charges at the extremities of the vertical wire in fig. 5 and can be calculated as follows: The initial induced electric intensity $\mathbf{E}$ will be the same as in (23.5). When the loop is set in motion with velocity v, we have to write the relative Newton-Lorentz equation in a frame K" moving with a velocity $\mathbf{V}+\mathbf{v}$ in absolute space, as only in this frame the originated laboratory magnetic potential will be as at the initial moment. As in this frame the test charge will have a velocity $-\mathbf{v}$, we obtain

$$c\mathbf{E}'' = -\mathbf{v}\times\mathrm{rot}\mathbf{A} + (\mathbf{v}+\mathbf{V})\times\mathrm{rot}\mathbf{A} + (\mathbf{v}+\mathbf{V}).\mathrm{grad}\,\mathbf{A}, \qquad (23.7)$$

and for the difference E" - E we obtain

$$\mathbf{E}'' - \mathbf{E} = \mathbf{E}_{mot-tr} = (\mathbf{v}.\mathrm{grad})\mathbf{A}/c. \qquad (23.8)$$

That's the whole "secret" of the space-time absoluteness which neither Lorentz and Poincare nor Einstein and *tutti quanti* could grasp. A problem to be solved by children!

If the loop and the test charge (the vertical wire in fig. 5) are first at rest in the laboratory and then move together with velocity $\mathbf{v}$, instead of equation (23.7), we have to write

$$c\mathbf{E}''' = (\mathbf{v}+\mathbf{V})\times\mathrm{rot}\mathbf{A} + \{(\mathbf{v}+\mathbf{V}).\mathrm{grad}\}\mathbf{A}, \qquad (23.9)$$

and for the difference E"' - E we obtain

$$\mathbf{E}''' - \mathbf{E} = \mathbf{E}_{mot} + \mathbf{E}_{mot-tr} = \mathbf{v}\times\mathrm{rot}\mathbf{A}/c + (\mathbf{v}.\mathrm{grad})\mathbf{A}/c. \qquad (23.10)$$

The different effects described by formulas (23.6), (23.8) and (23.10) were observed first by Faraday on his famous disk[16] with closed loops by using sliding contacts and by Kennard[14] with open loops. By transforming Kennard's rotational experiment to an inertial experiment, called by me the quasi-Kennard experiment, I succeeded (see Sect. 45) to measure the Earth's absolute velocity by using the first formula (23.5).

24. WHITTAKER'S AND NICOLAEV'S FORMULAS

24.1. WHITTAKER'S FORMULA.

Let us consider the Newton-Lorentz equation (8.4) and assume $\mathrm{grad}\Phi = 0$, $\partial\mathbf{A}/\partial t = 0$ and that the magnetic potential $\mathbf{A}$ is generated by a single current element I'dr'

$$\mathbf{A} = I'd\mathbf{r}'/cr. \qquad (24.1)$$

Puttung all this in (8.4) and presenting qv as a current element Idr, we shall obtain for the kinetic force of the current element Idr (or for the potential force with which the current element I'dr' acts on the current element Idr) the following expression, where **r** points from **dr'** to dr,

$$df = (II'/c^2)\{dr\times rot(dr'/r) - dr\,div(dr'/r)\} = (II'/c^2r^3)\{dr\times(dr'\times r) + dr(dr'.r)\} =$$

$$(II'/c^2r^3)\{(r.dr)dr' - (dr.dr')r + (r.dr')dr\}. \qquad (24.2)$$

I call (24.2) the WHITTAKER FORMULA, as allegedly Whittaker[17] was the first one who has written it on a piece of paper without presenting some motivations. I write Whittaker's formula also in another form in which the places of the different term are exchanged

$$df = (II'/c^2r^3)\{(r.dr')dr + (r.dr)dr' - (dr.dr')r\}. \qquad (24.3)$$

The GRASSMANN FORMULA[18], which can be obtained exactly in the same way from the LORENTZ EQUATION, what is equation (8.4) without the last term, is (24.2) without the last term, i.e.,

$$df = (II'/c^2r^3)\{(r.dr)dr' - (dr.dr')r\}. \qquad (24.4)$$

The AMPERE FORMULA[19] has the form

$$df = (II'/c^2r^5)\{3(r.dr)(r.dr') - 2(dr.dr')r^2\}r. \qquad (24.5)$$

Ampere's formula (24.5) shows that the potential forces with which two current elements act one on another are equal, oppositely directed, and lie on the line joining the two elements. Thus Ampere's formula preserves Newton's third law (at the deduction of his formula Ampere assumed that Newton's third law must be valid at the interaction of two current elements).

Whittaker's formula (24.3) shows that the potential forces with which two current elements act one on another are equal, oppositely directed, but may not lie on the line joining the elements. Thus Whittaker's formula violates Newton's third law.

Grassmann's formula (24.4) shows that the potential forces with which two current elements act one on another may be neither equal nor oppositely directed. This formula drastically violates Newton's third law and all professors in the world are caught by a panic fear when they have to teach it to the students. For this reason, although being the fundamental formula in official magnetism, it can be seen in only one of ten textbooks.

For the force with which a closed current loop L' acts on another closed current loop L all three formulas lead to the same result

$$f = -(II'/c^2)\oint\oint_{LL'}(dr.dr'/r^3)r, \qquad (24.6)$$

which preserves Newton's third law. The integration of formula (24.3) can easily be carried out as $r.dr/r^3 = -d(1/r)$ and $r.dr'/r^3 = d(1/r)$ are total differentials and at the integratiin along the closed loops L and L', respectively, give zeros.

On the same grounds one sees that Grassmann's formula also leads to formula (24.6).

The conclusion that Ampere's formula also leads to formula (24.6) is based on a theorem demonstrated by Lyness[20] that the force with which a closed current loop acts on a current element is the same according to Ampere's and Grassmann's formulas.

Let me emphasize that according to formula (24.6) the forces with which two current loops act one on another are equal and oppositely directed. Thus for an isolated system consisting of two current loops the momentum conservation law will be conserved. However formula (24.6) does not say whether the torques with which two current loops act one on another will be equal and oppositely directed, thus it does not say whether for an isolated system consisting of two current loops also the angular momentum conservation law will be conserved.

I could not prove this second theorem and to the best of my knowledge there is no such a theorem in the literature (of course when proceeding from Grassmann's formula, as Whittaker's formula is practically unknown).

This aspect for the interaction of the closed current loops remains for me open. As the reader will see in Sects. 50 and 56, I tried to construct machines which had to violate the angular momentum conservation law at the interaction of closed loops but without success and my intuition says that at the interaction of closed loops the angular momentum conservation law cannot be violated.

As shown in Sect. 63, I succeeded to violate the angular momentum conservation law only by constructing a machine with non-closed current loops.

Both Grassmann's and Ampere's formulas are wrong (see Sect. 26, 57, 58, 63) and Whittaker's formula is to be consdiered as the right one. I shall show, however, in Sect. 24.2 that certain theoretical considerations require the introduction of a certain change in Whittaker's formula which thus obtains a slightly different mathematical form, called by me the NICOLAEV FORMULA. It is Nicolaev's formula which is confirmed by the experiments (see Sects. 57 -60).

For the force with which a closed current loop L' acts on a current element Idr of the loop L we obtain from (24.3), taking again into account that $r.dr'/r^3 = d(1/r)$ is a total differential,

$$\Delta f = (II'/c^2)\oint_{L'} dr\times rot(dr'/r) = (Idr/c)\times\oint_{L'} rot(I'dr'/cr) = (Idr/c)\times B. \qquad (24.7)$$

Thus the Whittaker scalar magnetic intensity produced by a closed current loop is zero. For this reason during two centuries of experimental work humanity could not reveal the existence of the scalar magnetic field.

However, as it will be shown in Sect. 24.2, the Nicolaev scalar magnetic intensity produced by a closed current loop may not be zero and one has to wonder that after two centuries of experimental work Nicolaev was, as a matter of fact, the first one who has observed it in childishly simple experiments.

Before presenting Nicolaev's formula, let me show that if the current elements Idr and I'dr' are coplanar, then their Whittaker forces of interaction depend only on the distance between the elements but not on the angles defining their mutual positions. Indeed, according to formula (24.3), omitting the factor (II'/c^2r^2) and denoting by $n = r/r$ the unit vector pointing from dr' to dr, we shall have for the square of the magnitude of the force df with which I'dr' acts on Idr, taking into taking into account that the angle between **n** and d**r**×d**r**' is equal to π/2.

$$(df)^2 = \{(\mathbf{n}.d\mathbf{r}')d\mathbf{r} + (\mathbf{n}.d\mathbf{r})d\mathbf{r}' - (d\mathbf{r}.d\mathbf{r}')\mathbf{n}\}^2 = \{(\mathbf{n}.d\mathbf{r}')d\mathbf{r} - (\mathbf{n}.d\mathbf{r})d\mathbf{r}'\}^2 + (d\mathbf{r}.d\mathbf{r}')^2 = \{\mathbf{n}\times(d\mathbf{r}\times d\mathbf{r}')\}^2 + (d\mathbf{r}.d\mathbf{r}')^2 = dr^2 dr'^2 \sin^2\alpha + dr^2 dr'^2 \cos^2\alpha = dr^2 dr'^2, \quad (24.8)$$

where α is the angle between d**r** and d**r**'.

24.2. NICOLAEV'S FORMULA.

Let us consider two parallel current elements Id**r** and I'd**r**' lying on the y-axis and pointing in parallel to the x-axis whose radius vectors are, respectively, 0 and $y\hat{y}$, where $\mathbf{r} = -y\hat{y}$ is the vector distance pointing from the current element d**r**' to the current element d**r**. The force with which I'd**r**' acts on Id**r**, according to Whittaker's formula (24.3), will be

$$df = -(II'/c^2r^3)drdr'\mathbf{r} = (II'drdr'/c^2y^2)\hat{y} \quad (24.9)$$

and will point <u>towards dr'</u>, thus Id**r** will be <u>attracted</u> by I'd**r**'. The current element Id**r** will act on the current element I'd**r**' with the same and oppositely directed attractive force.

At the mutual attraction of Id**r** and I'd**r**', their magnetic energy, which is a <u>negative quantity</u>, will decrease (its absolute value will increase) and the loss of magnetic energy will be equal to the gain of mechanical energy, as the kinetic energies of the elements will increase.

Let us now suppose that the same current elements lie on the x-axis pointing again along the x-axis and their radius vectors are, respectively, 0 and $x\hat{x}$, where $\mathbf{r} = -x\hat{x}$ is the vector distance pointing from d**r**' to d**r**. The force with which I'd**r**' acts on Id**r**, according to Whittaker's formula (24.3), will be

$$df = (II'/c^2r^3)drdr'\mathbf{r} = -(II'drdr'/c^2x^2)\hat{x} \quad (24.10)$$

and will point <u>towards dr</u>, thus Id**r** will be <u>repulsed</u> by I'd**r**'. The current element Id**r** will act on the current element I'd**r**' with the same and oppositely directed repulsive force.

At the mutual repulsion of Id**r** and I'd**r**', their magnetic energy, which is a <u>negative quantity</u>, will increase (its absolute value will decrease) , but, on the other hand, also the kinetic energies of the two current elements, due to their repulsive forces, will <u>increase</u>. This is a patent <u>violation</u> of the energy conservation law. Thus something is wrong with Whittaker's formula.

There is also another delicate point. We <u>cannot imagine</u> how current elements may move along the current wire. If we have an elastic wire which we can extand mechanically, there will be motion of the <u>line</u> elements, but <u>from an electromagnetic point of view</u>, at such an extension, the electromagnetic system remains <u>exactly the same</u> and there is <u>no</u> motion of the <u>current</u> elements.

Proceeding from these speculations, I decided to write Whittaker's term in Whittaker's formula, i.e., the last term in formula (24.2) or the first term in formula

(24.3), in the following form

$$(\mathbf{r}.d\mathbf{r}')(1 - \frac{(d\mathbf{r}.d\mathbf{r}')^2}{dr^2dr'^2})d\mathbf{r} = (\mathbf{r}.d\mathbf{r}')\frac{(d\mathbf{r}\times d\mathbf{r}')^2}{dr^2dr'^2}\,d\mathbf{r} \quad (24.11)$$

and <u>I assumed *ad hoc*</u> that the right formula describing the interaction between two current elements is <u>not</u> Whittaker's formula (24.3) but the following one

$$df = (II'/c^2r^3)\{(\mathbf{r}.d\mathbf{r}')(d\mathbf{r}\times d\mathbf{r}')^2 d\mathbf{r}/dr^2dr'^2 + (\mathbf{r}.d\mathbf{r})d\mathbf{r}' - (d\mathbf{r}.d\mathbf{r}')\mathbf{r}\}. \quad (24.12)$$

Now the Newton-Lorentz equation is to be written <u>not</u> in the form (8.5) but in the following form

$$E_{glob} = -\,\mathrm{grad}\Phi - \partial\mathbf{A}/c\partial t + (\mathbf{v}/c)\times\mathrm{rot}\mathbf{A} - (\mathbf{v}/c)\{\mathrm{div}\!\int\! d\mathbf{A}(\mathbf{v}\times d\mathbf{A})^2/v^2dA^2\}, \quad (24.13)$$

where the integral is to be taken over all charges (current elements) any of whom generates the elementary magnetic potential d**A**.

And the scalar magnetic intensity will be presented <u>not</u> in the form (8.6) but in the folowing form

$$S = -\,\mathrm{div}\!\int\! d\mathbf{A}(\mathbf{v}\times d\mathbf{A})^2/v^2dA^2, \quad (24.14)$$

i.e., S will depend not only on the electric charges (and their velocities) of the surrounding system and on their distances to the test charge, but also <u>on the direction of motion of the test charge</u>. Thus the scalar magnetic intensity of a given system acting on two test charges with <u>different directions of motion are not equal.</u>

I call formula (24.12) NICOLAEV'S FORMULA and equation (24.13) the NEWTON-LORENTZ EQUATION IN ITS NICOLAEV'S FORM. Equation (8.5) will be then called the NEWTON-LORENTZ EQUATION IN ITS WHITTAKER'S FORM. And now the Whittaker electric intensity (21.1) is to be substituted by the NICOLAEV ELECTRIC INTENSITY

$$E_{nic} = -(\mathbf{v}/c)\mathrm{div}\!\int\! d\mathbf{A}(\mathbf{v}\times d\mathbf{A})^2/v^2dA^2, \quad (24.15)$$

where the integral is taken over the surrounding system, every current element of which generates the elementary magnetic potential d**A**.

Here I have to note that the equation of potential connection (8.8) preserves its validity, but we can no more replace Nicolaev's equation (24.13) by equation (8.9), so that the calculation of the global electric intensity is to be done proceeding only from Nicolaev's equation (24.13).

The reader has seen in Sect. 7 that the introduction of the Whittaker's term in equation (7.9), i.e., the middle term on the right side of equation (7.9), was not sufficiently lawful from a rigorous mathematical point of view. And now I make another <u>completely *ad hoc*</u> deformation of this formula. Thus the conclusion is to be done that the Divinity, when constructing the theoretical basis of electromagnetism, proceeding from the axiomatical Coulomb, Neumann and Newton laws, and when seeing that the theory leads to some <u>unpleasant contradictions</u>, trampling with both feet on the rigorous mathematical logic, introduced some "hocus pocus" tricks which no earthly scientist would allow himself to do.

What can I do, dear reader? You see, the Divinity is not perfect: *errare divinum est*. And I am only his prophet.

To a certain degree I can accept the introduction of the second term on the right side of equation (7.9) as a correct mathematical path (my friend Prof. U. Bartocci insists that the introduction of this term is inadmissible from a rigorous mathematical point of view). Indeed "physical mathematics" permits certain "frivolities" but the introduction of "Nicolaev's correction" in the Whittaker's term is a complete mathematical fiasco. If Nicolaev's formula is the right one and the Divinity was perfect, He had to arrive at this formula by logical mathematical steps.

When one introduces similar logical acrobatics in the edifice of electromagnetism, one cannot more be sure whether the fundamental axioms will preserve their absolute validity. And if on our Earth there are clever children recognizing the Mephistophelian mathematical manipulations of the Divinity, they will be able to construct machines violating the most divine of all divine laws - the law of energy conservation (see Sect. 60).

I must, of course, declare that I am not sure whether formula (24.12) introduced by me is the right one. The way to establish whether it is the right one is the following: The effects predicted by Nicolaev's formula for all known fundamental experiments are to be calculated on a computer. If always the formula will give the right prediction, it is to be accepted as right until the day when somebody will show that the right formula is another one.

I called formula (24.12) Nicolaev's formula, as the Russian physicist of Tomsk Genadi Nicolaev, whom I met at the space-time conference in Saint Petersburg in 1991, has done many experiments (see Sect. 58) showing that a formula of such a kind must be the right one.

It is possible, of course, that the Divinity has not changed *ad hoc* the Whittaker term into the Nicolaev term. Maybe the Divinity writes the space-time energy of two electric charges q_1, q_2 moving with velocities $\mathbf{v}_1$, $\mathbf{v}_2$ not in the Neumann's form (2.14) but in the following form

$$W = - (q_1 q_2 \mathbf{v}_1.\mathbf{v}_2/c^2 r^3)(\mathbf{v}_1 \times \mathbf{r})(\mathbf{v}_2 \times \mathbf{r})/v_1 v_2, \qquad (24.16)$$

or in the form

$$W = - (q_1 q_2 \mathbf{v}_1.\mathbf{v}_2/c^2 r^3)\{(\mathbf{v}_1 - \mathbf{v}_2)\times \mathbf{r}\}^2/(\mathbf{v}_1 - \mathbf{v}_2)^2. \qquad (24.17)$$

Now, perhaps, the Divinity will come to Nicolaev's formula on a rigorous mathematical way. I leave to the mathematicians the honour to prove this hypothesis, but I must declare that the form (24.16) is complicated, unesthetic, and if the Divinity is a Divinity He would not choose such a ghastly expression in His axiomatics.

In the next three sections I shall make calculations of the forces acting between the current wires in some simple but fundamental circuits. As pretty many experiments have shown that Grassmann's and Ampere's formulas are wrong (see Chapter VI), the formulas which still remain competitive are the Whittaker and Nicolaev formulas.

Thus the calculation of the forces of interaction between current wires will be done when proceeding from Whittaker's and Nicolaev's formulas. In certain fundamnetal cases only, in order to reveal the differences, calculations also according to Grassmann's and Ampere's formulas will be done.

25. THE PROPULSIVE AMPERE BRIDGE (PAB)

The calculation of the magnetic force with which a closed current loop acts on a current element or on another open or closed loop is a simple calculation problem. However when we have to calculate the magnetic force with which a current loop acts on some of its current elements or a part of a current loop acts on other its part, inconveniences may appear, as the integrals may contain singularities. In such cases we have to make use of certain calculation tricks to be able to evaluate the acting forces.

As a first example, I shall calculate the force with which the current in one half of a circle of radius R and wire's radius r acts on the currenr in the other half. This force can be measured if at the points where the two half-circles make contact sliding contacts will be put.

If we shall try to use Whittaker's formula (24.3) or Nicolaev's formula (24.12), taking as L' the one half of the circle ans as L the other half, we shall obtain an integral containing singularities, so that we must search for another way to solve the problem.

According to formulas (18.20) and (18.9), the magnetic energy of this circle when current I flows in it will be

$$W = - \sqrt{2}\pi^2 I^2 R^{3/2}/c\sqrt{r}. \qquad (25.1)$$

At an increase of the radius with dR, the magnetic energy will increase by dW and the magnitude of the force acting on an element dr_o of the circuit will be

$$df = (dr_o/2\pi R)(dW/dR) = 3\pi dr_o I^2/2\sqrt{2}c^2\sqrt{rR}. \qquad (25.2)$$

This force is perpendicular to dr_o and obviously directed outside of the circle. Thus if the circular wire is done of elastic material, it will expand delivering mechanical energy and decreasing its magnetic energy.

To obtain the net force acting on one half of the circle, we have to write in (25.2) $dr_o = Rd\phi$ and to take the projection of the force acting on dr_o along the central radius of the half circle. Taking then into account that in a half circle there are two fourth circles, we shall have for the net force

$$f = 2\int_0^{\pi/2} df\sin\phi = 2\int_0^{\pi/2} \frac{3\pi I^2 R\sin\phi\, d\phi}{2\sqrt{2}c^2\sqrt{rR}} = (3\pi/\sqrt{2}c^2)I^2\sqrt{R/r}. \qquad (25.3)$$

Thus the force pushing any of the two half-circles is proportional to the square root of R/r.

When the one half-circle is fixed to the laboratory and the other has sliding contacts and is free to move, we call it CIRCULAR PROPULSIVE AMPERE BRIDGE. Of course, when the half circle has moved a little, the circuit is no more circular and the pushing force may change.

In fig. 6 the HALF-CIRCULAR PROPULSIVE AMPERE BRIDGE is shown. The half circle is called SHOULDER of the bridge and the vertical wires are called ARMS of the bridge. With the notations given in fig. 6 I have calculated[21] the force pushing the half circle upwards when there are sliding contacts at the tops of the arms by using Whittaker's formula (24.3). The obtained integral which, of course, has singularities is given in Ref. 21. I could not find a way to evaluate the force pushing the half-circular Ampere bridge but it surely must be near (if not equal) to the force (25.3).

The classical half circular PROPULSIVE AMPERE BRIDGE (PAB) experiment was done by Ampere in 1823 and is presented in fig. 7. The difference between the bridges in figs. 6 and 7 is that in the former the bridge is in the plane of the arms, while in the latter it is perpendicular to the plane of the arms. The pushing force acting on these two bridges surely must be the same.

Ampere filled the troughs in fig. 7 with mercury, so that excellent sliding contacts have been realized. Tait exchanged the copper bridge of Ampere by a glass tube filled with mercury to show that the effect is magnetic and not due to some surface forces at the contact mercury-copper.

Instead of the half-circle in figs. 6 and 7 one can put a shoulder with a linear

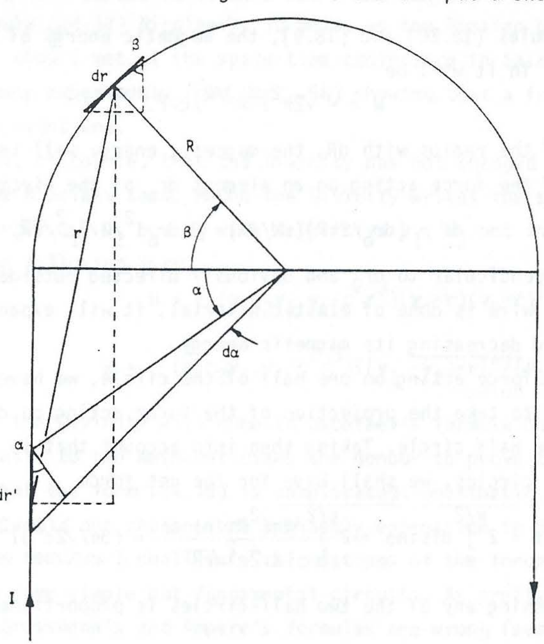

Fig. 6. Half-circular propulsive Ampere bridge.

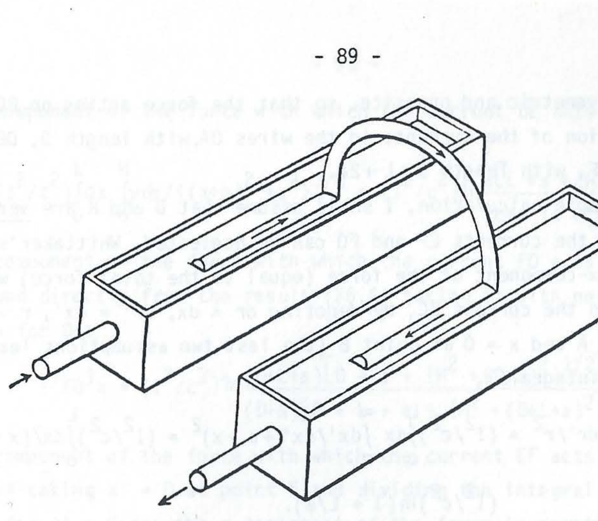

Fig. 7. The classical propulsive Ampere bridge.

form or with a Π-form.

The arms of the Ampere bridge can be done very long (theoretically one can assume them infinitely long) and the sliding contacts can be put at any two points at equal distances from the shoulder, so that the upper parts of the arms will be propulsive and lower stationary.

According to Nicolaev's formula, as there are no forces between colinear currents, with the increase of the propulsive arms the pushing force in the half-circular Ampere bridge must diminish. As far as I know, measurements for establishing the existence (or non-existence) of such an effect have not been done.

On the other hand, the change in the magnetic energy of the whole circuit of the Ampere bridge does not depend on the fact at which points of the arms the sliding contacts are taken and thus, for a definite circuit, the pushing force cannot depend on the relation between the propulsive and stationary arms. Here one has to take also into account that when increasing the length of the propulsive arms a pushing force acting on these propulsive arms appears generated by the current in the "opposite" shoulder.

26. ACTION OF RECTANGULAR CURRENT ON A PART OF IT

26.1. CALCULATION WITH WHITTAKER'S FORMULA.

Now I shall calculate the <u>longitudinal</u> magnetic force acting on the current wire BC in the rectangular circuit ODEF in fig. 8. It was claimed by Nicolaev[(21)] that there is a longitudinal force acting on the wire BC and that he has observed it. Now I shall show that, according to Whittaker's formula the net longitudinal force acting on the current BC is null.

The wire BC can slide at the contacts B and S and has the length L. The action of the currents between points A and B and between points C and D on the current in the wire BC is entirely symmetric and opposite, so that the force acting on BC will be determined by the action of the currents in the wires OA, with length D, DE and FO, with lengths H, and EF, with length D + L + 2a.

First, for more simple calculation, I shall assume that D and H are <u>very long</u>, so that the action of the currents EF and FO can be neglected. Whittaker's formula (24.3) gives for the x-component of the force (equal to the total force) with which the current OA acts on the current BC, by denoting dr = dx, dr' = dx', r = x + a + x', where x' = 0 at point A and x = 0 at point B (the last two assumptions lead to more simple limits in the integrals),

$$(f_{OA})_x = (I^2/c^2)\int_B^C\int_O^A dr dr'/r^2 = (I^2/c^2)\int_0^L dx\int_0^\infty dx'/(x'+a+x)^2 = (I^2/c^2)\int_0^L dx/(x+a) =$$

$$(I^2/c^2)\ln(1 + L/a). \qquad (26.1)$$

For the x-component of the force with which the current DE acts on the current BC we obtain, denoting dr = dx, dr' = dy, $r = \{(x+a)^2 + y^2\}^{1/2}$ and taking x = 0 at point C

$$(f_{DE})_x = (I^2/c^2)\int_B^C\int_D^E (\mathbf{r}.d\mathbf{r}')dr/r^3 = -(I^2/c^2)\int dx\int_0 y dy/\{(x+a)^2 + y^2\}^{3/2} =$$

$$-(I^2/c^2)\int_0^L dx/(x+a) = -(I^2/c^2)\ln(1 + L/a). \qquad (26.2)$$

Comparing formulas (26.1) and (26.2), we see that according to Whittaker's formula there is no force acting on the wire BC.

Formulas (26.1) and (26.2) show that, if x' = y, the current elements along the longitudinal wire OA which are near to point A act on the current elements along the wire BC with larger forces than the current elements along the transverse wire DE which are near to point D (put, for example, x' = y = 0). When the distances x' = y become larger and larger the first forces diminish more rapidly than the second forces, for certain $x'_0 = y_0 = b$ they become equal and then the first forces become less than the second ones. By equalizing the elementary forces in (26.1) and (26.2) and by putting there $x'_0 = y_0 = b$, we obtain

$$1/(b + a + x)^2 = b/\{(x+a)^2 + b^2\}^{3/2}, \qquad (26.3)$$

from where we can find b as a function of a and x.

Let us now find the net longitudinal force acting on the current BC when the action of the currents in EF and FO cannot be neglected. The integration will be more complicated but in the same lines as in the above two formulas; remembering that

$$\int(1 + x^2)^{-1/2}dx = \text{Arsinh}x = \ln\{x + (1 + x^2)^{1/2}\}, \qquad (26.4)$$

we shall have:

The x-component of the force with which the current OA acts on the current BC will be

$$(f_{OA})_x = (I^2/c^2)\int_0^L dx\int_0^D dx'/(x'+a+x)^2 = (I^2/c^2)\ln\frac{(D+a)(L+a)}{a(D+L+a)}. \qquad (26.5)$$

The x-component of the force with which the current DE acts on the current BC will be

$$(\mathbf{f}_{DE})_x = (I^2/c^2)\int_0^L dx\int_0^H y dy/\{(x+a)^2 + y^2\}^{3/2} = (I^2/c^2)\ln\frac{a[L + a + \{H^2 + (L+a)^2\}^{1/2}]}{(L+a)\{a + (H^2 + a^2)^{1/2}\}} \qquad (26.6)$$

The x-component of the force with which the current FO acts on the current BC can be found directly from the result (26.6) taking it with negative sign and exchanging a for D+a

$$(\mathbf{f}_{FO})_x = (I^2/c^2)\ln\frac{(D+L+a)[D + a + \{H^2 + (D+a)^2\}^{1/2}]}{(D+a)[D + L + a + \{H^2 + (D+L+a)^2\}^{1/2}]}. \qquad (26.7)$$

The x-component of the force with which the current EF acts on the current BC will be, if taking x' = 0 at point F and dividing the integral on x' into two integrals, as for x' < D+a+x the x-component of the force is negative and for x' > D+a+x positive,

$$(f_{EF})_x = -\frac{I^2}{c^2}\int_0^L dx\int_0^{D+a+x}\frac{(D+a+x-x')dx'}{\{(D+a+x-x')^2 + H^2\}^{3/2}} + \frac{I^2}{c^2}\int_0^L dx\int_{D+a+x}^{D+L+2a}\frac{(x'-D-a-x)dx'}{\{(x'-D-a-x)^2 + H^2\}^{3/2}} =$$

$$(I^2/c^2)\ln\frac{\{a + (H^2 + a^2)^{1/2}\}[D + L + a + \{H^2 + (D+L+a)^2\}^{1/2}]}{[D + a + \{H^2 + (D+a)^2\}^{1/2}][L + a + \{H^2 + (L+a)^2\}^{1/2}]}. \qquad (26.8)$$

The net longitudinal force acting on the wire BC will be the sum of the forces

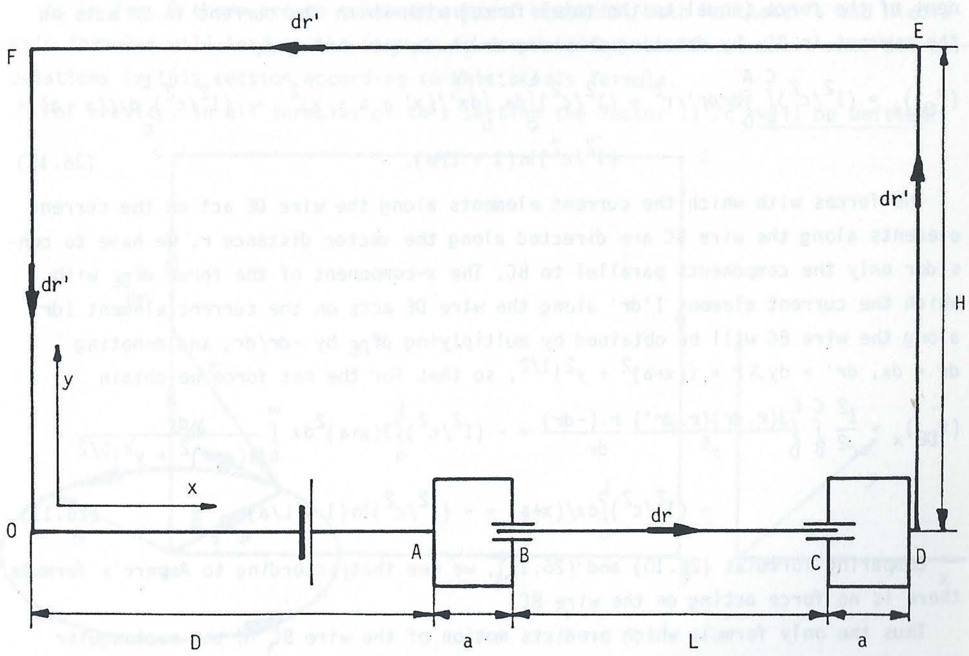

Fig. 8. Rectangular current loop acting on a part of it.

(26.5), (26.6), (26.7) and (26.8) and it is equal to zero

$$(f_{OA})_x + (f_{DE})_x + (f_{FO})_x + (f_{EF})_x = (I^2/c^2)\ln 1 = 0. \qquad (26.9)$$

26.2 CALCULATION WITH NICOLAEV'S FORMULA.

To obtain the prediction of Nicolaev's formula for the force with which the current in the open loop DEFOA acts on the current in the straight wire BC, at the assumption that the wires OA and DE are very long, we have to put in (26.1) $(f_{OA})_x = 0$ and the force which will remain to act on the wire BC will be only the force $(f_{DE})_x$ given by formula (26.2). Thus the wire BC will move to the left, as Nicolaev first has observed (see Sect. 58.4). I repeated Nicolaev's experiment in a very impressive variation where a continuous rotation could be observed (see Sect. 59).

26.3. CALCULATION WITH GRASSMANN'S FORMULA.

As according to Grassmann's formula (24.4) the forces acting on a current element must be always perpendicular to the latter, no longitudinal force can act on the current wire BC.

26.4. CALCULATION WITH AMPERE'S FORMULA.

Here also as above the force acting on BC will be determined by the action of the currents in the wires OA and DE. Ampere's formula (24.5) gives for the x-component of the force (equal to the total force) with which the current in OA acts on the current in BC, by denoting dr = dx, dr' = dx', r = x' + x,

$$(f_{OA})_x = (I^2/c^2)\int_B^C\int_O^A dr\,dr'/r^2 = (I^2/c^2)\int_0^L dx\int_0^\infty dx'/(x'+a+x)^2 = (I^2/c^2)\int_0^L dx/(x+a) =$$
$$(I^2/c^2)\ln(1 + L/a). \qquad (26.10)$$

The forces with which the current elements along the wire DE act on the current elements along the wire BC are directed along the vector distance **r**. We have to consider only the components parallel to BC. The x-component of the force $d\mathbf{f}_{DE}$ with which the current element I'dr' along the wire DE acts on the current element I**dr** along the wire BC will be obtained by multiplying $d\mathbf{f}_{DE}$ by -**dr**/dr, and denoting dr = dx, dr' = dy, $r = \{(x+a)^2 + y^2\}^{1/2}$, so that for the net force we obtain

$$(f_{DE})_x = \frac{I^2}{c^2}\int_B^C\int_D^E \frac{3(\mathbf{r}.d\mathbf{r})(\mathbf{r}.d\mathbf{r}')}{r^5}\,\frac{\mathbf{r}.(-d\mathbf{r})}{dr} = -(I^2/c^2)\int_0^L 3(x+a)^2 dx\int_0^\infty \frac{y\,dy}{\{(x+a)^2+y^2\}^{5/2}} =$$
$$-(I^2/c^2)\int_0^L dx/(x+a) = -(I^2/c^2)\ln(1 + L/a). \qquad (26.11)$$

Comparing formulas (26.10) and (26.11), we see that according to Ampere's formula there is no force acting on the wire BC.

Thus the only formula which predicts motion of the wire BC in the rectangular loop ODEF remains Nicolaev's formula.

27. INTERACTION BETWEEN CIRCULAR, RADIAL AND AXIAL CURRENTS

It is highly important to know the forces of interaction between a circular current, on one side, and radial and axial currents, on the other side. To the best of my knowledge, nobody has calculated these forces, even with the wrong Grassmann and Ampere formulas.

Let us consider the most simple circuit consisting of a circular current with radius R and a rectangular current acde perpendicular to it with its corner at the center of the circular current (fig. 9). This case is presented also in fig. 10 where two sliding contacts are put, so that one can observe the appearing forces, as done by Sigalov[21] (I call the experiment shown in fig. 10 the FIRST SIGALOV'S EXPERIMENT). In the single circuit of fig. 10 the current is I, in the two circuits of fig. 9 the currents can be different, I and I'.

I shall calculate the torques (moment of forces) about the axis ac (the z-axis) appearing because of the action:

1. of the internal radial current on the circular current,
2. of the circular current on the internal radial current,
3. of the external radial current on the circular current,
4. of the circular current on the external radial current,
5. of the axial current on the circular current.

As in fig. 9 there are no colinear current elements, both Whittaker's and Nicolaev's formulas will lead to the same or to very similar results. I shall make all calculations in this section according to Whittaker's formula.

For brevity, in all formulas of this section the factor II'/c^2 will be omitted.

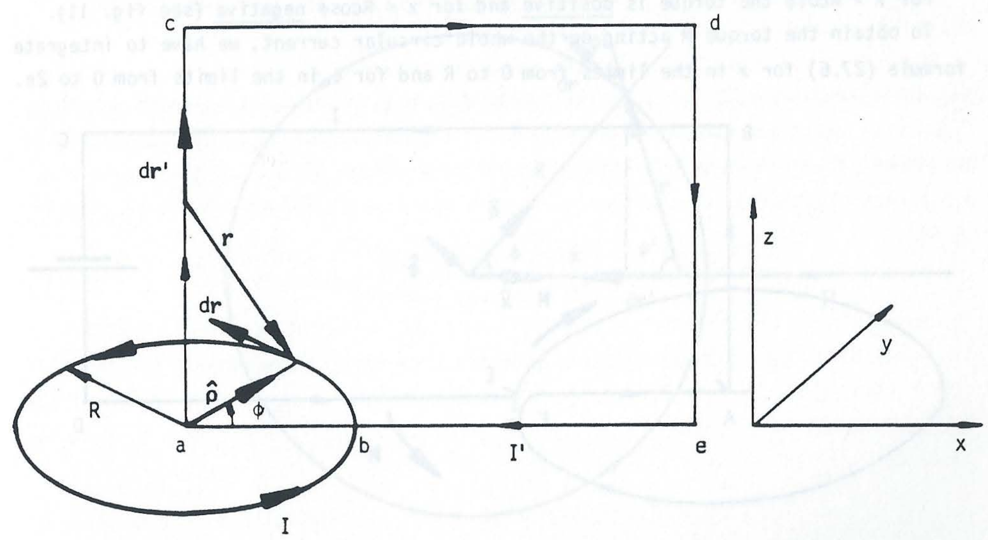

Fig. 9. Rectangular and circular circuits.

27.1. ACTION OF THE INTERNAL RADIAL CURRENT ON THE CIRCULAR CURRENT.

The unit vector along the x-axis is denoted by $\hat{x}$, the unit vector along the polar radius is denoted by $\hat{\rho}$, the unit vector which is perpendicular to the polar radius and corresponds to the polar angle ϕ is denoted by $\hat{\phi}$, and the unit vector along the z-axis is denoted by $\hat{z}$. The circular and internal radial currents are shown in fig. 11.

The elementary moment of force about the z-axis appearing as a result of the action of the radial current element $d\mathbf{r}'$ on the circular current element $d\mathbf{r}$ will be

$$d\mathbf{M} = R\hat{\rho}\times d\mathbf{f}, \qquad (27.1)$$

so that by substituting (24.3) into (27.1) we obtain

$$d\mathbf{M} = (R/r^2)\hat{\rho}\times\{\cos\psi(-\hat{x}) + \cos\psi'\hat{\phi} - \sin\phi(\mathbf{r}/r)\}drdr'. \qquad (27.2)$$

As

$$\mathbf{r}/r = \sin\psi\hat{\rho} + \cos\psi\hat{\phi}, \quad dr = Rd\phi, \quad dr' = dx, \quad \hat{\rho}\times\hat{x} = -\sin\phi\hat{z}, \quad \hat{\rho}\times\hat{\phi} = \hat{z}, \qquad (27.3)$$

we obtain

$$d\mathbf{M} = (R^2/r^2)\cos\psi' dx\, d\phi\hat{z}. \qquad (27.4)$$

We have from fig. 11

$$\sin\psi' = R\sin\phi/r, \qquad r^2 = x^2 - 2xR\cos\phi + R^2, \qquad (27.5)$$

so that by putting (27.5) into (27.4) we obtain for the component of the elementary torque about the z-axis

$$dM = \frac{R^2}{r^2}\left(1 - \frac{R^2\sin^2\phi}{r^2}\right)^{1/2}dxd\phi = \frac{R^2(x - R\cos\phi)\,dxd\phi}{(x^2 - 2xR\cos\phi + R^2)^{3/2}}. \qquad (27.6)$$

For $x > R\cos\phi$ the torque is <u>positive</u> and for $x < R\cos\phi$ <u>negative</u> (see fig. 11).

To obtain the torque M acting on the whole circular current, we have to integrate formula (27.6) for x in the limits from 0 to R and for ϕ in the limits from 0 to 2π.

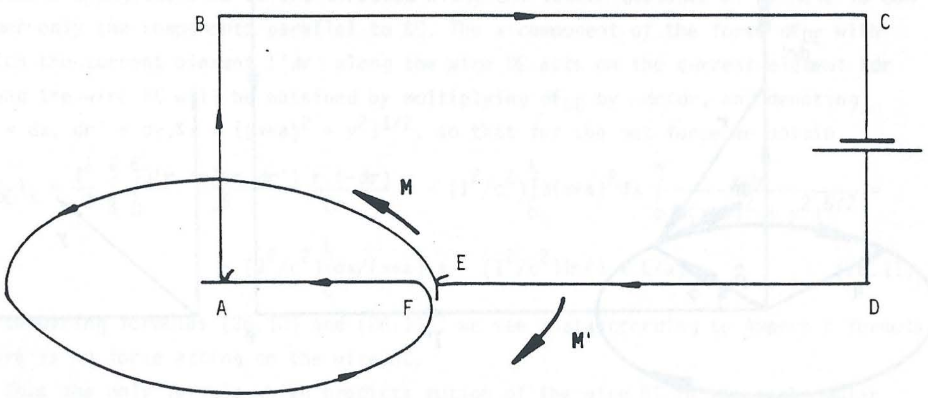

Fig. 10. Sigalov's first experiment.

Both integrations can easily be carried out in a final form, however at the point $x = R$, $\phi = 0$ there is a singularity: the distance between $d\mathbf{r}$ and $d\mathbf{r}'$ becomes equal to zero. Thus we shall write the solution in the following form

$$M = \int_0^{2\pi} d\phi \int_0^R \frac{R^2(x - R\cos\phi)dx}{(x^2 - 2xR\cos\phi + R^2)^{3/2}} = -\int_0^{2\pi}\frac{Rd\phi}{2\sin(\phi/2)} + \int_0^{2\pi} Rd\phi = -R\ln\frac{\tan\pi}{\tan 0} + 2\pi R. \qquad (27.7)$$

27.2. ACTION OF THE CIRCULAR CURRENT ON THE INTERNAL RADIAL CURRENT.

To find the torque with which the circular current acts on the radial current, we change the directions of the currents I and I' to the opposite. In such a case the acting forces remain the same, but we shall have now the angles ψ and ψ' less than $\pi/2$ and this will facilitate the matemantics (fig. 12).

The elementary torque about the z-axis appearing as a result of the action of the circular current element $d\mathbf{r}'$ on the radial current element $d\mathbf{r}$ will be

$$d\mathbf{M} = x\hat{x}\times d\mathbf{f}, \qquad (27.8)$$

so that by substituting (27.2) into (27.8) we obtain

$$d\mathbf{M} = (x/r^2)\hat{x}\times\{\cos\psi(-\hat{\phi}) + \cos\psi'\hat{x} - \sin\phi(\mathbf{r}/r)\}drdr'. \qquad (27.9)$$

As $\mathbf{r}/r = -\sin\psi'\hat{\rho} - \cos\psi'\hat{\phi}$, $dr = dx$, $dr' = Rd\phi$, $\hat{x}\times\hat{\phi} = \cos\phi\hat{z}$, $\hat{x}\times\hat{\rho} = \sin\phi\hat{z}$, we obtain

$$d\mathbf{M} = (x/r^2)\{-\cos\phi\cos\psi + \sin\phi(\sin\phi\sin\psi' + \cos\phi\cos\psi')\}\hat{z} =$$

$$(x/r^2)(-\cos\phi\cos\psi + \sin\phi\sin\psi)\hat{z}, \qquad (27.10)$$

as $\phi - \psi' = \pi/2 - \psi$.

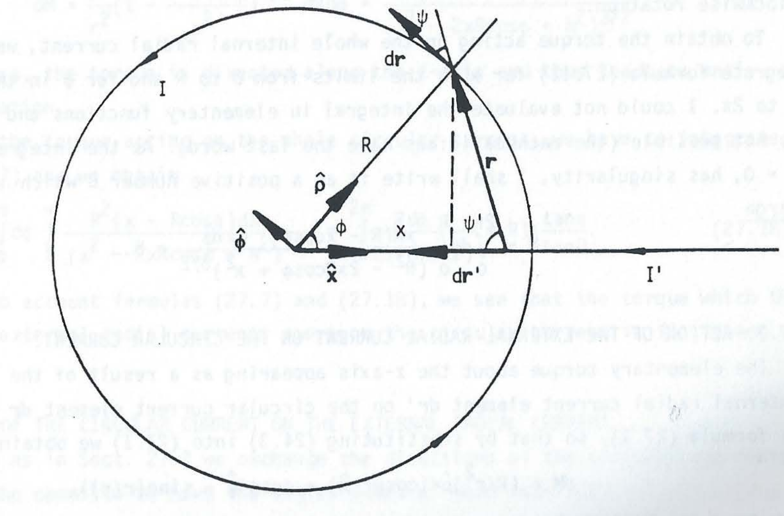

Fig. 11. Action of internal radial current on circular current.

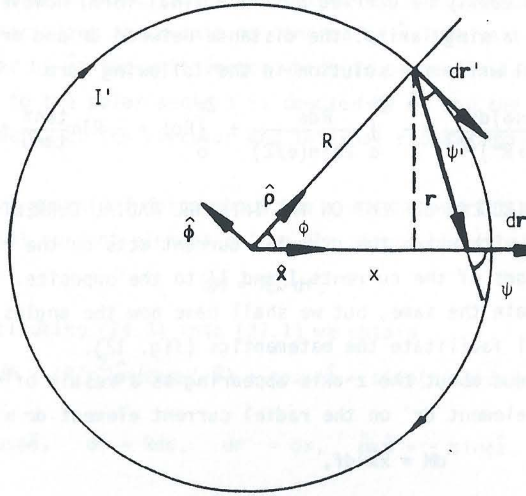

Fig. 12. Action of circular current on internal radial current.

We have from fig. 12

$$\cos\psi = (x - R\cos\phi)/r, \qquad \sin\psi = R\sin\psi/r, \qquad r^2 = R^2 - 2xR\cos\phi + x^2, \qquad (27.11)$$

so that by putting (27.11) into (27.10) we obtain for the z-component of the torque

$$dM = (xR/r^3)\{\cos\phi(R\cos\phi - x) + R\sin^2\phi\}dx d\phi = \frac{xR(R - x\cos\phi)\, dx\, d\phi}{(R^2 - 2xR\cos\phi + x^2)^{3/2}}. \qquad (27.12)$$

As $R > x\cos\phi$, the torque is directed along the z-axis and this leads to anti-clockwise rotation.

To obtain the torque acting on the whole internal radial current, we have to integrate formula (27.12) for x in the limits from 0 to R and for ϕ in the limits from 0 to 2π. I could not evaluate the integral in elementary functions and perhaps this is not possible (the mathematicians have the last word). As the integral for $x = R$, $\phi = 0$, has singularity, I shall write it as a positive number B which is <u>infinitely large</u>

$$M = \int_0^{2\pi} d\phi \int_0^R \frac{xR(R - x\cos\phi)\ dx\, d\phi}{(R^2 - 2xR\cos\phi + x^2)^{3/2}} = B. \qquad (27.13)$$

27.3. ACTION OF THE EXTERNAL RADIAL CURRENT ON THE CIRCULAR CURRENT.

The elementary torque about the z-axis appearing as a result of the action of the external radial current element $\mathbf{dr}'$ on the circular current element $\mathbf{dr}$ will be given by formula (27.1), so that by substituting (24.3) into (27.1) we obtain (fig. 13)

$$dM = (R/r^2)\hat{\rho}\times\{\cos\psi(-\hat{x}) + \cos\psi'\hat{\boldsymbol{\phi}} - \sin\phi(\mathbf{r}/r)\}. \qquad (27.14)$$

As $\mathbf{r}/r = \sin\psi\hat{\boldsymbol{\rho}} + \cos\psi\hat{\boldsymbol{\phi}}$, $dr = Rd\phi$, $dr' = dx$, $\hat{\rho}\times\hat{x} = -\sin\phi\hat{z}$, $\hat{\rho}\times\hat{\boldsymbol{\phi}} = \hat{z}$, we obtain

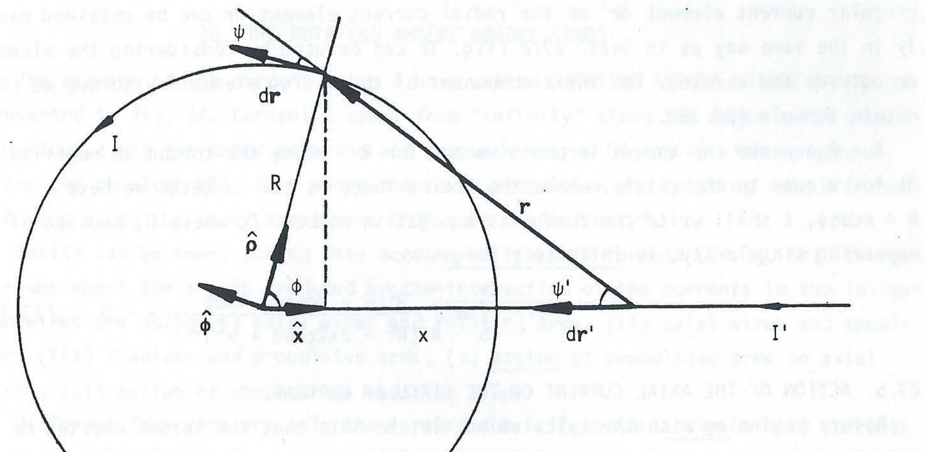

Fig. 13. Action of external radial current on circular current.

$$dM = (R^2/r^2)\cos\psi' dx d\phi\hat{z}. \qquad (27.15)$$

We have from fig. 13

$$\sin\psi' = R\sin\phi/r, \qquad r^2 = x^2 - 2xR\cos\phi + R^2, \qquad (27.16)$$

so that by putting (27.16) into (27.15) we obtain for the z-component of the elementary torque

$$dM = \frac{R^2}{r^2}\left(1 - \frac{R^2\sin^2\phi}{r^2}\right)^{1/2} dx d\phi = \frac{R^2(x - R\cos\phi)\, dx d\phi}{(x^2 - 2xR\cos\phi + R^2)^{3/2}}. \qquad (27.17)$$

As $x > R\cos\phi$, the torque is directed along the z-axis and thus leads to anti-clockwise rotation.

To obtain the torque acting on the whole circular current, we have to integrate formula (27.17) and we obtain

$$M = \int_0^{2\pi} d\phi \int_R^{\infty} \frac{R^2(x - R\cos\phi)dx}{(x^2 - 2xR\cos\phi + R^2)^{3/2}} = \int_0^{2\pi} \frac{Rd\phi}{2\sin(\phi/2)} = R\ln\frac{\tan\pi}{\tan 0}. \qquad (27.18)$$

Taking into account formulas (27.7) and (27.18), we see that the torque which the internal and external radial currents exerts on the circular current is finite and equal to $2\pi R$.

27.4. ACTION OF THE CIRCULAR CURRENT ON THE EXTERNAL RADIAL CURRENT.

Here again as in Sect. 27.2 we exchange the directions of the circular and radial currents to the opposite to have the angles ψ and ψ' less than $\pi/2$.

The elementary torque about the z-axis appearing as a result of the action of the circular current element **dr**' on the radial current element **dr** can be obtained exactly in the same way as in Sect. 27.2 (fig. 12 can be used by considering the element **dr** outside the circle). For the z-component of the acting elementary torque we shall obtain formula (27.12).

For $R > x\cos\phi$ the torque is positive and for $R < x\cos\phi$ the torque is negative. As for x near to the circle, where the acting force is the largest, we have $R < x\cos\phi$, I shall write the torque as a negative number -D, where D, because of the appearing singularity, is infinitely large

$$M = \int_0^{2\pi} d\phi \int_R^{\infty} \frac{R^2(R - x\cos\phi)\, dx d\phi}{(R^2 - 2xR\cos\phi + x^2)^{3/2}} = - D. \quad (27.19)$$

27.5. ACTION OF THE AXIAL CURRENT ON THE CIRCULAR CURRENT.

Before beginning with the calculation, let me note that the torque exerted by the circular current on the axial current obviously is zero as the levers of the forces are null (see fig. 9).

The elementary torque about the z-axis appearing as a result of the action of the axial current element **dr**' on the circular current element **dr** will be given by formula (27.1). Putting in it (24.3) we obtain

$$d\mathbf{M} = (R^2/r^2)\hat{\rho}\times\cos\psi'\hat{\boldsymbol{\phi}}drdr'. \quad (27.20)$$

We have from fig. 9

$$\cos\psi' = - z/r, \qquad r^2 = z^2 + R^2, \quad (27.21)$$

so that by putting (27.21) into (27.20) we obtain

$$dM = - \frac{R^2 z\, dz d\phi}{(z^2 + R^2)^{3/2}}. \quad (27.22)$$

The elementary torque is obviously negative. For the integral torque we obtain

$$M = - \int_0^{2\pi} d\phi \int_0^{\infty} \frac{R^2\, z\, dz}{(z^2 + R^2)^{3/2}} = - \int_0^{2\pi} R\, d\phi = - 2\pi R. \quad (27.23)$$

The torque with which the rectangular current acts on the circular current will be the sum of the torques (27.7), (27.18) and (27.23) and is null as it must be.

The torque with which the circular current acts on the rectangular current will be given by the sum of the torques (27.13) and (27.19). As it also must be null, we shall have B = D.

The torque acting on the moving part of Sigalov's experiment (fig. 10) will be the sum of the torques (27.7), (27.13), (27.18) and (27.23). Thus it will be equal to the positive number B. As a matter of fact Sigalov's experiment is a simplified variation of the cemented Barlow disk (see Sect. 47). If the sliding contact will be not at point E but at point F and the circular current will not rotate, Sigalov's experiment will be a simplified variation of the uncemented Barlow disk. As the net torque on the current in the circular wire is null, its rest or rotation is immaterial.

28. THE ROTATING AMPERE BRIDGE (RAB)

The drawing of the circuit which I have called ROTATING AMPERE BRIDGE (RAB) is presented in fig. 14. Current I comes from "infinity" along the upper axial wire PO, flows along the upper rotating and propulsive arms OA and AB with lengths R, along the shoulder BB', then along the lower propulsive and rotating arms B'A' and A'O' and along the lower axial wire O'P' goes to "infinity".

Easily can be seen, taking into account Whittaker's formula (24.3), that the net torques about the z-axis produced by the interaction of the currents in the following wires are null: (i) axial wires and rotating arms, (ii) axial wires and shoulder, (iii) shoulder and propulsive arms, (v) action of propulsive arms on axial wires, (vi) action of shoulder on rotating arms.

Different from zero are only the torques due: (i) to the action of the currents in the axial wires on the currents in the propulsive arms, (ii) to the interaction of the currents in the rotating and propulsive arms, and (iii) to the action of the currents in the rotating arms on the current in the shoulder.

Now I shall calculate the respective torques, omitting also in this section to write the factor I^2/c^2 in the formulas.

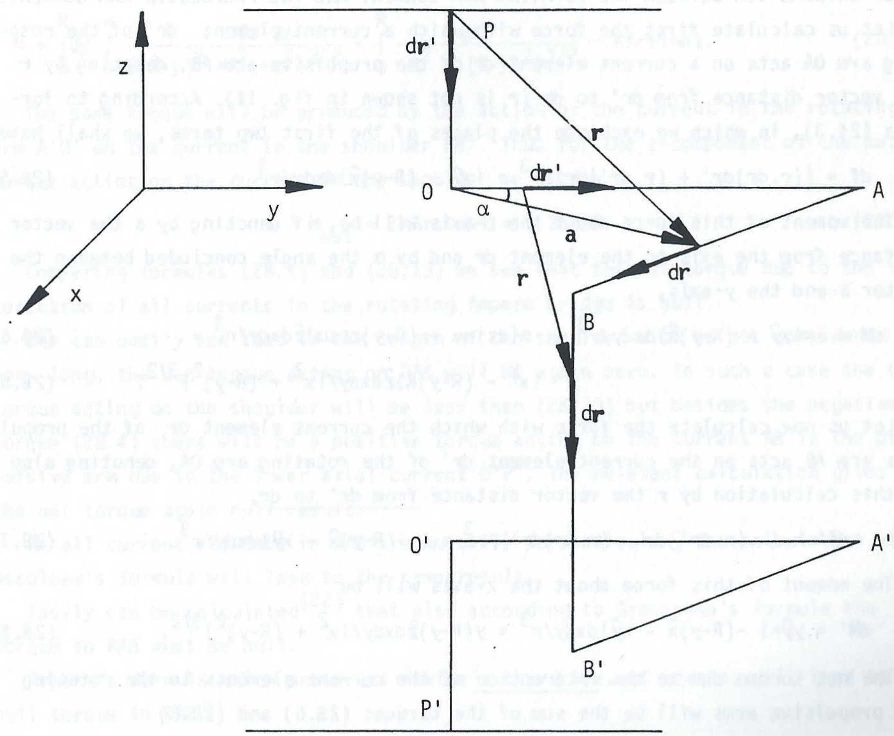

Fig. 14. the rotating Ampere bridge.

28.1. ACTION OF THE AXIAL CURRENT ON THE PROPULSIVE ARM CURRENT.

A current element Idr' along the axial wire PO acts on a current element Idr along the propulsive arm AB, to which the vector distance is **r**, with the elemental force generating torque about the z-axis

$$df = (\mathbf{r}.d\mathbf{r}')d\mathbf{r}/r^3 = \cos(\mathbf{r},d\mathbf{r}')drdr'\hat{\mathbf{x}}/r^2 = z\,dxdz\hat{\mathbf{x}}/(x^2+z^2+R^2)^{3/2}. \quad (28.1)$$

The moment of this force about the z-axis will be

$$dM = (x\hat{\mathbf{x}} + R\hat{\mathbf{y}})\times z dxdz\hat{\mathbf{x}}/(x^2+z^2+R^2)^{3/2} = -Rzdxdy\hat{\mathbf{z}}/(x^2+z^2+R^2)^{3/2}. \quad (28.2)$$

For the z-component of the integral torque we obtain, taking AB = R, PO = ∞,

$$M = -\int_0^R\int_0^\infty Rzdxdz/(x^2+z^2+R^2)^{3/2} = -R\int_0^R (x^2+R^2)^{-1/2}dx = -R\mathrm{Arsinh}1. \quad (28.3)$$

If the shoulder BB' is long enough, we can neglect the torque produced by the action of the axial wire current PO on the current in the propulsive arm B'A'. Thus taking into account also the torque due to the action of the current O'P' on the current B'A', we shall obtain for the z-component of the net torque

$$M_{net} = 2R\mathrm{Arsinh}1 = -1.7628R. \quad (28.4)$$

28.2. INTERACTION BETWEEN THE ROTATING ARM CURRENT AND THE PROPULSIVE ARM CURRENT.

Let us calculate first the force with which a current element dr' of the rotating arm OA acts on a current element dr of the propulsive arm AB, denoting by **r** the vector distance from dr' to dr (**r** is not shown in fig. 14). According to formula (24.3), in which we exchange the places of the first two terms, we shall have

$$df = \{(\mathbf{r}.d\mathbf{r})d\mathbf{r}' + (\mathbf{r}.d\mathbf{r}')d\mathbf{r}\}/r^3 = \{x\hat{\mathbf{y}} + (R-y)\hat{\mathbf{x}}\}dxdy/r^3. \quad (28.5)$$

The moment of this force about the z-axis will be, if denoting by **a** the vector distance from the axis to the element dr and by α the angle concluded between the vector a and the y-axis,

$$dM = \mathbf{a}\times\{x\hat{\mathbf{y}} + (R-y)\hat{\mathbf{x}}\}dxdy/r^3 = a\{x\sin\alpha - (R-y)\cos\alpha\}\hat{\mathbf{z}}dxdy/r^3 = \quad (28.6)$$

$$\{x^2 - (R-y)R\}\hat{\mathbf{z}}dxdy/\{x^2+(R-y)^2\}^{3/2}. \quad (28.6)$$

Let us now calculate the force with which the current element dr of the propulsive arm AB acts on the current element dr' of the rotating arm OA, denoting also in this calculation by **r** the vector distance from dr' to dr,

$$df' = \{-(\mathbf{r}.d\mathbf{r}')d\mathbf{r} - (\mathbf{r}.d\mathbf{r})d\mathbf{r}'\}/r^3 = \{-(R-y)\hat{\mathbf{x}} - x\hat{\mathbf{y}}\}dxdy/r^3. \quad (28.7)$$

The moment of this force about the z-axis will be

$$dM' = y\hat{\mathbf{y}}\times\{-(R-y)\hat{\mathbf{x}} - x\hat{\mathbf{y}}\}dxdy/r^3 = y(R-y)\hat{\mathbf{z}}dxdy/\{x^2+(R-y)^2\}^{3/2}. \quad (28.8)$$

The net torque due to the interaction of the current elements in the rotating and propulsive arms will be the sum of the torques (28.6) and (28.8)

$$dM_{net} = dM + dM' = \{x^2-(R-y)^2\}\hat{\mathbf{z}}dxdy/\{x^2+(R-y)^2\}^{3/2}. \quad (28.9)$$

The integral torque produced by the interaction of the currents in the rotating and propulsive arms will be obtained by integrating the elemental torque (28.9) for x in the limits from 0 to R and for y in the limits from 0 to R. If making then the substitution R-y = Y, dx = - dY, we obtain for the z-component of the net torque

$$M_{net} = \int_0^R\int_0^R\{x^2-(R-y)^2\}dxdy/\{x^2+(R-y)^2\}^{3/2} = \int_0^R\int_0^R(x^2-Y^2)dxdY/(x^2+Y^2)^{3/2} = 0. \quad (28.10)$$

Thus the net torque due to interaction of the currents in the rotating and propulsive arms is null.

28.3. ACTION OF THE ROTATING ARM CURRENT ON THE SHOULDER CURRENT.

A current element dr' along the rotating arm OA acts on a current element dr of the shoulder BB', to which the vector distance is **r**, with the elemental torque

$$dM = R\mathbf{x}\times d\mathbf{f}, \quad (28.11)$$

in which we have to put for the elemental force, denoting by z the distance from B to dr,

$$df = (\mathbf{r}.d\mathbf{r})d\mathbf{r}'/r^3 = (z/r)y/r^3. \quad (28.12)$$

Thus we obtain for the z-component of the whole torque, taking BB' = ∞,

$$M = \int_0^R dy\int_0^\infty \frac{Rz\,dz}{\{(R-y)^2+R^2+z^2\}^{3/2}} = \int_0^R\frac{dy}{\{R^2+(R-y)^2\}^{1/2}} = R\mathrm{Arsinh}1. \quad (28.12)$$

The same torque will be produced by the action of the current in the rotating arm A'O' on the current in the shoulder BB'. Thus for the z-component of the net torque acting on the current in the shoulder we obtain

$$M_{net} = 2R\mathrm{Arsinh}1 = 1.7628R. \quad (28.13)$$

Comparing formulas (28.4) and (28.13) we see that the net torque due to the interaction of all currents in the rotating Ampere bridge is null.

One can easily see that if the length of the shoulder will be not considered as very long, the net torque acting on RAB will be again zero. In such a case the net torque acting on the shoulder will be less than (28.13) but besides the negative torque (28.4) there will be a positive torque acting on the current AB in the propulsive arm due to the lower axial current O'P'. The relevant calculation gives for the net torque again null result.

As all current elements in RAB are mutually perpendicular, the calculation with Nicolaev's formula will lead to the same result.

Easily can be calculated[22] that also according to Grassmann's formula the torque in RAB must be null.

Ampere's formula which preserves Newton's third law, of course, will lead to a null torque in RAB.

29. ELECTROMOTORS DRIVEN BY VECTOR AND SCALAR MAGNETIC INTENSITIES

The vector and scalar magnetic intensities are defined, respectively, by the second and third formulas (8.6).

If not Whittaker's formula (24.3) but Nicolaev's formula (24.12) will be the right one, the scalar magnetic intensity is to be written not in the simple Whittaker's form (8.6) but in the complicated Nicolaev's form (24.14). Without precising the exact mathematical expression of the scalar magnetic intensity S through the magnetic potential **A** (for the time being when not enough experimental evidence is accumulated), I shall call scalar magnetic intensity this potential force which acts along the test current element and vector magnetic intensity this one which acts at right angles to the test current element. When it will be necessary, I shall present the scalar magnetic intensity preferably in its Whittaker's form.

The ELECTROMAGNETIC MOTORS which are driven by the vector magnetic intensity B (such are all electromotors built by humanity in two centuries of electromagnetism) will be called B-MOTORS and the electromagnetic motors which are driven by the scalar magnetic intensity S (see Sects. 58 -60) will be called S-MOTORS.

Here I shall present the most simple S-motor which still I have not constructed, but I have no doubts that it would not work in the predicted way.

We have found in Sect. 27.5 that the torque with which an axial current acts on a circular current (see fig. 9) is given by formula (27.23). As in all formulas of Sect. 27, for brevity's sake, the common factor II'/c^2 was omitted, let us write again this formula in its complete form: Thus the z-component of the torque with which a vertical positive current I' acts on a current I flowing along a circle with radius R in the positive (anti-clockwise) direction is

$$M = - 2\pi II'R/c^2 . \qquad (29.1)$$

Let us then construct our S-motor in the following way (fig. 15):

A condenser C with a big capacitance is charged to a high potential. The vertical wire ac, which at its lower end is connected with a big metal sphere, can make successively contact with the positive and negative electrodes of the condenser C. If this contact will be made with a frequency equal to the own frequency of oscillations of the suspended on strings permanent ring magnet, this magnet can be set in oscillations. Indeed, the permanent ring magnet can be presented as two circular currents, I, with radii equal to the internal and external radii of the ring magnet, R_{int} and R_{ext}. The torque acting on these circular currents, for the moment shown in the figure when electrons fly from the left plate of the condenser downwards to the big metal sphere (i.e., when the current is pointing upwards) at the indicated directions of the currents in the magnet (on the internal periphery the current is flowing clockwise and on the external periphery anti-clockwise) will be

$$M_{net} = M_{int} + M_{ext} = (2\pi II'/c^2)(R_{int} - R_{ext}). \qquad (29.2)$$

Thus the motion of the magnet at this laps of time will be negative (clock-wise). At the next laps of time, when the metal sphere will be connected to the right, positive electrode of the big condenser, the motion of the magnet will be positive.

Let now exchange the ring magnet in fig. 15 by a circular wire and let insert in it a source of alternating electric tension with frequency ν. If the frequency with which the wire ac is connected successively to the negative and positive electrodes of the condenser C will be also ν, the circular current wire will begin to rotate. As the moment of force with which the circular current wire acts on the vertical current wire is zero, this experiment will present a patent violation of the angular momentum conservation law.

It is interesting to note that the scalar magnetic intensity with which the electromagnetic system consisting of the driving big condenser C, the wire ca and the big "storage" sphere acts on the circular current can be calculated either as a magnetic effect by the help of the last equation (8.6) or as an electric effect by the help of equation (8.10). The force on the circular current will act in the direction of the current when divA < 0, i.e., $\partial\Phi/\partial t > 0$, or against the direction of the current when divA > 0, i.e., $\partial\Phi/\partial t < 0$.

These childichaly simple and clear effects are absolutely unknown to offial physics.

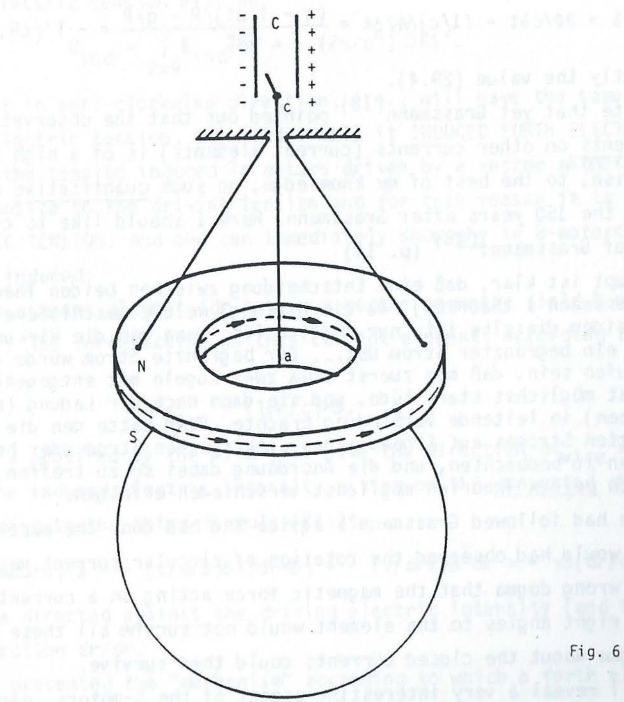

Fig. 15. S-motor with interrupted current.

Let us make these two types of calculation for the experiment shown in fig. 15, making use also of fig. 9. We suppose that the current wire ac is infinitely long and that a constant current I' flows along it from point a (where there is a big "storage" sphere charged with positive charges) to point c (where there is another "storage" sphere charged with negative charges). The magnetic potential generated by the current I' along the circular loop with radius R will be

$$A = \int_0^\infty I'dz\hat{z}/cr = (I'/c)\int_0^\infty dz\hat{\mathbf{z}}/(R^2 + z^2)^{1/2}. \qquad (29.3)$$

The scalar magnetic intensity generated by this vertical current along the circular loop will be

$$S = - \mathrm{div}A = - \partial A/\partial \mathbf{r} = - (I'/c)\int_0^\infty zdz/(R^2 + z^2)^{3/2} = - I'/cR. \qquad (29.4)$$

We shall obtain the same value for the scalar magnetic intensity, if calculating it according to formula (8.10). To make the calculation more simple, let calculate S in the equatorial plane of the storage sphere at a distance R from its center. The potential of the charges q on the sphere at a distance R from the center is $\Phi = q/R$, independently of the radius of the sphere(5). When the current extracting charges from the storage sphere is I', for a time Δt the extracted charges will be $I'\Delta t$ and we shall have for the scalar magnetic intensity

$$S = \partial\Phi/c\partial t = (1/c)\Delta\Phi/\Delta t = \frac{(q - I'\Delta t)/R - q/R}{c\Delta t} = - I'/cR, \qquad (29.5)$$

what is exactly the value (29.4).

Let me note that yet Grassmann(18) pointed out that the observation of the action of open currents on other currents (current elements) is of a high importance. For my big surprise, to the best of my knowledge, no such quantitative observations have been done in the 150 years after Grassmann. Here I should like to cite some remarkable lines of Grassmann:(18) (p. 14)

> Oberhaupt ist klar, daß eine Entscheidung zwischen beiden Theorien (Ampere's and Grassmann's theories), da die Wirkung, welche geschloßene Ströme üben, nach beiden dieselbe ist, nur möglich ist, wenn man die Wirkung betrachtet, welche ein begränzter Strom übt... Der begränzte Strom würde daher so hervorzurufen sein, daß man zuerst etwa zwei Kugeln mit entgegengesetzter Elektrizität möglichst stark lüde, und sie dann nach der Ladung (nicht während derselben) in leitende Verbindung brächte. Dann hätte man die Wirkung dieses begränzten Stromes auf irgend einen elektrischen Strom oder besser auf einen Magneten zu beobachten, und die Anordnung dabei so zu treffen, daß die Wirkungen nach beiden Theorien möglichst verschieden erfolgen.

If someone had followed Grassmann's advice and had done the experiment shown in fig. 15, one would had observed the rotation of circular current many and many years ago, and the wrong dogma that the magnetic force acting on a current element must be always at right angles to the element would not survive all these years. Neither Maxwell's dogma about the closed currents could then survive.

Now I shall reveal a very interesting aspect of the S-motors, namely that not

back but forth tension is induced at their rotation.

If the current along the circular loop is flowing anti-clockwise (as in fig. 9), the forces acting on the current conducting charges, according to the fourth formula (21.1) - as well as according to formula (24.15) - will be directed against their velocities, so that the circular wire will begin to rotate in a clockwise direction. At this motion, all positive charges in the wire which can become current conducting charges will obtain a low convection velocity in a clock-wise direction. The scalar magnetic intensity (29.4) will begin to act on these convected charges, according to the fourth formula (21.1), with an electromotive force opposite to their velocity, i.e., with a force pointing along the direction of the initial driving current.

The force acting on a unit convected positive charge will be the induced electric intensity (see again formula (29.4))

$$E_{ind} = (\mathbf{v}/c)S = \Omega RS\mathbf{n}/c^2 = - \Omega I'\mathbf{n}/c^2, \qquad (29.6)$$

where Ω is the angular velocity of rotation of the circular wire and **n** is the unit vector at any single point of the wire pointing along its linear rotational velocity, i.e., against the direction of the initial driving current. Thus the electric intensity induced by the scalar magnetic intensity is directed along the driving current and I call it INDUCED FORTH ELECTRIC INTENSITY.

The induced electric tension will be

$$U_{ind} = \int_{2\pi R} \mathbf{E}_{ind}.d\mathbf{r} = - (2\pi/c^2)\,\Omega RI'. \qquad (29.7)$$

and will also act in anti-clockwise direction, i.e., will have the same direction as the driving electric tension, U_{dr}, and I call it INDUCED FORTH ELECTRIC TENSION.

We know that the tension induced in motors driven by a vector magnetic intensity, B, is always opposite to the driving tension and for this reason it is called INDUCED BACK ELECTRIC TENSION. And one can immediately show why in B-motors a back electric tension is induced:

Let us have a current element Id**r** put in a vector magnetic field B which is perpendicular to dr. The force acting on this current element, according to the third formula (21.1) is

$$df_{wire} = (Id\mathbf{r}/c)\times\mathbf{B}. \qquad (29.8)$$

The velocity v acquired by the wire will have the direction df_{wire} which is $d\mathbf{r}\times\mathbf{B}/drB$, and the induced electric intensity acting on the convected charges will be, again according to the third formula (21.1),

$$cE_{ind} = v(d\mathbf{r}\times\mathbf{B}/drB)\times\mathbf{B} = - (v/drB)\mathbf{B}\times(d\mathbf{r}\times\mathbf{B}) = - (v/drB)B^2d\mathbf{r} = - vB(d\mathbf{r}/dr), \qquad (29.9)$$

i.e., it will be directed against the driving electric intensity (and tension) which acts in the direction $d\mathbf{r}/dr$.

After having presented the "mechanism" according to which a forth electric tension is induced in S-motors and a back electric tension is induced in B-motors, let us make a more detailed comparison between a B-motor and an S-motor.

Let us assume that both motors have the same ohmic resistance R_0 and that they are driven by equal driving tensions U_{dr}. Thus the rest current in both motors will be the same $I_{rest} = U_{dr}/R_0$.

If we let the B-motor rotate, it will acquire such an angular velocity Ω that its friction power $P_{fr} = \Omega M_{fr}$, where M_{fr} is the friction torque at the angular velocity Ω, will become equal to the induced back power $P_{ind} = IU_{ind}$, where U_{ind} is the induced back tension and I is the current in the motor at the angular velocity Ω.

Indeed, let us assume, for simplicity, that the motor is a Barlow disk (see Sect. 47) with radius R in which the cylindrical magnetic field with intensity B is generated by a cylindrical magnet. The driving torque is produced by the interaction of B and the current I which flows along the disk's radius. If we consider only one current element Idr at a distance r from the center, the driving torque produced by its interaction with B will be $dM_{dr} = rdf = rIdrB/c$, where $df = IdrB/c$ is the force acting on the current element. The motor will stop to increase its angular velocity when the sum of all these elementary torques will become equal to the friction torque M_{fr}. At the "equilibrium" angular velocity Ω, when the current in the circuit will be I, we shall have

$$\Omega M_{fr} = \Omega \int_0^R dM_{fr} = \Omega \int_0^R rIdrB/c = I \int_0^R vBdr/c = IU_{ind}, \qquad (29.10)$$

where v is the velocity of the disk's parts with radius r and U_{ind} is the induced <u>back</u> electric tension. For the current we shall have $I = (U_{dr} - U_{ind})/R_0$. At rest of the disk the power $P_{rest} = I_{rest}U_{dr} = I_{rest}^2 R_0$ will be released as heat. At rotation of the disk the power $P = I(U_{dr} - U_{ind}) = I^2 R_0$ will be released as heat and the power $P_{mech} = IU_{ind}$ will be delivered as mechanical power overwhelming the friction. The power delivered by the driving electric source $P_{dr} = IU_{dr}$ will be the <u>sum</u> of the last two powers.

If we let the S-motor rotate, it will acquire such an angular velocity Ω that its friction power $P_{fr} = M_{fr}$ will become equal to the iduced forth power $P_{ind} = IU_{ind}$.

Indeed, let us assume, for simplicity, that our motor is of the kind of the motor shown in fig. 9, assuming that at the point a there is a huge store of positive charges and at point c there is a huge store of negative charges, so that certain time a constant current I' flows from point a to point c. The driving torque produced by the action of the scalar magnetic intensity S on the current along the circular loop will be

$$M_{dr} = \int_{2\pi R} R\hat{\rho}\times df_{whit}, \qquad (29.11)$$

where (see (29.4))

$$df_{whit} = Id\mathbf{r}S/c = - II'dr/c^2R \qquad (29.12)$$

is the force acting on the current element Id**r**. Putting (29.12) into (29.11), we obtain for the z-component of the driving torque

$$M_{dr} = - \int_{2\pi R} II'dr/c^2 = - 2\pi RII'/c^2. \qquad (29.13)$$

The motor will stop to increase its angular velocity when its driving torque will become equal to its friction torque. At such an "equilibrium" angular velocity Ω we shall have (see (29.7)), noting that M_{fr} and M_{dr}, at the "equilibrium" angular velocity Ω, are equal but oppositely directed,

$$\Omega M_{fr} = \Omega M_{dr} = - (2\pi/c^2)\Omega RII' = IU_{ind}. \qquad (29.14)$$

At such a stationary rotation the power $P = I(U_{dr} + U_{ind}) = I^2 R_0$ will be released as heat and the power $P_{mech} = IU_{ind}$ will be delivered as mechanical power overwhelming the friction. The power delivered by the driving electric source $P_{dr} = IU_{dr}$ will be the <u>difference</u> of these two powers.

The driving torque of the B-motor is the largest at rest of the motor and reaches its minimum at the angular velocity Ω. The driving torque of the S-motor is the less at rest and reaches its maximum at the angular velocity Ω.

If the friction power ΩM_{fr} will always remain <u>less</u> than the mechanical power IU_{ind}, the S-motor will steadily increase its angular velocity until the destruction of the motor by the appearing centrifugal forces. Thus the S-motor <u>violates the energy conservation law.</u>

A B-motor can be run as a GENERATOR (machine generating electric tension and eventually electric current and power) if applying to it a mechanical torque. The mechanical torque which appears in a B-GENERATOR, because of the interaction of the induced current with the B-field, is always directed <u>oppositely</u> to the driving mechanical torque and brakes the rotation. In every conventional B-generator the produced electrical power is equal to the mechanical power <u>lost</u> by the source of mechanical energy. Let me note, however, that I have constructed B-generators where quite the whole produced power is "free", i.e., produced from nothing; such are my non-braking B-generator MAMIN COLIU (Sect. 53) and the self-accelerating generator VENETIN COLIU (Sect. 54).

The considered above S-motor can also be run as a generator, applying to it a mechanical torque. The mechanical torque which appears in an S-GENERATOR, because of the interaction of the induced current with the S-field, is always directed <u>in the direction</u> of the driving mechanical torque and supports the rotation. The produced electric power in the S-generator is equal to the mechanical power <u>gained</u> by the source of mechanical energy.

If Whittaker's formula is the right one, a scalar magnetic field can be not produced by <u>closed</u> current loops, as the divergence of the magnetic potential produced by a closed current loop is zero according to Whittaker's formula. As, however, it is very likely that Nicolaev's formula is the right one, S-motors and S-generators can be "driven" by closed currents. Such machines are considered in Sects. 58 -60.

30. QUASI-STATIONARY ELECTROMAGNETIC SYSTEMS

I make the following classification of the material systems (see also Sect. 9):

1. A material sytsem is called STATIC if there is such a frame of reference with respect to which its particles remain at rest. The image (see Sect. 2) of a static system remains the same in time.

2. A material system is called QUASI-STATIC if its images remain the same in time but there is no such a frame of reference with respect to which its particles remain motionless. According to this definition, the particles of a quasi-static system can move with respect to each other, but in the direction of their velocities they must be placed closely enough and they must have the same character, so that they may be distinguished by their serial numbers only. If we do not pay attention to their serial numbers, such a system will, in different moments of time, create the same image in our mind. The moving points of a quasi-static system always form ring-shaped current tubes.

3. A material system is called STATIONARY if some of its characteristics remain constant in time. The quasi-static system represents the most simple stationary system because the whole complex of characteristics, namely its image, remains constant in time.

4. A material system is called QUASI-STATIONARY if some of its characteristics change insignificantly in time or in certain specific time interval.

5. A material system is called DYNAMIC if its images change in time.

6. A material system is called PERIODIC if its images repeat themselves regularly after some time interval. This time interval is called PERIOD.

7. A material system is called QUASI-PERIODIC if its images repeat themselves after some time interval but not completely; however, after sufficiently long period of time (i.e., with the increase of the number of the "quasi-periods") the image of the system approaches closely enough its initial image.

The field of static and quasi-static systems of electric charges is called a CONSTANT ELECTROMAGNETIC FIELD.

Let us consider a system of electric charges which generates the potentials Φ and $\mathbf{A}$ (given by formulas (8.1)) in the different space points.

1. If

$$\partial\Phi/\partial t = 0, \qquad \mathbf{A} = 0, \tag{30.1}$$

the system is static.

2. If

$$\partial\Phi/\partial t = 0, \qquad \partial\mathbf{A}/\partial t = 0, \tag{30.2}$$

the system is quasi static or stationary.

3. If

$$\partial\Phi/\partial t \neq 0, \qquad \partial\mathbf{A}/\partial t \neq 0, \tag{30.3}$$

but we can assume

$$\partial^2\Phi/\partial t^2 = 0, \qquad \partial^2\mathbf{A}/\partial t^2 = 0, \tag{30.4}$$

the system is quasi-stationary.

The conditions (30.4) can be fulfilled strictly only if Φ and $\mathbf{A}$ are linear functions of time (for example a circular current which constantly increases its radius). If the system is periodic, the conditions (30.4) cannot be fulfilled. But if the periodic change is slow and for long enough time intervals we can accept that Φ and $\mathbf{A}$ are linear functions of time, we can accept the system to be quasi-stationary.

Usually if the shortest period of the system T_{min} is much larger than the time $t = D_{max}/c$, where D_{max} is the largest size of the system, the system is quasi-stationary.

Another criterion for accepting an electromagnetic system to be quasi-stationary is the following: The effects due to the accelerations (second time derivatives) of the charges (i.e., the radiation of the charges) must be feeble and thus can be neglected.

For a quasi-stationary system not equations (9.16) but equations (9.15) are valid. Let us write them again

$$\Delta\Phi \equiv \mathrm{div}(\mathrm{grad}\Phi) = -4\pi Q, \qquad \Delta\mathbf{A} \equiv \mathrm{grad}(\mathrm{div}\mathbf{A}) - \mathrm{rot}(\mathrm{rot}\mathbf{A}) = -4\pi\mathbf{J}. \tag{30.5}$$

As I showed in Sect. 9, these equations are trivial mathematical results of the definition equalities (8.1) for the electric and magnetic potentials and equalities (9.14) for the charge and current densities.

Another trivial result of equations (8.1) is the equation of potential connection (8.8) which I write here again

$$\mathrm{div}\mathbf{A} = -\partial\Phi/c\partial t. \tag{30.6}$$

Let us write again the first notation (21.1) and the second notation (8.6)

$$\mathbf{E}_{coul} = -\mathrm{grad}\Phi, \qquad \mathbf{B} = \mathrm{rot}\mathbf{A}, \tag{30.7}$$

called Coulomb electric intensity and magnetic intensity.

If we rewrite the second equation (21.1) and we take divergence from the second expression (30.7), we obtain

$$\mathbf{E}_{tr} = -\partial\mathbf{A}/c\partial t, \qquad \mathrm{div}(\mathrm{rot}\mathbf{A}) = 0, \tag{30.8}$$

or

$$\mathrm{rot}\mathbf{E}_{tr} = -\partial\mathbf{B}/c\partial t, \qquad \mathrm{div}\mathbf{B} = 0. \tag{30.9}$$

If we substitute (30.6) and the second expression (30.7) into the second equation (30.5) and if we rewrite the first expression (30.5), we shall have

$$\mathrm{rot}\mathbf{B} = -\partial(\mathrm{grad}\Phi)/c\partial t + 4\pi\mathbf{J}, \qquad \mathrm{div}(\mathrm{grad}\Phi) = -4\pi Q, \tag{30.10}$$

or

$$\mathrm{rot}\mathbf{B} = \partial\mathbf{E}_{coul}/c\partial t + 4\pi\mathbf{J}, \qquad \mathrm{div}\mathbf{E}_{coul} = 4\pi Q. \tag{30.11}$$

Equations (30.8) and (30.10) are the Maxwell-Lorentz equations for a quasi-stationary system of electric charges in their most logical form.

Equations (30.9) and (30.11) are the Maxwell-Lorentz equations for a quasi-stationary system in their usual form. It is extremely important to note that $\mathbf{E}_{tr}$ in the first equation (30.9) is completely different from E_{coul} in the first equation (30.11). These two electric intensities have noting in common. However **B** in the first equation (30.9) and **B** in the first equation (30.11) is one and the same quantity.

Official physics defends the opinion that a magnetic field can generate elecric field and electric field can generate magnetic field. This is a complete nonsense (this view-point is defended also by Jefimenko in his new book "Causality, electromagnetic induction and gravitation"(Electret Scientific Company, Star City, WV 26505, USA, 1992)). The electric and magnetic intensities are determined (and defined!) by the potentials and only by the potentials.

Now I shall examine the highly controversial problem about the "DISPLACEMENT CURRENT" (see Sect. 13). I shall show that there is nothing puzzling here if this notion will be rightly understood.

Maxwell supposed that if a conduction current becomes interrupted at the plates of a condenser, between those plates a current with density (13.12) "flows", called "displacement current". Maxwell supposed that displacement current has the same magnetic character as conduction current with the same density, i.e., that it acts with potential magnetic forces on other currents and reacts with kinetic forces against the potential magnetic action of other currents. And Maxwell supposed (or such was rather the interpretation of his epigones) that all this is done by the hypothetical current "flowing between the plates of the condenser". This is absolutely not true.

It is obvious that such a displacement current cannot react with kinetic forces against the action of other currents, as it flows in vacuum, and neither the Lord is able to set vacuum in motion. On other side vacuum cannot act with potential forces on other currents as vacuum is vacuum ("a rose is a rose, is a rose, is a rose").

To understand the essence of the displacement current, let us consider not the differential equation (30.11) but the integral equation (13.11), rewriting it for a quasi-stationary system

$$\oint_L \mathbf{B}.d\mathbf{r} = (\partial/c\partial t)\int_S \mathbf{E}_{coul}.d\mathbf{S} + (4\pi/c)\int_S \mathbf{J}.d\mathbf{S}. \qquad (30.12)$$

The magnetic intensity is generated by the currents in whole space. Meanwhile in (30.12) the linear integral of **B** along the closed loop L is related only to the conduction currents crossing the surface S. If from both sides of S there are condenser's plates which interrupt conduction currents, these interrupted currents generate such an electric intensity field $\mathbf{E}_{coul}$ between the condenser's plates that

$$\oint_L \mathbf{B}.d\mathbf{r} = (\partial/c\partial t)\int_S \mathbf{E}_{coul}.d\mathbf{S}. \qquad (30.13)$$

Thus it is not the changing electric field $\partial\mathbf{E}_{coul}/\partial t$ which generates **B**. The integral on the right side of (30.13) gives simply information about the quantity of conduc-

tion current interrupted on the surface S. Consequently the magnetic intensity calculated by formula (30.13) is generated by charges flowing to the condenser's plates and these charges react with kinetic forces to the action of other currents flowing between the condenser's plates or outside.

If $\partial\mathbf{E}_{coul}/\partial t = 0$, formula (30.12) shows that $\oint\mathbf{B}.d\mathbf{r}$ is determined only by the quantity of current crossing the surface. This is true. But when one begins to calculate to find **B**, one sees that one has to take into account the currents in whole space. The displacement current term in (30.12) indicates that when making integral calculations to find **B** one has to take into account also the interrupted by the surface S currents.

That's all about the displacement current!

Let us now assume that the considered electromagnetic system consists not only of charges (free or in conductors) but also of dielectrics and magnetics. In such a case the Maxwell-Lorentz equations (30.9) and (30.11) are to be written in the form

$$\mathrm{rot}\mathbf{E}_{tr} = -\partial\mathbf{B}/c\partial t, \qquad \mathrm{div}\mathbf{B} = 0, \qquad (30.14)$$

$$\mathrm{rot}\mathbf{H} = \partial\mathbf{D}/c\partial t + 4\pi\mathbf{J}, \qquad \mathrm{div}\mathbf{D} = 4\pi Q. \qquad (30.15)$$

Now, if there is a condenser between whose plates a dielectric with permittivity ε is put, between these plates a POLARIZATION CURRENT will flow with density

$$\mathbf{J}_{pol} = \partial(\mathbf{D}-\mathbf{E})/c\partial t = (\varepsilon - 1)\partial\mathbf{E}/c\partial t. \qquad (30.16)$$

This current does not transfer charges from one plate of the condenser to the other, as the case will be if the plates will be connected by a wire. Because of the orientation (or polarization) of the molecular electric dipoles along the field of the acting electric intensity **E**, generated by the charges on the plates, it seems that charges have been transferred, but, as a matter of fact, charges have not been transferred.

The same phenomenon appears also when there is vacuum between the plates: as the charges coming to one of the plates repel by electrostatic induction charges of the same sign from the other plate, it also seems that charges have been transferred. Thus there are many common features between polarization current and displacement current, and some people call also the polarization current "displacement current". I, however, rigirously separate them. In any case, both the displacement and polarization currents do not act with potential magnetic forces on other currents and do not react with kinetic forces against the potential action of other currents. I confirmed these assertions experimentally (see Sects. 61 and 62).

31. ELECTRIC DIPOLE MOMENT

Let us consider the constant electric field of a stationary system of charges at large distances from the system, that is, at distances large compared with the dimensions of the system.

We introduce a frame of reference with its origin somewhere in the system of charges. Let us denote the radius vector of the reference point by **r** and the radius vector of the various charges by $\mathbf{r}_i$. According to the first formula (8.1), the electric potential generated by the system at the reference point will be

$$\Phi = \sum_{i=1}^{n} q_i/R_i = \sum_{i=1}^{n} q_i/|\mathbf{r} - \mathbf{r}_i|, \qquad (31.1)$$

where

$$\mathbf{R}_i = \mathbf{r} - \mathbf{r}_i \qquad (31.2)$$

is the vector from the charge q_i to the reference point.

Let us investigate expression (31.1) for large r, i.e., for $r \gg r_i$. To do this, let us expand (31.1) as power series in $\mathbf{r}_i$, retaining only the terms linear in $\mathbf{r}_i$,

$$\Phi(|\mathbf{r} - \mathbf{r}_i|) = \Phi(r) - \sum_{i=1}^{n} \{\partial\Phi(r)/\partial\mathbf{r}\}.\mathbf{r}_i = \sum_{i=1}^{n} q_i/r_i - \mathrm{grad}(1/r).\sum_{i=1}^{n} q_i\mathbf{r}_i. \qquad (31.3)$$

If we denote the total charge by

$$q = \sum_{i=1}^{n} q_i, \qquad (31.4)$$

formula (31.3) can be written

$$\Phi = q/r + \mathbf{d}.\mathbf{r}/r^3, \qquad (31.5)$$

where the sum

$$\mathbf{d} = \sum_{i=1}^{n} q_i\mathbf{r}_i \qquad (31.6)$$

is called ELECTRIC DIPOLE MOMENT of the system of charges.

It is important to note that if the sum of all charges is equal to zero

$$q = \sum_{i=1}^{n} q_i = 0, \qquad (31.7)$$

then the dipole moment does not depend on the choice of the frame's origin. Indeed, the radius vectors $\mathbf{r}_i$ and $\mathbf{r}_i'$ of one and the same charge in two different frames of reference, K and K', are related by the formula

$$\mathbf{r}_i = \mathbf{R} + \mathbf{r}_i', \qquad (31.8)$$

where **R** is a constant vector, representing the radius vector of the origin of K' in K. Substituting (31.8) into (31.6) and taking into account (31.7), we obtain $\mathbf{d} = \mathbf{d}'$.

Under the condition (31.7), the electric potential in formula (31.5) becomes

$$\Phi = \mathbf{d}.\mathbf{r}/r^3. \qquad (31.9)$$

The electric intensity, according to the first formula (21.1), will be

$$\mathbf{E} = -\,\mathrm{grad}(\mathbf{d}.\mathbf{r}/r^3) = -\,(1/r)\mathrm{grad}(\mathbf{d}.\mathbf{r}) - (\mathbf{d}.\mathbf{r})\mathrm{grad}(1/r^3). \qquad (31.10)$$

Keeping in mind that **d** is a constant vector, we shall have (see p. 6)

$$\mathrm{grad}(\mathbf{d}.\mathbf{r}) = \mathbf{d}, \qquad (31.11)$$

so that

$$\mathbf{E} = \{3(\mathbf{d}.\mathbf{r})\mathbf{r} - r^2\mathbf{d}\}/r^5. \qquad (31.12)$$

If we shall expand Φ in (31.3) to higher orders in $\mathbf{r}_i$, we shall obtain other multipole moments. The moment which corresponds to the second order terms in the expansion of Φ is called ELECTRIC QUADRUPOLE MOMENT. Two nearly located opposite charges are called ELECTRIC DIPOLE.

32. MAGNETIC DIPOLE MOMENT

Let us consider the constant magnetic field of a stationary system at large distances from the system.

As in the previous section, we introduce a frame of reference with its origin somewhere in the system of charges. Again we denote the radius vector of the reference point by **r** and the radius vectors of the various charges by $\mathbf{r}_i$. According to the second formula (8.1), the magnetic potential generated by the system at the reference point will be

$$\mathbf{A} = \sum_{i=1}^{n} q_i\mathbf{v}_i/cR_i = \sum_{i=1}^{n} q_i\mathbf{v}_i/c|\mathbf{r} - \mathbf{r}_i|. \qquad (32.1)$$

Making the assumption $r \gg r_i$ and expanding (32.1) as a power series to within terms of first order in $\mathbf{r}_i$, we obtain

$$\mathbf{A}(|\mathbf{r} - \mathbf{r}_i|) = (1/cr)\sum_{i=1}^{n} q_i\mathbf{v}_i - (1/c)\sum_{i=1}^{n} q_i\mathbf{v}_i\{\mathrm{grad}(1/r).\mathbf{r}_i\}. \qquad (32.2)$$

As all currents in the system are closed, the first term on the right will be equal to zero and we shall have

$$\mathbf{A} = (1/cr^3)\sum_{i=1}^{n} q_i\mathbf{v}_i(\mathbf{r}_i.\mathbf{r}). \qquad (32.3)$$

Taking into account that $\mathbf{v}_i = d\mathbf{r}_i/dt$ and that **r** is a constant vector, we can write

$$\sum_{i=1}^{n} q_i\mathbf{v}_i(\mathbf{r}_i.\mathbf{r}) = \frac{1}{2}\frac{d}{dt}\{\sum_{i=1}^{n} q_i\mathbf{r}_i(\mathbf{r}_i.\mathbf{r})\} + \frac{1}{2}\sum_{i=1}^{n} q_i\{\mathbf{v}_i(\mathbf{r}_i.\mathbf{r}) - \mathbf{r}_i(\mathbf{v}_i.\mathbf{r})\}. \qquad (32.4)$$

If we average this equation in time, the first term on the right side will give zero as a total time derivative of a limited quantity. Thus introducing the quantity

$$\mathbf{m} = (1/2c)\sum_{i=1}^{n} q_i(\mathbf{r}_i\times\mathbf{v}_i) = (1/2c)\sum_{i=1}^{n} \mathbf{r}_i\times\mathbf{j}_i, \qquad (32.5)$$

which is called MAGNETIC (DIPOLE) MOMENT of the system of charges, we can present the magnetic potential (32.3) in the form

$$\mathbf{A} = \mathbf{m}\times\mathbf{r}/r^3. \qquad (32.6)$$

The magnetic intensity, according to the second formula (8.6), will be (see p. 6)

$$\mathbf{B} = \mathrm{rot}(\mathbf{m}\times\mathbf{r}/r^3) = \mathbf{m}\,\mathrm{div}(\mathbf{r}/r^3) - (\mathbf{m}.\mathrm{grad})(\mathbf{r}/r^3). \qquad (32.7)$$

First we have (see again p. 6)

$$\operatorname{div}\frac{\mathbf{r}}{r^3} = \frac{1}{r^3}\operatorname{div}\mathbf{r} + \mathbf{r}.\operatorname{grad}\frac{1}{r^3} = \frac{3}{r^3} - 3\,\frac{\mathbf{r}.\mathbf{r}}{r^5} = 0, \quad (32.8)$$

and then

$$(\mathbf{m}.\operatorname{grad})\frac{\mathbf{r}}{r^3} = \frac{1}{r^3}(\mathbf{m}.\operatorname{grad})\mathbf{r} + \mathbf{r}(\mathbf{m}.\operatorname{grad}\frac{1}{r^3}) = \frac{\mathbf{m}}{r^3} - \frac{3\mathbf{r}(\mathbf{m}.\mathbf{r})}{r^5}. \quad (32.9)$$

Thus for the magnetic intensity (32.7) we obtain

$$\mathbf{B} = \{3(\mathbf{m}.\mathbf{r})\mathbf{r} - r^2\mathbf{m}\}/r^5. \quad (32.10)$$

We see that the magnetic intensity is expressed in terms of the magnetic moment by the same formula by which the electric intensity is expressed in terms of the electric dipole moment (cf. formula (21.12)).

The magnetic moment of the electron is called MAGNETON OF BOHR and has the value

$$m_e = q_e h/4\pi m_e c, \quad (32.11)$$

where q_e and m_e are the charge and the mass of the electron, h is the Planck constant (see Sect. 2) and c is the velocity of light.

The formula for the magneton of Bohr can easily be obtained from formula (32.5) which I shall write in the form

$$\mathbf{m}_e = (1/2c)\mathbf{r}\times q_e\mathbf{v}, \quad (32.12)$$

considering the charge of the electron (and its mass, too) as a ring with radius r rotating with a velocity $\mathbf{v}$. Multiplying and dividing the right side of (32.12) by m_e and taking into account that the angular momentum (the spin) of the electron is

$$|\mathbf{r}\times m_e\mathbf{v}| = h/2\pi, \quad (32.13)$$

we obtain readily formula (32.11).

IV. HIGH-ACCELERATION ELECTROMAGNETISM

33. INTRODUCTION

In Chapter III the accelerations of the charges were assumed to be small and have been neglected. In this chapter I shall not assume the accelerations of the charges as negligibly small. Thus in this chapter the most general dynamic system of electric charges will be considered.

As it will be shown, charges moving with acceleration radiate energy. The radiated energy is emitted in the form of energetic quanta which are called PHOTONS (with more precision - see beneath - ELECTROMAGNETIC PHOTONS).

The photons always propagate with the velocity c (in absolute space!). The universal masses of the photons are equal to zero, so that their universal space and time momenta are always equal to zero and only their proper space and time momenta are different from zero.

The proper space and time momenta of the photons are very small quantities and one can observe with macroscopic instruments only the collective action of many photons. When observing the flux of many photons, as the latter may interfere (see axiom III), the observer remains with the impression that high-accelerated electromagnetic systems radiate waves, which are called ELECTROMAGNETIC WAVES. However with microscopic instruments, i.e., with particles, one can observe the action of single photons. Thus the assertion "photons are at the same time particles and waves" is wrong. The photons are particles, but these particles can interfere if at the moment of observation the distance between them is less than their proper wavelength (see axiom III).

When masses move with acceleration radiation of GRAVIMAGRETIC PHOTONS is to be expected. I shall show, however, that the radiated gravitational and magretic intensities are so feeble that the detection of gravimagretic photons (waves) is highly improbable.

In high-acceleration electromagnetism I shall ignore the scalar magnetic intensity. Until the present time experiments demonstrating the existence of high-acceleration effects due to the scalar magnetic intensity (SCALAR ELECTROMAGNETIC WAVES) have not been reported. Nicolaev tries to persuade me that he has observed (see "Deutsche Physik", 2(8), 24, 1993)) the existence of scalar electromagnetic waves but, as I show in my comments to his article, his experiments are not convincing me.

34. THE ELECTRIC AND MAGNETIC INTENSITY FIELDS OF AN ACCELERATED CHARGE

To obtain the electric and magnetic intensities generated by a particle moving with acceleration, we have to put in the definition equalities for the electric and magnetic intensities

$$\mathbf{E} = -\operatorname{grad}\Phi - \partial\mathbf{A}/c\partial t, \qquad \mathbf{B} = \operatorname{rot}\mathbf{A} \quad (34.1)$$

the electric and magnetic potentials of the particle

$$\Phi = q/r, \qquad \mathbf{A} = q\mathbf{v}/cr. \qquad (34.2)$$

However, as information cannot be transferred momentarily, the observation electric and magnetic potentials are to be expressed through the advanced and retarded elements of motion (see Sect. 11).

In fig. 1 the reference point P, for which we wish to know the electric and magnetic intensities at the moment of observation t, is taken at the frame's origin. The charge q generating the potentials and consequently the intensities is shown moving with a constant velocity **v**, but we shall assume now that this velocity is not constant, i.e., that the charge moves with acceleration.

Let us assume that at the observation moment t the charge is at point Q, called observation position. Information about the charge's velocity and acceleration can be obtained at P at the observation moment t = t' + r'/c = t" - r"/c, if at the advanced moment t' a signal moving with the velocity c will be sent with this information from the advanced position Q' towards P, or if at the retarded moment t" a signal moving with the velocity c will be sent with this information back in time from the retarded position Q" towards P (so that this signal will reach P at the moment t which is before the moment t"). My second axiom asserts that time has no the quality "reversibility", but "mathematics" does not know this!

The distances r', r and r" are, respectively, the advanced, observation and retarded distances, and the angles θ', θ, θ" between the charge's velocity **v** and the line joining the charge with the reference point (whose unit vectors are **n'**, **n**, **n"**) are, respectively, the advanced, observation and retarded angles.

I repeat (see Sect. 10.2) that official physics, proceeding from the wrong concept that the electromagnetic interactions "propagate" with the velocity c, calls all topsyturvy, i.e., official physics calls the advanced elements "retarded" and the retarded elements (to which it does not pay much attention) "advanced". I shall use only my terminology.

First I shall make the calculation when the observation elements are presented by the advanced elements and then by the retarded ones. As the character of light propagation is not Newton-aether but Marinov-aether, the potentials must be taken in their Lienard-Wiechert forms (see formulas (11.3)).

34.1. CALCULATION WITH THE ADVANCED ELEMENTS OF MOTION.

The observation Lienard-Wiechert potentials expressed through the advanced elements are

$$\Phi = \frac{q}{r'(1 - \mathbf{n}'.\mathbf{v}/c)}, \qquad \mathbf{A} = \frac{q\mathbf{v}}{cr'(1 - \mathbf{n}'.\mathbf{v}/c)}. \qquad (34.3)$$

The velocity in the denominators is a certain middle velocity between the advanced velocity **v'** and the observation velocity **v**, so that moving with this velocity in the time t - t' = r'/c, the charge covers the distance Q'Q. As this velocity appears only in corrective terms in the final result, we can take for it the advanced as well as the observation velocity. The velocity in the nominator of **A** is the observation velocity

$$\mathbf{v} = \mathbf{v}' + \mathbf{u}r'/c, \qquad (34.4)$$

where **u** is some middle acceleration between the advanced acceleration **u'** and the observation acceleration **u**. To be able to carry out the calculations, we must have the same symbol for **v** in the nominator and denominator of **A**. Then, after having done the differentiations, we shall substitute **v** in all corrective terms by **v'** and in the non-corrective (or substantial) terms according to the relation (34.4). Then we shall do the same with the acceleration which will appear after taking time derivative from the velocity. As we shall see, the velocity will appear in the final result only in corrective terms and the acceleration only in substantial terms. Thus the substitution which we have to do in the final result will be

$$\mathbf{v} = \mathbf{v}', \qquad \mathbf{u} = \mathbf{u}' + \mathbf{w}'r'/c, \qquad (34.5)$$

where **w'** is the advanced super-acceleration of the charge.

Official physics asserts that the potentials which one has to use at the calculation of the electromagnetic field of an accelerated charge must be given by formulas (34.3) where **v** is to be substituted by **v'**. Such potentials, however, are neither advanced nor observation, as the pure advanced potentials will be

$$\Phi' = q/r', \qquad \mathbf{A}' = q\mathbf{v}'/cr', \qquad (34.6)$$

while the observation potentials

$$\Phi = q/r, \qquad \mathbf{A} = q\mathbf{v}/cr, \qquad (34.7)$$

if expressed through the advanced elements of motion, are to be written in the form (34.3) where **v** in the nominator of **A** is to be presented according to (34.4) through the advanced velocity and acceleration (as already said, **v** in the denominators of Φ and **A** is neither the advanced nor the observation velocity of the charge but some middle velocity). Thus official physics works[23] with some "hybrid" potentials which are neither pure advanced nor observation and for this reason it cannot obtain the radiation reaction intensity straightforwardly, as I do it in my theory considering **v** in the nominator of **A** as the observation velocity, so that Φ and **A** in (34.3) are the exact observation potentials (when assuming that light has a Marinov-aether character of propagation).

But why must we express the observation elements of motion in (34.3) - the charge-observer distance and the charge's velocity - through the advanced ones? The reason is not the hypothetical "propagation of interaction". I noticed already that as the quickest "information link" can be established by the help of light signals, one cannot calculate the intensities of a moving charge taking its position, velocity and acceleration at this very moment because there is no way to know them. At the reference point one can have information only about the advanced (or retarded)elements of motion.

There is, however, also another reason. As the radiated energy propagates with the velocity of light, then to calculate the radiated intensities at the reference point at the observation moment, one must operate with the advanced charge and current densities. Thus we are impelled to express the observation elements of motion in (34.3) by the advanced ones in order to obtain right values for the radiated intensities. The mechanics of the right calculation when radiation and potential intensities are to be separated becomes very transparent and clear in Sect. 37.

Let us now do the calculations.

In formulas (34.1) we must differentiate Φ and $\mathbf{A}$ with respect to the coordinates x,y,z of the reference point and the time of observation t. But in the relations (34.3) the potentials are given as function of t' and only through the relation

$$r' = c(t - t') \qquad (34.8)$$

as composite functions of t. Now I shall write several relations which will be then used for the calculation of the composite derivatives.

Having in mind the first relation (34.5), we write

$$\mathbf{v} \doteq \mathbf{v}' = -\partial \mathbf{r}'/\partial t', \qquad (34.9)$$

where $\mathbf{r}'$ is the vector of the advanced distance pointing from the charge to the reference point.

Differentiating the equality $r'^2 = \mathbf{r}'^2$ with respect to t', we obtain

$$r' \frac{\partial r'}{\partial t'} = \mathbf{r}'.\frac{\partial \mathbf{r}'}{\partial t'} \qquad (34.10)$$

and using here (34.9), we find

$$\frac{\partial r'}{\partial t'} = -\mathbf{n}'.\mathbf{v}. \qquad (34.11)$$

Differentiating (34.8) with respect to t and considering r' as a direct function of t', we find

$$\frac{\partial r'}{\partial t'}\frac{\partial t'}{\partial t} = c(1 - \frac{\partial t'}{\partial t}); \qquad (34.12)$$

putting here (34.11), we obtain

$$\frac{\partial t'}{\partial t} = \frac{1}{1 - \mathbf{n}'.\mathbf{v}/c}. \qquad (34.13)$$

Similarly, differentiating relation (34.8) with respect to $\mathbf{r}$ and taking into account that t is the independent variable, we obtain

$$\frac{\partial r'}{\partial \mathbf{r}'}\frac{\partial \mathbf{r}'}{\partial \mathbf{r}} + \frac{\partial r'}{\partial t'}\frac{\partial t'}{\partial \mathbf{r}} = -c\,\frac{\partial t'}{\partial \mathbf{r}}; \qquad (34.14)$$

putting here (34.11), we obtain

$$\frac{\partial t'}{\partial \mathbf{r}} = -\frac{\mathbf{n}'}{c(1 - \mathbf{n}'.\mathbf{v})}. \qquad (34.15)$$

Finally we find the following relation (which will be used only for the calculation of $\mathbf{B}$)

$$\frac{\partial}{\partial \mathbf{r}}(r' - \frac{\mathbf{r}'.\mathbf{v}}{c}) = \frac{\partial}{\partial \mathbf{r}'}(r' - \frac{\mathbf{r}'.\mathbf{v}}{c}) + \frac{\partial}{\partial t'}(r' - \frac{\mathbf{r}'.\mathbf{v}}{c})\frac{\partial t'}{\partial \mathbf{r}} = \qquad (34.16)$$

$$\mathbf{n}' - \frac{\mathbf{v}}{c} + (\mathbf{n}'.\mathbf{v} - \frac{v^2}{c} + \frac{\mathbf{r}'.\mathbf{u}}{c})\frac{\mathbf{n}'}{c(1 - \mathbf{n}'.\mathbf{v}/c)} = -\frac{\mathbf{v}}{c} + (c - \frac{v^2}{c} + \frac{\mathbf{r}'.\mathbf{u}}{c})\frac{\mathbf{n}'}{c(1 - \mathbf{n}'.\mathbf{v}/c)}.$$

Thus the electric intensity is to be calculated according to the formula (see (34.1))

$$\mathbf{E} = \frac{\partial \Phi}{\partial \mathbf{r}} - \frac{1}{c}\frac{\partial \mathbf{A}}{\partial t} = -\frac{\partial \Phi}{\partial \mathbf{r}'} - \frac{\partial \Phi}{\partial t'}\frac{\partial t'}{\partial \mathbf{r}} - \frac{1}{c}\frac{\partial \mathbf{A}}{\partial t'}\frac{\partial t'}{\partial t}. \qquad (34.17)$$

If we substitute here the expressions (34.3) and take into account the relations (34.13) and (34.15), after some manipulations, the following final result can be obtained

$$\mathbf{E} = q\,\frac{1 - v^2/c^2}{(r' - \mathbf{r}'.\mathbf{v}/c)^3}(\mathbf{r}' - \frac{r'}{c}\mathbf{v}) + \frac{q\mathbf{r}'\times\{(\mathbf{r}' - r'\mathbf{v}/c)\times\mathbf{u}\}}{c^2(r' - \mathbf{r}'.\mathbf{v}/c)^3}, \qquad (34.18)$$

where, according to (34.5), $\mathbf{v}$ is to be replaced by $\mathbf{v}'$, as it appears only in corrective terms, and $\mathbf{u}$ is to be replaced by $\mathbf{u}' + \mathbf{w}'r'/c$, as it apppears in non-corrective terms.

One can easily check the equality of formulas (34.17) and (34.18) by reducing the first and the second to common denominators and by resolving all products to sums of single terms; then, after canceling mutually some terms in the nominator of formula (34.17), one sees that the remaining terms are equal to the terms in the nominator of formula (34.18).

Remembering the formula for rotation from a product of a vector and a scalar (see p. 6), we have to calculate the magnetic intensity according to the formula

$$\mathbf{B} = \mathrm{rot}\frac{q\mathbf{v}}{c(r' - \mathbf{r}'.\mathbf{v}/c)} = \frac{q}{c(r' - \mathbf{r}'.\mathbf{v}/c)}\,\mathrm{rot}\mathbf{v} + \frac{q}{c}\,\mathbf{v}\times\mathrm{grad}\frac{1}{r' - \mathbf{r}'.\mathbf{v}/c}. \qquad (34.19)$$

Since we consider the velocity $\mathbf{v}$ as a function of $\mathbf{r}$ through the advanced time t', we shall have according to the rules for the differentiation of a composite function

$$\mathrm{rot}\mathbf{v}(t') = -\frac{\partial \mathbf{v}}{\partial t}\times\frac{\partial t'}{\partial \mathbf{r}}. \qquad (34.20)$$

Substituting (34.15) into (34.20) and (34.20) into (34.19), we obtain

$$\mathbf{B} = \frac{q}{c^2(r' - \mathbf{r}'.\mathbf{v}/c)^2}\,\mathbf{u}\times\mathbf{r}' + \frac{q}{c(r' - \mathbf{r}'.\mathbf{v}/c)^2}\,\mathbf{v}\times\mathrm{grad}(r' - \mathbf{r}'.\mathbf{v}/c). \qquad (34.21)$$

Putting here (34.16), we get

$$\mathbf{B} = \frac{q}{c^2(r' - \mathbf{r}'.\mathbf{v}/c)^3}\,\mathbf{r}'\times(-r'\mathbf{u} + \frac{\mathbf{r}'.\mathbf{v}}{c}\mathbf{u} - c\mathbf{v} + \frac{v^2}{c}\mathbf{v} - \frac{\mathbf{r}'.\mathbf{u}}{c}\mathbf{v}). \qquad (34.22)$$

Forming the product $\mathbf{n}'\times\mathbf{E}$ (take $\mathbf{E}$ from (34.18)), we obtain an expression equal to the right side of (34.22) and, thus, we conclude

$$\mathbf{B} = \mathbf{n}'\times\mathbf{E}. \tag{34.23}$$

Now substituting $\mathbf{v}$ and $\mathbf{u}$ from (34.5), we can present $\mathbf{E}$ in a form where only advanced quantities are present

$$\mathbf{E} = q\,\frac{(1 - v'^2/c^2)(\mathbf{n}' - \mathbf{v}'/c)}{r'^2(1 - \mathbf{n}'.\mathbf{v}'/c)^3} + \frac{q}{c^2}\,\frac{\mathbf{n}'\times\{(\mathbf{n}' - \mathbf{v}'/c)\times\mathbf{u}'\}}{r'(1 - \mathbf{n}'.\mathbf{v}'/c)^3} + \frac{q}{c^3}\,\mathbf{n}'\times(\mathbf{n}'\times\mathbf{w}'). \tag{34.24}$$

In the last term depending on the super-acceleration we have not taken into account the factors which will give terms, where c will be in a power higher than 3 in the denominator, as such terms are negligibly small.

Substituting (34.24) into (34.23), we obtain the following expression for the magnetic intensity where only advanced quantities are present

$$\mathbf{B} = -\frac{q}{c}\,\frac{(1 - v'^2/c^2)\mathbf{n}'\times\mathbf{v}'}{r'^2(1 - \mathbf{n}'.\mathbf{v}'/c)^3} + \frac{q}{c^2}\,\frac{\mathbf{n}'\times[\mathbf{n}'\times\{(\mathbf{n}' - \mathbf{v}'/c)\times\mathbf{u}'\}]}{r'(1 - \mathbf{n}'.\mathbf{v}'/c)^3} - \frac{q}{c^3}\,\mathbf{n}'\times\mathbf{w}'. \tag{34.25}$$

34.2. CALCULATION WITH THE RETARDED ELEMENTS OF MOTION.

Entirely in the same way as in Sect. 34.1 we can calculate the electric and magnetic intensities produced by a charge moving with acceleration, if expressing the observation elements of motion through the retarded ones. These calculations are done in Ref. 5. Here I shall give only the final formulas which are analogous to formulas (34.24) and (34.25)

$$\mathbf{E} = q\,\frac{(1 - v''^2/c^2)(\mathbf{n}'' + \mathbf{v}''/c)}{r''^2(1 + \mathbf{n}''.\mathbf{v}''/c)^3} + \frac{q}{c^2}\,\frac{\mathbf{n}''\times\{(\mathbf{n}'' + \mathbf{v}''/c)\times\mathbf{u}''\}}{r''(1 + \mathbf{n}''.\mathbf{v}''/c)^3} - \frac{q}{c^3}\,\mathbf{n}''\times(\mathbf{n}''\times\mathbf{w}''), \tag{34.26}$$

$$\mathbf{B} = -\frac{q}{c}\,\frac{(1 - v''^2/c^2)\mathbf{n}''\times\mathbf{v}''}{r''^2(1 + \mathbf{n}''.\mathbf{v}''/c)^3} - \frac{q}{c^2}\,\frac{\mathbf{n}''\times[\mathbf{n}''\times\{(\mathbf{n}'' + \mathbf{v}''/c)\times\mathbf{u}''\}]}{r''(1 + \mathbf{n}''.\mathbf{v}''/c)^3} - \frac{q}{c^3}\,\mathbf{n}''\times\mathbf{w}'', \tag{34.27}$$

and the formulas for the observation potentials expressed through the retarded elements of motion, from which we proceed and which are analogical to formulas (34.3)

$$\Phi = \frac{q}{r'' + \mathbf{r}''.\mathbf{v}/c}, \qquad \mathbf{A} = \frac{q\mathbf{v}}{c(r'' + \mathbf{r}''.\mathbf{v}/c)}. \tag{34.28}$$

34.3. INTERPRETATION OF THE OBTAINED RESULTS.

I shall use the formulas written with the advanced elements of motion.

The three terms in formulas (34.24) and (34.25) are called, respectively, POTENTIAL, RADIATION and RADIATION REACTION ELECTRIC and MAGNETIC INTENSITIES.

Replacing again the advanced velocity by the observation velocity (see (34.5)), the potential electric intensity can be written

$$\mathbf{E}_{pot} = q\,\frac{1 - v^2/c^2}{(r' - \mathbf{r}'.\mathbf{v}/c)^3}(\mathbf{r}' - \mathbf{v}r'/c), \tag{34.29}$$

Using fig. 1, we can write

$$r' - \mathbf{r}'.\mathbf{v}/c = r' - r'v\cos\theta'/c = \{r^2 - (r'v\sin\theta'/c)^2\}^{1/2}. \tag{34.30}$$

According to the law of sines we have

$$r'/\sin(\pi - \theta) = r/\sin\theta', \tag{34.31}$$

so that we can write (34.30) in the form

$$r' - \mathbf{r}'.\mathbf{v}/c = r(1 - v^2\sin^2\theta/c^2)^{1/2}. \tag{34.32}$$

Substituting this into (34.29) and putting there $\mathbf{r} = \mathbf{r}' - \mathbf{v}r'/c$, we obtain

$$\mathbf{E}_{pot} = q\,\frac{1 - v^2/c^2}{(1 - v^2\sin^2\theta/c^2)^{3/2}}\,\frac{\mathbf{r}}{r^3} \cong q\,\frac{\mathbf{n}}{r^2}. \tag{34.33}$$

In the same way we obtain for the potential magnetic intensity

$$\mathbf{B}_{pot} = \frac{q}{c}\,\frac{1 - v^2/c^2}{(1 - v^2\sin^2\theta/c^2)^{3/2}}\,\frac{\mathbf{v}\times\mathbf{r}}{r^3} \cong \frac{q}{c}\,\frac{\mathbf{v}\times\mathbf{n}}{r^2}. \tag{34.34}$$

I consider the difference between the "exact" and "non-exact" values of the potential electric and magnetic intensities as due only to the aether-Marinov character of light propagation. Thus I hardly believe that this can be an effect which can be physically observed. Conventional physics accepts that the "field" of a rapidly moving charge concentrates to a plane perpendicular to its motion, as for $\theta \to \pi/2$ there is $(1 - v^2/c^2)(1 - v^2\sin^2\theta/c^2)^{3/2} \to \infty$ when $v \to c$. I think that the effect is only computational and that it cannot be observed. Of course, the last word has the experiment.

Thus the potential electric and magnetic intensities of an arbitrarily moving electric charge are determined by the distance from the charge to the reference point (being inversely proportional to the square of this distance) and (for $\mathbf{B}$) by the velocity of the charge, both taken at the moment of observation. These intensities are exactly equal to the electromagnetic intensities which the charge will originate at the reference point if the velocity is constant.

The second terms on the right sides of (34.24) and (34.25)

$$\mathbf{E}_{rad} = \frac{q}{c^2}\,\frac{\mathbf{n}'\times\{(\mathbf{n}' - \mathbf{v}'/c)\times\mathbf{u}'\}}{r'(1 - \mathbf{n}'.\mathbf{v}'/c)^3}, \qquad \mathbf{B}_{rad} = \mathbf{n}'\times\mathbf{E}_{rad} \tag{34.35}$$

determine the electric and magnetic intensities which the energy radiated by the charge originates at the reference point and we call them radiation electric and magnetic intensities. As the radiated energy propagates in space with the velocity of light c, we do not have to express here the advanced elements by the observation elemenets. Here the "directional" effects are no more computational and they can easily be observed[5]. The radiation electric and magnetic intensities are determined by the distance from the charge to the reference point (being inversely proportional to this distance) and by the acceleration of the charge taken at the advanced moment. Thus a charge moving with a constant velocity does not originate radiation intensities.

The third terms on the right sides of (34.24) and (34.25)

$$E_{rea} = \frac{q}{c^3} \mathbf{n}'\times(\mathbf{n}'\times\mathbf{w}'), \qquad B_{rea} = -\frac{q}{c^3}\mathbf{n}'\times\mathbf{w}' = \mathbf{n}'\times E_{rea} \qquad (34.36)$$

determine the electric and magnetic intensities acting on the radiating charge itself as a reaction to the photon radiation diminishing its velocity and consequently its kinetic energy with a quantity exactly equal to the quantity of energy radiated in the form of photons.

The radiation intensities are those which appear at the reference point when the radiated photons cross this point; if there are electric charges at the reference point, they will come into motion "absorbing" the radiated energy. The radiation reaction intensities act on the radiating charge itself. For this reason I call the intensities (34.36) electric and magnetic intensities of radiation reaction.

The electric and magnetic intensities of radiation reaction do not depend on the distance between charge and reference point and are determined by the charge's super-acceleration at the advanced moment, which, of course, can be taken equal to the super-acceleration at the observation moment.

Thus we see that only the potential and radiation intensities have a character of field quantities, because when position, velocity and acceleration of the charge are given, these intensities are determined in all points of space, the former "momentarily", the latter with a time delay r'/c. The radiation reaction intensities are determined only for the space point where the radiating charge is located and act only on this charge.

One may wonder that such precised, detailed and complicated information can be obtained with some simple mathematics from the extremely simple initial equations (34.3) and (34.1), so that here we have to admire the Divinity for His superb perfectness and amazing abilities.

Entirely in the same way, we can establish that the first terms in formulas (34.26) and (34.27) give, respectively, the potential electric and magnetic intensities (34.33) and (34.34). Thus we conclude that the calculation of the potential electric and magnetic intensities with the help of the advanced elements of motion as well as with the retarded elements of motion leads exactly to the same results.

Let us now compare the second and third terms in formulas (34.24), (34.25) and in formulas (34.26), (34.27). If we assume that the advanced elements of motion do not differ too much from the retarded ones, i.e., if we assume

$$\mathbf{r}' = \mathbf{r}'' = \mathbf{r}, \quad \mathbf{v}' = \mathbf{v}'' = \mathbf{v}, \quad \mathbf{u}' = \mathbf{u}'' = \mathbf{u}, \quad \mathbf{w}' = \mathbf{w}'' = \mathbf{w}, \qquad (34.37)$$

then the electric intensity given by formulas (34.24) and (34.26) and the magnetic intensity given by formulas (34.25) and (34.27) can be written as follows

$$E = E_{pot} + E_{rad} + E_{rea} = q\frac{\mathbf{n}}{r^2} + q\frac{\mathbf{n}\times(\mathbf{n}\times\mathbf{u})}{c^2 r} \pm q\frac{\mathbf{n}\times(\mathbf{n}\times\mathbf{w})}{c^3},$$

$$B = B_{pot} + B_{rad} + B_{res} = -q\frac{\mathbf{n}\times\mathbf{v}}{c\, r^2} \mp q\frac{\mathbf{n}\times\mathbf{u}}{c^2 r} - q\frac{\mathbf{n}\times\mathbf{w}}{c^3}, \qquad (34.38)$$

where the upper signs are obtained when the calculation is carried out by the help of the advanced elements of motion, and the lower signs are obtained when the calculation is carried out by the help of the retarded elements of motion.

As said above, the potential intensities are the same when calculated with the advanced and with the retarded elements of motion.

The electric intensity of radiation E_{rad} is the same when calculated with the advanced and with the retarded elements of motion. However the magnetic intensity of radiation B_{rad} is obtained with opposite sign if the retarded elements are used. Since we relate the intensities of radiation with the density of the energy flux (see Sect. 14)

$$I = (c/4\pi)E_{rad}\times B_{rad}, \qquad (34.39)$$

we see that the electric and magnetic radiation intensities calculated with the advanced elements of motion give an energy flux density directed from the charge to the reference point

$$(4\pi/c)I' = E'_{rad}\times B'_{rad} = -\frac{q^2}{c^4 r^2}\{\mathbf{n}\times(\mathbf{n}\times\mathbf{u})\times(\mathbf{n}\times\mathbf{u}) = -\frac{q^2}{c^4 r^2}\{(\mathbf{n}.\mathbf{u})\mathbf{n} - (\mathbf{n}.\mathbf{n})\mathbf{u}\}\times(\mathbf{n}\times\mathbf{u}) =$$

$$-\frac{q^2}{c^4 r^2}\{(\mathbf{n}.\mathbf{u})\mathbf{n}\times(\mathbf{n}\times\mathbf{u}) - \mathbf{u}\times(\mathbf{n}\times\mathbf{u})\} = -\frac{q^2}{c^4 r^2}\{(\mathbf{n}.\mathbf{u})^2\mathbf{n} - u^2\mathbf{n}\} = \frac{q^2}{c^4 r^2}\{u^2 - (\mathbf{n}.\mathbf{u})^2\}\mathbf{n}, \quad (34.40)$$

while the electric and magnetic intensities of radiation calculated with the retarded elements of motion give an energy flux density directed from the reference point to the charge

$$(4\pi/c)I'' = E''_{rad}\times B''_{rad} = -\frac{q^2}{c^4 r^2}\{u^2 - (\mathbf{n}.\mathbf{u})^2\}\mathbf{n}. \qquad (34.41)$$

As $u^2 - (\mathbf{n}.\mathbf{u})^2 \geq 0$, the flux (34.40) corresponds to the real electromagnetic wave radiated in the direction $\mathbf{n}$, while the flux (34.41) corresponds to a wave propagating in the direction $-\mathbf{n}$. This second wave is fictitious, as it must exist if time has the property "reversibility". Thus only the calculation with the advanced elements of motion corresponds to the real course of time (from the past to the future); the calculation with the retarded elements of motion corresponds to the negative course of time (from the future to the past).

The intensities of radiation reaction do not depend on the distance between the charge and the reference point, and, thus, they have mathematical sense also for the point where the charge itself is placed. So we are impelled to make the conclusion that the electric and magnetic intensities of radiation reaction act on the radiating charge itself. Here we cannot speak about advanced and retarded moments, as both these moments coincide with the observation moment.

However, as formulas (34.38) show, the intensities $\mathbf{E}_{rea}$ and $\mathbf{B}_{rea}$ depend on the angle between the super-acceleration and the line connecting the charge with the reference point. Since the reference point for the radiation reaction is the radiating charge itself, we have to eliminate such an angular dependence by averaging over all directions.

The averaging is to be performed in the following way: We plot the vectors of the intensities $\mathbf{E}_{rea}$ obtained when the reference point covers densily a whole sphere around the charge, so that the angle between $\mathbf{n}$ and $\mathbf{w}$ takes all possible values. Now if we add geometrically all these vectors $\mathbf{E}_{rea_i}$, $i = 1,2,....N$, whene $N \to \infty$, and if we divide the resultant vector by the number N, we shall find the average value (we write the intensity of radiation reaction calculated with the advanced elements of motion)

$$\overline{\mathbf{E}_{rea}} = \frac{1}{N}\sum_{i=1}^{N}\mathbf{E}_{rea_i} = \frac{1}{N}\sum_{i=1}^{N} q\mathbf{n}_i\times(\mathbf{n}_i\times\mathbf{w})/c^3. \qquad (34.42)$$

Multiplying both sides of this equation by 4π, we get

$$4\pi\overline{\mathbf{E}_{rea}} = \sum_{i=1}^{N}\mathbf{E}_{rea_i}\frac{4\pi}{N} = \int \mathbf{E}_{rea}\, d\Omega, \qquad (34.43)$$

by making the transition $N \to \infty$, and thus

$$\overline{\mathbf{E}_{rea}} = \frac{1}{4\pi}\int_0^{\pi}\int_0^{2\pi} q\,\frac{\mathbf{n}\times(\mathbf{n}\times\mathbf{w})}{c^3}\sin\theta\, d\theta\, d\phi = \frac{q}{4\pi c^3}\int_0^{\pi}\int_0^{2\pi}\{(\mathbf{n}.\mathbf{w})\mathbf{n} - \mathbf{w}\}\sin\theta\, d\theta\, d\phi, \qquad (34.44)$$

where $n_x = \sin\theta\cos\phi$, $n_y = \sin\theta\sin\phi$, $n_z = \cos\theta$, θ and ϕ being the zenith and azimuth angles of a spherical frame of reference with origin at the charge.

Thus formula (34.44) can be written

$$\overline{\mathbf{E}_{rea}} = \frac{q}{4\pi c^3}\int_0^{\pi}\int_0^{2\pi}\{(w_x\sin\theta\cos\phi + w_y\sin\theta\sin\phi + w_z\cos\theta)(\sin\theta\cos\phi\,\hat{\mathbf{x}} + \sin\theta\sin\phi\,\hat{\mathbf{y}} + \cos\theta\,\hat{\mathbf{z}} - \mathbf{w}\}\sin\theta\, d\theta\, d\phi =$$

$$\frac{q}{4\pi c^3}\Big\{w_x\hat{\mathbf{x}}\int_0^{\pi}\int_0^{2\pi}\sin^3\theta\cos^2\phi\, d\theta\, d\phi + w_y\hat{\mathbf{y}}\int_0^{\pi}\int_0^{2\pi}\sin^3\theta\sin^2\phi\, d\theta\, d\phi + w_z\hat{\mathbf{z}}\int_0^{\pi}\int_0^{2\pi}\cos^2\theta\sin\theta\, d\theta\, d\phi - \mathbf{w}\int_0^{\pi}\int_0^{2\pi}\sin\theta\, d\theta\, d\phi\Big\} =$$

$$\frac{q}{4c^3}\Big\{w_x\hat{\mathbf{x}}\int_0^{\pi}\sin^3\theta\, d\theta + w_y\hat{\mathbf{y}}\int_0^{\pi}\sin^3\theta\, d\theta + w_z\hat{\mathbf{z}}\int_0^{\pi}2\cos^2\theta\sin\theta\, d\theta - \mathbf{w}\int_0^{\pi}2\sin\theta\, d\theta\Big\} =$$

$$\frac{q}{4c^3}\left(\frac{4}{3}w_x\hat{\mathbf{x}} + \frac{4}{3}w_y\hat{\mathbf{y}} + \frac{4}{3}w_z\hat{\mathbf{z}} - 4\mathbf{w}\right) = \frac{q}{4c^3}\left(\frac{4}{3}\mathbf{w} - 4\mathbf{w}\right) = -\frac{2q}{3c^3}\mathbf{w}. \qquad (34.45)$$

The magnetic intensities of radiation reaction are the same when calculated with the help of the advanced and retarded elements of motion. But the averaging of the magnetic intensity of radiation reaction over all angles gives zero. Indeed,

$$\overline{\mathbf{B}_{rea}} = \frac{1}{4\pi}\int_{4\pi}\mathbf{B}_{rea}\, d\Omega = -\frac{q}{4\pi c^3}\int_0^{\pi}\int_0^{2\pi}\mathbf{n}\times\mathbf{w}\sin\theta\, d\theta\, d\phi =$$

$$-\frac{q}{4\pi c^3}\int_0^{\pi}\int_0^{2\pi}\{(w_z\sin\theta\sin\phi - w_y\cos\theta)\hat{\mathbf{x}} + (w_x\cos\theta - w_z\sin\theta\cos\phi)\hat{\mathbf{y}} +$$

$$(w_y\sin\theta\cos\phi - w_x\sin\theta\sin\phi)\hat{\mathbf{z}}\}\sin\theta\, d\theta\, d\phi = 0. \qquad (34.46)$$

Thus formulas (34.38) are to be written in the form

$$\mathbf{E} = \mathbf{E}_{pot} + \mathbf{E}_{rad} + \mathbf{E}_{rea} = q\frac{\mathbf{n}}{r^2} + q\frac{\mathbf{n}\times(\mathbf{n}\times\mathbf{u})}{c^2 r} - \frac{2q}{3c^2}\mathbf{w},$$

$$\mathbf{B} = \mathbf{B}_{pot} + \mathbf{B}_{rad} = -q\frac{\mathbf{n}\times\mathbf{v}}{cr^2} - q\frac{\mathbf{n}\times\mathbf{u}}{c^2 r}, \qquad (34.47)$$

where we have taken these signs which correspond to the calculation with the advanced elements of motion.

35. ELECTROMAGNETIC POTENTIALS OF PERIODIC SYSTEMS

Let us suppose that the charge and current densities of the considered system of electric charges are simple periodic (i.e., monoperiodic, or trigonometric) functions of time

$$Q = Q_{max}\cos\left(\frac{2\pi}{T}t + \alpha\right), \quad \mathbf{J} = \mathbf{J}_{max}\cos\left(\frac{2\pi}{T}t + \alpha\right), \qquad (35.1)$$

where Q_{max} and $\mathbf{J}_{max}$ are the amplitudes of the charge and current densities and represent their values for times $t = nT - (\alpha/2\pi)T$, where n is an integer.

The quantity T is the PERIOD of the charge and current fluctuations; this is the time after whose expiration the charge and current densities obtain again the same values. The argument $2\pi t/T + \alpha$ of the trigonometric function is the PHASE and the quantity α is the initial phase which usually, when considering the charge and current densities at a given space point only, can be taken equal to zero. The quantity $\omega = 2\pi/T$ is called (CIRCULAR) FREQUANCY and the quantity $k = \omega/c = 2\pi/cT$ is called (CIRCULAR) WAVE NUMBER. Such an electromagnetic SYSTEM is called MONOPERIODIC.

It is mathematically more convenient to write the real trigonometric relations as complex exponential relations. Thus we can present the expressions (35.1) in the form

$$Q = \mathrm{Re}\{Q_{max}e^{i(\omega t+\alpha)}\} = \mathrm{Re}\{Q_{max}e^{-i(\omega t+\alpha)}\},$$

$$\mathbf{J} = \mathrm{Re}\{\mathbf{J}_{max}e^{i(\omega t+\alpha)}\} = \mathrm{Re}\{\mathbf{J}_{max}e^{-i(\omega t+\alpha)}\}, \qquad (35.2)$$

where Re{ } means that we must take only the real part of the complex expression in the braces. The real parts of both expressions (35.2) are equal but usually the second forms are used, i.e., those with the negative exponents.

If we introduce the notations

$$Q_\omega = Q_{max} e^{-i\alpha}, \qquad \mathbf{J}_\omega = \mathbf{J}_{max} e^{-i\alpha}, \qquad (35.3)$$

we can write (35.2), by omitting the sign Re{ }, in the form

$$Q = Q_\omega e^{-i\omega t}, \qquad \mathbf{J} = \mathbf{J}_\omega e^{-i\omega t}, \qquad (35.4)$$

where the new amplitudes Q_ω, $\mathbf{J}_\omega$ must be considered as complex numbers which become real only under the condition $\alpha = 0$. The complex forms (35.2) are called SHORT EXPONENTIAL FORMS and the complex forms (35.4) are called LAPIDARY EXPONENTIAL FORMS. The LONG EXPONENTIAL FORMS are the following

$$Q = (1/2)\{Q_\omega e^{-i\omega t} + Q^*_\omega e^{i\omega t}\}, \qquad \mathbf{J} = (1/2)\{\mathbf{J}_\omega e^{-i\omega t} + \mathbf{J}^*_\omega e^{i\omega t}\}, \qquad (35.5)$$

where Q^*_ω, $\mathbf{J}^*_\omega$ are the quantities complex conjugated to Q_ω, $\mathbf{J}_\omega$.

The use of the complex exponential forms turns out to be very convenient when we perform linear operations (say, adding, differentiation, integration) over the trigonometric functions. By using the complex exponential forms, all linear operations are to be applied not to trigonometric but to much simpler exponential expressions. However, when we have to perform non-linear operations (say, multiplication), we have always to use the long exponential forms.

Let us find the electric and magnetic potentials originated by a monoperiodic system at an arbitrary reference point.

Following the concept that the potential electric and magnetic intensities appear "momentarily" in whole space, while the radiated intensities propagate with the velocity c, we shall bear in mind the following rules when calculating the intensities proceeding from the potentials:

1) When we calculate the potential intensities, we have to use the observation potentials (refer to formula (34.7)).

2) When we calculate the radiation intensities, we have to use the advanced potentials (refer to formula (34.6).

3) When we calculate both the potential and radiation intensities, we have to use the advanced potentials (see formulas (10.3))

$$\Phi = \int_V \frac{Q(t - R/c)}{R} dV, \qquad \mathbf{A} = \int_V \frac{\mathbf{J}(t - R/c)}{R} dV, \qquad (35.6)$$

where R is the distance to the elementary volume dV, but in the final result we have to put $c = \infty$ in all non-radiation intensities if this c appears as a result of manipulation with advanced time. The execution of this program will become clear in Sect. Sect. 37.

Thus if the charge and current densities at every elementary volume of the considered system are simple periodic functions of time, with equal periods of fluctuations, the electric and magnetic potentials will be also simple periodic functions of time with the same period and by putting (35.4) into (35.6) we obtain

$$\Phi(t) = \Phi_\omega e^{-i\omega t} = \int_V \frac{Q_\omega}{R} e^{-i(\omega t - kR)} dV, \qquad \mathbf{A}(t) = \mathbf{A}_\omega e^{-i\omega t} = \int_V \frac{\mathbf{J}_\omega}{R} e^{-i(\omega t - kR)} dV,$$

where

$$\Phi_\omega = \int_V \frac{Q_\omega}{R} e^{ikR} dV, \qquad \mathbf{A}_\omega = \int_V \frac{\mathbf{J}_\omega}{R} e^{ikR} dV \qquad (35.8)$$

are the complex amplitudes of the advanced electric and magnetic potentials.

Let us now suppose that the charge and current densities are periodic,but not trigonometric, functions of time. As it is known, any periodic function can be presented as a Fourier series, i.e., as a superposition of trigonometric functions with different periods. We shall call such SYSTEMS POLYPERIODIC and their potentials will be superposition of potentials of monoperiodic systems.

If the charge and current densities are arbitrary functions of time, then, as it is known, they can be presented by a Fourier integral as a superposition of monoperiodic functions and such will be also the potentials. We call such systems APERIODIC.

36. THE POTENTIALS AT LARGE DISTANCES FROM THE GENERATING SYSTEM.

Let us consider the potentials generated by an electromagnetic system of arbitrarily moving charges at large distances from the system, that is at distances which are large compared with the dimensions of the system.

We choose (fig. 16) the origin O of the reference frame somewhere in the interior of the system of charges using the following notations: the radius vector of the reference point P is denoted by **r** and the unit vector along it by **n**; the radius vector of the charges in the differential volume dV around point Q (where the charge and current densities are Q(t) and **J**(t), respectively) is denoted by **r'**; the radius vector from the the volume dV to the reference point P is denoted by **R**.

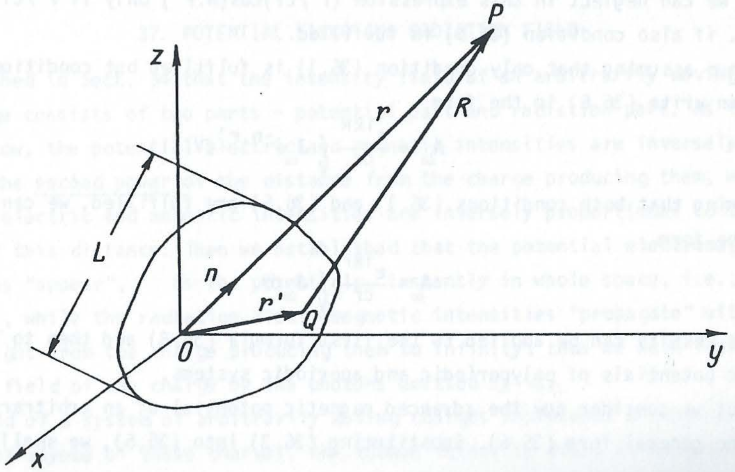

Fig. 16. Electromagnetic system and a far lying reference point.

Denoting by L the largest dimension of the system, we shall assume

$$r \gg L, \tag{36.1}$$

and therefore

$$r \gg r'. \tag{36.2}$$

From fig. 16 we have $\mathbf{R} = \mathbf{r} - \mathbf{r}'$, and thus we can write approximately

$$R = |\mathbf{r} - \mathbf{r}'| \cong (r^2 - 2\mathbf{r}.\mathbf{r}')^{1/2} = r(1 - 2\mathbf{n}.\mathbf{r}'/r)^{1/2} \cong r - \mathbf{n}.\mathbf{r}', \tag{36.3}$$

and with larger inaccuracy

$$R \cong r. \tag{36.4}$$

In addition to the condition (36.1) we shall sometimes assume also that the shortest period of oscillation T of the charge and current densities at the different elementary volumes of the system is much larger than the time in which light covers the largest dimension of the system, i.e.,

$$T \gg L/c. \tag{36.5}$$

Let us now consider the advanced magnetic potential of a monoperiodic system. Substituting (36.3) into the second formula (35.8), we shall have at this approximation

$$\mathbf{A}_\omega = \frac{1}{c}\int_V \frac{\mathbf{J}_\omega}{r - \mathbf{n}.\mathbf{r}'} e^{ik(r - \mathbf{n}.\mathbf{r}')} dV. \tag{36.6}$$

Taking into account assumption (36.2), we can neglect $\mathbf{n}.\mathbf{r}'$ with respect to r in the denominator. However, this condition is not enough to make the same neglection in the exponent of the nominator. Indeed, we have

$$\mathrm{Re}\{e^{ik(r - \mathbf{n}.\mathbf{r}')}\} = \cos\{\frac{2\pi}{cT}(r - \mathbf{n}.\mathbf{r}')\} = \cos[2\pi\{\frac{r}{cT} - \frac{r'}{cT}\cos(\mathbf{n}.\mathbf{r}')\}]. \tag{36.7}$$

Thus we can neglect in this expression $(r'/cT)\cos(\mathbf{n}.\mathbf{r}')$ only if $r'/cT < L/cT \ll 1$, i.e., if also condition (36.5) is fulfilled.

Thus assuming that only condition (36.1) is fulfilled but condition (36.5) is not, we can write (36.6) in the form

$$\mathbf{A}_\omega = \frac{e^{ikR}}{cr}\int_V \mathbf{J}_\omega e^{-\mathbf{n}.\mathbf{r}'} dV. \tag{36.8}$$

Assuming that both conditions (36.1) and (36.5) are fulfilled, we can write (36.6) in the form

$$\mathbf{A}_\omega = \frac{e^{ikr}}{cr}\int_V \mathbf{J}_\omega dV. \tag{36.9}$$

These results can be applied to the first formula (35.8) and then to the electromagnetic potentials of polyperiodic and aperiodic systems.

Let us consider now the advanced magnetic potential of an arbitrary system written in the general form (35.6). Substituting (36.3) into (35.6), we shall have

$$\mathbf{A} = \frac{1}{c}\int_V \frac{\mathbf{J}(t - r/c + \mathbf{n}.\mathbf{r}'/c)}{r - \mathbf{n}.\mathbf{r}'} dV. \tag{36.10}$$

Assuming that only condition (36.1) is fulfilled but condition (36.5) is not, we can write

$$\mathbf{A} = \frac{1}{cr}\int_V \mathbf{J}(t' + \mathbf{n}.\mathbf{r}'/c)dV, \tag{36.11}$$

where $t' = t - r/c$ is the common advanced moment for the whole system, i.e., the advanced moment taken with respect to the frame's origin.

Expanding the integral in (36.11) as a power series of the small quantity $\mathbf{n}.\mathbf{r}'/c$, we obtain

$$\mathbf{A} = \mathbf{A}^{(0)} + \mathbf{A}^{(1)} + \ldots = \frac{1}{cr}\int_V \mathbf{J}(t')dV + \frac{1}{c^2 r}\int_V (\mathbf{n}.\mathbf{r}')\frac{d\mathbf{J}(t')}{dt'} + \ldots . \tag{36.12}$$

Since $\mathbf{n}$ is a constant unit vector and the vectors $\mathbf{r}'$ are integration variables which do not depend on time, we can write, taking into account that $\mathbf{J}dV$ is equal to the sum of the charges in the volume dV multiplied by their velocities

$$\mathbf{A} = \frac{1}{cr}\sum_{i=1}^{n} q_i \mathbf{v}_i(t') + \frac{1}{c^2 r}\frac{d}{dt'}\sum_{i=1}^{n} q_i(\mathbf{n}.\mathbf{r}_i')\mathbf{v}_i(t') + \ldots\ldots . \tag{36.13}$$

In zero approximation we have

$$\mathbf{A}^{(0)} = \frac{1}{cr}\sum_{i=1}^{n} q_i \mathbf{v}_i = \frac{1}{cr}\frac{d}{dt'}\sum_{i=1}^{n} q_i \mathbf{r}' = \frac{\dot{\mathbf{d}}}{cr}, \tag{36.14}$$

where $\mathbf{d}$ is the advanced dipole moment of the system, and the point over the symbol signifies that time derivative is taken from this quantity. We remind that the elements of motion on the right side of the last formulas are taken at the common advanced moment.

37. POTENTIAL FIELD AND RADIATION FIELD

We established in Sect. 34 that the intensity field of an arbitrarily moving electric charge consists of two parts - potential part and radiation part. As formulas (34.38) show, the potential electric and magnetic intensities are inversely proportional to the second power of the distance from the charge producing them, while the radiation electric and magnetic intensities are inversely proportional to the first power of this distance. Then we established that the potential electromagnetic intensities "appear", as the potentials, instantly in whole space, i.e., they are immaterial, while the radiation electromagnetic intensities "propagate" with the velocity of light from the charge producing them to infinity; thus we have identified the radiation field of the charge by the photons emitted by it.

As the field of a system of arbitrarily moving charges represents a superposition of the fields of anyone of these charges, the common intensity field of the whole system will also consist of a potential part and a radiation part.

Let us now find the field of a system of charges at large distance from it. As mentioned in Sect. 35, for the calculation of the potential and radiation intensities we use the advanced potentials but then in all non-radiation intensity terms we have to put $c = \infty$ everywhere where this "c" appears as a result of manipulation with advanced time; non-radiation terms are all those which are not inversely proportional to the first power of the distance from the system to the reference point. The essence of this program will become clear in this section.

For simplicity sake, we shall make a calculation for the potentials taken in zero approximation. Thus the advanced magnetic potential will be given by formula (36.14). The advanced electric potential can be calculated by substituting (36.14) into the equation of potential connection (8.8)

$$\mathrm{div}(\dot{\mathbf{d}}/cr) = -(1/c)\partial\Phi/\partial t. \tag{37.1}$$

After integration we can determine the electric potential

$$\Phi = -\,\mathrm{div}(\mathbf{d}/r) + \mathrm{Const}, \tag{37.2}$$

where the constant of integration must have the form

$$\mathrm{Const} = \frac{1}{r}\sum_{i=1}^{n} q_i, \tag{37.3}$$

because if we put the dipole moment equal to zero, we shall have, at the assumption (36.1),

$$\Phi = \frac{1}{r}\sum_{i=1}^{n} q_i, \tag{37.4}$$

where n is the number of the charges in the system.

Let us assume that the sum of all charges in the system is zero. Then the advanced electric potential will have the form (37.2) with Const = 0. Putting this and (36.14) into the fundamental definition equalities (34.1), we obtain the following expressions for the electric and magnetic intensities

$$\mathbf{E} = \mathrm{grad}(\mathrm{div}\frac{\mathbf{d}}{r}) - \frac{1}{c^2}\frac{\ddot{\mathbf{d}}}{r}, \quad \mathbf{B} = \frac{1}{c}\,\mathrm{rot}\frac{\dot{\mathbf{d}}}{r}. \tag{37.5}$$

Now I shall calculate the monoperiodic amplitudes of the electric and magnetic intensities, assuming that the charge densities are monoperiodic functions of time; if they are polyperiodic or aperiodic functions of time, then we shall assume that a suitable expansion in a Fouruer series or Fourier integral is performed.

The resultant advanced dipole moment of the system can be presented as a superposition of the advanced monoperiodic moments of the form

$$\mathbf{d}(t') = \mathbf{d}_\omega e^{-i\omega t'} = \mathbf{d}_\omega e^{-i\omega(t - r/c)} = \mathbf{d}_\omega e^{-i\omega t + ik}. \tag{37.6}$$

We see that the velocity "c" which figures in the advanced time is included in the wave number k; hence in all non-radiation intensity terms of the final reslt we have to put k = 0.

The electric and magnetic intensities produced by this monoperiodic dipole moment will also be periodic functions with the same frequency

$$\mathbf{E}(t) = \mathbf{E}_\omega e^{-i\omega t}, \qquad \mathbf{B}(t) = \mathbf{B}_\omega e^{-i\omega t} \tag{37.7}$$

Substituting (37.6) and (37.7) into the first equation (37.5) and dividing the equation obtained by the common factor exp(-iωt), we obtain for the monoperiodic amplitude of the electric intensity with frequency ω the following expression

$$\mathbf{E}_\omega = \mathrm{grad}\{\mathrm{div}(\frac{e^{ikr}}{r}\mathbf{d}_\omega)\} + \frac{\omega^2}{c^2}\frac{e^{ikr}}{r}\mathbf{d}_\omega = \mathrm{grad}(\mathbf{d}_\omega.\mathrm{grad}\frac{e^{ikr}}{r}) + \frac{k^2}{r}e^{ikr}\mathbf{d}_\omega =$$

$$(\mathbf{d}_\omega.\mathrm{grad})\mathrm{grad}\frac{e^{ikr}}{r} + \frac{k^2}{r}e^{ikr}\mathbf{d}_\omega = (\mathbf{d}_\omega.\mathrm{grad})\{(\frac{ik}{r^2} - \frac{1}{r^3})e^{ikr}\,\mathbf{r}\} + \frac{k^2}{r}e^{ikr}\mathbf{d}_\omega =$$

$$\{\mathbf{d}_\omega.(-\frac{2ik}{r^3} + \frac{3}{r^4} - \frac{k^2}{r^2} - \frac{ik}{r^3})e^{ikr}\,\mathbf{n}\}\mathbf{r} + (\frac{ik}{r^2} - \frac{1}{r^3})e^{ikr}\mathbf{d}_\omega + \frac{k^2}{r}e^{ikr}\mathbf{d}_\omega =$$

$$(-\frac{k^2}{r} - \frac{3ik}{r^2} + \frac{3}{r^3})e^{ikr}(\mathbf{d}_\omega.\mathbf{n})\mathbf{n} + (\frac{ik}{r^2} - \frac{1}{r^3})e^{ikr}\mathbf{d}_\omega + \frac{k^2}{r}e^{ikr}\mathbf{d}_\omega =$$

$$\frac{k^2}{r}e^{ikr}\{\mathbf{d}_\omega - (\mathbf{d}_\omega.\mathbf{n})\mathbf{n}\} - \frac{ik}{r^2}e^{ikr}\{3(\mathbf{d}_\omega.\mathbf{n})\mathbf{n} - \mathbf{d}_\omega\} + \frac{1}{r^3}e^{ikr}\{3(\mathbf{d}_\omega.\mathbf{n})\mathbf{n} - \mathbf{d}_\omega\}. \tag{37.8}$$

The amplitude of the radiation electric intensity is the one which is inversely proportional to the first power of r; thus we can write

$$\mathbf{E}_{\omega rad} = \frac{k^2}{r}e^{ikr}\,\mathbf{n}\times(\mathbf{d}_\omega\times\mathbf{n}). \tag{37.9}$$

In all other terms we have to put k = 0 and these terms which remain will represent the amplitude of the potential electric intensity. Thus we shall have

$$\mathbf{E}_{\omega pot} = \frac{1}{r^3}\{3(\mathbf{d}_\omega.\mathbf{n})\mathbf{n} - \mathbf{d}_\omega\}. \tag{37.10}$$

I showed (see (31.12)) that this is the electric intensity generated by a static electric system with a total charge equal to zero and dipole moment (31.6) different from zero. The difference from the static system is only this that in the general dynamic monoperiodic case the potential electric intensity, according to formula (37.7) is a monoperiodic function of time.

The second term on the right side of (37.8) appears only as a result of the computation and when putting k = 0 disappears, i.e., it has no physical meaning.

Which are the errors of conventional physics which assumes that the interaction "propagates" with the velocity c? First it has to consider the second term on the right side of (37.8) as a real electric intensity. However nobody has measured such an intensity. Second, conventional physics considers the third term on the right side of (37.8) together with the factor e^{ikr}, i.e., it assumes that the potential electric intensity of a monoperiodic system has a "wave character". It is extremely easy to show experimentally that this assertion is not true, as I shall show beneath.

Let us now see which are the radiation and potential magnetic intensities of a system with monoperiodic dipole moment different from zero. Substituting (37.6) and (37.7) into the second equation (37.5) and dividing the equation obtained by the common factor $\exp(-i\omega t)$, we obtain for the monoperiodic amplitude of the magnetic intensity with frequency ω the following expression

$$\mathbf{B}_\omega = -i\frac{\omega}{c}\,\mathrm{rot}\Big(\frac{e^{ikr}}{r}\mathbf{d}_\omega\Big) = i\frac{\omega}{c}\,\mathbf{d}_\omega\times\mathrm{grad}\frac{e^{ikr}}{r} = i\frac{\omega}{c}\,\mathbf{d}_\omega\times\Big\{\Big(\frac{ik}{r}-\frac{1}{r^2}\Big)e^{ikr}\,\mathbf{n}\Big\} =$$
$$-\frac{k^2}{r}e^{ikr}\,\mathbf{d}_\omega\times\mathbf{n} - \frac{i\omega}{cr^2}e^{ikr}\,\mathbf{d}_\omega\times\mathbf{n}. \qquad (37.11)$$

The amplitude of the radiation magnetic intensity is the one which is inversely proportional to the first power of r; thus we can write

$$\mathbf{B}_{\omega rad} = \frac{k^2}{r}e^{ikr}\,\mathbf{n}\times\mathbf{d}_\omega. \qquad (37.12)$$

In the other term representing the amplitude of the potential magnetic intensity we have to put $k = 0$; so we obtain

$$\mathbf{B}_{\omega pot} = \frac{i\omega}{cr^2}\,\mathbf{n}\times\mathbf{d}_\omega. \qquad (37.13)$$

Having in mind (37.7) and (37.13), we can write the time depending potential magnetic intensity corresponding to the frequency ω in the form

$$\mathbf{B}_{pot}(t) = \frac{i\omega}{cr^2}\,\mathbf{n}\times\mathbf{d}_\omega e^{-i\omega t} = -\frac{\mathbf{n}}{cr^2}\times\frac{d}{dt}(\mathbf{d}_\omega e^{-i\omega t}) = -\frac{\mathbf{n}}{cr^2}\times\dot{\mathbf{d}}(t). \qquad (37.14)$$

Using now formula (36.14), we get

$$\mathbf{B}_{pot}(t) = -\frac{\mathbf{n}}{r}\times\mathbf{A}(t) = -\frac{\mathbf{n}}{r}\times\int_V\frac{\mathbf{J}(t)}{cr}dV = \int_V\frac{\mathbf{J}(t)\times\mathbf{n}}{cr^2}dV. \qquad (37.15)$$

Canceling the common factor $\exp(-i\omega t)$, we obtain for the amplitude of the potential magnetic intensity

$$\mathbf{B}_{\omega pot} = \int_V\frac{\mathbf{J}_\omega\times\mathbf{n}}{cr^2}dV. \qquad (37.16)$$

This is the magnetic potential of a stationary (quasi-static) system of electric charges, as it can be immediately shown taking rotation from $\mathbf{A} = \int\mathbf{J}dV/cr$.

The radiation electric and magnetic intensities (37.9) and (37.12) can be immediately obtained from formulas (34.35), which we can write in the form

$$\mathbf{E}_{rad} = \mathbf{n}\times(\mathbf{n}\times\dot{\mathbf{A}}/c), \qquad \mathbf{B}_{rad} = -\,\mathbf{n}\times\dot{\mathbf{A}}/c, \qquad (37.17)$$

in which form they are valid if $\mathbf{A}$ is the advanced magnetic potential not only of a single charge but of a whole system. Indeed, if we put here (36.14), using (37.6)

and (37.7), we easily obtain (37.9) and (37.12).

As said above, conventional physics has to consider the last terms on the right sides of equations (37.8) and (37.11) together with the factor $\exp(ikr)$. This will give to the potential electric and magnetic intensities a "wave character". A very easy experiment showing that this is not true, i.e., that the potential electromagnetic intensities have no "wave character" is the following one: Take two big coils set aside at a certain distance L and feeded by strong currents with the same high enough frequency, so that $c/\omega < L/2\pi$. Take another small coil closed shortly by an amperemeter in which current will be induced and so it will serve as an indicator of the potential electric field produced by the big coils. If moving the indicator coil between both powerful coils, we shall see that the induced current is the largest when the small coil is near the one or the other coil and gradually decreases, being the less at the middle point. If the potential magnetic field would have a "wave character", the induced current will not decrease gradually at the above motion of the small coil, as both potential fields will interfere and the indicator has to show "nodes" and "anti-nodes" of the produced "standing waves". Nobody nowhere has observed such an effect. This effect, however, can be very easily observed exactly in the above way for the radiation electromagnetic field of two antennas.

Now the big question is to be posed, how can we, by measuring a certain electric intensity $\mathbf{E}$ and a certain magnetic intensity $\mathbf{B}$, discern which is potential and which is radiation (or which parts in $\mathbf{E}$ and $\mathbf{B}$ have potential and which radiation character). This is a very important question to which official physics cannot give a clear answer.

The distinction which I make is the following: $\mathbf{E}$ and $\mathbf{B}$ are radiation elecric and magnetic intensities if and only if they are produced by the same charges, have equal magnitudes, are mutually perpendicular, and the vector $\mathbf{E}\times\mathbf{B}$ points away from the system producing them. Note that the requirement "produced by the same charges" is very important. So if we have a parallel plates condenser producing the electric intensity $\mathbf{E}$ and a cylindrical current coil whose axis is perpendicular to $\mathbf{E}$ producing a magnetic intensity $\mathbf{B}$ such that $B = E$, then the requirement of calling them radiation electromagnetic intensities are fulfilled except the requirement to be produced by the same charges. Thus these electric and magnetic intensities are potential.

The requirement "produced by the same charges" in the above definition can be replaced by the following one: On a unit surface placed perpendicularly to the vector $\mathbf{E}\times\mathbf{B}$, a pressure must act equal to the pressure which a gas with mass density $\mu = E^2/4\pi c$ moving with velocity 1 cm/sec exerts on a wall placed perpendicularly to its flow. Thus the radiation electric and magnetic intensities must transfer energy (mass).

I sketched in fig. 17 another experiment which can demonstrate the substantial difference between potential and radiation intensities.

Let us have an oscillating circuit consisting of an induction coil L, a conden-

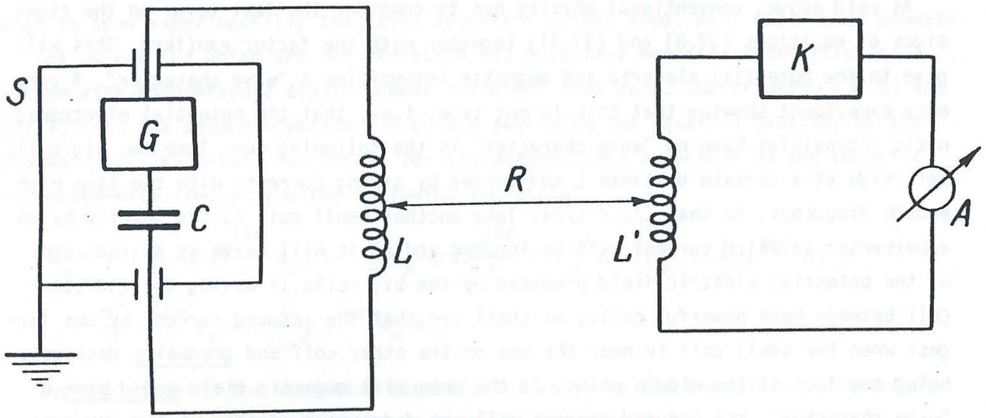

Fig. 17. Experiment demonstrating the momentary propagation of the potential magnetic intensity.

ser C and a generator G which maintains undamped electromagnetic oscillations of the circuit. As it is known, the period of oscillations and the circular frequency are given by the formulas (see Sect. 54.2)

$$T = 2\pi(LC)^{1/2}, \qquad \omega = 2\pi/T = (LC)^{-1/2}. \qquad (37.18)$$

Let us suppose that the condenser and the generator are enclosed in a screen-box S, so that this oscillating circuit cannot radiate electromagnetic waves into free space, where only its potential magnetic field will exist.

Let us put another induction coil L' at a distance R from the coil L. If coil L is long enough, we can assume that its potential magnetic intensity will be concentrated in the coil pointing along its axis and having the value $B = (4\pi nI/c)\cos(\omega t)$, where n is the number of the windings on a unit of length and I is the amplitude of the alternating current flowing in the windings (see formula (18.28)). The magnetic potential of L at the space domain where L' is placed is $A = (2\pi nIr^2/cR)\cos(\omega t)$, where r is the radius of the coil L. The magnetic potential A is tangential to a cylinder with raduis R having the same axis as the axis of coil L. According to the first formula (34.1), the electric intensity generated by the alternating current in L at the domain where L' is placed will be also tangential to the mentioned cylinder with radius R and have the magnitude $E = (2\pi nIr^2\omega/cR)\sin(\omega t)$. As in the windings' halves of L' which are nearer to L the induced electric intensity will be bigger than in the halves which are farther, a resultant sinusoidal tension will be induced in L'. This tension, however, is small (if L is infinitely long, it disappears), and it is better to make L' with a radius R encircling L.

Let now suppose that the condition

$$R > cT \qquad (37.19)$$

is fulfilled. According to official physics, for the time of one period of the oscillations the field of the magnetic potential propagating from coil L to coil L' cannot reach the latter. But, on the other hand, we know that at the beginning and the end of every half period the whole electromagnetic energy of the circuit is concentrated in the electric field of the condenser C (suppose for simplicity sake that the circuit L-C is without losses which, as a matter of fact, are covered by the energy coming from the generator G). Thus we have to conclude that under the condition (37.19) no electromagnetic energy can be transferred from the circuit L-C to the coil L'.

According to my primitive and childish concepts, the potential electric and magnetic fields do not "propagate" with velocity c but "appear" instantly in whole space. Thus even at the condition (37.19) electromagnetic energy will be transferred from the circuit L-C to the circuit of coil L', and the amperemeter will show the existence of induction current. As the field in the outer space is potential, at open circuit of L' no energy will be absorbed from the potential field and the generator G will cover only the inevitable losses in the circuit L-C. However, if the ciruit of L' will be closed, induced current will flow in it, energy will be absorbed and, because of the back induction of L' in L, the generator must increase its power, otherwise the energy consumed by L' will damp the oscillations in the L-C circuit.

Let us now put the screen box S away and let us begin to make the distance between the condenser's plates bigger and bigger, until the whole circuit will become a straight line with a condenser's plate at any of its ends and the coil L in the middle. If the coil will remain further very long and having the whole magnetic field inside, this system will again have only potential fields in the outer space and both fields (of the condenser and of the coil) will be electric. If, however, we shall begin to diminish the windings of the coil reducing it at the end to a straight wire, in the outer space will exist both the electric and magnetic intensities of the L-C circuit. The parts of them which will be with equal magnitudes, which will be mutually perpendicular and for which the product $E \times B$ will point away from the system will be their radiation electric and magnetic intensities. The coil L' will react both to the potential and radiation electric and magnetic intensities and current generated by their common action will flow in L'.

Here it is to be mentioned that if the predominant part of the energy absorbed by L' will have a radiation character, then the fact whether L' is closed (absorbs energy) or open (does not absorb energy) has no influence on the generator G which covers only the inevitable losses in the circuit and the energy radiated in the form of electromagnetic waves (photons).

All these experiments are enough simple for execution and their explanation is also extremely simple. Nevertheless official physics defends the wrong concept that also the potential electric and magnetic intensities, and even the electric and mag-

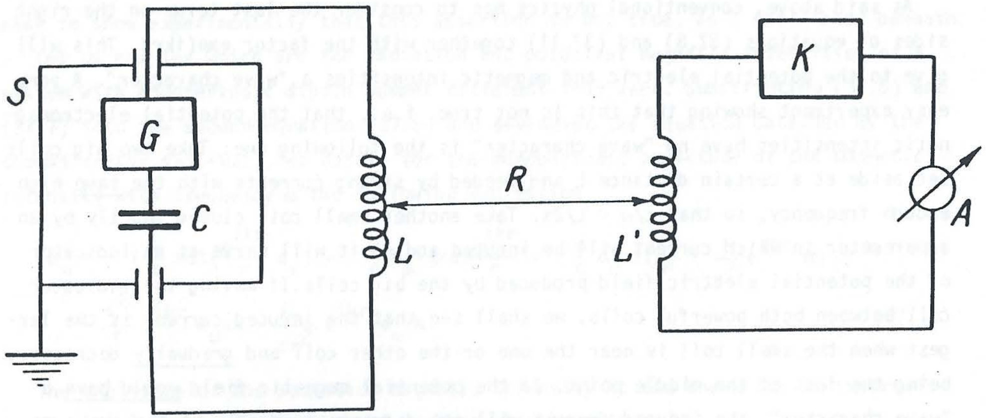

Fig. 17. Experiment demonstrating the momentary propagation of the potential magnetic intensity.

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Let now suppose that the condition

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is fulfilled. According to official physics, for the time of one period of the oscillations the field of the magnetic potential propagating from coil L to coil L' cannot reach the latter. But, on the other hand, we know that at the beginning and the end of every half period the whole electromagnetic energy of the circuit is concentrated in the electric field of the condenser C (suppose for simplicity sake that the circuit L-C is without losses which, as a matter of fact, are covered by the energy coming from the generator G). Thus we have to conclude that under the condition (37.19) no electromagnetic energy can be transferred from the circuit L-C to the coil L'.

According to my primitive and childish concepts, the potential electric and magnetic fields do not "propagate" with velocity c but "appear" instantly in whole space. Thus even at the condition (37.19) electromagnetic energy will be transferred from the circuit L-C to the circuit of coil L', and the amperemeter will show the existence of induction current. As the field in the outer space is potential, at open circuit of L' no energy will be absorbed from the potential field and the generator G will cover only the inevitable losses in the circuit L-C. However, if the ciruit of L' will be closed, induced current will flow in it, energy will be absorbed and, because of the back induction of L' in L, the generator must increase its power, otherwise the energy consumed by L' will damp the oscillations in the L-C circuit.

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Here it is to be mentioned that if the predominant part of the energy absorbed by L' will have a radiation character, then the fact whether L' is closed (absorbs energy) or open (does not absorb energy) has no influence on the generator G which covers only the inevitable losses in the circuit and the energy radiated in the form of electromagnetic waves (photons).

All these experiments are enough simple for execution and their explanation is also extremely simple. Nevertheless official physics defends the wrong concept that also the potential electric and magnetic intensities, and even the electric and magnetic potentials, "propagate" with the velocity of light.

At the end of this section I should like to emphasize once more that the potential electric and magnetic intensities are determined by the values of the charge and current densities at the different elementary volumes of the system, while the radiation electric and magnetic intensities are determined by the rate of change of these densities.

38. DIPOLE RADIATION

In zero approximation at large distances from the generating system the magnetic potential can be expressed by the dipole moment of the system according to formula (26.14). Substituting this expression for the advanced magnetic potential into the general formula (37.17) for the radiated electric and magnetic intensities, we obtain

$$\mathbf{E}_{rad} = \frac{1}{cr}\,\mathbf{n}\times(\mathbf{n}\times\ddot{\mathbf{d}}), \qquad \mathbf{B}_{rad} = \frac{1}{c^2 r}\,\ddot{\mathbf{d}}\times\mathbf{n}. \tag{38.1}$$

The radiation described by the formulas (38.1) is called DIPOLE RADIATION because the electric and magnetic radiation intensities depend only on the dipole moment of the system (on its second time derivative).

As already said, the radiated electromagnetic waves (photons) are carrying away a definite amount of energy from the radiating system. The intensity of the radiated energy flux is given by formula (34.39). Taking into account the relations (see formulas (34.35)) $\mathbf{B}_{rad} = \mathbf{n}\times\mathbf{E}_{rad}$, $\mathbf{E}_{rad}.\mathbf{n} = 0$, $E_{rad} = B_{rad}$, we can write

$$\mathbf{I} = \frac{c}{4\pi}\,\mathbf{E}_{rad}\times\mathbf{B}_{rad} = \frac{c}{4\pi}\,\mathbf{E}_{rad}\times(\mathbf{n}\times\mathbf{E}_{rad}) = \frac{c}{4\pi}\,E^2_{rad}\,\mathbf{n} = \frac{c}{4\pi}\,B^2_{rad}\,\mathbf{n}. \tag{38.2}$$

Taking into account our third axiom, we have to understand the above equation always in the following form

$$\mathbf{I} = \frac{c}{T}\int_{-T/2}^{T/2}(E^2_{rad}/4\pi)\,dt = \frac{c}{T}\int_{-T/2}^{T/2}(B^2_{rad}/4\pi)\,dt, \tag{38.3}$$

where T is the period of the electromagnetic wave (the period of the photon). Indeed, according to the third axiom, only when time equal to the period of a particle has elapsed can we affirm that the particle has crossed a given surface. For times shorter than the period we cannot say on which side of the surface is the particle.

It is more convenient to express $\mathbf{I}$ by $\mathbf{B}_{rad}$ (see the right-hand expression in (38.2)) as $\mathbf{B}_{rad}$ can be expressed by $\ddot{\mathbf{d}}$ more simply than $\mathbf{E}_{rad}$ (see (38.1)).

The energy flux of radiation dP in a unit of time into the element of a solid angle $d\Omega$ is defined as the amount of energy passing in a unit of time through the element $dS = r^2 d\Omega$ of the spherical surface with center at the frame's origin and radius r (see fig. 16). This quantity is clearly equal to the intensity of the energy flux density $\mathbf{I}$ multiplied by dS, so that using (38.1) we obtain

$$dP = IdS = (c/4\pi)B^2 r^2 d\Omega = (1/4\pi c^3)(\mathbf{n}\times\ddot{\mathbf{d}})^2 d\Omega. \tag{38.4}$$

The whole energy flux can be obtained if we integrate (38.4) over a sphere containing the radiating system at its center. Let us introduce spherical frame of reference with polar axis along the vector $\ddot{\mathbf{d}}$. Let the zenith angle and the azimuth angle of the unit vector n be θ and ϕ; θ is consequently the angle between $\ddot{\mathbf{d}}$ and n. As $d\Omega = \sin\theta\, d\theta\, d\phi$,

$$P = \int\frac{(\mathbf{n}\times\ddot{\mathbf{d}})^2}{4\pi\; 4\pi c^3}\,d\Omega = \int_0^{\pi}\int_0^{2\pi}\frac{\ddot{d}^2}{4\pi c^3}\sin^3\theta\, d\theta\, d\phi = \frac{2}{3c^3}\,\ddot{d}^2. \tag{38.5}$$

If we have just one charge moving in an external field, we shall have, keeping in mind (31.6), $\ddot{\mathbf{d}} = q\ddot{\mathbf{r}} = q\mathbf{u}$, so that the total energy radiated in a unit of time by this charge will be

$$P = \frac{2q^2}{3c^2}\,u^2. \tag{38.6}$$

We note that a system of particles, for which the ratio of charge to mass is the same, cannot radiate (by dipole radiation). Indeed, for such a system

$$\mathbf{d} = \sum_{i=1}^{n}(q_i/m_i)m_i\mathbf{r}_i = \text{Const}\sum_{i=1}^{n}m_i\mathbf{r}_i = \text{Const}\,\mathbf{R}\sum_{i=1}^{n}m_i, \tag{38.7}$$

where Const is the charge-to-mass ratio common for all charges and R is the radius vector of the center of mass of the system. As the center of mass moves uniformly, its acceleration is zero and consequently the second time derivative of $\mathbf{d}$ is zero, too.

If the particle performs such a motion that its dipole moment is a simple periodic function of time with a period $T = 2\pi/\omega$, we shall have

$$d(t) = d_\omega e^{-i\omega t}, \tag{38.8}$$

where d_ω is the complex amplitude of the dipole moment (which, at a suitable choice of the initial moment, can be taken real and equal to the maximum value of the dipole moment - see Sect. 35).

Hence, substituting (38.8) into (38.5), we obtain for the total energy flux

$$P = \frac{2}{3c^3}\,|\ddot{d}(t)|^2 = \frac{2}{3c^3}\,\omega^4|d_\omega|^2. \tag{38.9}$$

39. RADIATION REACTION

As formulas (34.47) show, the radiation reaction electric and magnetic intensities are as follows

$$\mathbf{E}_{rea} = -(2q/3c^3)\mathbf{w}, \qquad \mathbf{B}_{rea} = 0. \tag{39.1}$$

Let us calculate the change of the energy of a system of n charges due only to the action of the electric intensities of radiation reaction E_{rea_i} of the various charges. On each charge of the system the "kinetic" force

$$\mathbf{f}_i = q_i \mathbf{E}_{rea_i} = -(2q_i^2/3c^2)\mathbf{w}_i, \quad i = 1,2,\dots,n \tag{39.2}$$

will act, called RADIATION REACTION FORCE (or radiating damping force, or LORENTZ FRICTION FORCE). The power of these forces acting on all charges of the system, i.e., the work done by the radiation reaction forces in a unit of time, is (see formula (8.7))

$$P = \sum_{i=1}^{n} \mathbf{f}_i.\mathbf{v}_i. \tag{39.3}$$

Substititing here (39.2), we get

$$P = -\frac{2}{3c^3}\sum_{i=1}^{n} q_i^2\, \mathbf{w}_i.\mathbf{v}_i = -\frac{2}{3c^3}\sum_{i=1}^{n} q_i^2\{\frac{d}{dt}(\mathbf{u}_i.\mathbf{v}_i) - u_i^2\}. \tag{39.4}$$

Let us average this equation over time. At the averaging the first term on the right side will vanish as a total time derivative of a bounded function. Thus the average work performed in a unit of time by the damping force will be

$$P = \frac{2}{3c^3}\sum_{i=1}^{n} q_i^2 u_i^2 = \frac{2}{3c^3}\ddot{d}^2, \tag{39.5}$$

where **d** is the dipole moment of the whole system of charges.

Comparing this formula with formula (38.5), we conclude that the average work done in a unit of time by the radiation reaction forces over the charge (i.e., the power of the radiation reaction) is just equal to the total energy flux of radiation (i.e., to the power of radiation). This conclusion gives a firm ground to consider the radiation reaction as an energetic balance to the radiated by the charges energy in the form of electromagnetic waves (photons).

In a frame of reference in which the velocity of the particle is low, the equation of motion, when we include the radiation reaction, has the form (see equation (8.5))

$$m\mathbf{u} = q\mathbf{E} + (q/c)\mathbf{v}\times\mathbf{B} + (q/c)S\mathbf{v} + (2q^2/3c^3)\mathbf{w}, \tag{39.6}$$

where the first three terms on the right side represent the potential electromagnetic force of the external field and the last term represents the radiation reaction force. This radiation reaction force has the character of "kinetic" force and must be written on the left side of the equation of motion (8.3), so that on the right side of equation (39.6) it figures with opposite sign.

The charge can obtain an acceleration only when an external potential force acts on it. The accelerated charge will radiate photons and the radiation reaction will diminish its acceleration. Therefore the change (positive or negative) of the potential energy which the charge has with the external system will lead to a change in the kinetic energy of the charge (respectively, negative or positive) but will also lead to radiation; this radiation must always be considered as a positive change because the radiated photons have zero potential energy with the external system and carry away only energy. Therefore radiation damping can exist only when the

charge moves in an external field and the radiation reaction force (at $v \ll c$) is always small with respect to the potential electromagnetic force.

If we take time derivative from equation (39.6), then, neglecting the Whittaker force and the term with the super-super-acceleration $\dot{\mathbf{w}}$ as small, we can write the super-acceleration in the following form

$$\mathbf{w} = (q/m)\dot{\mathbf{E}} + (q/mc)\mathbf{u}\times\mathbf{B}. \tag{39.7}$$

Let us consider now the motion of the radiating charge in a frame in which it is at rest, i.e., where $\mathbf{v} = 0$. Now neglecting the radiation reaction force with respect to the potential electromagnetic force, we can write equation (39.6) in this frame as follows

$$\mathbf{u} = (q/m)\mathbf{E}. \tag{39.8}$$

Substituting (39.8) into (39.7), we obtain (in the particular frame in which we now work there is $\mathbf{v} = 0$, but $\mathbf{u} \neq 0$, $\mathbf{w} \neq 0$)

$$\mathbf{w} = (q/m)\dot{\mathbf{E}} + (q^2/m^2c)\mathbf{E}\times\mathbf{B}. \tag{39.9}$$

Thus after the substitution of (39.9) into (39.2), the radiation reaction force can be expressed by the external electric and magnetic intensities as follows

$$\mathbf{f} = -(2q^3/3mc^3)\dot{\mathbf{E}} - (2q^4/3m^2c^4)\mathbf{E}\times\mathbf{B}. \tag{39.10}$$

In Ref. 5 I give the fundamental formulas for the radiation of polyperiodic and aperiodic systems and I consider the higher than zero approximations which lead to quadrupole and magnetic dipole radiations. Then I consider the effects which appear when the velocity of the radiating charge is comparable with light velocity and I give the most detailed calculations of the synchrotron radiation. I analyze also the the radiation damping at $v \to c$ when the radiation reaction force acting on the radiating charge can become larger than the potential electromagnetic force acting on it. One can make all these high-velocity considerations only by the use of the Lorentz invariance (see the end of Sect. 1).

40. GRAVIMAGRETIC WAVES

My mathematical apparatus in electromagnetism and gravimagretism are almost identical. Thus if taking into account the fundamental Newton-Marinov equation (7.11), by analogy with the electric and magnetic intensities (34.24) and (34.25), we can introduce the gravitational and magretic intensities produced by an arbitrarily moving mass m

$$\mathbf{G} = -\gamma m_0\frac{(1 - v'^2/c^2)(\mathbf{n}' - \mathbf{v}'/c)}{r'^2(1 - \mathbf{n}'.\mathbf{v}'/c)^3} - \gamma\frac{m_0}{c^2}\frac{\mathbf{n}'\times\{(\mathbf{n}' - \mathbf{v}'/c)\times\mathbf{u}'\}}{r'(1 - \mathbf{n}'.\mathbf{v}'/c)^3} - \gamma\frac{m_0}{c^3}\mathbf{n}'\times(\mathbf{n}'\times\mathbf{w}'), \tag{40.1}$$

$$\mathbf{B} = \gamma\frac{m_0}{c}\frac{(1 - v'^2/c^2)\mathbf{n}'\times\mathbf{v}'}{r'^2(1 - \mathbf{n}'.\mathbf{v}'/c)^3} - \gamma\frac{m_0}{c^2}\frac{\mathbf{n}'\times[\mathbf{n}'\times\{(\mathbf{n}' - \mathbf{v}'/c)\times\mathbf{u}'\}]}{r'(1 - \mathbf{n}'.\mathbf{v}'/c)^3} + \gamma\frac{m_0}{c^3}\mathbf{n}'\times\mathbf{w}', \tag{40.2}$$

where γ is the gravitational constant, m_0 is the proper mass of the particle and **v'**, **u'**, **w'** are its velocity, acceleration and super-acceleration at the advanced moment $t' = t - r'/c$, t being the observation moment and r' the advanced distance.

The calculation of **G** and **B** can also be done with the retarded elements of motion, according to formulas analogical to (34.26) and (34.27).

I attribute the first terms in the above equations to the potential gravimagretic intensities, $\mathbf{G}_{pot}$, $\mathbf{B}_{pot}$, the second terms to the radiation gravimagretic intensities, $\mathbf{G}_{rad}$, $\mathbf{B}_{rad}$, and the third terms to the radiation reaction gravimagretic intensities $\mathbf{G}_{rea}$, $\mathbf{B}_{rea}$. I call the radiation gravimagretic field also gravimagretic waves. By analogy with the photons, we can introduce the gravitons as quanta of gravimagretic radiation.

The GRAVIMAGRETIC WAVES are extremely feeble and I am sceptical whether their existence can be detected at the present state of experimental technique. As an example I shall calculate the gravitation radiation intensity produced by a mass $m = 9$ g, performing oscillations with an acceleration $u = 10^6$ cm/sec (such is the acceleration of a steel ball falling from 1 m, if after the fall it must make repercussions between two steel surfaces, the distance between which is a little bit bigger than the diameter of the ball), at a distance $r = 6.67$ cm. Using formula (40.1) at the condition $v \ll c$, we obtain for the intensity along the direction of maximum radiation

$$G = \gamma mu/c^2 r = 10^{-22} \text{ cm/sec}^2. \qquad (40.3)$$

This is such a feeble gravitational intensity that there are no methods for its detection.

V. SYSTEMS OF UNITS

41. NATURAL SYSTEMS OF UNITS

A SYSTEM OF UNITS of a science, where the logical apparatus of mathematics is used, represents the totality of the measuring standards (units of measurement) of all fundamental (non-definable) and derivative (definable) quantities which are common in this science.

A MEASURING STANDARD (UNIT OF MEASUREMENT) of a given quantity is such an element, chosen on the grounds of some considerations, which has the same character as the quantity to be measured, i.e., the difference between any particular representative of this quantity and its measuring standard can only be quantitative.

As it follows from my axioms, in physics only three non-definable quantities have been introduced: space, time and energy. I showed that all other physical quantities can be defined by the help of these three.

The three measuring standards for the fundamental physical quantities can be chosen arbitrarily on the grounds of some stipulation. The system of units used by the terrestrial inhabitants, where attributes of the Earth's dimensions and motion are used, cannot be introduced by the inhabitants of other planets. But in nature there exist standards representing universal constants, which can be chosen as measuring standards for the three fundamental quantities, say:

a) the wavelength of a certain spectral line,

b) the half-life of a certain isotope,

c) the value of a certain energetic quantum.

It is expedient to construct systems of units making use of such universal standards for the fundamental physical quantities. However, the choice of "universal" standards is to a great extent arbitrary. Such systems of units were proposed by Planck, Hartree and others.

In my axioms I postulated the existence of four universal constants that represent four fundamental measuring standards:

a) velocity of light,

b) Planck constant,

c) electron mass,

d) electron charge.

It is logical to build our system of units on the basis of these qualitatively different natural standards which are introduced in the axiom directly. As a matter of fact, all these standards have not the character of fundamental physical quantities, length, time and energy, as they are derivative, but it is easy to express the quantities velocity, action, mass and electric charge by the three fundamental quantities.

The unit of measurement E, T, L, i.e., the measuring standards for energy, time and length, are determined by the relations (2.5), (2.4) and (2.1), which I rewrite here in the form

$$E = e = mc^2, \qquad T = h/E = h/mc^2, \qquad L = cT = h/mc. \qquad (41.1)$$

The first of these equalities must be understood as a symbolical one, i.e., if we choose the number m expressing the universal mass of a certain particle arbitrarily, then its universal energy e will have mc^2 energy units, and vice versa, if we choose the number e expressing the universal energy of a certain particle, then its universal mass will have e/c^2 mass units.

Thus, if we take $m = m_e = 1$, $c = 1$, $h = 1$, the measuring standards for energy, time and length are determined, namely, the energy unit will be equal to the universal energy of the electron

$$e_e = m_e c^2, \qquad (41.2)$$

the time unit will be equal to the universal period of the electron

$$\tau_e = h/e_e = h/m_e c^2, \qquad (41.3)$$

and the length unit will be equal to the universal wavelength of the electron (see (2.8))

$$\lambda_e = h/m_e c. \qquad (41.4)$$

When the units for energy and length are established, the gravitational constant is to be established by measuring the gravitational energy of two electrons, the distance between which is equal to unity (see formula (2.9)). Analogically, the electric constant is to be determined by measuring the electric energy of two electrons, the distance between which is equal to unity (see formula (2.11)).

We must note that the electron mass does not represent a universal constant of such a fundamental importance as the electron charge, because all elementary particles have electric charges equal to q_e, $-q_e$ or 0 (see axiom V), while their masses are largely different. From an axiomatical point of view, we can choose the mass of the proton or of another elementary particle as a fourth measuring standard, as it is not possible to decide which elementary particle is the most important in nature. In general, any system of units in which the units of measurement for the fundamental (and thus for all derivative) physical quantities can be expressed with the help of some NATURAL STANDARDS (or of their combination) is called a NATURAL SYSTEM OF UNITS.

42. THE NATURAL SYSTEM OF UNITS CES. THE GAUSS SYSTEM OF UNITS CGS

I call the system of units in which the numerical values for c, h, m_e (or γ) and q_e (or ε_0) are chosen equal to unity the NATURAL SYSTEM OF UNITS CES. The following four types of natural systems of units CES are possible (see the fourth and fifth axioms):

1. When $\gamma = 1$, $m_e^2 = 2.78\times10^{-46}$, the system is of type γ.
2. When $m_e = 1$, $\gamma = 2.78\ 10^{-46}$, the system is of type m_e.
3. When $\varepsilon_0 = 1$, $q_e^2 = 1/861$, the system if of type ε_0.
4. When $q_e = 1$, $\varepsilon_0 = 861$, the system is of type q_e.

From these four systems CES-$\gamma\varepsilon_0$, CES-$m_e\varepsilon_0$, CES-γq_e and CES-$m_e q_e$ I shall only use the system CES-$m_e\varepsilon_0$ which I shall shortly call NATURAL SYSTEM OF UNITS CES.

Thus the numerical values of the universal constants in the system CES (i.e., in the system CES-$m_e\varepsilon_0$) are

$$c = 1, \quad h = 1, \quad \gamma \cong 2.78\ 10^{-46}, \quad m_e = 1, \quad \varepsilon_0 = 1, \quad q_e \cong 3.41\ 10^{-2}. \qquad (42.1)$$

The values of γ and q_e (or of ε_0 if we put $q_e = 1$) are not exact because only the experiment can say what part of the energetic unit represents the gravitational energy, respectively, the electric energy of two electrons separated by a unit distance. The experiment continuously increases the accuracy with which these two constants can be measured, and therefore the numerical values which we ascribe to γ and q_e (i.e., ε_0) will always be approximate.

The units of measurement for the fundamental physical quantities in the natural system CES are called:

a) the unit of length - NATURAL CENTIMETER,
b) the unit of energy - NATURAL ERG,
c) the unit of tim - NATURAL SECOND.

The GAUSS SYSTEM OF UNITS CGS is this one in which the numerical values for c, h, γ, m_e, ε_0, q_e are chosen as follows

$$c = (2.997925 \pm 0.000003)\times10^{10},$$
$$h = (6.62517 \pm 0.00023)\times10^{-27},$$
$$\gamma = (6.670 \pm 0.007)\times10^{-8}$$
$$m_e = (9.1083 \pm 0.0003)\times10^{-28}$$
$$\varepsilon_0 = 1,$$
$$q_e = (4.80298 \pm 0.00009)\times10^{-10}. \qquad (42.2)$$

Here we can say the same as for the figures (42.1). But here we must add the following: In the system CGS first the units for length, time and mass (energy) are determined, and then, on the grounds of these arbitrarily chosen units, the numerical values of the universal constants are calculated. This has led to the result that the universal constants cannot be expressed with such simple and exact numbers as in the system CES. The value of these constants will vary with time, because, first, the standards for the fundamental units can vary (although in the last years mankind has firmly chosen these standards and, probably, will not change them in the future) and, second, the accuracy with which the constants can be measured increases incessantly. For the inexactitude of the universal constants in the system CES only the second cause is valid, and in this system four of the constants (c, h, m_e, ε_0) do not change in time at all. In the system CGS only one constant (ε_0) does not change in time. But in the system CGS the standards for the fundamental unit of measurement (say, the wavelength of a certain particle, its mass and its period), being once firmly chosen for good, do not change in time (i.e., all these standards will always be expressed by the same number), while in the system CES the standards for the fundamental units of measurement will change in time (i.e., the numbers with which these standards are expressed will vary in time).

Thus in both systems of units five elements suffer changes: in the system CGS those are the constants c, h, γ, m_e, q_e, while in the system CES those are the constants γ, q_e and the standards with which the units for length (L), time (T) and energy (E) are materialized.

The units of measurement for the fundamental physical quantities in the Gauss system CGS, called GAUSS UNITS OF MEASUREMENT, are:

a) the unit of length - CENTIMETER,

b) the unit of energy (mass) - ERG (GRAM),

c) the unit of time - SECOND.

We can establish the numerical relations between the units of measurement for the fundamental physical quantities in the systems CES and CGS as follows:

1. To find the relation between the units for energy, we calculate according to formula (2.5) with how many energetic units the universal energy of the electron is expressed in the systems CES and CGS

$$e_e = m_e c^2 = 1 \text{ nat.erg}, \qquad e_e = m_e c^2 = 8.19\times10^{-7} \text{ erg}. \tag{42.3}$$

Thus

$$1 \text{ nat. erg} = 8.19\times10^{-7} \text{ erg}. \qquad (72.4)$$

2. To find the relation between the units for time, we write formula (2.4) in the systems CES and CGS

$$h_n = E_n T_n, \qquad h = ET. \tag{42.5}$$

Dividing the first of these equalities by the second, we obtain

$$T_n = h_n ET/hE_n, \tag{42.6}$$

and using (42.1), (42.2) and (42.4), we get

$$1 \text{ nat. second} = 8.09\times10^{-21} \text{ second} \tag{42.7}$$

3. To find the relation between the units for length, we write formula (2.1) in the systems CES and CGS

$$L_n = c_n T_n, \qquad L = cT. \tag{42.8}$$

Dividing the first of these equalities by the second, we obtain

$$L_n = c_n T_n / cT, \tag{42.9}$$

and using (42.1), (42.2) and (42.7), we get

$$1 \text{ nat. centimeter} = 2.43\times10^{-10} \text{ centimeter}. \tag{42.10}$$

If the relations (42.4), (42.7) and (42.10) between the units for the fundamental physical quantities are given as well as the numerical values of the universal constants in one of the system, we can find the values of the universal constants in the other system.

Let find the numerical values of the universal constants in the system CGS if the mentioned relations and the values of the universal constants in the system CES are given:

1. The numerical value if c can be found using formulas (2.1), (42.7) and (42.10).

2. The numerical value of h can be found using formulas (2.4), (42.4) and (42.7).

3. The numerical value of m_e can be found using formulas (2.5), (42.4) and the numerical values of c in the systems CES and CGS.

4. The numerical value of γ can be found writing formula (2.9) in the form

$$E = \gamma m_e^2/L, \tag{42.11}$$

using formulas (42.4), (42.10), the numerical values of m_e in the systems CES and CGS and the numerical value of γ in the system CES.

5. The numerical value of q_e can be found writing formula (2.11) in the form

$$E = q_e^2/\varepsilon_0 L, \tag{42.12}$$

using formulas (42.47), (42.10), the numerical value of q_e in the system CES and choosing the electric constant in the system CGS equal to unity, as it is also in the system CES.

Theoretically it is more expedient to choose the unit for energy as fundamental unit in the Gauss system and not the unit for mass, as it is commonly accepted. Taking into account (2.5), we conclude that both these approaches are almost identical. In the future, in principle, we shall not make difference between the Gauss systems "centimeter - gram - second" and "centimeter - erg - second". If necessary, we shall denote the first CGS-gr and the second CGS-erg.

We shall call the units of measurement in the system CES by the same names as in the Gauss system CGS, but when speaking we shall pronounce the word "natural" before the respective term, and when writing, as a rule, we shall omit the word "natural" but noting the respective term with a capital letter. For concise writings of the names of the three fundamental units of measurement we shall also use only the letters Cm, E, S. Thus relations (42.4), (42.7) and (42.10) between the units of measurement for the fundamental physical quantities in systems CES and CGS can be written as follows:

$$1 \text{ natural centimeter} = 1 \text{ Cm} = 1 \text{ Cm} = 2.43\times10^{-10} \text{ cm},$$

$$1 \text{ natural erg} = 1 \text{ Erg} = 1 \text{ E} = 8.19\times10^{-7} \text{ erg}.$$

Table 42.1

Physical quantity	Symbol and definition equality	Name CGS: CES: natural	Dimensions CGS	Dimensions CES	Conversion factor 1 unit CES = ... units CGS
		FUNDAMENTAL UNITS			
Length	$r = r$	centimeter	cm	Cm	2.43×10^{-10}
Energy	$e = e$	erg	g cm^2 s^{-2}	E(rg)	8.19×10^{-7}
Time	$t = t$	second	s(ec)	S(ec)	8.09×10^{-21}
		AUXILIARY UNITS			
Area	$s = r^2$	cm^2	cm^2	Cm^2	5.90×10^{-20}
Volume	$V = r^3$	cm^3	cm^3	Cm^3	1.43×10^{-29}
Angle	$\theta = \theta$	radian	-	-	1
		MECHANICAL UNITS			
Frequency	$\nu = 1/t$	hertz	s^{-1}	S^{-1}	1.24×10^{20}
Velocity	$\vec{v} = d\vec{r}/dt$	ces	cm s^{-1}	Cm S^{-1}	3.00×10^{10}
Acceleration	$\vec{u} = d\vec{v}/dt$	gal	cm s^{-2}	Cm S^{-2}	3.71×10^{30}
Super-acceler.	$\vec{w} = d\vec{u}/dt$	supergal	cm s^{-3}	Cm S^{-3}	4.59×10^{50}
Angul. velocity	$\vec{\Omega} = d\vec{\theta}/dt$	ras	s^{-1}	S^{-1}	1.24×10^{20}
Mass	$m = e/c^2$	gram	g	E Cm^{-2} S^2	9.11×10^{-28}
Mass density	$\mu = dm/dV$	gram/cm^3	g cm^{-3}	E Cm^{-5} S^2	6.37×10^{1}
Energy density	$\varepsilon = de/dV$	erg/cm^3	g cm^{-1} s^{-2}	E Cm^{-3}	5.73×10^{22}
Energy flux	$P = de/dt$	erg/sec	g cm^2 s^{-3}	E S^{-1}	1.01×10^{14}
Energy fl. dens.	$\vec{I} = \varepsilon\vec{v}$	erg/cm^{2}sec	g s^{-3}	E Cm^{-2} S^{-1}	1.72×10^{33}
Space momentum	$\vec{p} = de/d\vec{v}$	erg/ces	g cm s^{-1}	E Cm^{-1} S	2.73×10^{-17}
Time momentum	$\bar{p} = e/c$	erg/ces	g cm s^{-1}	E Cm^{-1} S	2.73×10^{-17}
Force	$\vec{f} = d\vec{p}/dt$	dyne	g cm s^{-2}	E Cm^{-1}	3.37×10^{3}
Power	$P = \vec{f}.\vec{v}$	erg/sec	g cm^2 s^{-3}	E S^{-1}	1.01×10^{14}
Angul. momentum	$\vec{I} = \vec{p}\times\vec{r}$	ergsec	g cm^2 s^{-1}	E S	6.62×10^{-27}
Action	$S = e\,t$	ergsec	g cm^2 s^{-1}	E S	6.62×10^{-27}
Inertial moment	$J = m r^2$	gram cm^2	g cm^2	E S^2	5.37×10^{-47}
Force moment	$\vec{M} = \vec{r}\times\vec{f}$	dyne cm	g cm^{2}s^{-2}	E	8.19×10^{-7}

Physical quantity	Symbol and definition equality	Name CGS: CES: natural	Dimensions CGS	Dimensions CES	Conversion factor 1 unit CES = units CGS
		GRAVIMAGRETIC UNITS			
Gravit. potential	$\Phi = -\gamma m/r$	gravpotent	cm^{2}s^{-2}	Cm^{2}S^{-2}	8.99×10^{20}
Gravit. intensity	$\vec{G} = -\mathrm{grad}\Phi$	gravintens	cm s^{-2}	Cm S^{-2}	3.71×10^{30}
Magr. potential	$\vec{A} = -\gamma m\vec{v}/cr$	magrepotent	cm^{2}s^{-2}	Cm^{2}S^{-2}	8.99×10^{20}
Magr. intensity	$\vec{B} = \mathrm{rot}\vec{A}$	magreintens	cm s^{-2}	Cm S^{-2}	3.71×10^{30}
		ELECTROMAGNETIC UNITS			
Electric charge	$q = U r$	abcoulomb	g$^{1/2}$cm$^{3/2}$s^{-1}	E$^{1/2}$Cm$^{1/2}$	1.41×10^{-8}
Charge density	$Q = dq/dV$	abcoul./cm^3	g$^{1/2}$cm$^{-3/2}$s^{-1}	E$^{1/2}$Cm$^{-5/2}$	9.86×10^{20}
Space current	$\vec{j} = q\vec{v}$	abampere cm	g$^{1/2}$cm$^{5/2}$s^{-2}	E$^{1/2}$Cm$^{3/2}$S^{-1}	4.23×10^{2}
Time current	$\bar{j} = q\,c$	abampere cm	g$^{1/2}$cm$^{5/2}$s^{-2}	E$^{1/2}$Cm$^{3/2}$S^{-1}	4.23×10^{2}
Electric current	$I = dq/dt$	abampere	g$^{1/2}$cm$^{3/2}$s^{-2}	E$^{1/2}$Cm$^{1/2}$S^{-1}	1.74×10^{12}
Current density	$\vec{J} = Q\vec{v}$	abampere/cm^2	g$^{1/2}$cm$^{-1/2}$s^{-2}	E$^{1/2}$Cm$^{-3/2}$S^{-1}	2.96×10^{31}
Electr. potential	$\Phi = q/r$	abvolt	g$^{1/2}$cm$^{1/2}$s^{-1}	E$^{1/2}$Cm$^{-1/2}$	5.80×10^{1}
Electr. intensity	$\vec{E} = -\mathrm{grad}\Phi$	abvolt/cm	g$^{1/2}$cm$^{-1/2}$s^{-1}	E$^{1/2}$Cm$^{-3/2}$	2.39×10^{11}
Magn. potential	$\vec{A} = q\vec{v}/cr$	gauss cm	g$^{1/2}$cm$^{1/2}$s^{-1}	E$^{1/2}$Cm$^{-1/2}$	5.80×10^{1}
Magn. intensity	$\vec{B} = \mathrm{rot}\vec{A}$	gauss	g$^{1/2}$cm$^{-1/2}$s^{-1}	E$^{1/2}$Cm$^{-3/2}$	2.39×10^{11}
Magnetic flux	$\Phi = \vec{B}.\vec{s}$	maxwell	g$^{1/2}$cm$^{3/2}$s^{-1}	E$^{1/2}$Cm$^{1/2}$	1.41×10^{-8}
El. dipole moment	$\vec{d} = q\vec{r}$	abcoul. cm	g$^{1/2}$cm$^{5/2}$s^{-1}	E$^{1/2}$Cm$^{3/2}$	3.43×10^{-18}
Magn. dip. moment	$\vec{m} = \vec{r}\times\vec{j}/2c$	abcoul. cm	g$^{1/2}$cm$^{5/2}$s^{-1}	E$^{1/2}$Cm$^{3/2}$	3.43×10^{-18}

$$1 \text{ natural second} = 1\ \text{Sec} = 1\ \text{S} = 8.09\times10^{-21}\ \text{s}. \qquad (42.13)$$

We see that the name of the system CES is constituted from the first letters of the units of measurement for the fundamental physical quantities length, energy and time.

The name of the system CGS is constituted from the first letters of the units of measurement for the fundamental quantities length, mass and time.

All formulas in the first four chapters of this book are written in the system CGS. If we put the fundamental constants c and h equal to untity, we obtain all formulas in the system CES.

Since the standard for mass as gravitational charge of the particle and the standard for mass as a measure of its time energy are one and the same quantity, the dimensions of the mass obtained with the help of the time energy (see formula (2.5)) determine the dimensions of the gravitational constant γ (see formula (2.9)).

This is not the case with the dimensions of the electric charge and the electric constant ε_0. If we choose the electric constant dimensionless (as we do in the systems CES and CGS), then the dimensions of the electric charge are established by the dimensions of the fundamental physical quantities. If we appropriate the dimensions of a fundamental (fourth) physical quantity to the electric charge (as we do in the system SI - see Sect. 43), then the electric constant will obtain definite dimensions. We must note that whether one chooses the electric constant dimensionless or not is only a question of taste (the choice of the electric constant with dimensions is an indication of bad taste!).

In table 42.1 I give the names and the dimensions of the units of measurement of the most important physical quantities in the systems CGS and CES. The physical quantities are fundamental (primary), auxiliary (which can be considered as fundamental) and derivative (secondary). Of the derivative physical quantities (mechanical, gravimagretic and electromagnetic) I give only these which are mainly used in this book. In the table I give also the connections which exist between the units of measurement in the systems CES and CGS. The dimensions of the physical quantities in the system CGS-erg are the same as in the system CES, only instead of the natural Cm, E, S, one must write the "normal" cm, erg, sec.

It is easy to see that if we assume the definition equalities in the second column as given, we can find the conversion factors between the units of measurement of all derivative physical quantities by making use only of the conversion factors between the fundamental physical quantities.

In table 42.2 the values and dimensions of the universal constants are given.

Table 42.2

Universal constant	Symbol	Dimensions CGS	Dimensions CES	Numerical value CGS	Numerical value CES
Velocity of light	c	$cm\ s^{-1}$	$Cm\ S^{-1}$	3.00×10^{10}	1
Planck constant	h	$g\ cm^2 s^{-1}$	E S	6.62×10^{-27}	1
Gravit. constant	γ	$g^{-1} cm^3 s^{-2}$	$E^{-1} Cm^5 S^{-4}$	6.67×10^{-8}	2.78×10^{-46}
Electron mass	m_e	g	$E\ Cm^{-2} S^2$	9.11×10^{-28}	1
Electric constant	ε_o	-	-	1	1
Electron charge	q_e	$g^{1/2} cm^{3/2} s^{-1}$	$E^{1/2} Cm^{1/2}$	4.80×10^{-10}	3.41×10^{-2}

43. SYSTEM OF UNITS SI

The systems of units CGS and CES are of common use in theoretical physics. In the last time, however, the RATIONALIZED SYSTEM OF UNITS MKSA (meter-kilogram-second-ampère) which was used first in the engineering sciences is used also in theoretical physics. It is also called the INTERNATIONAL SYSTEM OF UNITS (or SYSTEM SI) and one introduces it worldwide as the only system to be used. I am definitely against the use of the system SI in theoretical physics, and I write my theoretical papers and books in the system CGS (see the preface).

In the system MKSA (or SI) meter, kilogram (joule for energy) and second are chosen as units of measurement for the fundamental physical quantities. The relations between the units of measurement for the fundamental physical quantities in the systems MKSA (or SI) and CGS are:

$$1\ m = 100\ cm,$$

$$1\ kg = 1000\ g \quad (\text{or } 1\ \text{joule} = 10^7\ \text{erg}),$$

$$1\ s = 1\ s. \tag{43.1}$$

For the universal constants c, h and γ in the system SI we obtain

$$c = 3.00\times10^8\ m\ s^{-1},$$

$$h = 6.62\times10^{-34}\ kg\ m^2\ s^{-1},$$

$$\gamma = 6.67\times10^{-11}\ kg^{-1}\ m^3\ s^{-2}. \tag{43.2}$$

With the aim of avoiding the fractional powers in the dimensions of the electromagnetic quantities in the system SI, the unit for electric charge is introduced as a fourth fundamental unit of measurement (in one line with the meter, kiligram and second) and is called COULOMB (denoted by C). Some prefer to consider $A = C\ s^{-1}$, called AMPERE, as the fourth fundamental unit and for this reason the system is called MKSA. This is again a bad taste. Although now in the system SI the ampere is sanctioned as the fourth fundamental quantity, I shall consider here the coulomb as such a one, as this consideration is more "didactic".

Besides, with the aim of obtaining most formulas used in electro-engineering practice in a simpler form (to avoid factors 2π and 4π appearing in situations not involving circular or spherical symmetry, respectively), we work in system SI not with formula (2.11) but with $U_e = q_1 q_2/4\pi\varepsilon_0 r$ and the numerical value of the electric constant is chosen

$$\varepsilon_o = \frac{10^7}{4\pi c^2} = \frac{1}{36\pi 10^9}\ C^2 kg^{-1}\ m^{-3}\ s^2. \tag{43.3}$$

One can easily see that if the electric charge is considered as a fourth fundamental physical quantity, the electric constant obtains the dimensions indicated in formula (43.3).

The relation between the electric and magnetic constants can be taken either in the form $\varepsilon_o\mu_o = 1$ or in the form $\varepsilon_o\mu_o = c^{-2}$. In the Gauss system CGS the first form is chosen. If we choose the second form, assuming $\varepsilon_o = 1$, we obtain the so-called ELECTROSTATIC CGS SYSTEM OF UNITS (or SYSTEM CGSe), where all units of the electric quantities are the same as in the system CGS, but the units for the magnetic quantities are different, and the magnetic constant obtains the numerical value

$$\mu_o = (1/9)10^{-20}\ cm^{-2}\ sec^2, \qquad (43.4)$$

with the dimensions written on the right side.

If we choose the second form, assuming $\mu_o = 1$, we obtain the so-called ELECTROMAGNETIC CGS SYSTEM OF UNITS (or SYSTEM CGSm), where all units for the magnetic quantities are the same as in the system CGS, but the units for the electric quantities are different, and the electric constant obtains the numerical value

$$\varepsilon_o = (1/9)10^{-20}\ cm^{-2}\ sec^2, \qquad (43.5)$$

with the dimensions written on the right side.

In the system SI the connection between the electric and magnetic constants is taken in the form $\varepsilon_o\mu_o = c^{-2}$; thus, the numerical value of the magnetic constant in the system SI is

$$\mu_o = 4\pi 10^{-7}\ C^{-2}\ kg\ m. \qquad (43.6)$$

Now we shall find the value of the electron charge in the system SI. Dividing formula (2.11) by the formula

$$U_e = q_1 q_2 / 4\pi\varepsilon_o r, \qquad (43.7)$$

which is the Coulomb law in the system SI, we obtain, putting $q_1 = q_2 = q_e$,

$$q_e = q_e'\left(4\pi \frac{\varepsilon_o U_e r}{\varepsilon_o' U_e' r'}\right)^{1/2}, \qquad (43.8)$$

where the unprimed quantities are in the system SI and the primed quantities are in the system CGS. Substituting ε_o from (43.3), putting $\varepsilon_o' = 1$, $q_e' = 4.80\times10^{-10}$, and taking from (43.1) the conversion factors between the units of measurement for energy and length, we obtain the numerical value of the electron charge in the system SI

$$q_e = 1.6\times10^{-19}\ C. \qquad (43.9)$$

From here and from table 42.2 we obtain the connection between the units of measurement for electric charge in the systems SI and CGS

$$1\ \text{Coulomb} = 3\times10^9\ \text{abcoulomb}. \qquad (43.10)$$

Let us note (see table 42.1) that the names of the electric quantities in the system CGS are obtained putting "ab" before the corresponding name in the system SI, as the Gauss system of units CGS is called also ABSOLUTE SYSTEM OF UNITS; the magnetic quantities in the system CGS have their proper names.

The names and dimensions of the units of measurement for the most important physical quantities in the system SI, and their relationship to the corresponding units of mesurement in the system CGS are given in table 43.1.

Concerning table 43.1 the following is to be noted:

The conversion factors between the units of measurement in the systems SI and

Table 43.1

Physical quantity	Symbol and definition equality	Name and symbol of the unit		Dimensions	Corr. factor	Conv. factor 1 unit SI = ... units CGS
		FUNDAMENTAL UNITS				
Length	$r = r$	meter	m	m		10^2
Mass	$m = m$	kilogram	kg	kg		10^3
Time	$t = t$	second	s	s		1
		MECHANICAL UNITS				
Velocity	$\vec{v} = d\vec{r}/dt$	mes	m/s	$m\ s^{-1}$		10^2
Energy	$e = mc^2$	joule	J	$kg\ m^2 s^{-2}$		10^7
Force	$\vec{f} = md\vec{v}/dt$	newton	N	$kg\ m\ s^{-2}$		10^5
Power	$P = \vec{f}.\vec{v}$	watt	W	$kg\ m^2 s^{-3}$		10^7
		ELECTROMAGNETIC UNITS				
Electric charge	$q = q$	coulomb	C	C		3×10^9
Space current	$\vec{j} = q\vec{v}$	ampere m	A m	$C\ m\ s^{-1}$		3×10^{11}
Time current	$\vec{j} = qc$	ampere m	A m	$C\ m\ s^{-1}$		3×10^{11}
Charge density	$Q = dq/dV$	coulomb/m^3	C/m^3	$C\ m^{-3}$		3×10^3
Electric current	$I = dq/dt$	ampere	A	$C\ s^{-1}$		3×10^9
Current density	$\vec{J} = Q\vec{v}$	ampere/m^2	A/m^2	$C\ m^{-2}s^{-1}$		3×10^5
Electr. potential	$\Phi = q/4\pi\varepsilon_o r$	volt	V	$C^{-1}kg\ m^2 s^{-2}$		$(1/3)10^{-2}$
Electr. intensity	$\vec{E} = -\text{grad}\Phi$	volt/m	V/m	$C^{-1}kg\ m\ s^{-2}$		$(1/3)10^{-4}$
Magnetic potential	$\vec{A} = \mu_o q\vec{v}/4\pi r$	tesla m	T m	$C^{-1}kg\ m\ s^{-1}$	c	10^6
Magnetic intensity	$\vec{B} = \text{rot}\vec{A}$	tesla	T	$C^{-1}kg\ s^{-1}$	c	10^4
Magnetic flux	$\Phi = \vec{B}.\vec{s}$	weber	Wb	$C^{-1}kgm^2 s^{-1}$	c	10^8
El. dipole moment	$\vec{d} = q\vec{r}$	coulomb m	C m	$C\ m$		3×10^{11}
Magn. dipole moment	$\vec{m} = \vec{r}\times\vec{J}/2$	ampere m^2	A m^2	$C\ m^2\ s^{-1}$	c	9×10^{23}

CGS can be obtained if in the dimensions of the corresponding unit of measurement in the system SI we substitute the conversion factors for the fundamental physical quantities (relations (43.1) and (43.10)). When calculating the conversion factors for the magnetic units of measurement, we must take into account the corresponding correction factor c (the fifth column in table 43.1) appearing as a result of the fact that the system CGS is built proceeding from the relation $\varepsilon_0 = 1/\mu_0$, while the system SI is built proceeding from the relation $\varepsilon_0 = 1/c^2\mu_0$.

If the magnetic potential in the Gauss system would be defined not in the form given in table 42.1 but in the following form

$$A = qv/c^2 r, \tag{43.11}$$

then we had not to take into account the correction factor. At such a definition of A, c in the denominators of many formulas in the Gauss system would disappear and the formulas would look much more similar to the formulas in the system SI.

Furthermore we have to note that the number 3 appearing in some conversion factors is to be substituted in more precise calculations by 2.99793 (see the transition between formulas (43.8), (43.9) and (43.10)).

With the help of table 43.2 we can make the transition from a formula written in

Table43.2

Physical quantity	System CGS	System SI
Velocity of light	c	$(\varepsilon_0\mu_0)^{-1/2}$
Electric charge	q	q
Electric charge density	Q	Q
Space current	$\vec{j}$	$\vec{j}$
Time current	$\vec{J}$	$(4\pi\varepsilon_0)^{-1/2}\times$ $\vec{J}$
Electric current	I	I
Electric current density	$\vec{J}$	$\vec{J}$
Electric dipole moment	$\vec{d}$	$\vec{d}$
Magnetic dipole moment	$\vec{m}$	$(\mu_0/4\pi)^{1/2}$ $\vec{m}$
Electric potential	Φ	Φ
Electric intensity	$\vec{E}$	$(4\pi\varepsilon_0)^{1/2}\times$ $\vec{E}$
Magnetic potential	$\vec{A}$	$\vec{A}$
Magnetic intensity	$\vec{B}$	$(4\pi/\mu_0)^{1/2}\times$ $\vec{B}$
Magnetic flux	Φ	Φ

the system CGS to the corresponding formula written in the system SI, and vice versa. To make this transition, it is necessary to substitute all quantities in the formula written in the system CGS (see column "system CGS") by the corresponding quantities taken with the attached coefficient from the column "system SI". For the inverse transition (from a formula written in the system SI to obtain the formula written in the system CGS) we have to transfer the coefficients from the column "system SI" to the corresponding quantities in the column "system CGS", according to the rules of proportion, and to proceed analogically as above.

Table 43.2 is obtained in the following way:

1. The connection between the constant c in the system CGS and the constants ε_0, μ_0 in the system SI is found on the grounds of the fundamental relation $\varepsilon_0\mu_0 = 1/c^2$.

2. The conversion factor for the electric charge is to be found from the relations

$$U_e = \frac{q^2}{4\pi\varepsilon_0 r}, \qquad U'_e = \frac{q'^2}{r}, \tag{43.12}$$

where the first relation is written in the system SI and the second in the system CGS, so that

$$q' = \frac{q}{(4\pi\varepsilon_0)^{1/2}}. \tag{43.13}$$

3. All other conversion factors are obtained on the grounds of the dimensions of the corresponding quantity in the system SI (see table 43.1), where the meter, kilogram and second are to be taken without any corrective multiplier, and only the coulomb is to be taken according to the relation (43.13).

In the SI system the electric displacement D and the magnetic intensity H in vacuum are expressed through the electric intensity E and the magnetic induction B (which, I repeat, I call "magnetic intensity", as B and H have exactly the same physical character!) not according to formula (20.2) and (20.8), with $\varepsilon = 1$, $\mu = 1$ (as we do in the system CGS) but according to the formulas $D = \varepsilon_0 E$, $H = (1/\mu_0)B$, and as ε_0 and μ_0 in the system SI are quantities with dimensions (see (43.3) and (43.6)), D and H have dimensions different from E and B. The name of the SI unit of D is coulomb/m^2 and the symbol and the dimensions are C m^{-2}. The name of the SI unit of H is ampere/m, the symbol is A/m and the dimensions are C s^{-1}m^{-1}.

If some quantity is not included in table 43.2, in order to find the conversion factor, the quantity is to be presented by some of the indicated quantities. So we shall have:

For resistance, $R = U/I = \Phi/I$, the conversion factor is $4\pi\varepsilon_0$.

For capacitance, $C = q/U = q/\Phi$, the conversion factor is $1/4\pi\varepsilon_0$.

For inductance, $L = \Phi/I$, the conversion factor is $4\pi(\varepsilon_0/\mu_0)^{1/2}$.

The following prefixes should be used to indicate decimal fractions or multiples of a unity:

Table 43.3

Name	Value	Symbol	Name	Value	Symbol
deci	10^{-1}	d	deca	10^{1}	da
centi	10^{-2}	c	hecto	10^{2}	h
milli	10^{-3}	m	kilo	10^{3}	k
micro	10^{-6}	μ	mega	10^{6}	M
nano	10^{-9}	n	giga	10^{9}	G
pico	10^{-12}	p	tera	10^{12}	T
femto	10^{-15}	f	peta	10^{15}	P
atto	10^{-18}	a	exa	10^{18}	E

All formulas in Chapter VI, which is dedicated only to experiments, will be written in the system SI, with the exception of Sect. 46.2 which has important theoretical character and thus this Subsection is written in the Gauss system.

VI. EXPERIMENTAL VERIFICATIONS

44. THE COUPLED SHUTTERS EXPERIMENT

44.1. INTRODUCTION.

The first experimental verification of the theory presented in the preceding chapters will be my "coupled shutters" experiment for measurement of the Earth's absolute velocity in a laboratory.

This was my third optical measurement of the Earth's absolute velocity. For a first time I measured this velocity with my DEVIATIVE "COUPLED MIRRORS" EXPERIMENT in 1973[1] and for a second time with my INTERFEROMETRIC "COUPLED MIRRORS" EXPERIMENT in 1975/76.[4] With this second experiment which was carried out during a year I could register the absolute motion of the Sun.

I give here only the report on my "coupled shutters" experiment.

The COUPLED SHUTTERS EXPERIMENT was carried out for a first time in 1979 in Brussels[24]. The accuracy achieved with this first experiment was not sufficient for registering the Earth's absolute velocity. Thus with its help I could only establish that this velocity was not larger than 3,000 km/sec. The "coupled shutters" experiment is relatively very simple and cheap[24], however no scientist in the world has repeated it. The general opinion expressed in numerous letters to me, in referees' comments on my papers, and in speeches on different space-time conferences which I visited or organized[25] is that my experiments are very sophisticated and difficult for execution. The only discussion in the press on the technical aspects of my experiments is made by Chambers.[26] Here I should like to cite the comments of my anonymous FOUNDATIONS OF PHYSICS referee sent to me by the editor, Prof. van der Merwe, on the 23 June 1983:

> I was informed by (the name deleted) of the Department of the Air Force, Air Force Office of Scientific research, Bolling Air Force Base, that Dr. Marinov's experiments were to be repeated by the Joint Institute for Laboratory Astrophysics. On inquiry, I learnt that JILA is not carrying out the experiments, because preliminary engineering studies had indicated that it lay beyond the expertise of the laboratory to achieve the mechanical tolerances needed to ensure a valid result.

After presenting my objections that the fact that JILA in the USA is unable to repeat my experiments cannot be considered as a ground for the rejection of my papers dedicated not at all to measurement of absolute velocity, Prof. van der Merwe sent me on the 24 January 1984 the following "second report" of the same referee:

> It is with regret that I cannot change my recommandation regarding Dr. Marinov's papers. In trying to justify the validity of his experimental

work, Dr. Marinov highlights the points which cause the rest of the community so much concern. He states, "If I in a second-hand workshop in a fortnight for $ 500 achieve the necessary accuracy, then, I suppose, JILA can achieve it too." I know of no one in the precision measurement community who believes that measurements of the quality claimed by Dr. Marinov could be realized under such conditions and in so short a time. It will take very much more than this to change the direction of physics. I suspect that even scientists working in the most reputable laboratories in the U.S. or the world, would encounter great opposition in attempting to publish results as revolutionary as those claimed by Dr. Marinov.

In this paper I present the account on the measurement of the laboratory's absolute velocity, executed by me in Graz with the help of a new construction of my "coupled shutters" experiment. Now the apparatus was built not in seven days but in four. As the work was "black" (a mechanician in a university workshop did it after the working hours and I paid him "in the hand"), the apparatus was built predomenantly at the week-end and cost 12,000 Shillings. The driving motor was taken from an old washing-machine and cost nothing.

As no scientific laboratory was inclined to offer me hospitality and possibility to use a laser source and laboratory mirrors, my first intention was to use as a light source the sun. As I earn my bread and money for continuing the scientific research working as a groom and sleeping in a stall in a small village near Graz, I carried out the experiment in the appartment of my girl-friend. The sensitivity which I obtained with sun's light (a perfect source of homogeneous parallel light) was good, but there were two inconveniences: 1) The motion of the sun is considerable during the time when one makes the reversal of the axle and one cannot be sure whether the observed effect is due to the delay times of the light pulses or to the Sun's motion. 2) One can perform measurements only for a couple of hours about noon and thus there is no possibility to obtain a 24-hours "sinusoid" (see further the paper for explanation of the measuring procedure). On the other hand, at fast rotation of the axle the holed rotating disks became two sirens, so that when my apparatus began to whistle the neighbours knocked on the door, asking in dismay: "Fliegt schon der Russe über Wien?" (Is Ivan over Vienna flying?). After a couple of altercations, my girl-friend threw away from her appartment not only my apparatus but also me.

Later, however, I found a possibility to execute the experiment in a laboratory (fig. 18). The scheme of the experiment, its theoretical background and measuring procedure are exactly the same as of the Brussels variation[24]. Since the description is extremely simple and short, I shall give it also here, noting that the mounting of the laser and of the mirrors on the laboratory table lasted two hours.

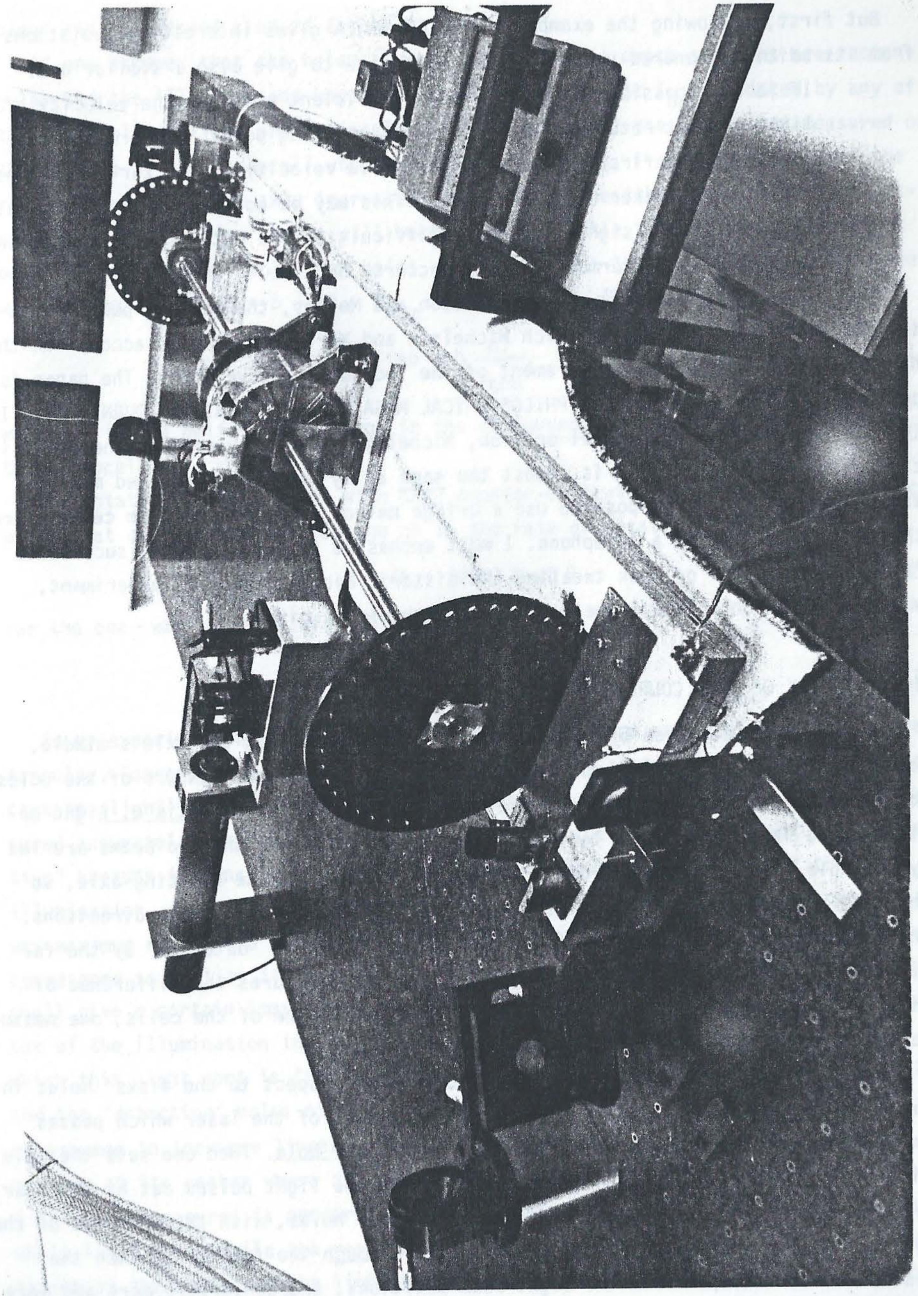

Fig. 18. The "coupled shutters" experiment.

But first, following the example of NATURE which gives interesting quotations from its editions hundred years ago, I should like to give also a similar one:

> If it were possible to measure with sufficient accuracy the velocity of light without returning the ray to its starting point, the problem of measuring the first power of the relative velocity of the Earth with respect to the aether would be solved. This may be not as hopeless as might appear at first sight, since the difficulties are entirely mechanical and may possibly be surmounted in the course of time.

The names of the authors are Michelson and Morley, the year of publication is 1887. This is the paper in which Michelson and Morley give their account on the historical experiment for "measurement" of the two-way light velocity. The paper is published in two journals: THE PHILOSOPHICAL MAGAZINE and AMERICAN JOURNAL OF SCIENCE. After giving this general opinion, Michelson and Morley present the proposition of an experiment which is almost the same as my deviative "coupled mirrors" experiment.(1) They propose to use a bridge method with two selenium cells where the null instrument is a telephone. I must emphasize that I could not succeed to find a single paper or book treating the historic Michelson-Morley experiment, where information on their one-way proposal should be given.

44.2. THEORY OF THE COUPLED SHUTTERS EXPERIMENT.

A rotating axle driven by an electromotor, put exactly at the axle's middle, has two holed disks at its extremities. The distance from the centers of the holes to the center of the axle is R and the distance between the disks is d. Light coming from a laser is divided by a semitransparent prism and the two beams are led by a couple of adjustable mirrors to the opposite ends of the rotating axle, so that the beams can fly through the disks' holes in mutually opposite directions. Any of the beams, after being chopped by the near disk and "detected" by the far disk, illuminates a photocell. By a galvanometer one measures the difference of the currents generated by both photocells. If covering one of the cells, one measures the current produced by the other cell.

One arranges the position of the laser beam with respect to the disks' holes in such a manner that when the axle is at rest the light of the laser which passes through the near hole illuminates the half of the far hole. Then one sets the axle in rotation gradually increasing its speed. Since the light pulses cut by the near holes have a transit time in order to reach the far holes, with the increase of the rate of rotation less and less light will pass through the far holes, when the distant holes "escape" from the light beam positions, and, conversely, more and more light will pass through the far holes, when the distant holes "enter" into the light beam positions. For brevity I shall call the first kind of far holes "escaping" and the second kind of far holes "entering".

If one assumes that the holes as well as the beams' cross-sections are rectangular and the illuminations homogeneous, then the current I_{hom} produced by any of the photocells will be proportional to the breadth b of the light spot measured on the surface of the photocell when the axle is rotating, i.e., $I_{hom} \sim b$. When the rotational rate of the axle increases with ΔN, the breadth of the light beam passing through "escaping" holes will become $b - \Delta b$, while the breadth of the light beam passing through "entering" holes will become $b + \Delta b$, and the produced currents will become $I_{hom} - \Delta I \sim b - \Delta b$, $I_{hom} + \Delta I \sim b + \Delta b$. Thus

$$\Delta b = b \frac{\Delta I}{I_{hom}}, \qquad (44.1)$$

where ΔI is the half of the change in the difference of the currents produced by the photocells.

One rotates the axle first with $\Delta N/2$ counter-clockwise and then with $\Delta N/2$ clockwise, that corresponds to a change ΔN in the rate of rotation. Since

$$\Delta b = (d/c)\, 2\pi\, \Delta N\, R\,, \qquad (44.2)$$

for the one-way velocity of light one obtains

$$c = \frac{2\pi\, \Delta N\, R\, d}{b} \frac{I_{hom}}{\Delta I}. \qquad (44.3)$$

In my experiment the holes as well as the light beams were circular and not rectangular. Consequently instead of the measured light spot's breadth one has to take certain slightly different "effective" breadth. As the breadth b can never be measured accurately, the discussion of the difference between real breadth and "effective" breadth is senseless. Much more important, however, was the fact that the illumination in the beams' cross-sections was not homogeneous: at the center it was maximum and at the periphery minimum. Thus the simplified relation (44.1) did not correspond to reality if under I_{hom} one would understand the measured current. I shall give a certain improvement of formula (44.1), taking into account the character of the illumination intensity over the light spot and the speciphic way in which this light spot is "projected" across the "chopping" holes of the near disk and the "detecting" holes of the far disk. At this consideration the illumination will be assumed to increase linearly from zero on the periphery of the light beam to a maximum at its center where the beam is "cut" by the holes' rims. The real current I which one measures is proportional to a certain middle illumination across the whole light beam, while the real current ΔI is proportional to the maximum illumination at the center of the light beam. On the other hand, one must take into account that when the holes let the light beam fall on the photocell, first light comes from the peripheral parts and at the end from the central parts. When the half of the beam has illuminated the photocell, the "left" part of the beam begins to disappear and its "right" part begins to appear, the breadth remaining always the half of the beam. Then the holes' rims begin to extinguish first the central parts of the beam and at the end the peripheral parts. Here, for simplicity, I suppose that the cross-sections of the beams and of the holes are the same (in reality the former were smaller than the latter). Thus during the first one-third of the time of illumination the "left" half of the light beam appears, during the second one-third of the time of illumination the "left" half goes over to the "right" half, and during the last one-third of the time of illumination the "right" half disappears. Consequently, the real current, I, produced by the photocell will be related with the idealized current, I_{hom}, corresponding to a homogeneous illumination with the central intensity and generated by a light spot having the half-breadth of the measured one, by the following connection

$$I = \frac{1}{2}\int_0^1 I_{hom}\, x\left(\frac{2}{3} - \frac{x}{3}\right) dx = \frac{I_{hom}}{6}\left(x^2 - \frac{x^3}{3}\right)\Big|_0^1 = \frac{I_{hom}}{9}. \quad (44.4)$$

In this formula $I_{hom}\, x\, dx$ is the current produced by a strip with breadth dx of the light beam; at the periphery of the beam (where x = 0) the produced current is zero and at the center (where x = 1) it is $I_{hom} dx$. The current $I_{hom}\, x\, dx$ is produced (i.e., the corresponding photons strike the photocell) during time 2/3 - x/3; for the periphery of the beam this time is 2/3 - 0/3 = 2/3 and for the center of the beam this time is 2/3 - 1/3 = 1/3. The factor 1/2 before the integral is taken because the measured breadth of the light spot over the photocell is twice its working breadth. Putting (44.4) into (44.3), one obtains

$$c = \frac{2\pi\,\Delta N\, R\, d}{b}\,\frac{9\,I}{\Delta I}. \quad (44.5)$$

According to my absolute space-time theory [3,5] (and according to everybody who is acquainted even superficially with the experimental evidence accumulated by humanity), if the absolute velocity's component of the laboratory along the direction of light propagation is v, then the velocity of light is c - v along the propagation direction and c + v against. For these two cases formula (44.5) is to be replaced by the following two

$$c - v = \frac{2\pi\,\Delta N\, R\, d}{b}\,\frac{9\,I}{\Delta I + \delta I}, \qquad c + v = \frac{2\pi\,\Delta N\, R\, d}{b}\,\frac{9\,I}{\Delta I - \delta I}, \quad (44.6)$$

where $\Delta I + \delta I$ and $\Delta I - \delta I$ are the changes of the currents generated by the photocells when the rate of rotation changes by ΔN. Dividing the second formula (44.6) by the first one, one obtains

$$v = (\delta I/\Delta I)\, c. \quad (44.7)$$

Thus the measuring method consists in the following: One changes the rotational rate with ΔN and one measures the change in the current of any of the photocells which is $\Delta I \cong \Delta I \pm \delta I$; then one measures the difference of these two changes which

is $2\,\delta I$. I made both these measurements by a differential method with the same galvanometer, applying to it the difference of the outputs of both photocells. To measure $2\Delta I$ I made the far holes for one of the beam "escaping" and for the other "entering". To measure $2\,\delta I$ I made all far holes "escaping" (or all "entering").

44.3. MEASUREMENT OF c.

In the Graz variation of my "coupled-shutters" experiment I had: d = 120 cm, R = 12 cm. The light source was an Ar laser, the photocells were silicon photocollectors, and the measuring instrument was an Austrian "Norma" galvanometer. I measured I = 21 mA (i.e., I_{hom} = 189 mA) at a rotational rate of 200 rev/sec. Changing the rotation from clockwise to counter-clockwise, i.e., with ΔN = 400 rev/sec, I measured ΔI = 52.5 μA (i.e., the measured change in the difference current at "escaping" and "entering" far holes was $2\Delta I$ = 105 μA). I evaluated a breadth of the light spot b = 4.3 ± 0.9 mm and thus I obtained $c = (3.0 \pm 0.6)\times 10^8$ m/sec, where as error is taken only the error in the estimation of b, because the "weights" of the errors introduced by the measurement of d, R, ΔN, I, ΔI were much smaller. I repeat, the breadth b cannot be measured exactly as the peripheries of the light spot are not sharp. As a matter of fact, I chose such a breadth in the possible incertainty range of ±1 mm, so that the exact value of c to be obtained. I wish once more to emphasize that the theory for the measurement of c is built on the assumption of rectangular holes and light beams cross-sections and linear increase of the illumination from the periphery to the center. These simplified assumptions do not correspond to the more complicated real situation. Let me state clearly: The "coupled shutters" experiment is not to be used for an exact measurement of c. It is, however, to be used for an enough exact measurement of the variations of c due to the absolute velocity of the laboratory when during the different hours of the day the axis of the apparatus takes different orientations in absolute space due to the daily rotation of the Earth (or if one will be able to put the set-up on a rotating platform). The reader will see this now.

44.4. MEASUREMENT OF v.

The measurement of c is an absolute, while the measurement of v is a relative, taking the velocity of light c as known. According to formula (44.7) one has to measure only two difference currents: $2\Delta I$ (at "escaping" and "entering" far holes) and $2\delta I$ (at "escaping" or "entering" far holes). The measurement in the air of the laboratory had two important inconveniences: 1) The dust in the air led to very big fluctuations in the measured current differences and I had to use a big condenser in parallel to the galvanometer's entrance, making the apparatus very sluggish. 2) The shrill of the holed disks at high rotational rate could lead to the same gloomy result as when executing the experiment in the appartment of my girl-friend. Thus I covered the whole set-up with a metal cover and evacuated the air by an oil pump (this amelioration cost additional 9,000 Shilling). The performance of the experiment in vacuum has also this advantage that the people who wish to save at any price the wrong light velocity constancy dogma cannot raise the objection that the observed effect is due to temperature disturbances.

The measurement of ΔI is a simple problem as the effect is huge. Moreover all existing physical schools cannot raise objections against the presented above theory. However, the measurement of δI which is with three orders lower than ΔI has certain peculiarities which must be well understood. When changing the rotation from clockwise to counter-clockwise, the current produced by the one photocell changes, say, from I_1 to $I_1 + \Delta I_1 + \delta I_1$ and of the other photocell from, say, I_2 to $I_2 + \Delta I_2 - \delta I_2$. One makes I_1 to be equal to I_2 changing the light beam positions by manipulating the reflecting mirrors micrometrically. One can difficultly receive an exact compensation, so that the galvanometer shows certain residual current I'. The current change ΔI_1 will be equal to the current change ΔI_2 only if the experiment is entirely symmetric. But it is difficult to achieve a complete symmetry (and, of course, I could not achieve it in my experiment). There are the following disturbances: On the one hand, the distribution of the light intensities in the cross-sections of both beams and the forms of the beams are not exactly the same; thus the covering of the same geometrical parts of both beams when changing the rotation of the axle does not lead to equal changes in the light intensities of both beams and, consequently, to $\Delta I_1 = \Delta I_2$. On the other hand, although the photocells were taken from a unique sun collector cut in two pieces, even if the changes in the illuminations should be equal, the produced currents may become different (the current gain at the different points of the photocells is not the same, the internal resistances of the cells are not equal, etc. etc). Thus after changing the rotational rate from clockwise to counter-clockwise, I measured certain current I", but I" - I' was not equal to $2\delta I$, as it must be for an entirely symmetric set-up. However, measuring the difference I" - I' during different hours of the day, I established that it was "sinusoidally modulated". This "sinusoidal modulation" was due to the absolute velocity v. All critics of my "rotating axle" experiments vociferate at the most against the vibrations of the axle, affirming that these vibrations will mar the whole measurement. Meanwhile the axle caused me absolutely no troubles. When measuring in vacuum the axis of the apparatus pointed north/south.

I measured the "sinusoidal modulation" during 5 days, from the 9th to the 13th February 1984. As I did the experiment alone, I could not cover all 24 hours of every day. The results of the measurements are presented in fig.19. The most sensible scale unit of the galvanometer was 10 nA and the fluctuations were never

bigger than 20 nA. The day hours are taken on the abscissa and the current differences on the left ordinate. After plotting the registered values of I" - I' and drawing the best fit curve, the "null line" (i.e., the abscissa) is drawn at such a "height" that the curve has to cut equal parts of the abscissa (of 12 hours any). Then on the right ordinate the current $2\delta I$ is taken positive upwards from the null line and negative downwards. Since 105 μA correspond to a velocity 300,000 km/sec, 10 nA will correspond approximately to 30 km/sec. Considering the fluctuations of the galvanometer as a unique source of errors, I took ± 30 km/sec as the uncertainty error in the measurement of v.

When $2\delta I$ has maximum or minimum the Earth's absolute velocity lies in the plane of the laboratory's meridian (fig.20). The velocity components pointing to the north are taken positive and those pointing to the south negative. I note by v_a always this component whose algebraic value is smaller. When both light beams pass through "escaping" holes, then, in the case that the absolute velocity component points to the north, the "north" photocell produces less current than the "south" photocell (with respect to the case when the absolute velocity component is perpendicular to the axis of the apparatus), while, in the case that the absolute velocity component points to the south, the "north" photocell produces more current. If the light beams pass through "entering" holes, all is vice versa. Let me note that for the case shown

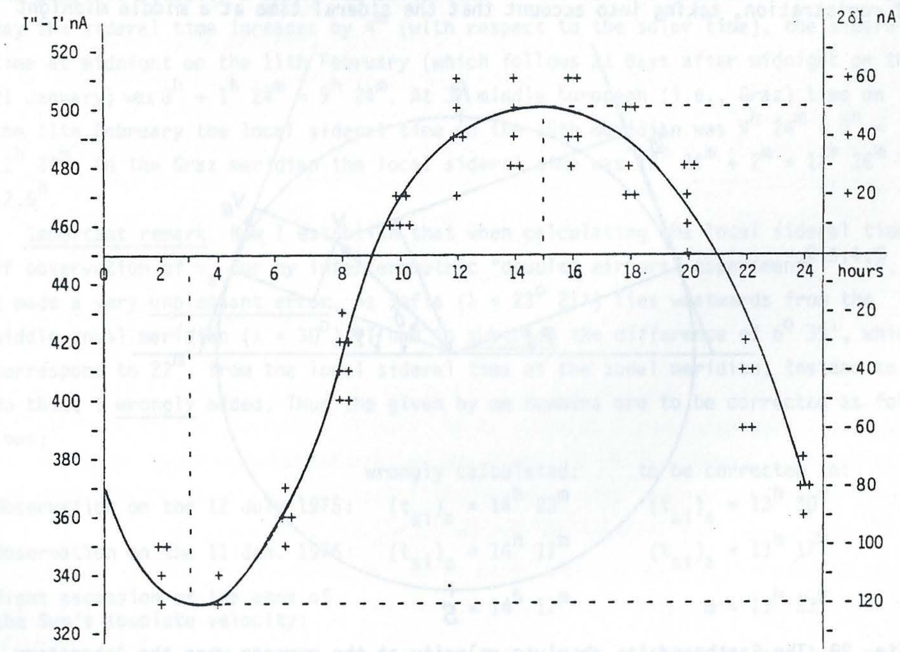

Fig. 19. Measurement of $2\delta I$ in the "coupled shutters" experiment.

in fig. 20 (which does not correspond to the real situation, as in reality v_a is negative) both velocity components point to the north and both v_a and v_b are positive. In this case the "variation curve" has no more the character of a "sinusoid"; it has 4 extrema (for 24 hours) and the "null line" must be drawn tangent to the lowest minimum.

As it can be seen from fig. 20, the two components of the Earth's absolute velocity in the horizontal plane of the laboratory, v_a and v_b, are connected with the magnitude v of the absolute velocity by the following relations

$$v_a = v\sin(\delta - \phi), \qquad v_b = v\sin(\delta + \phi), \tag{44.8}$$

where ϕ is the latitude of the laboratory and δ is the declination of the velocity's apex. From these one obtains

$$v = \frac{\{v_a^2 + v_b^2 - 2v_a v_b(\cos^2\phi - \sin^2\phi)\}^{1/2}}{2\sin\phi\cos\phi}, \qquad \tan\delta = \frac{v_b + v_a}{v_b - v_a}\tan\phi. \tag{44.9}$$

Obviously the apex of v points to the meridian of v_a. Thus the right ascension α of the apex equaled the local sideral time of registration of v_a. From fig. 19 it is to be seen that this moment can be determined with an accuracy of $\pm 1^h$. Thus it was enough to calculate (with an inaccuracy not larger than $\pm$ 5 min) the sideral time t_{si} for the meridian where the local time is the same as the standard time t_{st} of registration, taking into account that the sideral time at a middle midnight

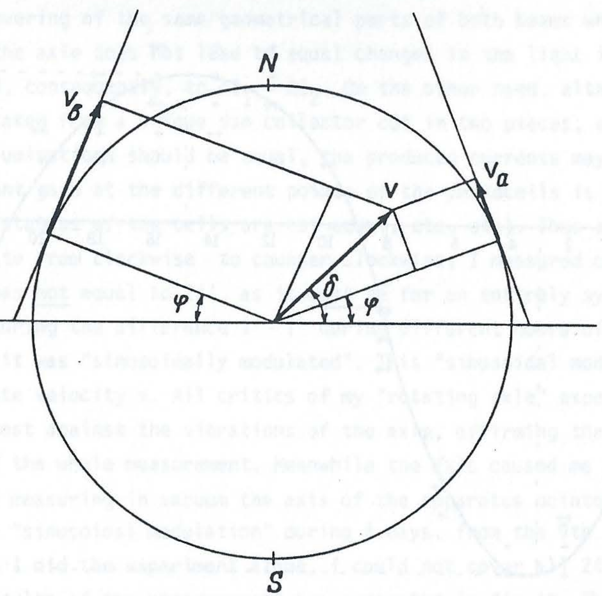

Fig. 20. The Earth and its absolute velocity at the moments when the laboratory meridian lies in the velocity's plane.

is as follows:

22 September	- 0^h	23 March	- 12^h
22 October	- 2^h	23 April	- 14^h
22 November	- 4^h	23 May	- 16^h
22 December	- 6^h	22 June	- 18^h
21 January	- 8^h	23 July	- 20^h
21 February	- 10^h	22 August	- 22^h.

The graph in fig.19 shows that on the 11th February (the middle day of observation) I registered in Graz ($\phi = 47^o$, $\delta = 15^o\ 26'$) the following absolute velocity's components at the following hours (for $2(\delta I)_a$ = - 120 nA, $2(\delta I)_b$ = 50 nA)

$$v_a = -342 \pm 30 \text{ km/sec}, \qquad (t_{st})_a = 3^h \pm 1^h,$$
$$v_b = +143 \pm 30 \text{ km/sec}, \qquad (t_{st})_b = 15^h \pm 1^h, \tag{44.10}$$

and formulas (9) give

$$v = 362 \pm 40 \text{ km/sec}, \qquad \delta = -24^o \pm 7^o, \qquad \alpha = (t_{si})_a = 12.5^h \pm 1^h, \tag{44.11}$$

where the errors are calculated supposing $\phi = 45^o$.

The local sideral time for the observation of v_a (i.e., the right ascension of the absolute velocity's apex) was calculated in the following manner: As for any day the sideral time inreases by 4^m (with respect to the solar time), the sideral time at midnight on the 11th February (which follows 21 days after midnight on the 21 January) was $8^h + 1^h\ 24^m = 9^h\ 24^m$. At 3^h middle European (i.e., Graz) time on the 11th February the local sideral time on the 15th meridian was $9^h\ 24^m + 3^h = 12^h\ 24^m$. On the Graz meridian the local sideral time was $12^h\ 24^m + 2^m = 12^h\ 26^m \cong 12.5^h$.

Important remark. Now I establish that when calculating the local sideral time of observation of v_a for my interferometric "coupled mirrors" experiment[2,3,4,5], I made a very unpleasant error. As Sofia ($\lambda = 23^o\ 21'$) lies westwards from the middle zonal meridian ($\lambda = 30^o$), I had to subtract the difference of $6^o\ 39'$, which correspond to 27^m, from the local sideral time of the zonal meridian. Instead to do this, I wrongly added. Thus the given by me numbers are to be corrected as follows:

	wrongly calculated:	to be corrected to:
Observation on the 12 July 1975:	$(t_{si})_a = 14^h\ 23^m$	$(t_{si})_a = 13^h\ 30^m$
Observation on the 11 Jan. 1976:	$(t_{si})_a = 14^h\ 11^m$	$(t_{si})_a = 13^h\ 17^m$
Right ascension of the apex of the Sun's absolute velocity:	$\alpha = 14^h\ 17^m$	$\alpha = 13^h\ 23^m$

I beg the persons who will refer to the measurement of the Sun's absolute velocity done by me in 1975/76 to cite always the corrected here figures and not the wrongly calculated figures presented in Refs. 1-5, 27, 28 and in some other of my papers.

44.5. CONCLUSIONS.

Comparing the figures obtained now by the Graz variation of my "coupled shutters" experiment with the figures obtained some ten years ago in Sofia by the interferometric "coupled mirrors" experiment, one sees that within the limits of the supposed errors they overlap. Indeed, on the 11 January 1976 I registered in Sofia the following figures

$$v = 327 \pm 20 \text{ km/sec}, \qquad \delta = -21^o \pm 4^o, \qquad \alpha = 13^h\ 17^m \pm 20^m. \qquad (44.12)$$

As for the time of one month the figures do not change significantly, one can compare directly the figures (44.11) with the figures (44.12). The declinations are the same. As the Graz measurements were done every two hours, the registration of the right ascension was not exact enough and the difference of about one hour is not substantial. I wish to point only to the difference between the magnitudes which is 35 km/sec. I have the intuitive feeling that the figures obtained in Sofia are more near to reality. The reason is that I profoundly believe in the mystic of the numbers, and my Sofia measurements led to the magic number 300 km/sec for the Sun's absolute velocity (which number is to be considered together with 300,000 km/sec for light velocity and 30 km/sec for the Earth's orbital velocity). The Graz measurement destroys this mystic harmony.

The presented acount on the Graz "coupled shutters" experiment shows that the experiment is childishly simple, as I always asserted(29). If the scientific community so many years refuses to accept my measurements and nobody tries to repeat them, the answer can be found in the following words of an acanite fighter against authorities:

TERRIBLE IS THE POWER WHICH AN AUTHORITY EXERTS OVER THE WORLD.

Albert Einstein

I wish to add in the end that with a letter of the 29 December 1983 I informed the Nobel committee that I am ready at any time to bring (for my account) the "coupled shutters" experiment to Stockholm and to demonstrate the registration of the Earth's absolute motion. With a letter of 28 January 1984 Dr. B. Nagel of the Physics Nobel committee informed me that my letter has been received.

After about forty submissions, this report on the execution of the "coupled shutters" experiment was finaly published in Ref. 30.

45. THE QUASI-KENNARD EXPERIMENT

The electromagnetic experiment with whose help I succeeded to measure the Earth's absolute velocity (as a matter of fact to register the right ascension of its apex) was the QUASI-KENNARD EXPERIMENT whose theory was shortly considered in Sect. 21 and whose diagram was given in fig. 5. The execution of the experiment was the following (see fig. 5):

In a rectangular loop with length $d = 150$ cm and breadth $b = 15$ cm a metal bar with length $b - b_o = 14.5$ cm was placed. The loop had $N = 100$ windings and a current $I_o = 3$ A was sent through the wire, so that the total current along the rectangle was $I = NI_o = 300$ A. Let us assume that the magnetic intensity generated by the horizontal wires of the loop at a distance r from the wires is the same as of an infinitely long wire, i.e., $B = \mu_o I/2\pi r$ (see formula (21.12)).

If moving the bar to the right with a velcoity v, at the indicated direction of the current along the loop, an induced motional electric tension with the indicated polarity will appear along the bar, whose magnitude will be (take into account that the horizontal current wires are double and assume $b \gg b_o$)

$$U_{mot} = \int_{b_o/2}^{b-b_o/2} 2vBdy = \frac{\mu_o vI}{\pi} \int_{b_o/2}^{b-b_o/2} dy/y \cong \frac{\mu_o vI}{\pi} \ln\frac{2b}{b_o}, \qquad (45.1)$$

what is formula (21.10) which was written in the CGS system of units.

Let us now assume that the vertical bar is kept at rest and the rectangular loop is moved with the same velocity to the left. Now the induction will be motional-transformer and the calculation is to be done by using formula (21.4). The x-component of the magnetic potential, A_x, will be a function only of y, the y-component (for $d \gg |x|$),

$$A_y = \frac{\mu_o Ib}{4\pi(d/2 - x)} - \frac{\mu_o Ib}{4\pi(d/2 + x)} = \frac{2\mu_o Ibx}{\pi d^2}, \qquad (45.2)$$

will be a function only of x, and the z-component, A_z, will be equal to zero. Thus the only term of the vector gradient (21.4) which is different from zero gives the motional-transformer electric intensity which will be induced

$$\mathbf{E}_{mot-tr} = v_x \frac{\partial A_y}{\partial x} \hat{y} = -\frac{2\mu_o vIb}{\pi d^2} \hat{y}, \qquad (45.3)$$

as $v_x = -v$. From formula (45.3) we find the magnitude of the induced motional-transformer tension

$$U_{mot-tr} = 2\mu_o vIb^2/\pi d^2 \cong 0, \qquad (45.4)$$

and the approximate null result (for $d \gg b$) was obtained in formula (21.11). Thus U_{mot} is much bigger than U_{mot-tr} and the latter, to a good approximation can be taken equal to zero.

If the loop and the bar will be moved together, then, as $U_{mot-tr} \cong 0$, the tension which will remain to act along the bar will be the motional tension. But if the loop and the bar move together, the question is to be posed: with respect to what? The answer, of course, can be only one: with respect to absolute space. This answer was given also in Sect. 23 by the help of the relative Newton-Lorentz equation.

Taking[4,30] for the Earth's absolute velocity approximately $V = 300$ km/sec (see Sect. 44), we obtain from formula (45.1) for our experiment $U = 147$ V.

It is clear that this tension cannot be measured by a voltmeter, as the tension in a closed loop must be null (see the end of Sect. 21). Thus I did "electrometric" measurements by putting very thin foils of damped aluminium at the extremities of the bar. The dimensions of the bar were 14.5×1.5×0.3 cm. The one side of the foils was conducting and the other not. The foils were attached to the bar by their conducting faces.

The detector showed an effect (opening of the foils) by putting on the bar tensions down to 12 V.

As in the laboratory there were many different causes which led to an opening of the aluminium foils (let us call them disturbing effects), I did not care about to try to specify and eventually eliminate them. Thus the Al-foils were always to a certain extent open and during the different days the opening was different. I could observe the effect of the absolute motion of the Earth only by mounting the set-up on a rotating platform. I observed by rotation that there were two positions where the opening of the foils was maximal and two positions where it was minimal. The difference between those positions was always about 90^0.

It was difficult to make calibration of the detector, as the check tension was applied by connecting the bar with one electrode of a variable tension, while the induced tension to be measured was applied between the end points of the bar. Thus it was very difficult to fit the degree of opening of the foils to formula (45.1) as the geometry of the experiment was not easily calculable (the foils had to cover the smallest sides of the bar, not the extremities of the largest side, as it was in my experiment) and the readings were not enough stable and repeatable.

The method for establishing the magnitude of the Earth's absolute velocity and of the equatorial coordinates of its apex (if the readings of the calibrated detector would reliably correspond to the tension induced along the bar) is given in Sect. 44.4. I used this method only for establishing the right ascension of the apex. For this reason I registered the two moments when the opening of the foils was maximum for a direction of the axis of the set-up "north-south".

On the 22 January 1989 I registered in Graz ($\phi = 47^0$, $\lambda = 15^0 26'$) maximum openings of the leaves at the following two moments of Middle-European standard time: $(t_{st})_a = 3.8^h$, $(t_{st})_b = 15.8^h$. The local sideral times corresponding to these two moments were: $(t_{si})_a = 11.8^h$, $(t_{si})_b = 23.8^h$. One of these times was equal to the right ascension of the velocity's apex. The inaccuracy was estimated $\pm 1^h$. (Cf. Sect. 44.4.)

This report on the quasi-Kennard experiment was published in Refs. 31 and 32.

46. THE DIRECT AND INVERSE ROWLAND EXPERIMENTS

46.1. INTRODUCTION.

Rowland [33] carried out in 1876 the following experiment: A disk was charged with positive (or negative) electricity. There was a magnetic needle in the neighbourhood of the disk. When the disk was set in rotation, the needle experienced a torque due to the magnetic action produced by the convection current of the charges rotating with the disk. A call this the DIRECT ROWLAND EXPERIMENT (fig. 21).

According to the principle of relativity, if the disk will be kept at rest and the needle will be set in rotation, the same torque has to act on it. Such an experiment is called by me the INVERSE ROWLAND EXPERIMENT (fig. 22). However, as I shall show in the following subsection, according to the relative Newton-Lorentz equation (23.4), the magnetic needle will not experience a torque at the inverse Rowland experiment.

The above two experiments can be called ROTATIONAL Rowland experiments. It is easy to transform them into INERTIAL experiments. So if we charge a conveyer belt and set it in action, the motion of the charges can be considered as intertial (i.e., with a velocity constant in value in direction) over a considerable length of the belt and we shall realize thus the inertial direct Rowland experiment. On the other

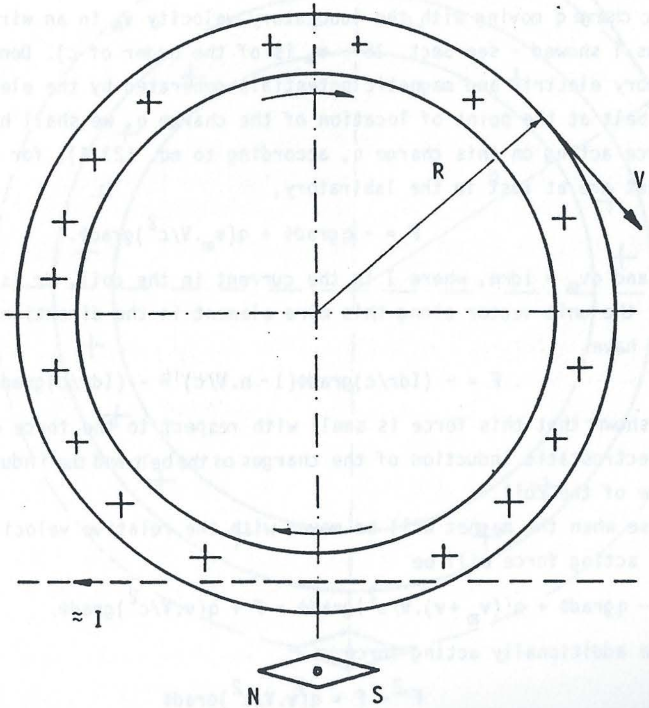

Fig. 21. The direct Rowland experiment.

hand, if we move the magnetic needle with a constant velocity along the belt at rest, this will be the inertial inverse Rowland experiment.

As far as I know nobody has carried out either the rotational nor the inertial inverse Rowland experiments.

46.2. THE EFFECT IN THE INVERSE ROWLAND EXPERIMENT IS NULL.

Now I shall show that, contrary to the prediction of the principle of relativity, the inverse Rowland experiment must be null, i.e., a magnet moving with respect to charges at rest does not experience torque.

As the treatement of the inverse Rowland experiment has an important theoretical aspect, the formulas in Sect. 46.2 will be written in the CGS system of units.

Thus, proceeding from the Newton-Lorentz equation (23.4), I shall show that when there is an infinitely long (or very long) belt covered with electric charges and a magnet in its neighbourhood (let us consider a solenoid feeded by constant current), then, in the case that the belt will be moved with the relative velocity v in the laboratory, there will be a torque acting on the magnet at rest, however, in the case that the belt will be at rest and the magnet will be moved with the same velocity **v**, there will be <u>no</u> torque.

Let us suppose that the absolute velocity of the laboratory is **V** and let us consider an electric charge q moving with the laboratory velocity $\mathbf{v}_m$ in an wire element of the magnet (as I showed - see Sect. 16 - $\mathbf{v}_m$ is of the order of c). Denoting by Φ and **A** the laboratory electric and magnetic potentials generated by the electric charges fixed to the belt at the point of location of the charge q, we shall have for the potential force acting on this charge q, according to eq. (23.4), for the case when belt and magnet are at rest in the labiratory,

$$\mathbf{F} = -q\,\mathrm{grad}\Phi + q(\mathbf{v}_m.\mathbf{V}/c^2)\mathrm{grad}\Phi. \qquad (46.1)$$

As $v_m \cong c$ and $q\mathbf{v}_m = Id\mathbf{r}\mathbf{n}$, where I is the current in the coil, dr is its wire element and **n** is the unit vector along this wire element in the direction of the current, we shall have

$$\mathbf{F} = -(Idr/c)\mathrm{grad}\Phi(1-\mathbf{n}.\mathbf{V}/c) \cong -(Idr/c)\mathrm{grad}\Phi. \qquad (46.2)$$

It can be shown that this force is small with respect to the force of attraction due to the electrostatic induction of the charges on the belt and the induced charges on the metal wire of the coil.

For the case when the magnet will be moved with the relative velocity **v** in the laboratory, the acting force will be

$$\mathbf{F}' = -q\,\mathrm{grad}\Phi + q\{(\mathbf{v}_m+\mathbf{v}).\mathbf{V}/c^2\}\mathrm{grad}\Phi = \mathbf{F} + q(\mathbf{v}.\mathbf{V}/c^2)\mathrm{grad}\Phi. \qquad (46.3)$$

As v ≪ c, the additionally acting force

$$\mathbf{F}' - \mathbf{F} = q(\mathbf{v}.\mathbf{V}/c^2)\mathrm{grad}\Phi \qquad (46.4)$$

is extremely small with respect to the initial force **F** and surely there will be no experimental possibility to register it, so that we can write

$$\mathbf{F}' = \mathbf{F}. \qquad (46.5)$$

For the case when the belt will be moved with the velocity **v** in the laboratory, the force acting on the charge q of the magnet at rest will be, taking now the laboratory magnetic potential of the charges on the belt as $\mathbf{A} = \Phi\mathbf{v}/c$ and using in the last two terms of (46.6) the formulas for rotation and vector-gradient of double products,

$$\mathbf{F}'' = -q\,\mathrm{grad}\Phi + q(\mathbf{v}_m.\mathbf{V}/c^2)\mathrm{grad}\Phi + (q/c)\mathbf{v}_m\times\mathrm{rot}\mathbf{A} + (q/c)\mathbf{V}\times\mathrm{rot}\mathbf{A} + (q/c)(\mathbf{V}.\mathrm{grad})\mathbf{A} =$$

$$-q\,\mathrm{grad}\Phi + q(\mathbf{v}_m.\mathbf{V}/c^2)\mathrm{grad}\Phi + (q/c)\mathbf{v}_m\times\mathrm{rot}\mathbf{A} + q(\mathbf{v}.\mathbf{V}/c^2)\mathrm{grad}\Phi =$$

$$\mathbf{F} + (q/c)\mathbf{v}_m\times\mathrm{rot}\mathbf{A} + q(\mathbf{v}.\mathbf{V}/c^2)\mathrm{grad}\Phi. \qquad (46.6)$$

Now, taking into account that v ≪ c, we shall obtain for the additionally acting force

$$\mathbf{F}'' - \mathbf{F} \cong (q/c)\mathbf{v}_m\times\mathrm{rot}\mathbf{A} = Idr\mathbf{n}\times\mathbf{B}/c, \qquad (46.7)$$

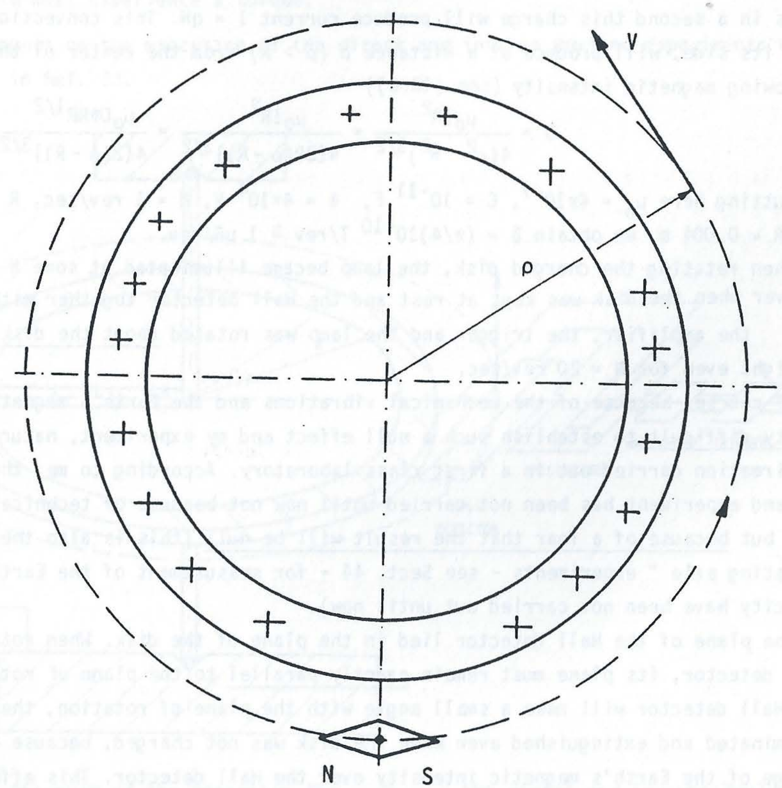

Fig. 22. The inverse Rowland experiment.

where **B** is the magnetic intensity generated by the charges moving with the belt. This force is considerable and there will be a torque acting on the magnet.

46.3. THE EXPERIMENT SUPPORTS THE ABSOLUTE SPACE-TIME CONCEPTS.

I carried out the rotational direct and inverse Rowland experiments (fig. 23). A rim of a plastic disk was covered with a brass ring. This metal ring, cut over a small distance, was connected by a wire with the axle of rotation and this axle was connected by the help of sliding contacts with one pole of a Wimshurst machine which produced tension between both poles U = 80 kV, and I assumed that the potential to which the disk was charged was $\Phi = U/2 = 40$ kV. For a detector of the magnetic field I took not a magnetic needle, as was the case in the historic Rowland experiment, but a small Hall detector whose output was led to an amplifier ending with a trigger. When the trigger was overturned, it illuminated a lamp. The trigger could be tuned so that an increase of the magnetic intensity over the Hall detector of few micro Gauss the lamp was illuminated. The capacitance of the disk with radius R = 20 cm was of the order of $C = 10^{-11}$ F.

If charged to a potential Φ, the charge over the disk will be $q = C\Phi$. At N rotations in a second this charge will produce current $I = qN$. This convection current, from its side, will produce at a distance ρ ($\rho > R$) from the center of the disk the following magnetic intensity (see (18.6))

$$B = \frac{\mu_o I R^2}{4(\rho^2 - R^2)^{3/2}} = \frac{\mu_o I R^2}{4\{2R(\rho - R)\}^{3/2}} = \frac{\mu_o C\Phi N R^{1/2}}{4\{2(\rho - R)\}^{3/2}}. \qquad (46.8)$$

Putting here $\mu_o = 4\pi 10^{-7}$, $C = 10^{-11}$ F, $\Phi = 4\times 10^4$ V, N = 1 rev/sec, R = 0.2 m, $\rho - R = 0.004$ m, we obtain $B = (\pi/4)10^{-10}$ T/rev $\cong 1$ μG/rev.

When rotating the charged disk, the lamp became illuminated at some N = 10 rev/sec. However when the disk was kept at rest and the Hall detector together with its battery the amplifier, the trigger and the lamp was rotated about the disk, there was no light even for N = 20 rev/sec.

Of course, because of the mechanical vibrations and the Earth's magnetism, it was pretty difficult to establish such a null effect and my experiment, naturally, needs confirmation carried out in a first class laboratory. According to me, the inverse Rowland experiment has been not carried until now not because of technical difficulties but because of a fear that the result will be null (this is also the reason that "rotating axle " experiments - see Sect. 44 - for measurement of the Earth's absolute velocity have been not carried out until now).

The plane of the Hall detector lied in the plane of the disk. When rotating the Hall detector, its plane must remain exactly parallel to the plane of rotation. If the Hall detector will make a small angle with the plane of rotation, the lamp was illuminated and extinguished even when the disk was not charged, because of the change of the Earth's magnetic intensity over the Hall detector. This effect served as an indication of the sensitivity of the Hall detector. As the Earth's magnetic

intensity is $B_E = 0.5$ G $= 5\times 10^{-5}$ T, then if the angle between B_E and the plane of the Hall detector is θ, the component of the Earth's magnetic intensity p rpendicularly to the plane of the detector will be $B_{E\perp} = B_E \sin\theta$. Thus, for $\theta = 0$, $\Delta\theta = 1^o = 1/57$ rad, we shall have $\Delta B_{E\perp} \cong 10$ mG $= 10^{-6}$ T Earth's magnetic intensity over the whole detector. With the increase of θ the change $\Delta B_{E\perp}$ for $\Delta\theta = 1^o$ decreases.

It is obvious that there are no technical problems for realizing also the inertial direct and inverse Rowland experiments.

46.4. CONCLUSIONS.

Thus the direct and inverse Rowland experiments carried out by me showed that the effects observed are not the same. Contrary to the prediction of my absolute space-time theory and contrary to the experimental results, the theory of relativity predicts the following nonsense:(34)

> A stationary magnetic dipole (e.g., a compass needle) in general experiences a torque in the presence of a moving charge, since the latter creates a B field; transferring our observations once more to the inertial rest frame of the charge, we conclude that a magnetic dipole moving through a static electric field must experience a torque.

This report on the execution of the direct and inverse Rowland experiments was published in Ref. 33.

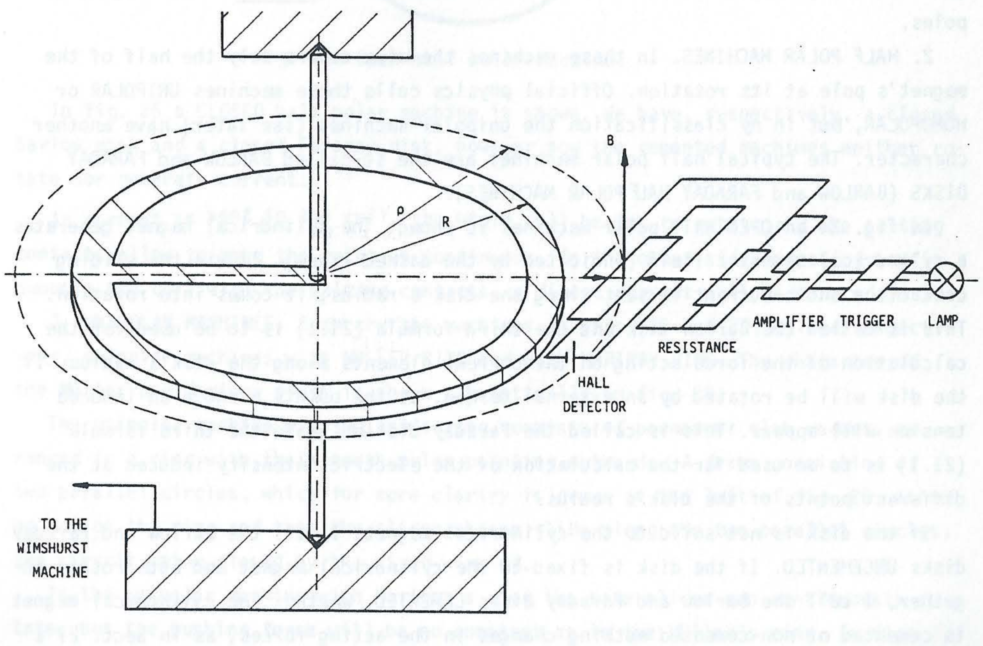

Fig. 23. Diagaram of the apparatus for the direct and inverse Rowland experiments.

47. CLASSIFICATION OF THE ELECTROMAGNETIC MACHINES (THE B-MACHINES)

The ELECTROMAGNETIC MACHINES consist of a magnet (permanent magnet, electromagnet or current wire) and a coil (wire). In Sect. 29 I separated the electromagnetic machines in motors and generators with respect to the kind of forces which the machine produces: ponderomotive or electromotive. Then in Sect. 29 I separated the electromagnetic machines in B-motors and generators and in S-motors and generators with respect to the kind of the driving magnetic field: vector or scalar.

Now I shall introduce a classification of the B-motors and B-generators with respect to the part of the magnet's pole covered by the wire at its motion (rotation). Of course, in the B-machine the wire can remain at rest and the magnet can be rotated, but, for definiteness, I shall always assume that the magnet is at rest and the wire moves. Formulas (21.14) and (24.6) show that for the electromagnetic machines with closed loops the principle of relativity holds good.

1. NONPOLAR MACHINES. In these machines there is no motion of the wire at all. Such machines are only generators and their coil always has an iron core. A change in the magnetic flux through the coil is caused by a respective motion of permanent magnets, however, current sent in the coil does not set these permanent magnets in motion. Such machine is my MAMIN COLIU machine which produces energy from nothing (see Sect. 53). In the nonpolar machines the wire covers no part of the magnet's poles.

2. HALF POLAR MACHINES. In these machines the wire covers only the half of the magnet's pole at its rotation. Official physics calls these machines UNIPOLAR or HOMOPOLAR, but in my classification the unipolar machines (see later) have another character. The typical half polar machines are the so-called BARLOW and FARADAY DISKS (BARLOW and FARADAY HALF POLAR MACHINES).

In fig. 24 an OPEN half polar machines is shown: The cylindrical magnet generates a cylindrical magnetic field (indicated by the dashed lines). If via the sliding contacts a and b current is sent along the disk's radius, it comes into rotation. This is called the Barlow disk and the third formula (21.1) is to be used for the calculation of the force acting on the current elements along the disk's radius. If the disk will be rotated by an external torque, at the points a and b an induced tension will appear. This is called the Faraday disk and again the third formula (21.1) is to be used for the calculation of the electric intensity induced at the different points of the disk's radius.

If the disk is not solid to the cylindrical magnet, I call the Barlow and Faraday disks UNCEMENTED. If the disk is fixed to the cylindrical magnet and both rotate together, I call the Barlow and Faraday disks CEMENTED. Whether the cylindrical magnet is cemented or non-cemented nothing changes in the acting forces, as in Sect. 27 I showed that the torque exerted by a rectangular wire on a circular wire is null and N circular wires make a circular solenoid.

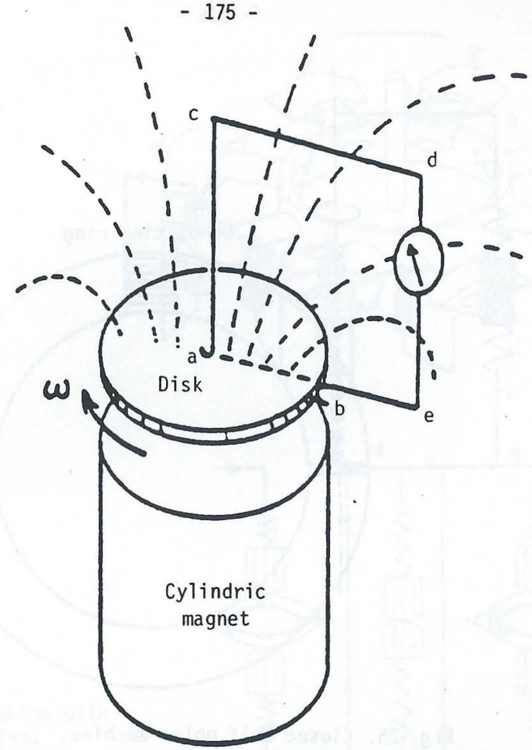

Fig. 24. Open half polar machine.

In fig. 25 a CLOSED half polar machine is shown. We have, respectively, a closed Barlow disk and a closed Faraday disk, however now the cemented machines neither rotate nor generate current.

If current is sent in the coil, the whole coil begins to rotate and the salting contacts allow to make the rotation continuous. On the other side, rotating continuously the coil with the salting contacts, a direct current will be induced in it.

3. UNIPOLAR MACHINES. Such are the machines in figs. 26 and 27, called, respectively, unipolar machines with MÜLLER RING and with MARINOV RING. The character of the Müller and Marinov rings is shown schematically in fig. 28.

The unipolar machine with Müller's ring consists of permannet slab magnets arranged in a ring with their north poles pointing outwards. A frame consisting of two parallel circles, which for more clariry is drawn at the left of fig. 26, is to be put on the ring and then the slider ab can slide along the two parallel circles, the circuit being closed by the fixed wire cd.

In the unipolar machine with Marinov's ring the same slider can continuously rotate, but the pushing force will be no constant as in the Müller's ring. In fig. 27 a variation is shown for realizing continuous rotation of the magnets by the help of salting contacts; meanwhile a Müller's ring cannot be set in rotation.

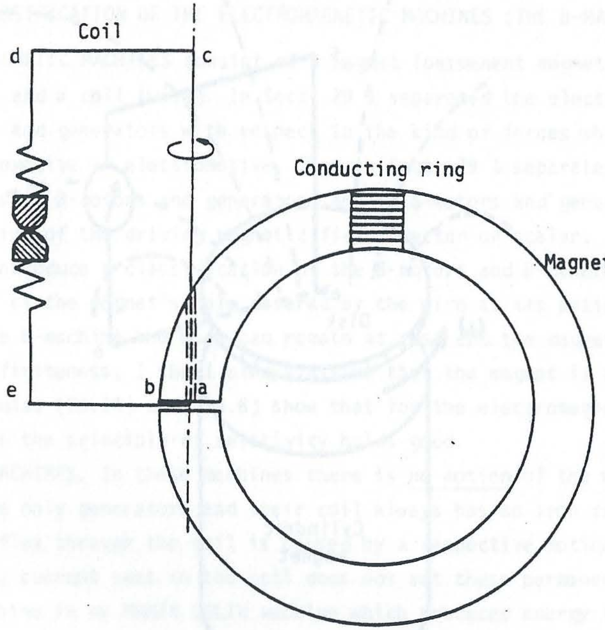

Fig. 25. Closed half polar machine.

4. ONE-AND-A-HALF POLAR MACHINES. This is the machine BUL-CUB analysed in Sect. 48. The inventor of this machine is F. Müller.[36] Müller observed its electromotive effects. I constructed variation for observing also its ponemotive effects and called this hybrid MACHINE BUL-CUB, an abbreviation of BULgaria - CUBa, my and Müller's native countries.

5. TWO POLAR MACHINES. Those are almost all electromagnetic machines which huma-

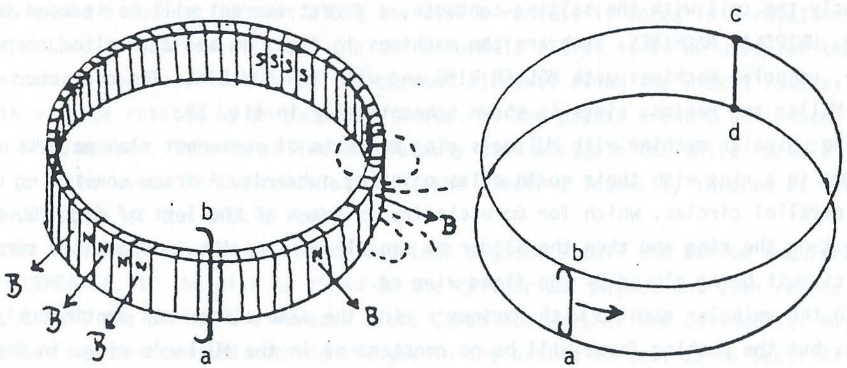

Fig. 26. Unipolar machine with Müller's ring.

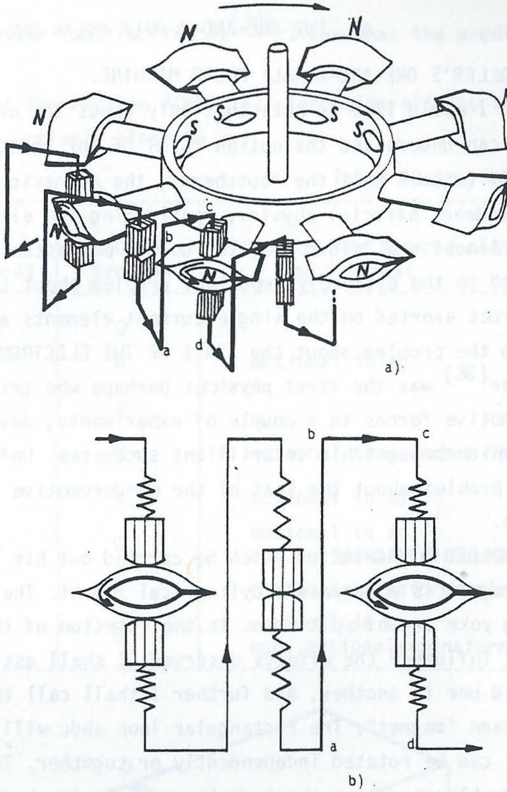

Fig. 27. Unipolar machine with Marinov's ring.

nity builds. Here the wire covers both poles of the magnet at its motion.

In the half and unipolar machines the induced current is direct continuous. In the one-and-a-half polar machines the induced current is direct interrupted. In the non-polar and two polar machines the induced current is alternating.

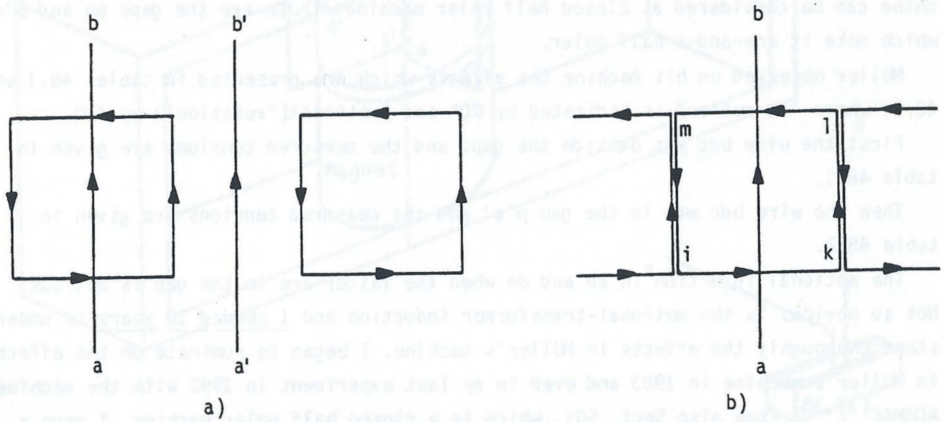

Fig. 28. Diagrams of the Marinov and Müller rings.

48. THE ONE-AND-A-HALF POLAR BUL-CUB MACHINE

48.1. MÜLLER'S ONE-AND-A-HALF POLAR MACHINE.

First I would like to note that only about 10% of the physicists and electro-engineers can understand the notion "SEAT OF THE INDUCED ELECTRIC TENSION", as for the other 90% (whom I call the "butchers") the magnetic flux is a sausage and the loop a knife. Indeed, official physics, considering the electromagnetic effects as "field", "closed lines" and "flux" effects, do not pay attention to the differential interactions and to the extremely important problem about the electromotive and ponderomotive forces exerted on the single current elements and on the single wire's elements, i.e., to the problem about the SEATS OF THE ELECTROMOTIVE AND PONDEROMOTIVE FORCES.

Müller[36] was the first physicist perhaps who tried to locate the seat of the electromotive forces in a couple of experiments, developing a very clever technology[36] which brought him to brilliant successes. Unfortunately he has not investigated the problem about the seat of the ponderomotive forces which is of no less importance.

The MÜLLER'S MACHINE on which he carried out his measurements is shown in fig. 29. The magnet is a permanent cylindrical magnet. The almost cylindrical core and the two-wing yoke are of soft iron. As the rotation of the cylindrical magnet and core does not influence the effects observed, I shall assume that magnet, core and yoke are solid one to another, and further I shall call this "magneto-core-yoke" with the common name "magnet". The rectangular loop abdc will be called "coil". The magnet and the coil can be rotated independently or together. The wires ab and bdc can also be independently moved (at short distances). It is shown at the right of fig. 29 how Müller has realized this independent motion of the wires by the help of sliding contacts in mercury.

The yoke has the gaps pq and p'q' through which the coil can pass, so that a continuous rotation can be realized. At rotation of the coil outside the gaps the machine can be considered as closed half polar machine. Those are the gaps pq and p'q' which make it one-and-a-half polar.

Müller observed on his machine the effects which are presented in tables 48.1 and 48.2, where "no motion" is indicated by "0" and "motion" ("rotation") by "m".

First the wire bdc was outside the gaps and the measured tensions are given in table 48.1.

Then the wire bdc was in the gap p'q' and the measured tensions are given in table 48.2.

The motional induction in ab and de when the latter are in the gap is obvious. Not so obvious is the motional-transformer induction and I needed 10 years to understand thoroughly the effects in Müller's machine. I began to ruminate on the effects in Müller's machine in 1983 and even in my last experiment in 1992 with the machine ACHMAC[37,38] (see also Sect. 50), which is a closed half polar machine, I gave a

wrong prediction[37] and only after constructing it[38] I saw that the prediction was wrong.

But after the construction of the machine ACHMAC all induction effects in the electromagnetic machines became entirely clear to me.

Table 48.1

	Motion or rest of wire ab	wire bdc	magnet	Induced tension	Kind of the induced tension and its seat
1	0	0	0	0	
2	m	0	0	U	motional in ab
3	0	m	0	0	
4	0	0	m	U	motional-transformer in ab
5	m	m	0	U	motional in ab
6	m	0	m	0	motional in ab opp. motional-transformer in ab
7	0	m	m	U	motional-transformer in ab
8	m	m	m	0	motional in ab opp. motional-transformer in ab

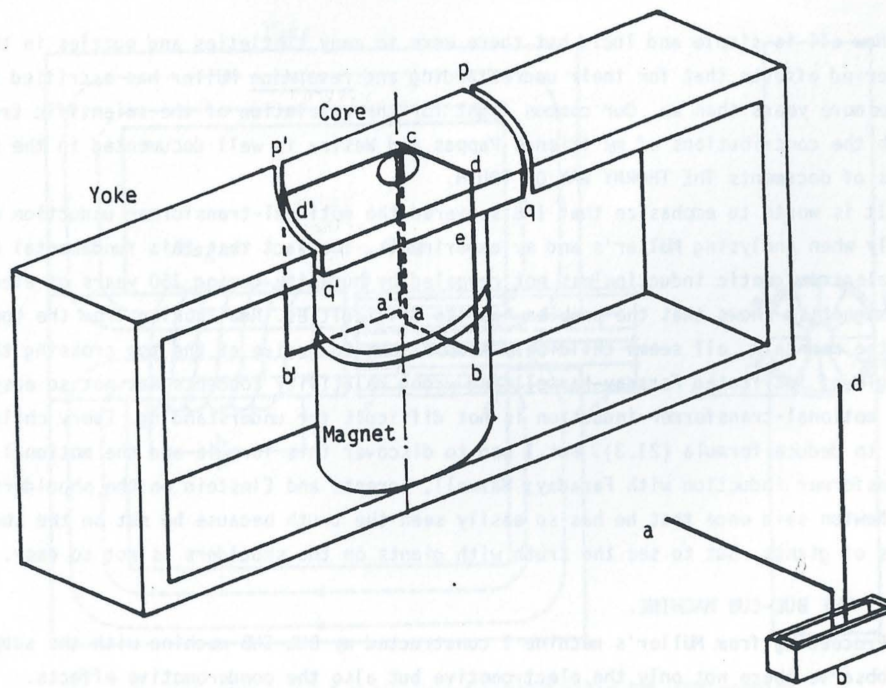

Fig. 29. Müller's one-and-a-half polar machine.

Table 48.2

	Motion or rest of wire ab	wire bdc	magnet	Induced tension	Kind of the induced tension and its seat
1	0	0	0	0	
2	m	0	0	U	motional in ab
3	0	m	0	U	motional in de
4	0	0	m	0	motional-transformer in ab opp. motional-transformer in de
5	m	m	0	0	motional in ab opp. motional in de
6	m	0	m	U	motional in ab opp. motional-transformer in ab motional-transformer in de
7	0	m	m	U	motional-transformer in ab motional in de opp. motional-transformer in de
8	m	m	m	0	motional in ab opp. motional-transformer in ab motional in de opp. motional-transformer in de

Now all is simple and lucid but there were so many subtleties and puzzles in the observed effects that for their undrestanding and revelation Müller has sacrified two times more years than me. Our common fight for the revelation of the scientific truth with the contributions of my friends Pappas and Wesley is well documented in the series of documents THE THORNY WAY OF TRUTH.

It is worth to emphasize that I discovered the motional-transformer unduction exactly when analysing Müller's and my experiments. The fact that this fundamental kind of electromagnetic induction was not revealed by humanity during 150 years of electromagnetism shows that the problem has its difficulties. Now looking from the top of the mountain, all seems childishly simple, but to arrive at the top crossing the jungle of intricated Faraday-Maxwell and wrong relativity concepts was not so easy. The motional-transformer induction is not difficult for understanding. Every child has to deduce formula (21.3). But I had to discover this formula and the motional-transformer induction with Faraday, Maxwell, Lorentz and Einstein on the shoulders.

Newton said once that he has so easily seen the truth because he sat on the shoulders of giants. But to see the truth with giants on the shoulders is not so easy.

48.2. THE BUL-CUB MACHINE.

Proceeding from Müller's machine I constructed my BUL-CUB machine with the scope to observe there not only the electromotive but also the ponderomotive effects.

The diagram of the BUL-CUB machine is shown in fig. 30 and the photographs of the first and second variations in figs. 31 and 32.

The BUL-CUB MACHINE consists of a cylindrical magnet (I had an electromagnet but a permanent magnet can also be used), a yoke of soft iron, and a coil wound as shown in the figures on a cylindrical core of soft iron with a cylindrical axial hole. The winding goes along the generatrix of the cylinder, along the radius of one of its bases, along the generatrix of the axial hole, along the radius of the other basis, and then again along the generatrix of the cylinder, tightly to the previous winding, until the whole cylinder is covered by windings. I note by "ab" the radial wires of the coil and by "cd" the parts of the cylindrical wires which "enter under the yoke". The coil's wires between the marginal points p and q (resp., p' and q') are "under the yoke" and between the marginal points p and p' (resp., q and q') are "outside the yoke". In fig. 30 the magnetic flux in the iron of the magnet, core and yoke is indicated by dashed lines. I assume B ≠ 0 only in the magnet's and both yoke's gaps.

To calculate the electromotive and ponderomotive effects in the BUL-CUB machine, take a reference frame as follows (fig.30): The x-axis is horizontal pointing to the left, the y-axis is horizontal pointing to the reader and the z-axis is vertical pointing upwards.

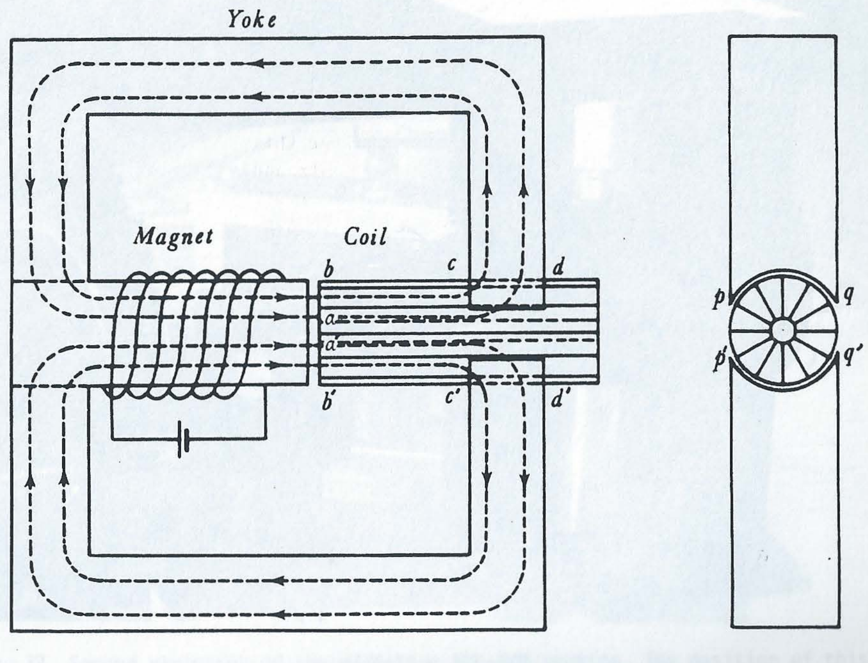

Fig. 30. Diagram of the one-and-a-half polar BUL-CUB machine.

48.3. THE BUL-CUB GENERATOR.

The following motional electric intensity will be induced in the wires cd in the yoke's gap when they move with a velocity **v**, indicating by a subscript "yo" the quantities related to the yoke's gap and by "ma" the quantities related to the magnet's gap

$$E_{yo} = \mathbf{v}\times\mathbf{B} = v\hat{\mathbf{y}}\times B\hat{z} = vB\hat{\mathbf{x}}, \qquad (48.1)$$

and the following intensity in the wires ab of the magnet's gap

$$E_{ma} = \mathbf{v}\times\mathbf{B} = \Omega r\hat{\mathbf{y}}\times(-B\hat{\mathbf{x}}) = \Omega rB\hat{z}, \qquad (48.2)$$

where Ω is the angular velocity of rotation of the coil and r is the distance of the wire's element from the coil's axis. The average electric intensity induced along the wires ab will be

$$\overline{E_{ma}} = (\Omega R/2)B\hat{z} = (v/2)B\hat{z}, \qquad (48.3)$$

where R is the radius of the coil.

Let us assume that the cross-section of the yoke is rectangular with a side s parallel to the wires and a side h perpendicular to the wires. To make the calculation simpler, I shall suppose h much smaller than R, consequently s much bigger than R, as the cross-section of the magnet's gap and of both yoke's gaps will be assumed equal

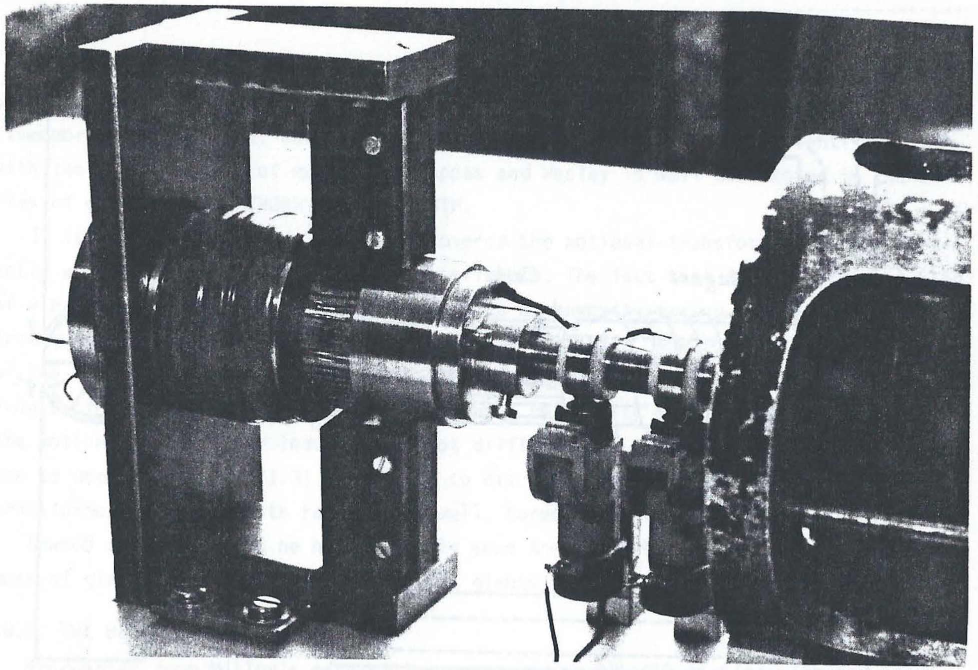

Fig. 31. First variation of the effective BUL-CUB machine.

to have the same magnetic intensity in all gaps. Thus, at this assumption, the cylindrical surface of the coil in the yoke's gaps can be considered as a plane rectangle. If n wires pass through a unit of length on the circumference of the coil's cylinder, we find that the length of the wire in both yoke's gaps is $l_{yo} = 2(nh)s = 2nsh$, so that the tension induced in the yoke's gaps will be

$$U_{yo} = \int_{l_{yo}} \mathbf{E}_{yo}\cdot dl\hat{\mathbf{x}} = E_{yo} l_{yo} = vB(2nsh) = 2nshvB = nv\Phi, \qquad (48.4)$$

having taken (here and below) a positive orientation along the wire in the direction d-c-b-a, and denoting by $\Phi = 2shB$ the magnetic flux produced by the magnet.

To calculate the induced tension in the magnet's gap, we must multiply scalarly the average induced intensity (48.3) by the oriented length (positive from b to a) of the wire in the magnet's gap which is $l_{ma} = n(\pi R)2R = 2\pi nR^2 = 4nsh$, as $\pi R^2 = 2sh$. Thus the tension induced in the magnet's gap will be

$$U_{ma} = \int_{l_{ma}} \overline{E_{ma}}\cdot(-dl\hat{z}) = -\overline{E_{ma}}\, l_{ma} = -2nshvB = -nv\Phi. \qquad (48.5)$$

As U_{yo} and U_{ma} are equal and oppositely directed, the motional tension induced in the whole coil will be null.

The tension induced in the coil when the magnet (magnet + yoke + core) rotates and the coil is at rest, or when the magneto-yoke rotates and coil+core are at rest, can

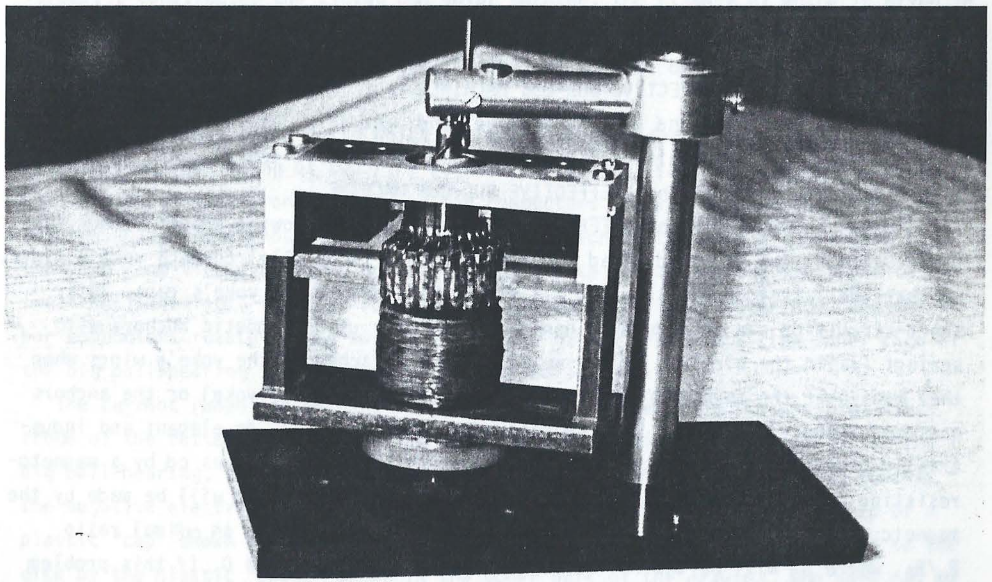

Fig. 32. Second variation of the effective BUL-CUB machine. The position of this machine corresponds to the position of Müller's machine in fig. 29.

be found on the ground of the general theorem (21.13) that for a closed loop (as our coil) the motional and motional-transformer induced tensions are equal.

48.4. THE BUL-CUB MOTOR.

For the force acting on a unit of length of the wire in the yoke's and magnet's gaps we shall have

$$F_{yo} = I\times B = I\hat{x}\times B\hat{z} = -IB\hat{y}, \qquad F_{ma} = I\times B = (-I\hat{z})\times B\hat{x} = IB\hat{y}. \qquad (48.6)$$

The moments of force with respect to the coil's axis, applied to a unit of length of the wires cd and ab, will be, respectively,

$$\mathbf{M}_{yo} = \mathbf{R}\times F_{yo} = R\hat{z}\times(-IB\hat{y}) = IBR\hat{x}, \qquad \mathbf{M}_{ma} = \mathbf{r}\times F_{ma} = r\hat{z}\times IB\hat{y} = -rIB\hat{x}, \qquad (48.7)$$

where **R** is the radius of the coil taken as vector and **r** is an arbitrary vector-distance along it taken from the coil's axis. The average moment of force applied to a unit of length of the wire will be

$$\mathbf{M}_{ma} = -(1/2)IBRx. \qquad (48.8)$$

As the length of the wires ab in the magnet's gap is twice the length of the wires cd in the yoke's gaps (see Sect. 48.3), we conclude that the net moments of force acting on the wires in the magnet's and both yoke's gaps are equal and oppositely directed, so that the coil will not rotate.

As the magnet (magnet+yoke) and coil (coil+core) can be considered as two independent circuits, the force and consequently the torque with which the coil acts on the magnet will be the same.

48.5. UNEFFECTIVE AND EFFECTIVE BUL-CUB MACHINES.

Thus formulas (48.4) and (48.5), one one hand, and formulas (48.7), on the other, show that the BUL-CUB machine can neither generate electric tension, nor be driven as a motor and I call it the UNEFFECTIVE BUL-CUB MACHINE.

To make the BUL-CUB machine EFFECTIVE, I applied to following trick: I made the upper parts of the wires cd naked and I put brushes in parallel to both yoke's wings, so that the latter short-circuited all wires which are in the yoke's gaps. This short-circuiting can be made by a non-contact way by using magnetic anchors with springs (as in the electric bells) which will be attached by the yoke's wings when they pass over the anchors (in the case of a rotating magneto-yoke) or the anchors pass under the yoke's wings (in the case of a rotating coil). An elegant and industrially prospective way is to make the insulation between the wires cd by a magneto-resisting material, so that the short-circuiting of the wires cd will be made by the magneic field in the yoke's gaps. One must find a material with an optimal ratio R_0/R_B, where R_0 will be the resistance for $B = 0$ and R_B for $B \neq 0$. If this problem can be solved technically, the BUL-CUB machines can win the competition with the other d.c. machines, as it has no collector and for the case of a coil at rest no

sliding contacts at all.

My BUL-CUB generator with naked cd-wires is shown in fig. 31, driven by an electromotor: the produced continuous d.c. tension is taken from the two rings on the axle by the help of sliding contacts. If the coil should be at rest and the magneto-yoke should be rotated, no sliding contacts for taking the generated tension are needed.

If the driving motor in fig. 31 will be taken away and d.c. will be sent to the coil via the sliding rings, the coil has to begin to rotate. In my machine shown in fig. 31 the torque was so feeble that it could not overwhelm the friction and for this reason I constructed the second variation shown in fig. 32 where the wires of the coil are in sections which are led to a collector and the brushes which make the short-circuiting of the cd-wires slide on this collector. In the variation in fig. 32 the coil is fixed to the magnet and only the yoke can rotate on ball-bearings. The coil is connected in series with the magnet's coil and the common current is sent via the vertical supports of the coil+magnet, so that when sending current the yoke with the short-circuiting brushes which are attached to it begins to rotate.

The detailed report on my BUL-CUB machine is published in Ref. 6, p. 132.

49. THE DEMONSTRATIONAL CLOSED HALF POLAR FARADAY-BARLOW MACHINE (FAB)

To be able to clearly determine the seats of the electromotive and ponderomotive forces, I constructed the closed half polar machine, the diagarm of which is given in fig. 33 and the photograph in fig. 34. I called this the DEMONSTRATIONAL FARADAY-BARLOW MACHINE (FAB), as the Faraday and Barlow disk of the open half polar machine is its fundamental element.

The machine has three parts which can rotate independently one of another: 1) the magneto-yoke consisting of two ring magnets and yoke of soft iron, 2) the Faraday-Barlow disk of soft iron, and 3) six bar conductors of aluminium crossing the yoke through holes large enough, so that a limited motion of the bars with respect to the yoke (and vice versa) can be realized. The yoke rotates on the first and third small ball-bearings, the disk rotates on the second small ball-bearings, and the bar conductors rotate on the middle and on the big ball-bearings (the inner race of the big ball-bearing is solid to the Faraday-Barlow disk).

The current (when the machine is used as a motor) goes from the positive electrode of the battery through the second small ball-bearing, crosses the disk, the big ball-bearing, the bar conductors, and through the middle ball-bearing reaches the negative electrode. The bars can be made solid to the magnet by the help of a plastic "cap" shown on the left of the diagram. The magnet can be made solid to the disk by the plastic "spoke" shown in the upper part of the drawing. The bars can be made solid to the disk by the help of the plastic "cap" shown in the lower part of the drawing which blocks the big ball-bearing. The disk can be made solid to the lab by the help of a "spoke" (not shown in the figure!) which blocks the second small ball-bearing. The magnet and the bar can be made solid to the lab by hand. The effects observed are presented in table 49.1.

Table 49.1

	Rotation or possibility for rotation of: Disk	Bars	Magnet	GENERATOR EFFECTS Induced tension	kind of induction	seat of induction	MOTOR EFFECTS torque on the	reaction on the
1	0	0	0	0			0	
2	m	0	0	U	motional	disk	disk	magnet
3	0	m	0	0			0	
4	0	0	m	U	mot.-tr.	bars	magnet	disk
5	m	m	0	U	motional	disk	disk	magnet
6	m	0	m	0	motional opp. mot.-tr	disk bars	0	
7	0	m	m	U	mot.-tr.	bars	magnet	disk
8	m	m	m	0	motional opp. mot.-tr	disk bars	0	

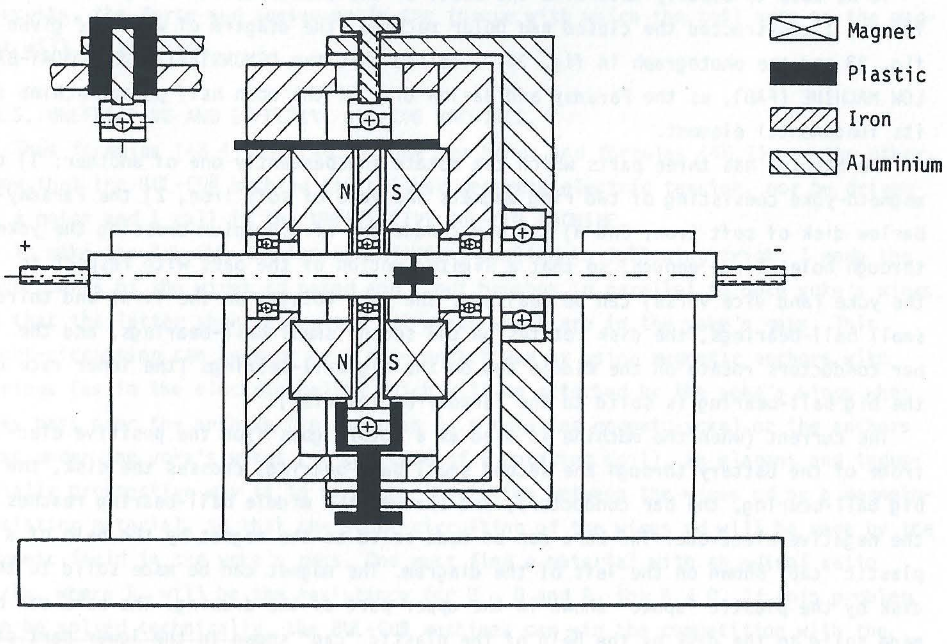

Fig. 33. Diagram of the demonstrational closed half polar Faraday-Barlow machine.

When comparing table 49I with table 48I, we see that the tensions induced in the different cases are exactly the same. There are differences only in the seats of the induced tensions, namely in the seats of the induced motional-transformet tensions.

For the cases 4,6,7,8 the seat of the induced motional-transformer tension in Müller's machine is in the wire ab, while in FAB it is in the bars (which correspond to the wire bdc in Müller's machine).

Why this difference does appear? - Assuming that the holes through which the bars cross the yoke are very small, we see that the field of the magnetic potential across the disk has an absolute cylindric symmetry. Such a cylindrically symmmetric magnetic potential field cannot induce motional-transformer tension at rotation of the magnet. In the "limiting case" of Müller's machine, we can consider the yoke as very slim, and in such a case the field of the magnetic potential across the gap between the magnet and the core becomes highly asymmetric. This leads to the induction of motional-transformer tension for the case where the magneto-yoke, or only the yoke, in fig. 29 rotates.

The seats of the induced motional-transformer tension in tables 48.1 and 49.1 are given for the two limiting cases: a very slim yoke in fig. 29 and a cylindrical yoke in fig. 33. For a yoke between these two extremities there will be motional-transformer induction both in the disk (wire ab) and in the bars (wire bdc).

Very interesting is case 7 in table 49.1. Here, at a continuous rotation of the magnet and the bars, a constant tension is generated, although the seat of this tension is in the bars where the magnetic intensity B is equal to zero.

The last fact can be patently seen when we compare cases 6 and 7: the rotation of

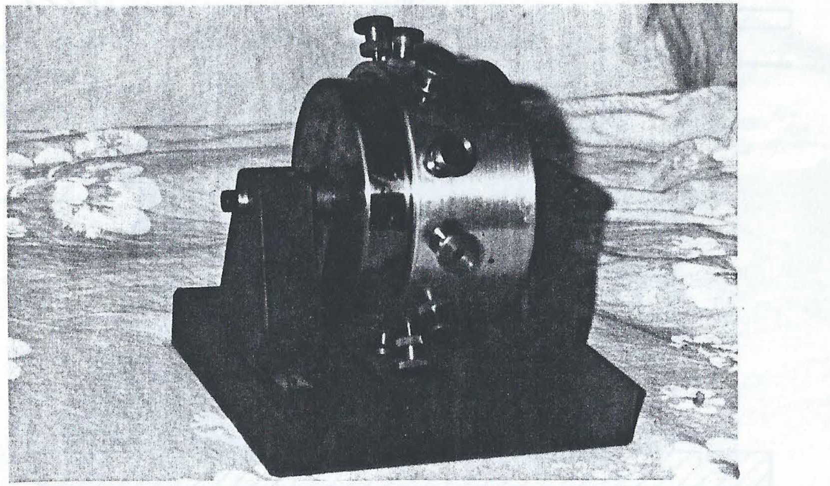

Fig. 34. Photograph of the demonstrational Faraday-Barlow machine.

the bars is immaterial for the tension induced in the bars, of importance is only the rotation of the magneto-yoke which leads to a continuous change of the magnetic potential in the reference point taken with respect to the laboratory (absolute space), not with respect to the bars, as the magnetic potential in the bars for co-moving bars and magneto-yoke remains constant.

For the relativity blind all these deductions and considerations will be a Chinese grammar, but as Marx considered Hegel's dialectic as "the algebra of revolution", so they have to begin to consider equations (21.1) - (21.4) as "the algebra of induction".

The report on my demonstrational Faraday-Barlow machine was published in Ref. 39.

50. THE ANTI-DEMONSTRATIONAL CLOSED HALF POLAR MACHINE ACHMAC

The mentioned in Sect. 48.1 differences between tables 48.1 and 49.1 became entirely clear to me only after the construction of the machine ACHMAC.[37,38]

I thought that the magnetic intensity and magnetic potential fields in the gap of the closed half polar machine shown in fig. 25 preserve their cylindric symmetry relevant for a very long circular, or even toroidal, solenoid. Thus, I thought, that at rotation of the magnet in fig. 25, a motional-transformer tension can be induced only in the wire de of the coil when it is near to the magnet. But when it is far from the magnet (as in fig. 25), a motional-transformer tension cannot be induced.

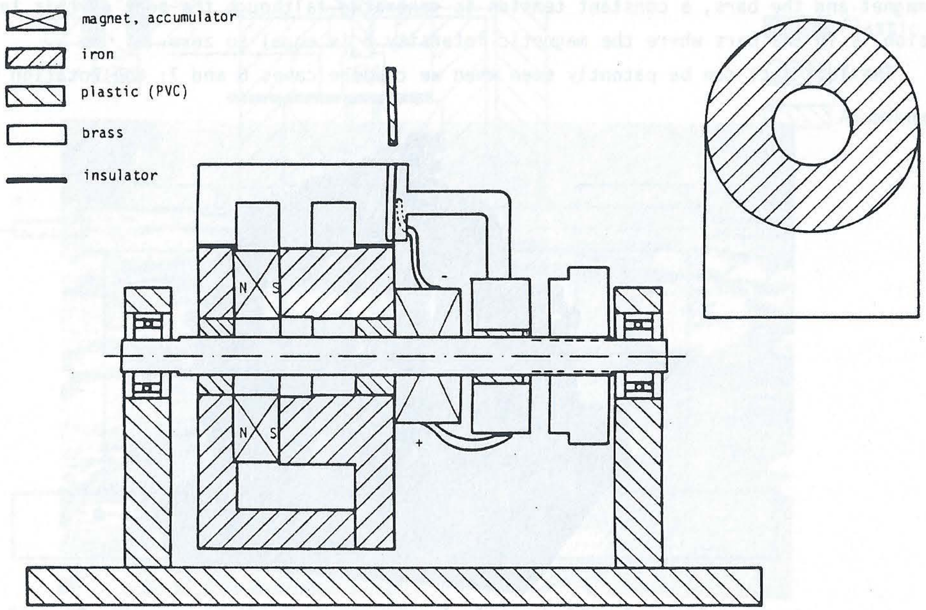

Fig. 35. Diagram of the anti-demonstrational closed half polar machine ACHMAC.

This, of course, is true, but I did not expect that motional-transformer tension will be induced also in the wire ab. Thus I came to the conclusion that by rotating the whole system in fig. 25 about the axis, a tension will be induced in the coil. And I expected further that by sending current in the coil, the whole rigid system will begin to rotate, as a torque will act on ab but no reaction will act on the magnet.

Although all this seemed highly incredible, I constructed the MACHINE ACHMAC (Autonomous Closed Half polar MAChine) to see which will be the answer of the Divinity. The diagram of the machine is shown in fig. 35 and the photograph in fig. 36.

As neither tension was generated nor torque was observed, I understood that the magnetic intensity and magnetic potential fields in the gap in fig. 25 have no circular symmetry, so that, on one side, there will be motional-transformer tension induced in the disk's radius and, on the other side, a current going along the disk's radius and the axial wire will exert a torque on the magnet.

The construction of the machine ACHMAC and its expected (!) functioning is clear from the figures. I do not enter into these deteil here, as the machine has not demonstrated the expected effects. For this reason I called the machine "anti-demonstrational".

I should like to add that an eventual rotation of the machine ACHMAC was expected also proceeding from the speculation that there is no a theorem asserting that the net torque of interacting closed current loops must be null (see in Sect. 24 the text after formula (24.6)). Thus the machine ACHMAC is one more experimental support in favour of this (quite sure!) theorem for the case when closed loops are involved (see in Sect. 63 the violation of this theorem for open current loops).

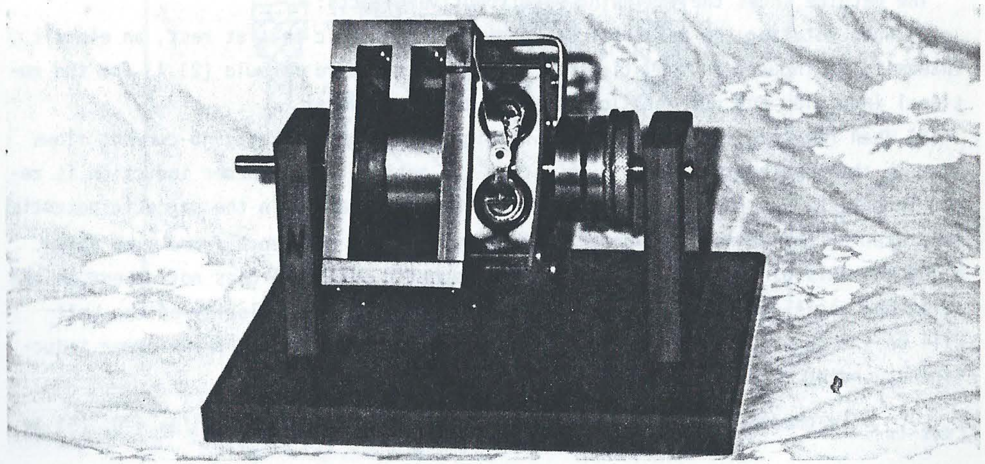

Fig. 36. Photograph of the machine ACHMAC.

51. THE DEMONSTRATIONAL UNIPOLAR MARINOV-MÜLLER MACHINE (MAMUL)

If we wish that the students can quickly grasp the essence of electromagnetism, the demonstrational Faraday-Barlow machine must be available in every college.

Another such didactic machine is the unipolar MARINOV-MÜLLER MACHINE (MAMUL) which I have constructed (fig. 37). I gave to it Müller's name, as its essential part is the magnetic Müller's ring (see fig. 26) on which Müller has carried out many induction experiments allowing to clear the problem about the seat of the induced tensions (see Ref. 6, p. 239), and my name, as with this Müller's ring I did ponderomotive experiments allowing to clear the problem about the seat of the ponderomotive forces.

The machine MAMUL is constructed and functions as follows (fig. 37):

On a metal axle four ball-bearings are mounted. A "magnetic belt", i.e., a magnetic Müller's ring, consisting of many slab magnets with a square cross-section and arranged tightly one to another with their negative poles pointing to the axle, is mounted on the outer races of the external bearings. The outer races of the internal bearings are connected with metal sticks. One can also connect the outer races by a metal cylinder but the sticks are more convenient from a didactic point of view. The axle on which the ball-bearings are mounted consists of two electrically insulated pieces. The electric circuit goes to the left axle piece, crosses the left internal ball-bearing, the sticks, the right internal ball-bearing and goes out from the right axle piece. The external wires of the circuit contain an amperemeter if electromotive effects are to be observed or a battery if ponderomotive effects are to be observed. In this experiment the ball-bearing motor effects based on the current thermal dilatation effect (see Sect. 63) will be neglected.

The machine shows the following electromotive effects:

1) When rotating the metal sticks keeping the magnetic belt at rest, an elecric intensity is induced in the sticks according to the third formula (21.1) for the motional induction and current flows through the amperemeter.

2) When rotating the magnetic belt keeping the sticks at rest, no current flows through the amperemeter, as in such a case the motional-transformer induction is zero. Indeed, at the rotation of the magnetic belt no changes in the magnetic potential generated by the magnets do appear as in a cylindrical reference frame with axis along the axis of the cylindrical belt the magnetic potential does not depend on the azimuthal angle ϕ. As in such a frame the components of the velocity of the belt will be $\mathbf{v} = (v_\rho, v_\phi, v_z) = (0, v, 0)$, we obtain for the motional transformer induction according to formula (21.4)

$$E_{mot-tr} = (\mathbf{v}.\mathrm{grad})\mathbf{A} = \{v_\rho \partial/\partial\rho + (v_\phi/\rho)\partial/\partial\phi + v_z \partial/\partial z\}\mathbf{A} = (v/\rho)\partial\mathbf{A}(\rho,z)/\partial\phi = 0. \quad (51.1)$$

3) When belt and sticks rotate together, the same current as in the first case flows through the amperemeter because this case is a superposition of the cases 1) and 2).

The machine shows the following ponderomotive effects when sending current through the sticks by the help of external battery:

1) When the external bearings are blocked and the internal are free to rotate, the sticks are set in motion. The effect is described by the third formula (21.1) if putting there $\mathbf{v} = I d\mathbf{r}/q$, where I is the flowing current, $d\mathbf{r}$ is the current element of the stick pointing along the current, and q are the charges transferring current in this current element, so that E_{mot} is the potential force acting on the wire element $d\mathbf{r}$.

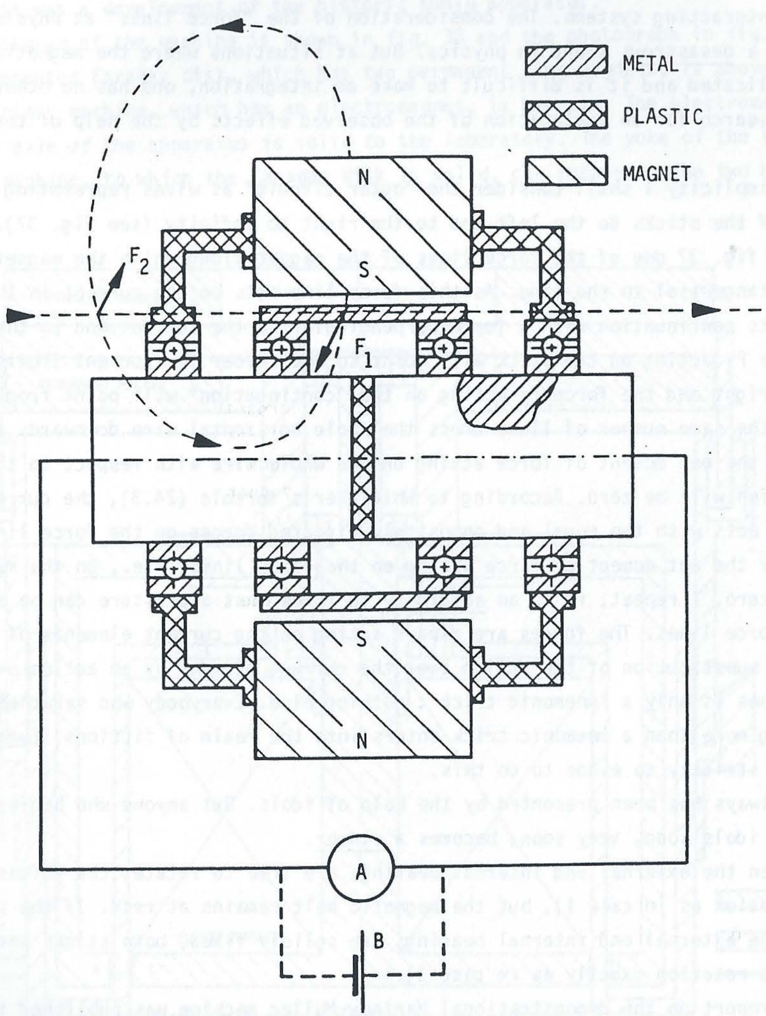

Fig. 37. Diagram of the demonstrational unipolar Marinov-Müller machine.

2) When the internal bearings are blocked and the external are free to rotate, the magnetic belt does not come into motion. This case is rather complicated to be explained by a simple formula as one must make integration of the elementary potential forces acting on all current elements of the magnet caused by all current elements of the circuit (not only by the current elements of the sticks). Thus I am impelled here to use the Faraday-Maxwell language with the "force lines" which I definitely consider of having no physical substance. In my concepts, I repeat, the force lines are a "model" alowing an easier, if not calculation, at least evaluation. The right and exact calculation is to be done only proceeding from the current elements of the interacting systems. The consideration of the "force lines" as physical reality was a desastrous trend in physics. But at situations where the magnetic systems are complicated and it is difficult to make an integration, one has no other choice than to search for an explanation of the observed effects by the help of the "force lines".

For simplicity I shall consider the "outer circuit" as wires representing continuations of the sticks to the left and to the right to infinity (see fig. 37). I have drawn in fig. 37 one of the force lines of the magnet along which the magnetic intensity is tangential to the line. As this force line acts on the current in the stick and on its continuation with a force perpendicular to the current and to the line, the force F_1 acting on the stick will point to the reader for current flowing from left to right and the force F_2 acting on the "continuation" will point from the reader. As the same number of lines cross the whole horizontal wire downwards and then upwards, the net moment of force acting on the whole wire with respect to the axis of rotation will be zero. According to Whittaker's formula (24.3), the current in the wire acts with the equal and oppositely directed forces on the force line. Consequently the net moment of force acting on the force lines, i.e., on the magnet, will be zero. I repeat, it is an absurdity to think that a pressure can be executed on the force lines. The forces are always acting on the current elements of the magnet. The substitution of the action over the current element by an action over the force lines is only a "mnemonic trick", nothing else. Everybody who serаches here something more than a mnemonic trick enters into the realm of fictions. Every physicist has strictly to evade to do this.

God always has been presented by the help of idols. But anyone who begins to believe in idols soon, very soon, becomes a sinner.

3) When the external and internal bearings are free to rotate, the sticks come into rotation as in case 1), but the magnetic belt remains at rest. If the outer races of the external and internal bearings are solidly fixed, both sticks and belt come into rotation exactly as in case 1).

This report on the demonstrational Marinov-Müller machine was published in Ref. 40.

52. THE OPEN HALF POLAR MACHINE ADAM

Bruce de Palma[41] reported of having observed that the mechanical braking power of a cemented Faraday disk (see Sect. 47) is less than the generated electric power. Many people have then reported of having observed this effect too, and some of having not observed.

To check whether these claims are real, I constructed my MACHINE ADAM (Apparatus Discovered in Austria by Marinov) which was a cemented Faraday disk as generator coupled with a motor invented by me, to which I gave the name the KÖNIG-MARINOV MOTOR, as it was a development of the historic König apparatus.[42]

The diagram of the machine is shown in fig. 38 and the photograph in fig. 39.

The cemented Faraday disk, which has two permanent ring magnets, is above, the König-Marinov machine, which has an electromagnet, is beneath. The electromagnet with the axle of the apparatus is solid to the laboratory. The yoke of the König-Marinov machine, to which the Faraday disk is solid, can rotate on the two ball-bearings.

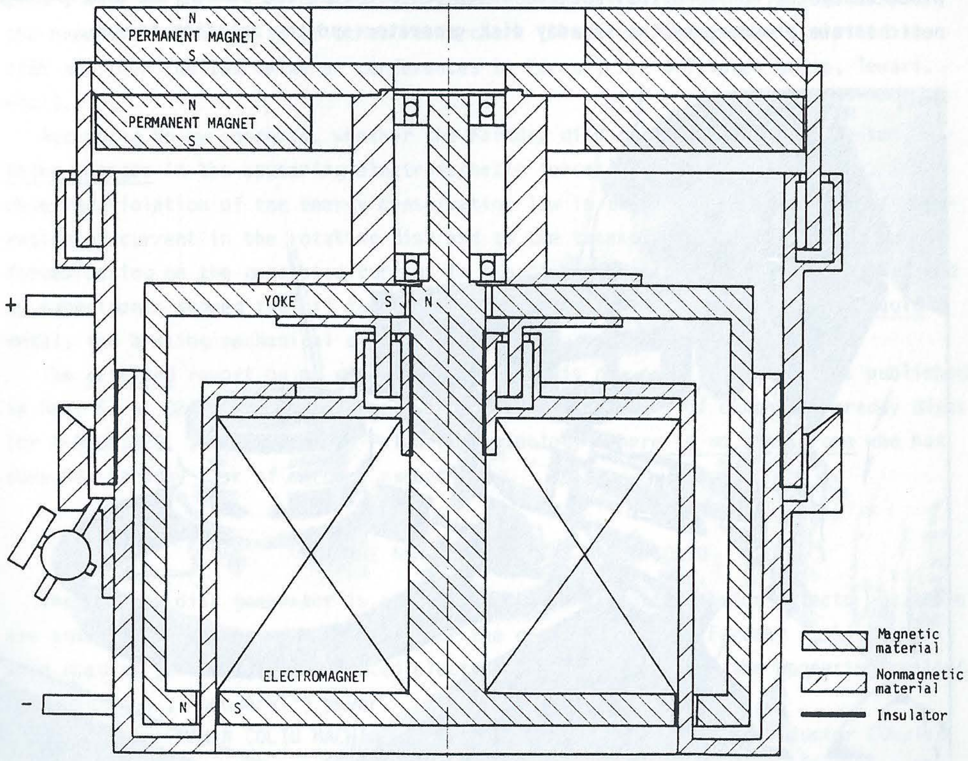

Fig. 38. Diagram of the open half polar machine ADAM.

Let us see first how the machine works as a motor, supplying a driving tension to it as shown in fig. 38. The current goes from the positive electrode up through the large upper mercury trough, then along the radii of the disk (which now serves as a Barlow disk), then down through the small mercury trough, and reaches the negative electrode. It is easy to see that the torque will be anti-clockwise (if looked from above), while the torque on the yoke will be clockwise. Thus the machine will rotate in this direction in which the torque is stronger.

Let us then see how the machine works as a generator, rotating it by an external torque (I used a boring machine as shown in fig. 39). If the torque is anti-clockwise, the Faraday disk will drive the positive charges to the positive electrode, while the König-Marinov machine will drive the positive charges to the negative electrode. Thus current will flow in this direction in which the induced tension is stronger.

In my machine the stronger tension was induced in the Faraday disk and thus when rotated by an external torque the tension induced in the circuit was the difference between the tensions induced in the Faraday disk and in the König-Marinov machine. The idea of the machine was to run it as a perpetuum mobile if the driving torque produced by the König-Marinov machine would be more than the sum of the braking magnetic torque produced by the Faraday disk generator and the friction torque.

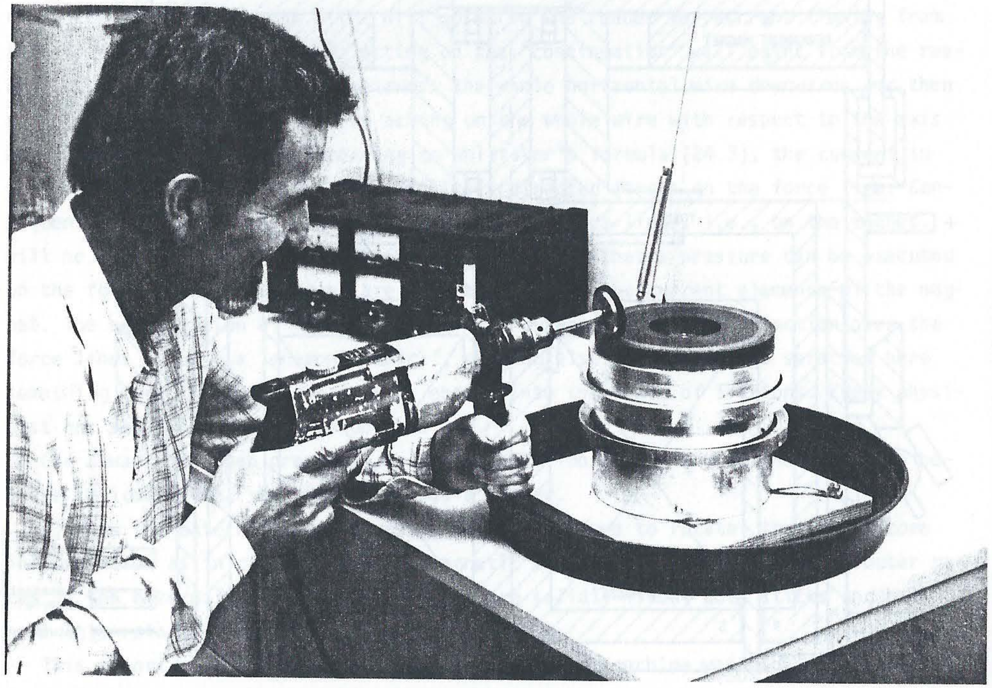

Fig. 39. Photograph of the machine ADAM.

The experiments carried out with the machine ADAM were the following: I set the machine in motion with a certain definite angular velocity and I measured the coast-down times once when the circuit was open and current was generated and then when the circuit was closed. Because of the produced heat energy, due to the ohmic losses in the circuit, according to the energy conservation law, in the second case the coast-down time must be shorter.

With my solid Faraday disk of copper, the coast-down times in the second case were always shorter and thus it was not possible to say whether energy was produced from nothing.

However, I exchanged the copper Faraday disk by a disk filled with mercury. With such a liquid Faraday disk I measured coast-down times at a closed circuit longer than the coast-down times at open circuit. This was a clear indication that energy was produced from nothing (see the data in Ref. 6, p. 324). The differences, however, were too small, and in 1985 I took the decision that it will be extremely difficult (perhaps impossible, because of the big heat losses) to "close the energetic circle" and to make ADAM or another similar machine runnig as a perpetuum mobile. Thus since 1985 I have no more experimented with cemented Faraday disks but I follow actively the experimental activity of other researchers (Bruce de Palma, whom I visited in 1985 and then invited twice at conferences in Europe, the Dillingen group, Tewari, etc.).

According to my concepts, whether the Faraday disk is cemented or uncemented, nothing changes in the appearing electromagnetic forces. Thus, according to me, the observed violation of the energy conservation law is due to the "mechanism" of generation of current in the rotating disk and to the transmission of the ponderomotive forces acting on the generated current to the "ions' lattice" of the bulk metal. And my experiments showed that if the current is generated not in solid but in liquid metal, the braking mechanical effect is less.

The detailed report on my machine ADAM (which is now sold in England) is published in Ref. 6, p. 324, but between the hundreds of constructors of cemented Faraday disks (or N-MACHINES, according to de Palma's terminology) there is no single one who has done his Faraday disk of mercury except me.

53. THE NONPOLAR MACHINE MAMIN COLIU

The Faraday disk generator is a machine with generator and motor effects but there are suspicions (confirmed by me only for the case of a liquid Faraday disk) that when used as generator the produced electric power is more than the appearing braking mechanic (i.e., "ponderal") power.

My nonpolar MAMIN COLIU MACHINE (MArinov's Motional-transformer INductor COupled with a LIghtly rotating Unit) is a generator without motor effect, so that when the machine generates electric power the braking mechanic power is zero.

I constructed six variations of MAMIN COLIU (their diagrams and photographs are given in Ref. 43, p. 84), but I was unable to "close the energetic circle" and to run it as a perpetuum mobile (the reasons are given beneath).

The explanation why a violation of the energy conservation law appears in the MAMIN COLIU machine certainly is to be searched in the non-linear character of magnetization of iron (see beneath).

The scheme of the MAMIN COLIU machine with toroidal yoke (the first four variations were with toroidal yokes) is shown in fig. 40 and with cylindrical yoke (the last two variations were with cylindrical yokes) in fig. 41 which was the drawing serving for the construction of the fifth model (MAMIN COLIU V). The photograph of MAMIN COLIU V is given in fig. 42 and MAMIN COLIU V dismounted is shown in fig. 43.

I shall give the principle of action referring to fig. 40 which is the most simple.

In the gap of a torus of soft iron with permeability μ there are two similar disks consisting of an equal number of sectors of axially magnetized magnets. In the space between the sectorial magnets there are sectors of non-magnetic material (in my first

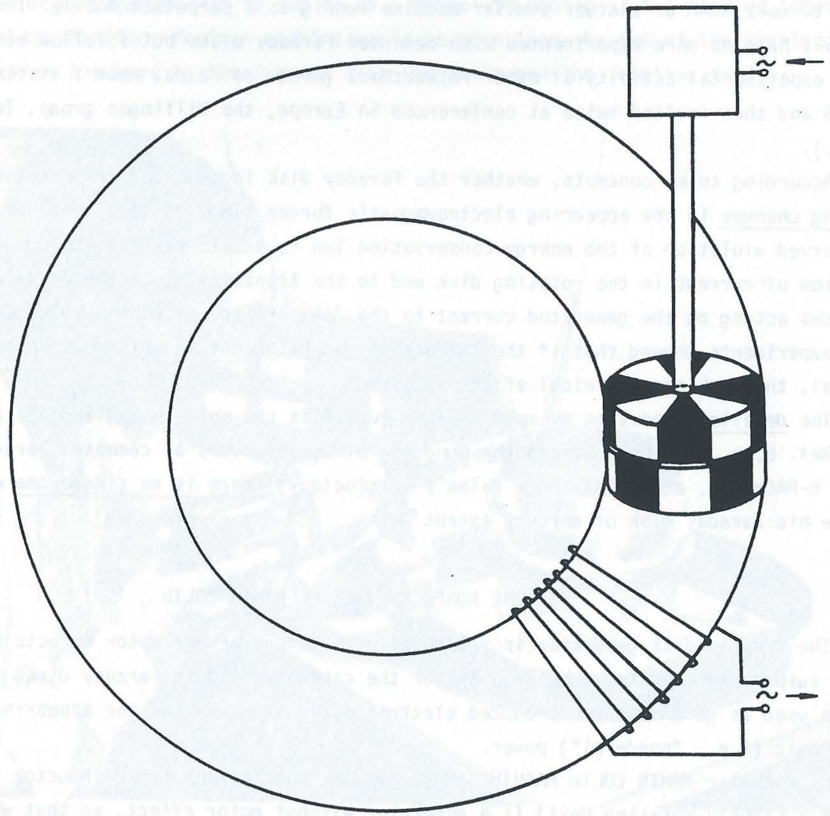

Fig. 40. Principal diagram of the nonpolar machine MAMIN COLIU.

variations I used bronze). The one disk is solid to the torus and the other can be rotated by an electromotor. When the sectorial magnets of the rotating disk overlap the bronze sectors, there is a certain magnetic flux Φ in the torus and when the sectorial magnets overlap the solid sectorial magnets, there is another flux Φ' in the torus. Because of the changing magnetic flux, a tension is induced in the coil and if short-circuiting it, current flows. However, if sending current to the coil, because of the complete symmetry (nonpolar machine), there is no motion of the rotor.

To make some simple calculations, let us suppose that the half of the rotor and of the solid disk is a permanent magnet and the other half bronze and that the torus has a very large radius. To make the analysis still more pure, let us consider the two half circular magnets as electromagnets generating magnetic tension U_m every one.

According to formula (20.11), when the rotating magnets overlap the stationary bronze sectors, the magnetic flux generated by any of them will be $\Phi_1 = U_m/R_m$, where R_m is the reluctance of the torus and is given by formula (20.13), so that the common flux will be $\Phi = 2\Phi_1 = 2U_m/R_m$. When the rotating magnets overlap the stationary magnets, their common magnetic tension will be $2U_m$ and the generated magnetic flux will be $\Phi' = 2U_m/R_m = \Phi$, if R_m will remain the same. However in the second case the magnetic intensity in one half of the torus will be higher and in the other much lower (in the ideal case equal to zero). As μ depends in a very complicated way on the magnetic intensity, the reluctance R_m (see formula (20.13)) does not remain constant and $\Phi' \neq \Phi$. This difference in the magnetic fluxes leads to the induction of electric tension in the coil. I even can not say whether Φ or Φ' is larger, I measured only induced tension and induced current and I noted that this induced current has no braking action (i.e., zero Lenz effect - see Sect. 54.2).

The electric tension generated in VENETIN COLIU VI reached at high velocities of the rotor 50 V. Because of the complete symmetry of the system (see fig. 41), the current induced in the coil could not produce a torque on the magnets. Thus the electric power generated by the coil was produced from nothing.

As I used magnets whose hysteresis loop was not an ideal rectangle, there was a feeble torque acting on them when big current was sent in the coil because the material of the magnets with a differential permeability (see fig. 3) different from unity introduced certain assymetry. But if the magnets should be ideal, say, electromagnets, no torque can appear.

In figs. 41 and 42 one sees how have I neutralized the attractive and repulsive forces between the magnets in the stationary and rotating disks (the four rotating magnets and the two stationary magnets are clearly seen in fig. 43). For this aim I added another system of stationary and rotating disks with permanent magnets (above in fig. 41) identical to the initial system of stationary and rotating disks generating the variable magnetic flux (below in fig. 41). The upper system serves only to balance the forces between the permanent magnets in the lower system, as when the upper magnets attract one another the lower magnets repel each other (and vice versa). So the axle rotates very easily and a small 6-volt motor (see it in fig. 42 on the top) smoothly rotates the axle.

In the machine MAMIN COLIU VI both systems of stationary and rotating magnets are "in the iron" and thus both systems generate variable magnetic flux (fig. 44). Here

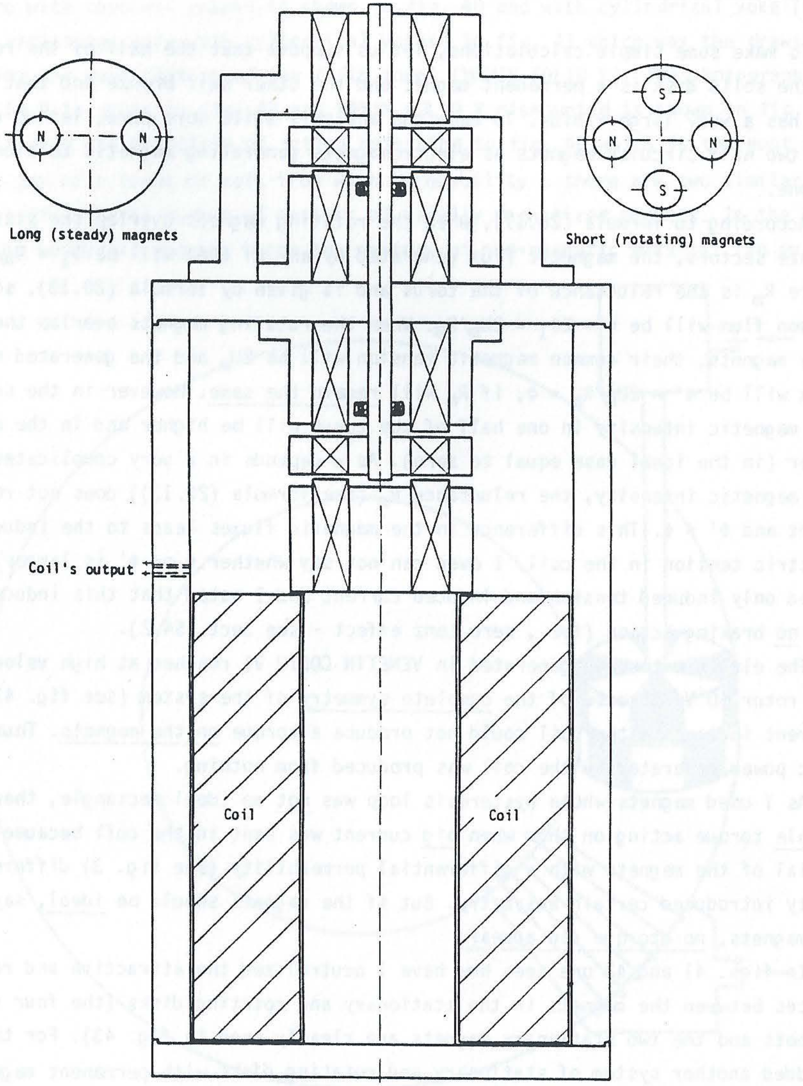

Fig. 41. Diagram of the machine MAMIN COLIU V.

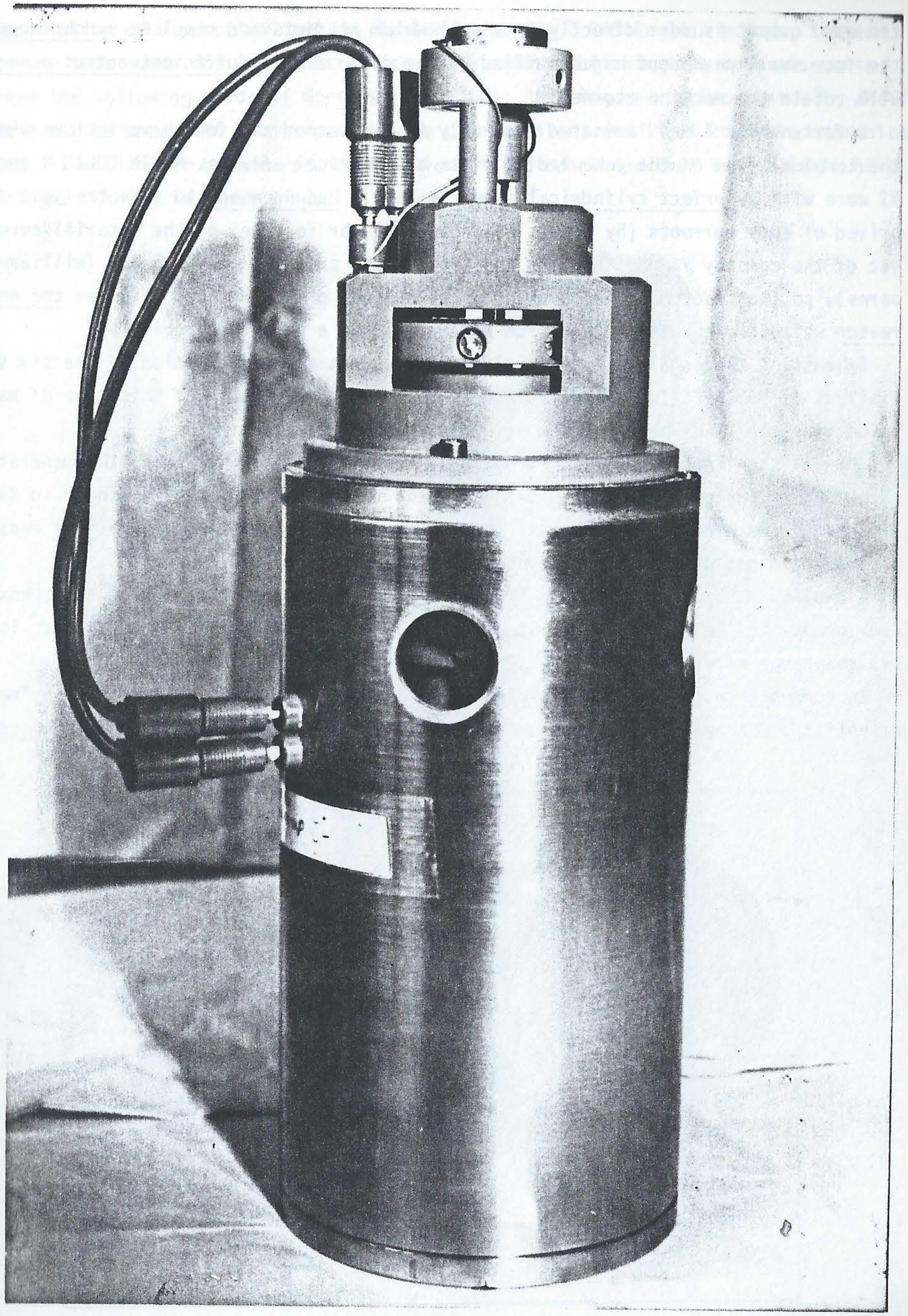

Fig. 42. Photograph of the machine MAMIN COLIU V.

the a.c. output is sent directly to a coil which attracts and repulses synchronously the four small permanent magnets fixed to the rotor and at sufficient output power will rotate the machine eternally.

Unfortunately I had laminated iron only in the second and fourth variations where the toroidal form of the yoke led to other asymmetrical effects. MAMIN COLIU V and VI were with a perfect cylindrical symmetry, but I had no money to make the yoke deprived of eddy currents (by using laminated iron, or ferrite, or the material corovac of the company VACUUMSCHMELZE) and the current produced was very low (milliamperes), so that the power was not enough to run the driving motor. This was the only reason which did not allow me to run MAMIN COLIU as a perpetuum mobile.

Exhausting thoroughly my financial resources with the construction of the six variations of MAMIN COLIU, I interrupted in 1988 the construction of this type of machines for the time when enough money will be available.

Thus if the iron in MAMIN COLIU would be deprived of eddy currents, the generated output power, after rectification, can be sent to the driving motor as shown in fig. 42, and the machine can be run as a perpetuum mobile. I repeat once more, the reason that I could not do this was only one: the lack of money.

I published the description of MAMIN COLIU in two paid advertisments[44,45], however nobody in the world tried to construct this simple machine and to see that it has generator effect but no motor effect.

In comments to the second advertisment, S. A. Hayward wrote[46] that I am a "mad scientist". Perhaps Mr. Hayward was right, as only a mad man can publish the exact

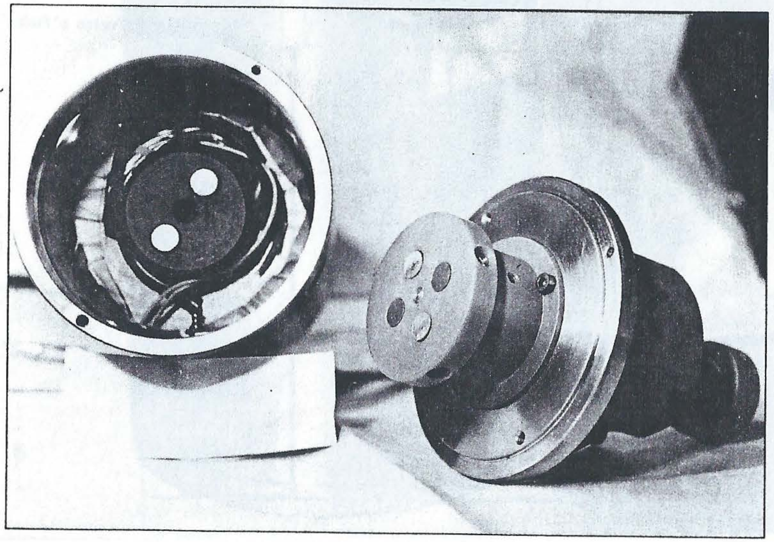

Fig. 43. The machine MAMIN COLIU V dismounted.

description of a perpetual motion machine by paying 3.942 English pounds, instead to use this money for its construction. Only after publishing the advertisements, I read the following words of Gorgias (483 - 380): "Nothing can be known at all; and if it could be known, it cannot possibly be communicated; and if it could be communicated, it will never be understood or believed" and concluded that two millenia have changed nothing in human mind.

Fig. 44. Photograph of the machine MAMIN COLIU VI.

54. THE TWO POLAR MACHINE VENETIN COLIU

54.1. INTRODUCTION.

In 1990 Manuele Cavalli and Bruno Vianello, who have read in an Italian magazine about my electromagnetic experiments and machines, invited me to visit them and to discuss the matter. I started immediately with pleasure for their town Treviso "*in dem Land wo die Zitronen blüh'n*" and after having spent a couple of days in their and their charming wives' company, I left them the machine MAMIN COLIU VI, which I took with me (25 kg) to demonstrate the effects, as they promised to dedicate time and money for its further development.

Having done their own measurements on VENETIN COLIU VI and on other electromagnetic generators, they informed my of having found some generators which not only that have no magnetic braking torque, but when generating current obtain, at certain conditions, a torque supporting the rotation.

These generators were not specially constructed: Cavalli and Vianello observed the self-accelerating effect first in the Bosch ignition coils which produce the electric alternating tension activating the high voltage used for ignition of the sparks in the benzine car cylinders (I give the whole description of these generators to show the dinosauric character of today's technology), then in stepper motors.

After doing measurements on the generators suggested by Cavalli and Vianello and then on similar generators constructed by me, I understood that every electromagnetic generator diminishes its braking magnetic torque when its phase angle ϕ (see beneath) approaches $\pi/2$. This character of the electromagnetic generators can easily be explained and calculated. The effect of changing the braking torque to supporting torque, with the increase of the current frequency, is not so clear and needs more profound theoretical and experimental analysis.

I decided to call any generator working with ϕ near to $\pi/2$ and losing its braking torque the VENETIN COLIU MACHINE (in Italian NICOLINO VENETO), throwing in this way a bridge to the generator MAMIN COLIU where there is no braking magnetic torque at any velocity of the rotor (i.e., at any current frequency). The term "VENETIN" comes from "Veneto", the Italian province where Cavalli and Vianello live.

In the last years I have no more experimented with MAMIN COLIU and dedicated my whole time and scarce money to VENETIN COLIU, as it seemed to me that it was easier to construct a VENETIN COLIU machine with a closed energetic circle, i.e., to run it as a perpetuum mobile.

The story of my contacts with Cavalli and Vianello (with many photographs) is well documented in Ref. 47, p. 8.

54.2. THEORETICAL BACKGROUND.

Let us consider the most ordinary two polar generator (later an example will be given) in which a magnet performing periodic motion generates in a coil at rest a tension

$$U_{gen} = U_{gen\text{-}max}\sin(\omega t), \tag{54.1}$$

where $U_{gen\text{-}max}$ is the maximum value of the generated tension, $\omega = 2\pi/T$ is its circular frequency and T is the period of motion of the magnet (the time in which it returns to its initial state).

Putting (54.1) into (19.15), we shall have

$$U_{gen\text{-}max}\sin(\omega t) = RI + L(dI/dt), \tag{54.2}$$

where R is the resistance of the coil, L its inductance and I the flowing current.

This is a differential equation with respect to I and the solution can be searched in the form

$$I = I_{max}\sin(\omega t - \phi), \tag{54.3}$$

where I_{max} and ϕ are two positive (as we shall see later) constants.

Indeed, substituting (54.3) into (54.2), we obtain

$$U_{gen\text{-}max}\sin(\omega t) = RI_{max}\sin(\omega t - \phi) + LI_{max}\cos(\omega t - \phi). \tag{54.4}$$

This equation can be written in the form

$$(U_{gen\text{-}max}/I_{max})\sin(\omega t) = (R\cos\phi + \omega L\sin\phi)\sin(\omega t) - (R\sin\phi - \omega L\cos\phi)\cos(\omega t). \tag{54.5}$$

Obviously it must be

$$R\sin\phi - \omega L\cos\phi = 0, \tag{54.6}$$

so that

$$\tan\phi = \omega L/R \tag{54.7}$$

and

$$U_{gen\text{-}max}/I_{max} = R\cos\phi + \omega L\sin\phi = (R^2 + \omega^2 L^2)^{1/2}. \tag{54.8}$$

The quantity

$$Z = (R^2 + \omega^2 L^2)^{1/2} \tag{54.9}$$

is called IMPEDANCE of the circuit and ωL is called INDUCTIVE REACTANCE.

The quantity

$$\phi = \arctan(\omega L/R) = \arccos(R/Z) \tag{54.10}$$

is called PHASE ANGLE and shows the angular delay in radians with which the maximum of current appears after the maximum of the generated tension. As T is the period of the generated tension, then $\Delta t = (\phi/2\pi)T = \phi/\omega$ is the time after which the maximum of the current appears after the maximum of the generated tension.

Let us consider the most simple generator consisting of a solenoidal coil and a permanent magnet which will be pushed in the coil and then pulled out (figs. 45 and 46). In fig. 47 I give the generated in the coil magnetic flux Φ, when it has a cosinusoidal character. Such a character of the generated flux can be obtained if we assume that at the farthest position of the magnet the flux in the coil is zero, at the nearest position when the magnet points with its north pole to the coil, it is maximum positive, and that when reaching again the farthest position after half of the period, we turn round the magnet momentarily, so that during the second half of the period it faces the coil with its south pole.

The tension generated in the coil is to be calculated from the formula (19.14)

$$U_{gen} = -\partial\Phi/\partial t \qquad (54.11)$$

and to have the generated tension (54.1), the magnetic flux must be a cosinusoidal function of time

$$\Phi = \Phi_{max}\cos(\omega t). \qquad (54.12)$$

In fig. 47 I have chosen $R = 1\ \Omega$, $L = \sqrt{3}\ \Omega$, so that, according to formula (54.8)

$$I_{max} = U_{gen-max}/(R^2 + \omega^2 L^2)^{1/2} = 0.5U_{gen-max}, \qquad (54.13)$$

and according to (54.2) we obtain for the amplitudes of the ohmic and induced tensions

$$U_{max} = RI_{max} = 0.5U_{gen-max},$$

$$U_{ind-max} = LI_{max} = (\sqrt{3}/2)U_{gen-max} = 0.87U_{gen-max}. \qquad (54.14)$$

Thus equation (54.4) can be rewritten in the following form, giving the graphs of U_{gen}, U_{ind} and U,

$$U_{gen-max}\sin(\omega t) - 0.87U_{gen-max}\cos(\omega t - \phi) = 0.5U_{gen-max}\sin(\omega t - \phi). \qquad (54.15)$$

The phase angle has the value

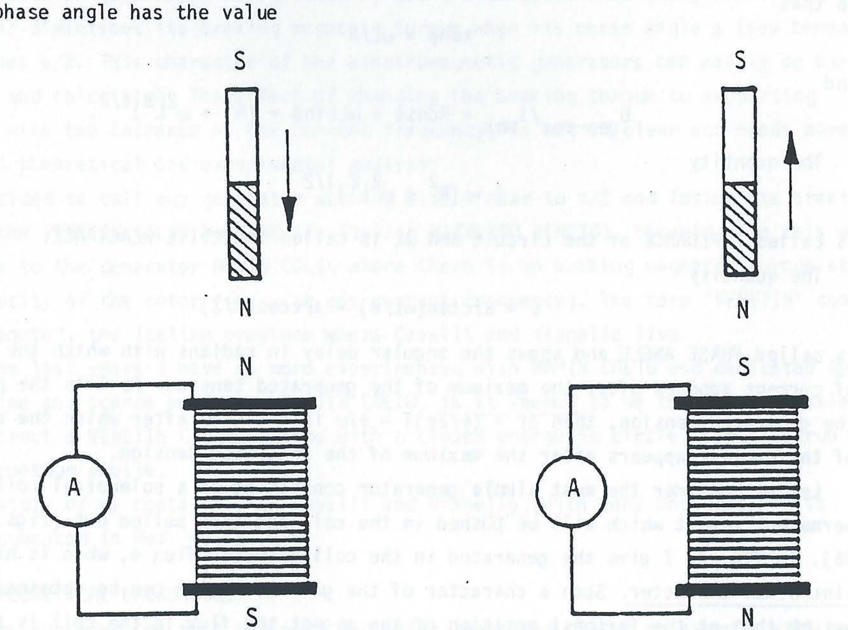

Fig. 45. The polarity obtained by a cylindrical coil when a permanent magnet is pushed in and pulled out.

$$\phi = \arctan(\omega L/R) = \arctan\sqrt{3} = 1.05 \text{ rad} = 60^{\circ}. \qquad (54.16)$$

The positive current in fig. 47 (i.e., the current above the x-axis) produces south pole at the upper end of the coil in fig. 45, and the negative current produces north pole.

The motion of the magnet is as follows:

a) during the time t_1-t_2 a push motion with the south pole pointing to the magnet,
b) during the time t_2-t_3 a pull motion with the south pole pointing to the magnet,
c) during the time t_3-t_4 a push motion with the north pole pointing to the magnet,
d) during the time t_0-t_1 a pull motion with the north pole pointing to the magnet.

If at a given moment the magnetic action of the current flowing in the coil opposes the motion of the permanent magnet, I call this MOMENTARY LENZ EFFECT; if however it supports the motion of the permanent magnet, I call this MOMENTARY ANTI-LENZ EFFECT (if precision is necessary, the Lenz effect will be called also NORMAL Lenz effect). The effect of opposing (supporting) the motion of the permanent magnet for the whole period of motion is called INTEGRAL LENZ EFFECT (INTEGRAL ANTI-LENZ EFFECT). If for the whole period the motion of the magnet is neither opposed nor supported, I call this INTEGRAL ZERO LENZ EFFECT. The MOMENTARY ZERO LENZ EFFECT appears when the current in the coil is zero.

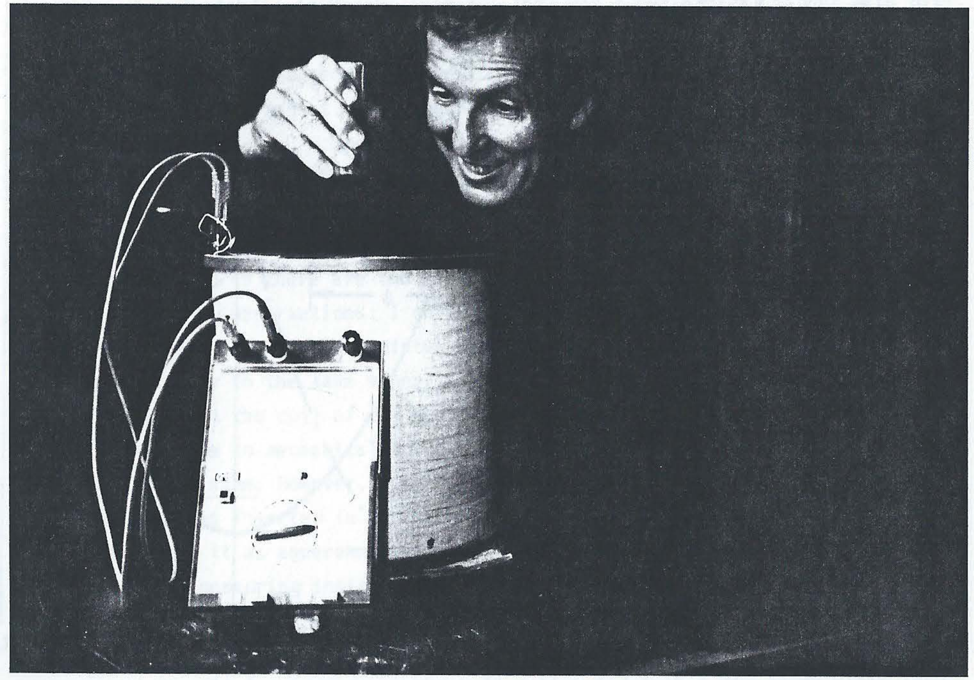

Fig. 46. Photograph of my big cylindrical coil and strong permanent bar magnet.

Let me note that if there will be a condenser with capacitance C inserted in series in the circuit, we have to use not the differential equation (19.15) but the differential equation (19.21). Now putting (54.1) into (19.21), we shall have

$$U_{gen\text{-}max}\sin(\omega t) = RI + (1/C)\int I dt + L(dI/dt). \qquad (54.17)$$

Searching again the solution in the form (54.3), we shall have

$$U_{gen\text{-}max}\sin(\omega t) = RI_{max}\sin(\omega t - \phi) - (1/\omega C)I_{max}\cos(\omega t - \phi) + \omega L I_{max}\cos(\omega t - \phi). \quad (54.18)$$

This equation can be written in the form

$$(U_{gen\text{-}max}/I_{max})\sin(\omega t) =$$
$$\{R\cos\phi + (\omega L - 1/\omega C)\sin\phi\}\sin(\omega t) - \{R\sin\phi - (\omega L - 1/\omega C)\cos\phi\}\cos(\omega t). \qquad (54.19)$$

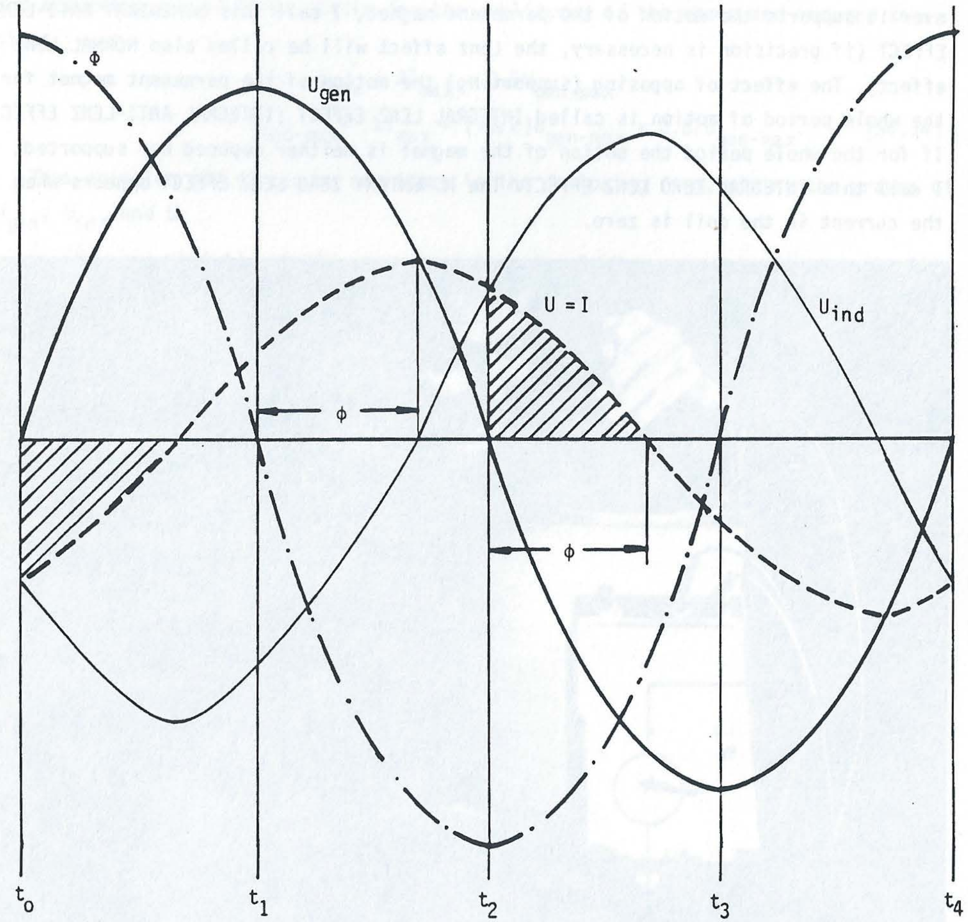

Fig. 47. Graph of the generated in the coil magnetic flux Φ, of the generated tension U_{gen}, of the self-induced tension U_{ind}, of the ohmic tension U, and of the current I (at the assumption R = 1 Ω).

Now the phase angle will be

$$\tan\phi = (\omega L - 1/\omega C)/R \qquad (54.20)$$

and the impedance

$$Z = \{R^2 + (\omega L - 1/\omega C)^2\}^{1/2}. \qquad (54.21)$$

The quantity $1/\omega C$ is called CAPACITIVE REACTANCE.

For

$$\omega L - 1/\omega C = 0, \quad \text{i.e., for} \quad \omega^2 = 1/LC \qquad (54.22)$$

there is the so-called RESONANCE: the impedance is equal to the resistance, Z = R, and the phase angle is zero, $\phi = 0$.

54.3. HOW THE ANTI-LENZ EFFECT CAN BE DEMONSTRATED BY AN AMPEREMETER.

One can very easily demonstrate the momentary anti-Lenz effect, i.e., one can demonstrate that at certain moments the current induced in the coil supports the motion of the magnet and does not brake it, as Lenz[48] generalized in 1834 formulating his famous LENZ RULE.

I made such demonstrations (see figs. 48 and 49) with my big coil which has 140,000 turns of wire with thickness 0.3 mm, ohmic resistance R = 20,000 Ω and inductance L = 3,700 H. My permanent magnet was of neodymium (VACODYM 335) produced by the plant Vacuumschmelze in Hanau, Germany. This was a cylindrical magnet with dismeter 3 cm and length 10 cm.

First I registered the generated tension by a d.c. voltmeter when pushing and pulling the permanent magnet. The pointer of the voltmeter always "followed" the motion of my hand.

Then I registered the flowing current by an amperemeter when pushing and pulling the permanent magnet. I could easily see that the pointer of the same apparatus "followed" with a delay the motion of my hand.

In figs. 48 and 49 there are two photographs which can persuade the reader in the authenticity of my observations: I chose such ranges of the voltmeter and amperemeter that the deviations of the pointer were quite the same when pushing and pulling the magnet exactly in the same manner. This signified that always the same current has passed through the coil of the measuring instrument and the delays in the motion of the pointer due to mechanical and electrical causes of the measuring instrument were exactly the same. However, when using the measuring instrument as voltmeter, a big resistance was inserted in series with the coil of the measuring instrument, while when using it as amperemeter, a small resistance was inserted in parallel to the coil of the measuring instrument.

I took the photographs always when pulling out the magnet from the coil (after having pushed it). As fig. 48 shows, when my big induction coil was closed by a big resistance, the flowing current at the pull motion had such a direction (note that the bottom "+" was pressed) that the current opposed the motion of the magnet.

However, as fig. 49 shows, when my big induction coil was closed by a small resistance, the flowing current at the moment of taking the picture during the pull motion had such a direction (note that the bottom "-" was pressed) that the current supported the motion.

54.4. HOW THE ANTI-LENZ EFFECT CAN BE DEMONSTRATED ON AN OSCILLOGRAPH.

With the aim to observe the time delay of the current flowing in the coil of a generator with respect to the generated tension, I fixed the rotors of two stepping motors to a common axle and drove them by a d.c. motor (fig. 50).

But first I should like to make clear to the reader what a stepping motor is, considering one of the motors in fig. 50 which were of the type KP4M4, produced in India for IBM computers.

In fig. 51 one of these motors is presented open. The rotor consists of two fixed one to another parallel cogged disks with 25 strongly magnetized cogs each, so that the cogs of the one disk have north magnetism and the cogs of the other disk south magnetism. The angular distance between two neighbouring cogs is $\alpha = 360:25 = 14^{\circ}.4$. The cogs of the two disks are displaced at an angle $\alpha/2 = 7^{\circ}.2$, so that when looking at the generatrix of the cylindrical surfaces of the disks one sees the cogs of the

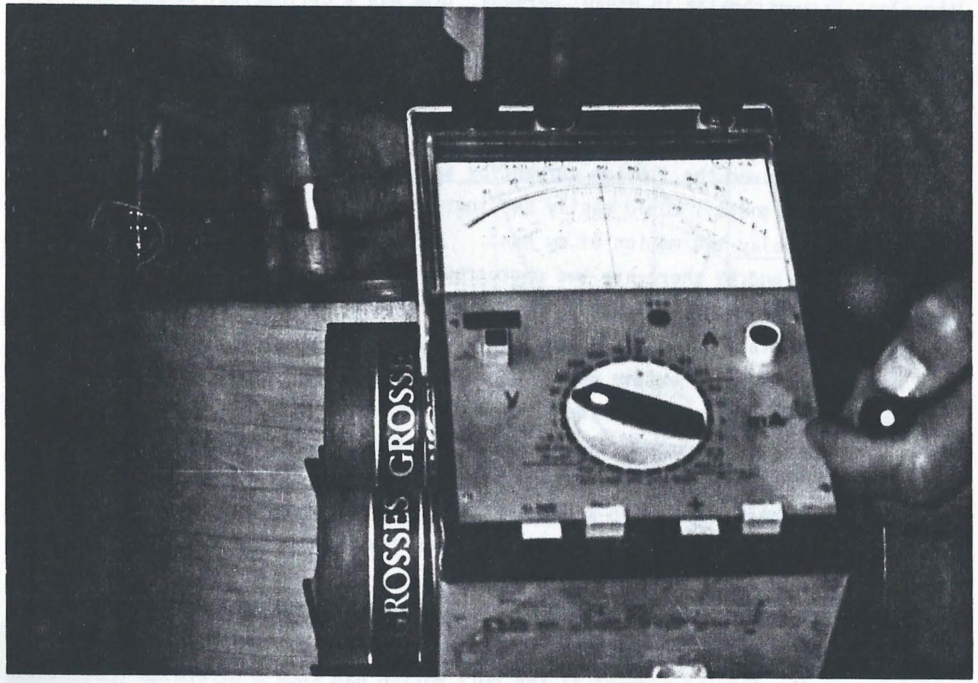

Fig. 48. Momentary Lenz effect when pulling the permanent magnet (after having pushed it) and the measuring instrument is a voltmeter, i.e., $R \gg \omega L$.

one disk in front of the notches of the other.

The stator has four cores, any of which has four cogs, so that in the space between two neighbouring cores there are "missing" $n_o = (25 - 16):4 = 2.25$ cogs. Around the cores four double coils are wound in such a way that every one of these double coils is connected in series with one of the double coils wound around the opposite core.

Thus there are eight issues. Four of these eight issues are connected to a common point (a black issue) and the other four (coulored) issues are the free ends of the four coils (any of which, I repeat, is wound about two opposite cores). Every such coil has ohmic resistance $R = 80\ \Omega$ and inductance $L = 0.04$ H.

I present in fig. 52 a very simplified diagram of the stepping motor, from which one can easily grasp the principle of tension generation when rotating the rotor.

I reduced in fig. 52 the cogs of the rotor to 13 and the cogs on every core to two. Then I have drawn only two opposite cores, omitting the two other cores.

At the situation shown in the figure the anterior (north) upper cogs of the rotor come in front of the cogs of the upper core, while the posterior (south) lower cogs of the rotor come in front of the cogs of the lower core. Thus the magnetic intensity in the upper core increses in direction up (and reaches its maximum when the north

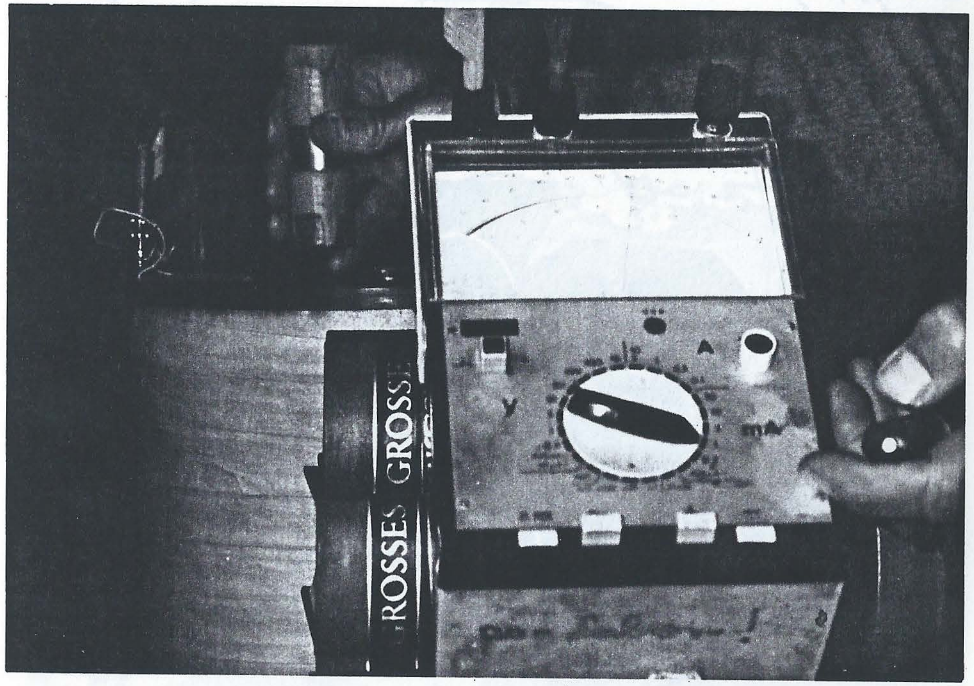

Fig. 49. Momentary anti-Lenz effect when pulling the permanent magnet (after having pushed it) and the measuring instrument is an amperemeter, i.e., $R \ll \omega L$.

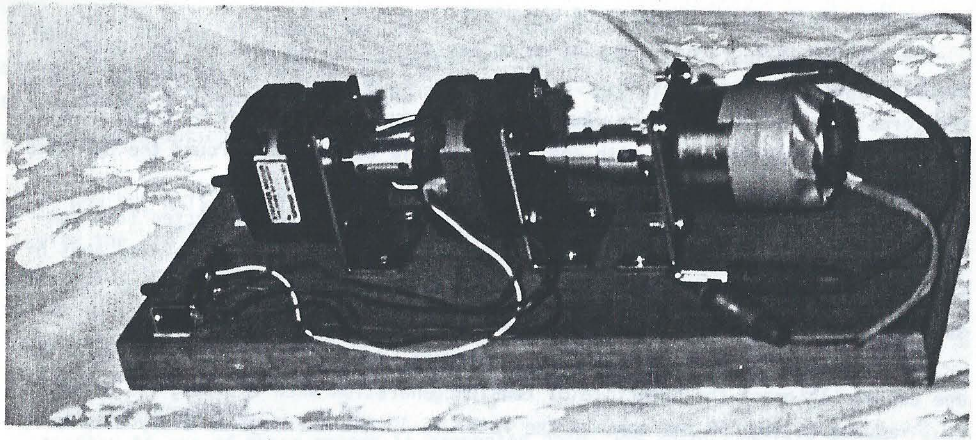

Fig. 50. Two mechanically coupled stepping motors (used as generators) driven by a common d.c. motor.

upper rotor's cogs will be exactly in front of the upper stator's cogs), while the magnetic intensity in the lower core increses also in direction up (and reaches its maximum when the south lower rotor's cogs will be exactly in front of the lower stator's cogs).

The tension induced in the windings of the upper and lower coils will be such that the magnetic intensity, generated by the current flowing in the windings, must point down, as it must oppose the change of the magnetic intensity in the core (I apply the Lenz rule at the condition $\phi \cong 0$!). Thus the direction of the induced

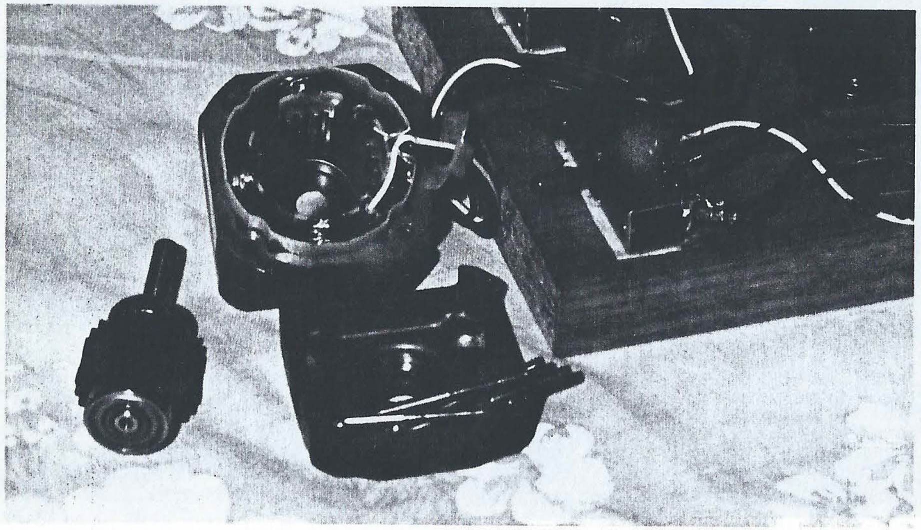

Fig. 51. A stepping motor open.

current will be as shown in the figure. There are two parallel such coils. In fig. 52 their initial points are connected but in my motor (fig. 51) the final point of the one parallel coil was connected with the initial point of the other one.

Thus when (at $\phi \cong 0$) the upper north rotor's cogs approach the stator's cogs, the current in the upper half of the coil has the indicated in fig. 52 direction, becoming zero when the north rotor's cogs are exactly in front of the stator's cogs. When the north rotor's cogs go away from the stator's cogs, i.e., when the upper south rotor's cogs approach the upper stator's cogs, the current in the upper half of the coil has the opposite direction, becoming zero when the south rotor's cogs are exactly in front of the stator's cogs. Consequently, at a rotation on "one cog" the induced tension (and induced current) complete one cycle. The time, T, for this cycle is called period. The quantity $\nu = 1/T$ is called LINEAR FREQUENCY and the quan-

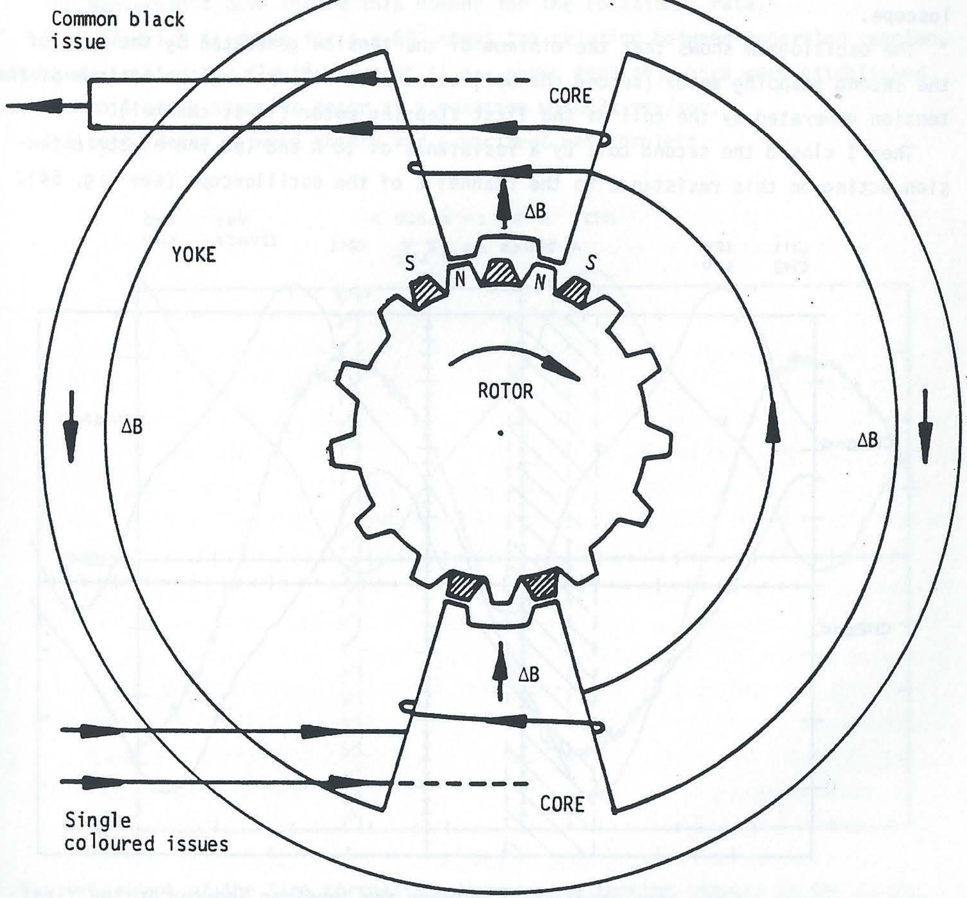

Fig. 52. Diagram of a stepping motor.

tity $\omega = 2\pi\nu$ is the circular frequency.

As the rotor has n = 25 cogs, at a rotation with N rev/sec, the circular frequency will be

$$\omega = 2\pi nN = 50\pi N. \qquad (54.23)$$

The inductive reactance of the coil will be

$$\omega L = 50\pi NL. \qquad (54.24)$$

The phase angle is

$$\phi = \arctan(\omega L/R) = \arctan(50\pi NL/R) = \arctan(0.08N). \qquad (54.25)$$

Thus at N = 12.5 rev/sec we have $\phi = 45^0$.

In fig. 53 one sees the oscillogram of the tensions generated by two coils of the two stepping motors shown in fig. 50 whose rotors were rotated on a common axle by a d.c. motor. The tensions were conducted to the two channels of a double-beam oscilloscope.

The oscillogram shows that the minimum of the tension generated by the coil of the second stepping motor (second channel) comes with $74^0_.5$ before the minimum of the tension generated by the coil of the first stepping motor (first channel).

Then I closed the second coil by a resistance of 10 Ω and led the electric tension acting on this resistance to the channel 2 of the oscilloscope (see fig. 54).

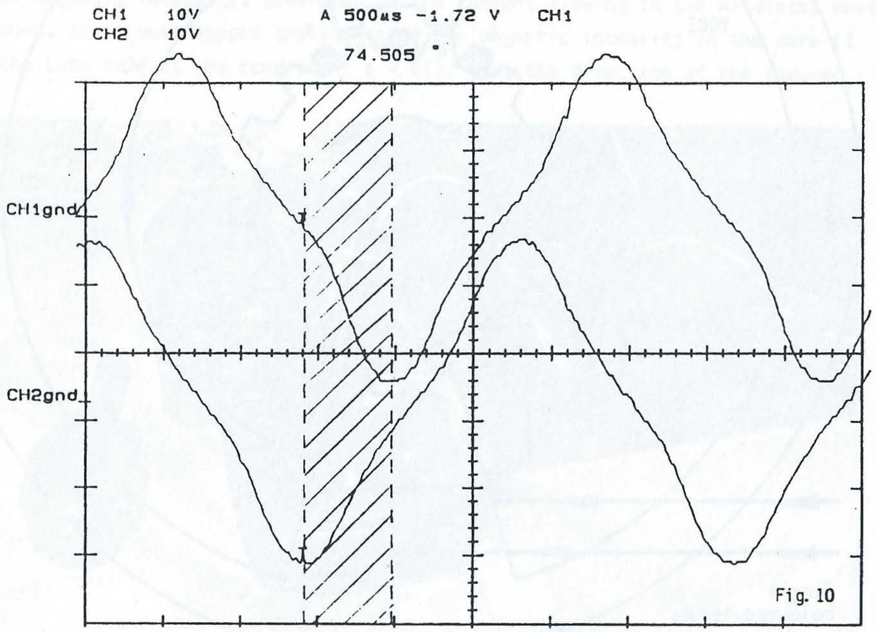

Fig. 53. Graph of the time correlation between the tensions induced in the first and second stepping motors (oscillogram).

The tension from the resistance was taken in such a way that on the oscilloscope it was inverted with 180^0 with respect to the induced tension (this inversion could be evaded if I had earthed not the "left" end of the resistance but its "right" end!). Now we see that the maximum of the current (as a matter of fact, the minimum of the current if the 180^0-inversion was evaded!) appears with $180^0 - 164^0_.9 = 15^0_.1$ before the minimum of the tension generated by the coil of the first stepping motor.

Thus the retardation of the current in the second coil with respect to the tension generated in it, i.e., the phase angle, was

$$\phi = 74^0_.5 - 15^0_.1 = 59^0_.4. \qquad (54.26)$$

According to formula (54.25) this phase angle corresponds to the following rate of rotation

$$N = 12.5\tan 59^0_.4 = 21 \text{ rev/sec}. \qquad (54.27)$$

The measurement gave indeed this number for the rotational rate.

Fig. 47 which is drawn for $\phi = 60^0$ shows the relation between generated tension, induced tension and flowing current (i.e., ohmic tension) which were established in the coil of my stepping motor at a rotation with 21 rev/sec.

The coincidence between theory and experiment was complete.

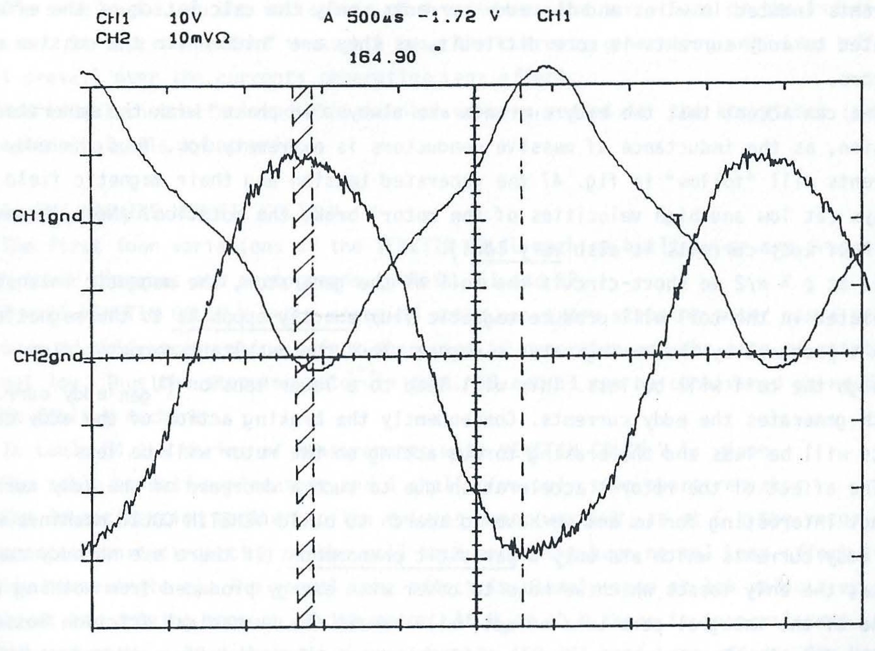

Fig. 54. Graph of the time correlation between the tension induced in the first stepping motor and the current induced in the second one (oscillogram).

54.5. GENERAL ANALYSIS OF THE ANTI-LENZ EFFECT.

It is clear when looking at fig. 47 that the magnetic field generated by the hatched current supports the rotation and only the magnetic field generated by the unhatched current brakes the rotation, or to put it shortly, the hatched current produces anti-Lenz effect and only the unhatched current produces normal Lenz effect.

For $\phi = 0$ the whole generated current produces Lenz effect, for $0 < \phi < \pi/2$ the Lenz effect is prevailing over the anti-Lenz effect and we have integral normal Lenz effect. For $\phi \to \pi/2$ the Lenz effect becomes equal to the anti-Lenz effect and we have integral zero Lenz effect. Thus the machine VENETIN COLIU can reach at the most an integral zero Lenz effect.

However, at short-circuiting of the coils in our VENETIN COLIU machines we observed that the consumption of the driving motors diminished and the rate of rotation increased. Thus we observed an integral anti-Lenz effect.

Now I shall show that a part of this effect, i.e., a part of the acceleration of the rotor, was due not to the production of energy from nothing but to the decrease of certain "friction energy", namely to a decrease of the energy losses due to the eddy currents.

EDDY CURRENTS are the currents induced in massive conductors when the magnetic flux through the conductors varies. There is no principal difference between the currents induced in wires and the eddy currents, only the calculation of the effects related to addy currents is more difficult, as they are "hidden" in the massive conductors.

One can accept that the eddy currents are always "in phase" with the generated tension, as the inductance of massive conductors is extremely low. Thus the eddy currents will "follow" in fig. 47 the generated tension and their magnetic field will always (at low and high velocities of the rotor) brake the rotation. (Note, however, the R of eddy currents is also very low!).

If at $\phi \cong \pi/2$ we short-circuit the coil of the generator, the magnetic intensity generated in the coil will produce magnetic flux exactly opposite to the magnetic flux Φ produced by the moving rotor's magnet. Thus the resultant magnetic flux through the coil will be less. This will lead to a lower tension $(U_{gen})_{eddy\ curr.}$ which generates the eddy currents. Consequently the braking action of the eddy currents will be less and the braking torque acting on the rotor will be less.

The effect of the rotor's acceleration due to such a decrease of the eddy currents is not interesting for us and we have to search to build VENETIN COLIU machines without eddy currents which are only a parasitic phenomenon. If there are no eddy curnets, the only losses which we have to cover with energy produced from nothing (because of the integral zero Lenz effect) will remain the mechanical friction losses. As the friction losses can be made very low, a part of the energy produced at the zero Lenz effect which can be extracted from the machine can cover them.

However my experiments showed quite clearly that if disregarding the eddy currents, there is still a self-accelerating torque acting on the rotor at short-circuiting of the coil (see the data below).

I could not find a firm and clear explanation of this integral anti-Lenz effect and I presume that it can be due to the EWING EFFECT.

The effect observed for the first time (to the best of my knowledge) by Ewing[49] has many different names: magnetic viscosity, magnetic after affect, time effect in magnetization. Recently my friend Ch. Monstein[50] revived this almost forgottrn but very important effect with a series of beautiful experiments.

The Ewing effect consists in the retardation of the magnetization of a magnetic slab if the magnetizing intensity is applied to the one of its extremities and we look for the magnetization at the other extremity. This time is pretty large, of the order of tens of milliseconds per meter.

Thus I made the hypothesis that, because of this retardation in the magnetization of the iron in our VENETIN COLIU machines, the magnetic flux in the coil reaches its maximum (when the length of the yoke is not negligible) not for the moment when the moving magnet reaches the neutral position (the moments t_o, t_2, t_4 in fig. 47) but with some retardation. Thus the graph of the flux Φ will be displaced at a certain angle α to the right in fig. 47. Consequently all other graphs will be displaced at the same angle, as the variations of Φ determine the variations of the induced tension. It is evident that in such a case the currents generating anti-Lenz effect will prevail over the currents generating Lenz effect.

Additional theoretical and experimental work is needed for the acceptance (or rejection) of this hypothesis.

54.6. THE MACHINE VENETIC COLIU V.

The first four variations of the VENETIN COLIU machine built by me are presented with their diagrams and photographs in Refs. 51 and 52.

I call VENETIN COLIU V every stepping motor, as every stepping motor has a very pronounced self-accelerating effect when used as generator and the rate of rotation is not low. Thus the stepping motor in figs. 50 and 51 can be considered as my VENETIN COLIU V machine.

In table 54.1 a series of measurements with VENETIN COLIU V is given.

The table is self-explanatory and I shall give only some short remarks:

The lowest tension applied to the driving motor was 6 V, as at 5 V the motor stopped at short-circuiting of the coil because of the huge normal Lenz effect (very low phase angle ϕ). The normal Lenz effect is clearly seen at low velocities, i.e., at low driving tension of the motor. At U_m = 10 V there is integral zero Lenz effect and at U_m = 30 V there is a considerable (52.3%) anti-Lenz effect. One has to take into account that in stepping motors the eddy currents are very high (see

Table 54.1

Tension applied to the motor	Current consumed by the motor: at open coils	Current consumed by the motor: at closed coils	Power consumed by the motor: at open coils	Power consumed by the motor: at clos. coils	Increase of the consum. power	$\frac{\Delta P_m}{P_m}$	Tension induced in the coils	Current flowing in the coils	Power produced by the generator	$\frac{P_g}{P'_m}$
U_m (V)	I_m (mA)	I'_m (mA)	P_m (W)	P'_m (W)	ΔP_m (W)	%	U_g (V)	I_g (mA)	P_g (W)	%
6	123	220	0.74	1.32	+0.58	+78.4	7.2	20	0.13	9.8
10	160	160	1.60	1.60	0	0	14.5	42	0.56	35.0
20	224	124	4.48	2.48	-2.00	-44.6	30.0	43	0.59	23.8
30	260	124	7.80	3.72	-4.08	-52.3	49.0	43	0.59	15.9

the high power consumption at open coils when the driving torque has to overcome only the friction (which is low) and the braking torque of the eddy currents), but nevertheless it seems highly improbable that such a considerable decrease in the power consumed is due only to the decrease of the eddy currents.

54.7. THE MACHINE VENETIC COLIU VI.

With the aim to exclude the action of the eddy currents, I constructed the machine VENETIN COLIU VI with ferrite magnets and soft ferrites which had low eddy currents.

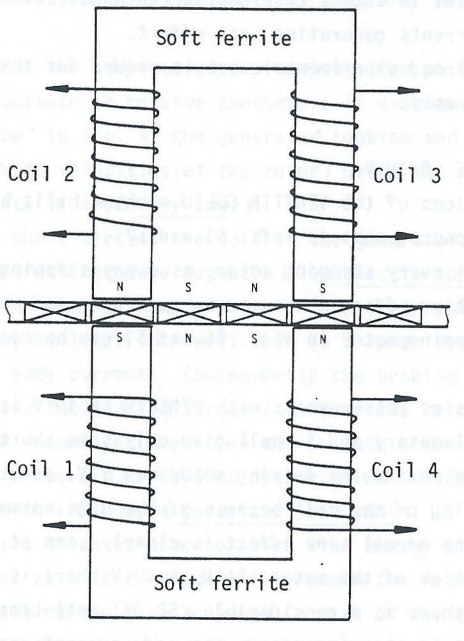

Fig. 55. Schematic diagram of the two polar machine VENETIN COLIU VI.

(Let me note that my machine VENETIN COLIU II was also built only with hard and soft ferrites and the machine VENETIN COLIU III with soft ferrites [51].)

I went specially to a plant in former East Germany to buy them, as it was promised to me that the ferrites will be thoroughly without eddy currents. This was not the case as the reader will see: the ferrites had eddy currents, but low.

A detailed report on VENETIN COLIU VI is given in Ref. 53. Here only a short account:

The schematic diagram of one generator knot of VENETIN COLIU VI is given in fig. 55 and the photograph of the machine with three generator knots is given in fig. 56. The VENETIN COLIU VI machine with only one generator knot is shown in fig. 58. Further I shall speak and give data for the machine with only one mounted generator knot. The description of the machine is the following:

Along the rim of the rotating disk with diameter 180 mm there are arranged 24 cylindrical magnets with diameter 19 mm and height 6 mm. Every Π-form yoke (which can be see in the middle of fig. 57) has the following dimensions: length 80 mm and height 90 mm. The disk is fixed to an axle with diameter 4 mm which can rotate on two ball-bearings fixed to the upper part of the machine. When the upper yoke with its two coils is fixed to the upper part, the disk is fixed to the axle at a respective distance from the coils (about 1 mm). Then the upper part is put on the four brass columns and, by letting it fall micrometrically down, the distance between the

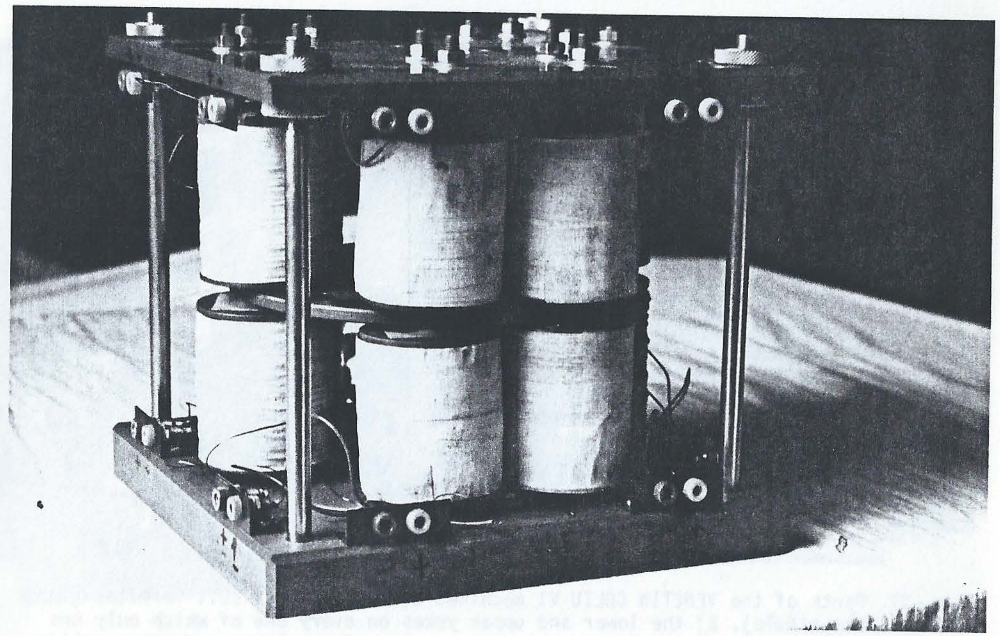

Fig. 56. Photograph of the machine VENETIN COLIU VI (with three generator knots).

disk and the lower coils is fixed at the respective 1 mm.

I made coils with different thickness of the wire, beginning with thickness 1.8 mm. The best results, of course, were obtained with coils having the thinest wire, as their inductance was the highest. I shall describe the measurements only with such coils.

Thus I made four coils with wire of thickness 0.2 mm, 23,000 turns and resistance R = 1600 Ω each. Here the phase angles were the highest and the anti-Lenz effect also the highest. Let me note that the currents in the different coils, because of the appearing mutual inductances, depended strongly one on another. So I measured the following currents in coil 1 (see fig. 55):

I = 7.4 mA when coils 2,3,4 were open,

I = 5.4 mA when coil 2 was closed and coils 3,4 open,

I = 6.2 mA when coil 3 was closed and coils 2,4 open,

I = 5.1 mA when coil 4 was closed and coils 2,3 open,

I = 3.7 mA when all coils 2,3,4 were closed.

The measurements are presented in table 54.2.

The driving tensions, U_{mot}, are given in the first column, the currents I_o consumed by the motor when the disk rotated alone are given in the second column, the currents I_{oo} consumed by the motor when the coils are mounted without the yokes (and even without the wires) are given in the third column. I show in fig. 57 (at the left) how the coils without the yokes were mounted. Comparing columns 2 and 3

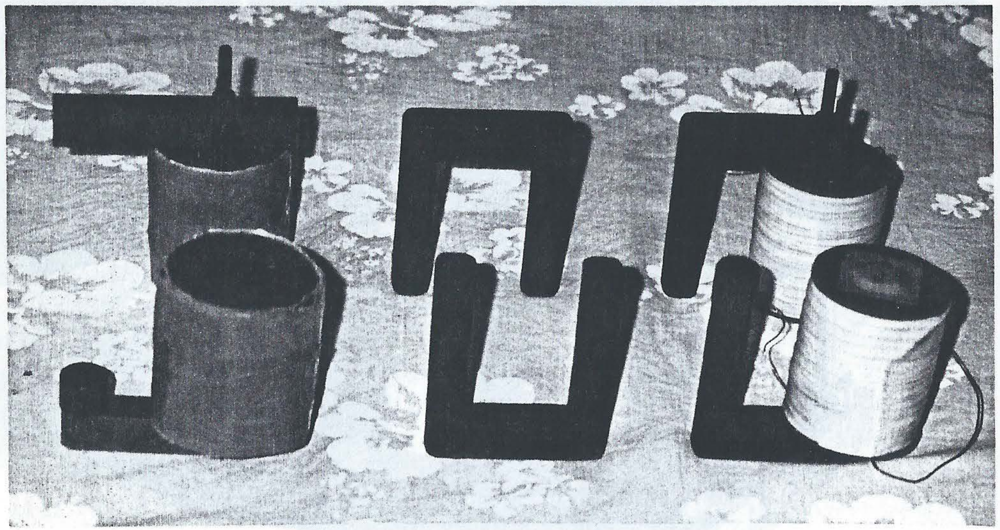

Fig. 57. Parts of the VENETIN COLIU VI machine: 1) the yokes of soft ferrites (in the middle), 2) the lower and upper yokes on every one of which only one coil is mounted (at the right), 3) mounting of the lower and upper coil's supports without wire (at the left).

Table 54.2

Driving tension U_{mot} (V)	Driving current: without yokes without coils I_o (mA)	without yokes with coils I_{oo} (mA)	with yokes with coils (open) I (mA)	with yokes with coils (closed) I' (mA)	Current difference $I-I_o$ (mA)	Current change $\Delta I = I'-I$ (mA)	Power change ΔP (mW)
5	33	33	38	53	5	15	75
10	46	46	53	54	7	1	10
15	65	65	80	70	15	-10	-150
20	88	89	104	91	16	-13	-260

Generated current: I_{gen} = 3.7 mA, Generated power: $P_{gen} = 4I_{gen}^2 R_5$ = 88 mW

one sees that the friction in the air when the coils are mounted is so feeble, that it can be neglected. The currents, I, consumed by the motor when the coils are mounted with the yokes of soft ferrites are given in the fourth column, for the case where the coils are open. The currents, I', for the case where the coils are closed (i.e., short-circuited) are given in the fifth column. The differences of the currents I and I_o are given in the sixth column. The changes $\Delta I = I' - I$ of the currents at closed and open coils are given in the seventh column. The changes ΔP =

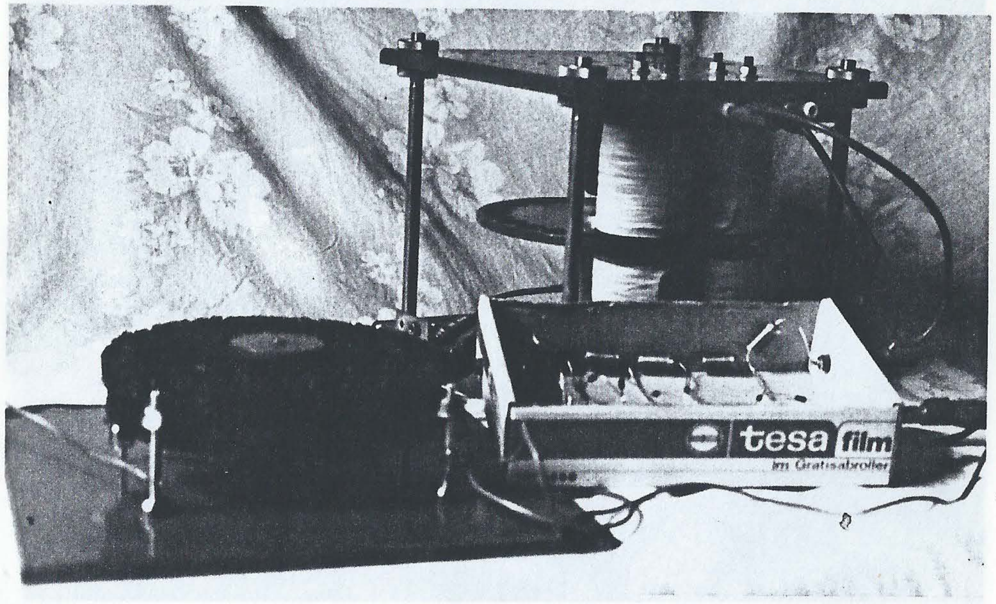

Fig. 58. Driving a corona motor by the output of VENETIN COLIU VI increasing the tension via a cascade (on the machine one generator knot is mounted).

$U_{mot}(I' - I)$ in the driving power are given in the eighth column.

If considering the last line of this table, we see that the law of energy conservation is violated. Indeed, at U_{mot} = 20 V and closed coils the driving current is 91 mA. Of this current I_{oo} = 89 mA are spent for overwhelming the mechanical friction and only $I' - I_{oo}$ = 2 mA or $P' - P_{oo}$ = 40 mW are spent for producing electric energy. Meanwhile only the electric power produced as heat in the wires of the coils is P_{gen} = 88 mW. To this power one must add also the heat power of the remaining eddy currents (which, unfortunately, cannot be measured).

If at eddy currents equal to zero, we can still have an integral anti-Lenz effect, then one can run the VENETIN COLIU machine as a perpetuum mobile by short-circuiting its coils.

If we can arrive at the most at a zero Lenz effect, then to run the machine as a perpetuum mobile, a part of the produced electric energy is to be sent to the driving motor.

I established[54] that the electrostatic CORONA MOTOR needs less electric power for its rotation than the delivered mechanic power. In fig. 58 a corona motor is shown driven by the tension generated by the VENETIN COLIU VI machine which was enhanced to about 10,000 V direct tension by the help of a cascade shown in the photo-

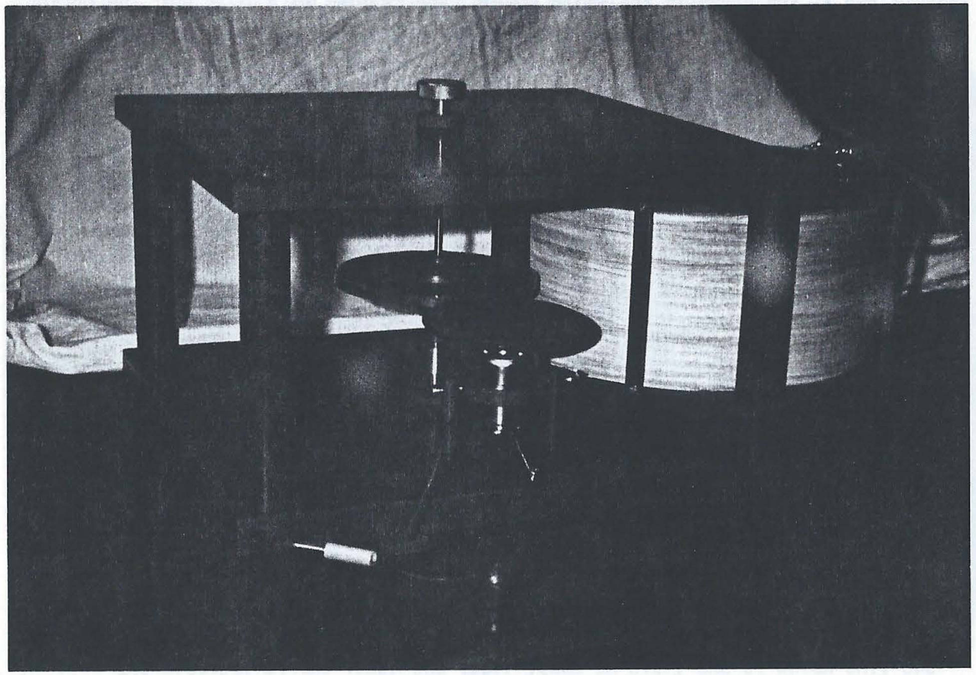

Fig. 59. Photograph of the machine VENETIN COLIU VII.

graph (later I made four such blocks). At rotation or non-rotation of the corona motor the input of the driving motor remained exactly the same. The rotation of the corona motor was powerful but much more feeble than the rotation of the driving motor. However the losses in the cascade, done by the most cheap diodes and condensers, consumed a considerable power from the generator. At a cascade without losses there are no problems to drive the VENETIN COLIU machine with low friction (see Sect. 54.8) and without eddy currents by a corona motor.

54.8. THE MACHINE VENETIN COLIU VII.

VENETIN COLIU VII is constructed exactly in the same manner as VENETIN COLIU VI and with the same (bad!) hard and soft ferrites (fig. 59). The difference is that the rotor of VENETIN COLIU VII is suspended on jewel axle and the earth attraction is balanced by a magnetic repulsion (see Sect. 59), so that the mechanical friction is reduced practically to zero. There is only one coil in a generator knot (we can have three such knots, as one side in the apparatus must be left free for the driving motor - see fig. 59). I made only one coil with thickness 0.6 mm, 27,300 turns and resistance R = 730 Ω.

The yoke for this big coil was much longer and this increased the Ewing effect.

Fig. 60. The stand of the pupils on the "anti-Lenz effect" at the regional middle school competition in Münster.

Now, however, because of the much longer yoke, the reluctance became too high and the magnetic flux was considerably diminished.

I hope that with good ferrites (without eddy currents, with larger cross-sections outside the coil, possibly with higher permeability) and stronger magnets (also without eddy currents) I shoul be able to run VENETIN COLIU VII as a perpetuum mobile with the coil and the rotor suspension shown in fig. 59.

54.9. THE ANTI-LENZ EFFECT AND THE CHILDREN.

Official science makes as if my theory, experiments, machines and publications do not exist. The same do all professors and students all over the world, as even the minds of the students are already deformed by the existing scientific dogmas.

But the minds of the pupils in the middle schools are free. So the pupils in the *Friedensschule* in Münster, Germany, reproduced my ball-bearing motor (see Sect. 64) and won with it the first prize at the competition *Schüler experimentieren* for the year 1989.

The pupils of the same school made also demonstrations of the anti-Lenz effect on stepping motors and presented their experiments at the regional competition *Schüler experimentieren* for the year 1993. The pupils received however the second prize, as if the first prize would be awarded, they would have the right to present their experiments at the national competition. This, surely, would anger the national Jury of eminent German high-school professors.

Thus official science is afraid even of the experiments of the pupils in the middle schools and makes all possible to suppress their research and to silence their observations.

The stand of the pupils at the regional competition is shown in fig. 60.

55. MOLLER'S SIMPLE EXPERIMENT REVEALING THE ROLE OF IRON CORES IN THE ELECTROMAGNETIC MACHINES

Fr. Müller carried out(36) the following experiment which he presented in a simplified form(55) shown here in fig. 61.

The current in the rectangular loop generates a certain magnetic intensity field. On the loop there is a cylindrical core of soft iron in whose hole a wire ab (very long) passes. At the end points of the wire there are sliding contacts and the wire can be moved at right angles to its length in the cylindrical hole of the iron. The cylindrical iron can also be moved, alone, or together with the wire.

In Müller's experiment the following electromotive and ponderomotive effects can be observed (Müller has observed only the electromotive effects):

If the wire is moved but the shield and the loop are at rest, there will be no induced tension because there is rotA = 0 in the domain of the wire's location. If sending current through the wire ab and only ab has a freedom of motion, there will be no

motion of ab, as rotA = 0.

If the wire ab is at rest and the shield is moved with a velocity **v**, a motional-transformer electric intensity will be induced in ab because we shall have (**v**.grad)**A** ≠ 0. If also the wire ab moves with the same velocity as the shield, the induced tension will remain exactly the same, as the motion of ab in a domain where rot**A** = 0 is immaterial.

If the shield has a freedom of motion (resp., the shield and the wire solidly fixed to the shield have freedom of motion), there will be motion of the shield (respectively, there will be motion of the shield and the wire). The explanation of this motor effect is the following: At the right side of fig. 61 are designed the lines of the magnetic intensity (i.e., the lines of the magnetic induction). If we look from point a to point b, then, at the indicated direction of the current in the rectangular loop, the lines of the magnetic intensity (induction) will be pointing from down to up. Let us now suppose that along the wire ab current flows from the reader (i.e., from point a to point b). In such a case the magnetic intensity lines of the wire's current are to be added to the existing lines of magnetic intensity. As at the right from the wire ab the magnetic lines generated by the wire's current will be opposite to the existing magnetic lines, the resulting lines will become more rare; similarly at the left from the wire ab the resultant magnetic lines will become more dense. As the magnetic lines can be considered as "elastic strings", forces will appear pushing the shield to the right tending to equalize the density of the resulting magnetic lines at the right and at the left of the wire ab. Thus the shield will be pushed to the right.

I have to emphasize once more (see Sect. 51) that there are no magnetic lines and it is senseless to imagine that some "elastic tensions" exist between the magnetic lines. The magnetic lines and the "elastic tensions" are only a symbolical language. But with this symbolic language Faraday, who was not a mathematician, could give right predictions to many effects in electromagnetism. Although this figurative

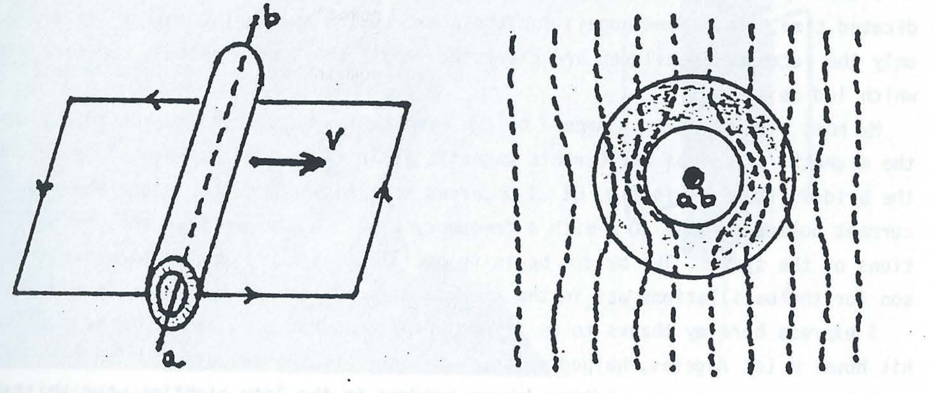

Fig. 61. Müller's experiment revealing the role of iron cores.

Faraday language has no some material (physical) background, I use it too to be able to explain with a couple of sentences pretty complicated effects which one observes. If one would like to give an adequate physical explanation, one has to describe the interaction between the single current elements (in the rectangular wire, in the wire ab, but also in the iron of the shield) and then to integrate. This way is cumbersome and we can give a quick qualitative answer by using Faraday's symbolic language. This is the whole "puzzle" with the forces which act on the shield but do not act on the wire.

The explanation of the above effects allows to explain the effects in the rotors and stators of the electromagnetic machines where the current wires are put in the holes of iron cores. Official physics is unable to present logical physical explanation of these effects, as it ignores the notion "motional-transformer induction" and the notion "absolute space" in which all electromagnetic phenomena are to be described.

56. THE ANTI-DEMONSTRATIONAL ROTATING AMPERE BRIDGE (RAB) EXPERIMENTS

The story with my ROTATING AMPERE BRIDGE (RAB) EXPERIMENT was very dramatic. Because of a wrong calculation when proceeding from Whittaker's formula, I came to the wrong conclusion that, according to Whittaker's formula (24.3), RAB must rotate.

I constructed several RAB-MACHINES all of whom, more or less, showed some acting torques. I became actively involved in the construction of RAB-machines, as their executions were relatively easy and cheap and I hoped[21,56,57] to demonstrate in this way the validity of Whittaker's formula.

However, later I established that all effects of rotation which I have observed were due to side effects and that there is no magnetic torque acting on the rotating Ampere bridge. Thus all my RAB-experiments are, as a matter of fact, anti-demonstrational (null) experiments.

I shall present here the photographs of some of my RAB-experiments, as I have dedicated time, money (and hopes) for their expecution and to the mother's heart not only the successful children are cherished. And I shall point out at the side effects which led me astray.

My most simple rotating Ampere bridge with two symmetric shoulders (to exclude the magnetic action of the Earth's magnetic field if constant current is sent through the bridge) is shown in fig. 62. I observed oscillations of the bridge when sending current pulses of some 10 A with a frequency equal to the own frequency of oscillations of the system. The bridge began to oscillate. Later I understood that the reason for the oscillations was in the thermal deformations of the suspension wires.

I express here my thanks to my friend, Prof. Pappas, who, during my sojourn in his house in Los Angeles, helped me in revealing this thermal effect.

I began to construct rotating Ampere bridges in the late eighties when Whittaker's

formula was still unknown to me. At that time I thought that Grassmann's formula (24.4) is the right one and that Ampere's formula (24.5) is wrong. To give an experimental support to this my conviction, I constructed the machine whose drawing is in fig. 63 and the photograph in fig. 64. As according to Grassmann's formula, on the Π-form wire ABB'A' in fig. 14 there must be a force pushing it in the direction AB (A'B'), I decided to put sliding contacts at the points A and A', to make the wires OA and O'A' current conducting disks, and to observe the "propulsive" motion of the Amepere bridge ABB'A', which because of the motional limitations will become rotational.

The machine was done and it rotated in the direction "predicted" by Grassmann's formula. With the aim to be able to measure the induced electric tension and to make also energetic measurements with this "rotating Ampere bridge", I coupled the bridge with the Faraday disk generator shown on the left side of figs. 63 and 64 and called the whole machine "Rotating Ampere bridge with sliding contacts coupled with a Faraday disk generator" or shortly the RAF-MACHINE The detailed description of this beautiful machine with all data of the observed electromotive, ponderomotive and energetic effects is presented in Refs. 22 and 58.

Later, however, I understood that the driving torque was due not to the "Grassmann's forces" allegedly acting on the Π-form rotating bridge, but to the forces ge-

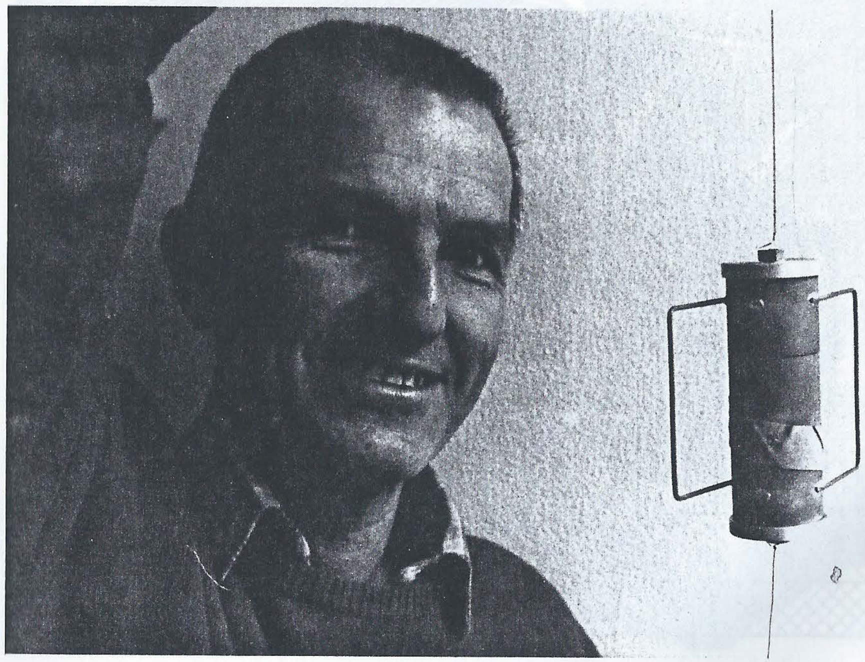

Fig. 62. The anti-demonstrational RAB-machine with two shoulders.

nerated by the currents solid to the laboratory. The diagram explaining why a torque acts on the rotating Ampere bridge with sliding contatcs is shown in fig. 65 and the detailed explanation of the appearing forces and torque according to Whittaker's formula (Nicolaev's formula will not lead to some substantial changes) is given in Ref. 56.

When I realized that in the rotating Ampere bridge suspended on a wire the thermal side effects lead to a torque, I decided to make an autonomous rotating Ampere bridge where such thermal forces will be eliminated. In such an AUTONOMOUS ROTATING AMPERE BRIDGE (ARAB) EXPERIMENT also a violation of the angular momentum conservation law would be observed, according, I repeat, to the wrong calculations done by me when proceeding from Whittaker's formula.

The photograph of my first ARAB-MACHINE is shown in fig. 66. The source of the direct current are the 18 Cd-Ni accumulators arranged radially on the bottom and connected in parallel producing current of hundreds of ampere. The current leaving the positive electrode of the accumulators, goes up along the six vertical peripheral columns to the upper metal disk. By screwing down the top central massive nut bolt (of which on the photograph only the lower part is seen), one makes contact and the current crossing downwards the rotating Ampere bridge (with four shoulders) returns to the negative electrode of the accumulators.

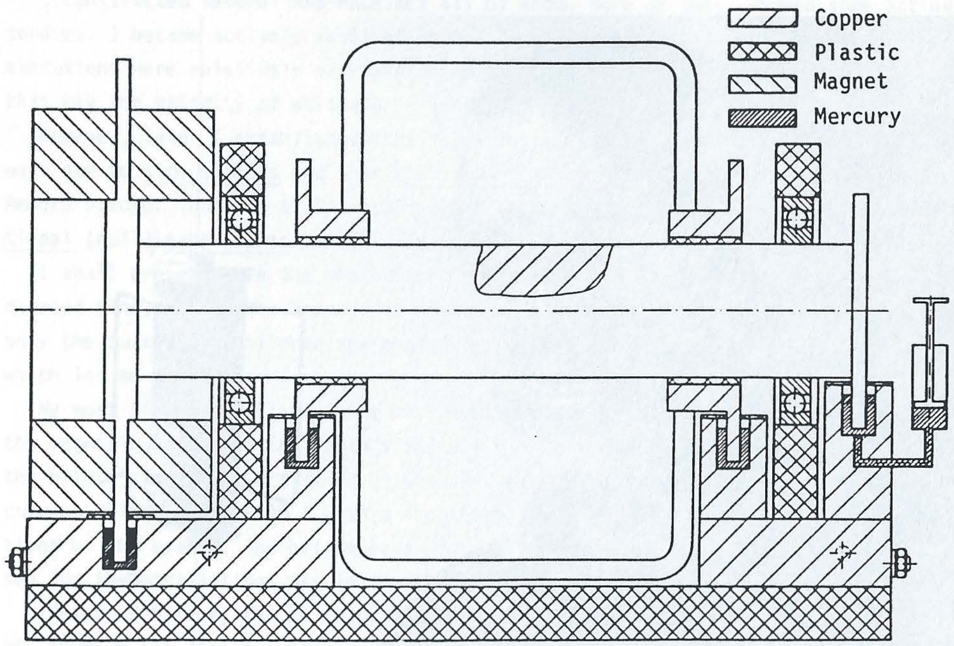

Fig. 63. Diagram of the rotating Ampere bridge with sliding contacts coupled with a cemented Faraday disk generator (RAF-machine).

The ARAB-machine, indeed, came into rotation, as I reported in Ref. 56. Later, however, I understood[57] that the reason for the rotation of my ARAB-machine was the interaction with the Earth's magnetic field.

The Earth's magnetic field, however, cannot set the ARAB-machine in rotation but only in oscillation about a certain neutral position. Meanwhile I observed rotation. The explanation of this effect came after many experiments carried out during about two months as I charged the batteries once or twice in a day. The explanation of this rotational effect was the following: When switching on the circuit, the current produced by the accumulators was maximum and rapidly decreased. Thus the initial push (due to inevitable current assymetries in the columns) was the most powerful, the heavy body, because of its big inertia, could overwhelm the opposite torque, as the current producing the opposite torque was substantially less, and so I observed a continuous rotation.

To exclude the action of the Earth's magnetic field, I put the ARAB-machine in an iron "saucepan", manufactured specially for this aim (fig. 67), but the thin iron walls of the "saucepan" could not screen effectively enough the Earth's magnetic

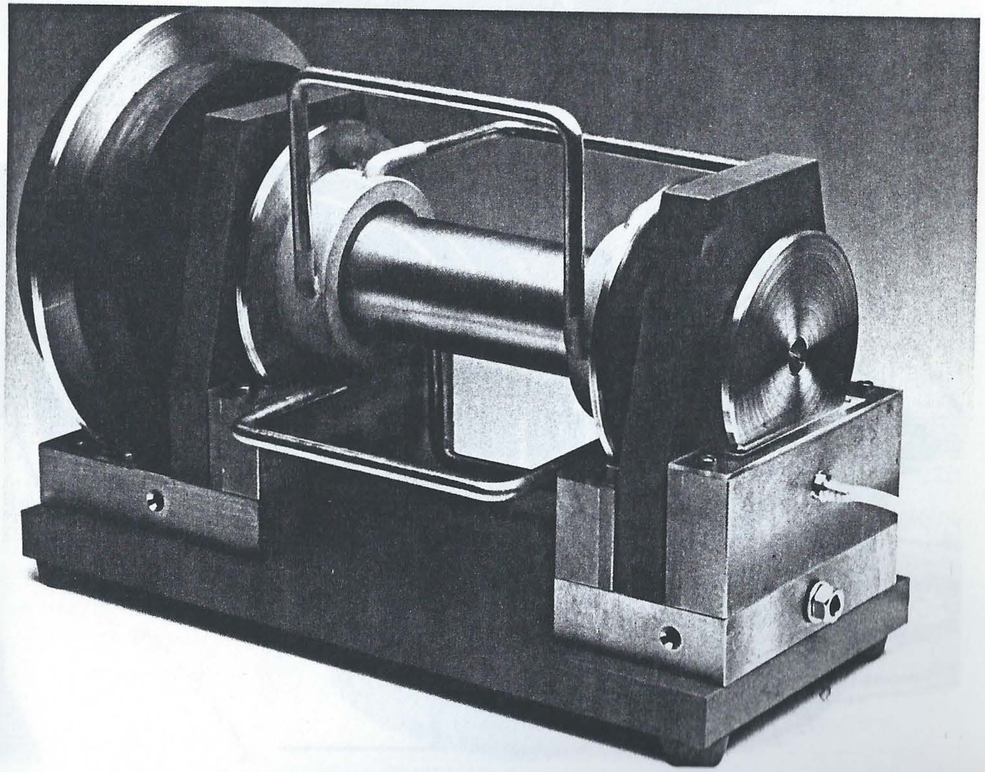

Fig. 64. Photograph of the RAF-machine.

field.

The best way was to send alternating current in the ARAB-machine, but I could not mount on it a source supplying such a big current. Thus I constructed the second ARAB-machine shown in fig. 68 suspending it on strings. Here many wires (about 20) have been wound as one can see on the photograph and the mains supplied alternating current of tens of amperes. Absolutely no oscillation has been observed.

To esclude the thermal effects of the suspension, also the second ARAB-machine shown in fig. 68 was put to swim in water and the current conducting wires were loosely connected with the body of ARAB, so that no torque due to thermal deformations could be communicated. One the other side, as the current conducting wires were bifilar (i.e., going and returning), their magnetic action was null.

Finally I constructed a "rotating Ampere bridge" not with linear but with circular arms (fig. 69) sending to it direct and alternating current. Absolutely no rotation has been observed. If the current conducting wires in this machine will be very long,

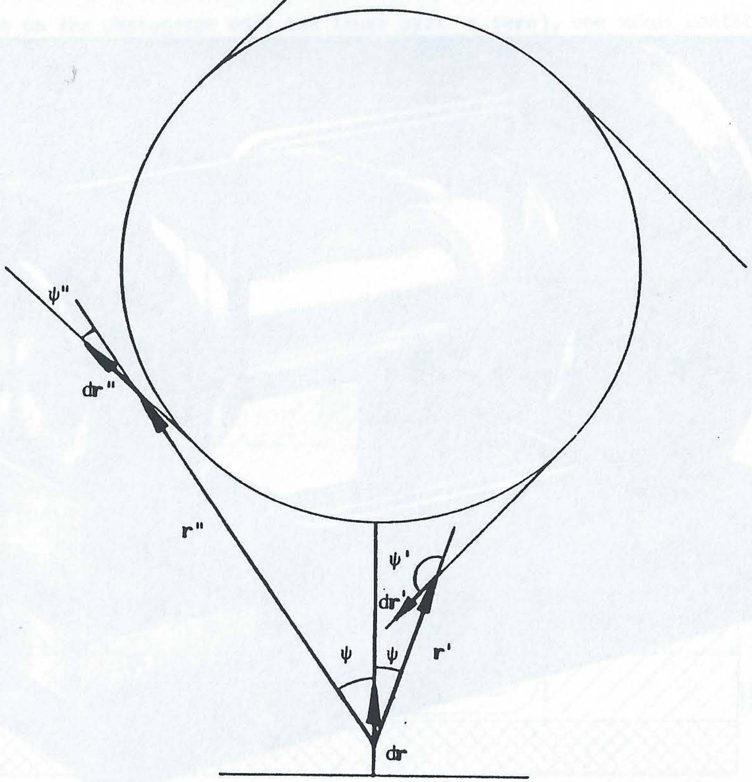

Fig. 65. Diagram for explanation of the torque acting on the rotating Ampere bridge with sliding contacts which is the motor part of the RAF-machine.

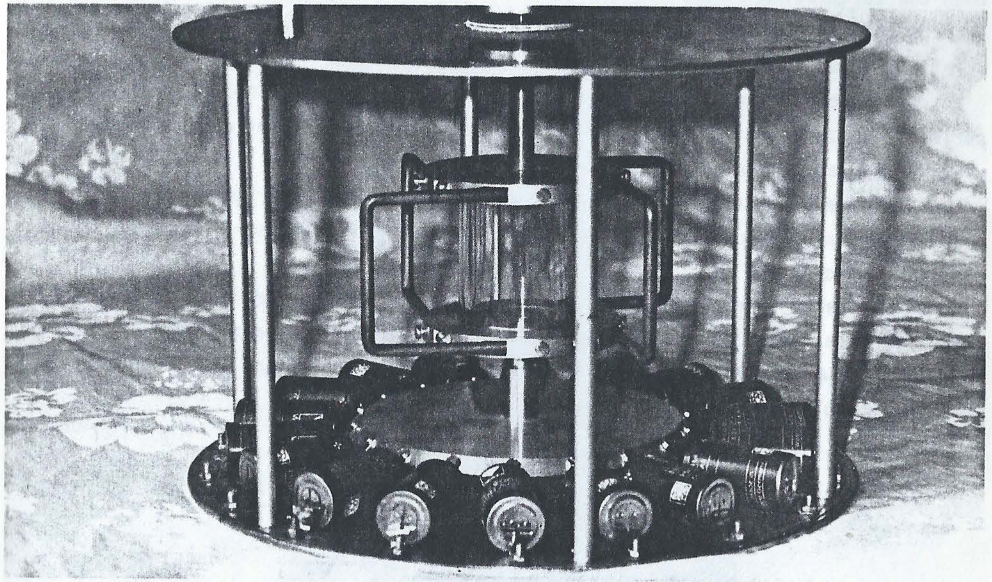

Fig. 66. Photograph of the anti-demonstrational ARAB-machine.

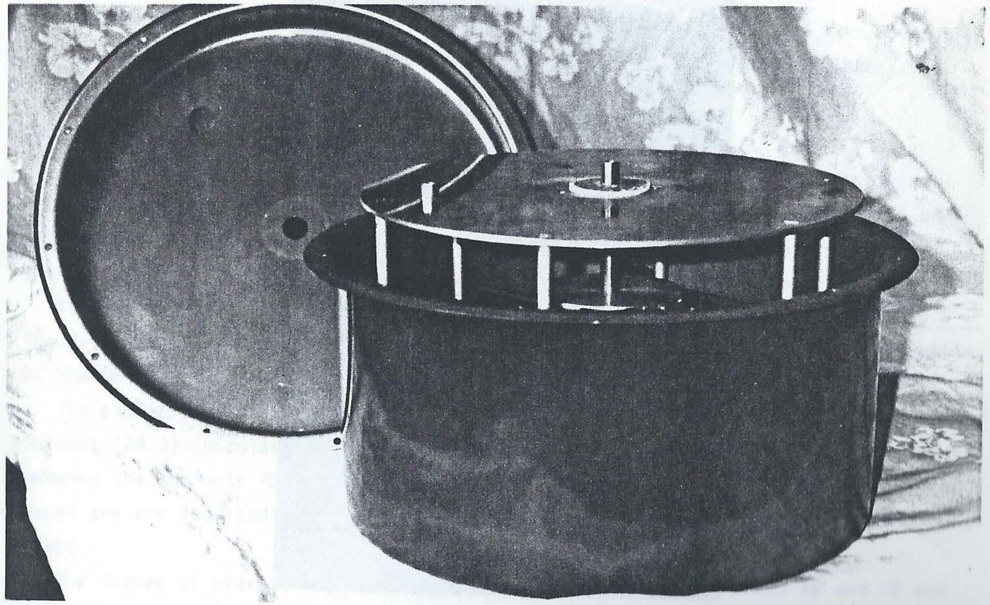

Fig. 67. The ARAB-machine put in an iron saucepan for screening Earth's magnetism.

then the calculation of the zero torque (not for vertical wire conducting current to or from the periphery of the circular wires but for horizontal such "external radial wire") is given in Sect. 27.

I gave here short reports on some (not of all!) of the rotating Ampere bridge experiments constructed by me to show to the reader that when doing experiments:

1) it is very important to have the right formula,

2) it is very important to make right calculations with the right formula,

3) otherwise side effects may lead the researcher very far astray from the way of the scientific truth.

I communicated some (I did many other!) of my failures and errings, so that the reader can see that I landed on Olymp of electromagnetism not on the back of Pegasus, but climbing up on its thorny and stony precipices as a blind and faulty man during years of diabolic experimental and theoretical work.

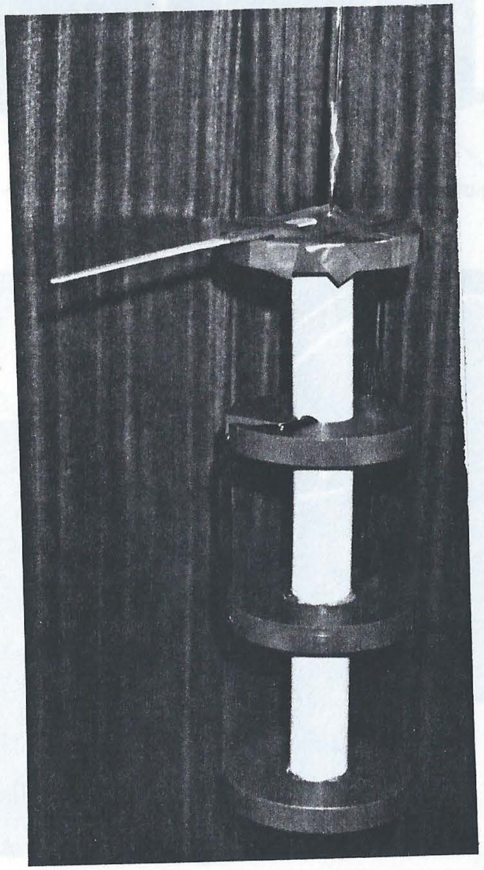

Fig. 68. The second anti-demonstrational ARAB-machine with many windings.

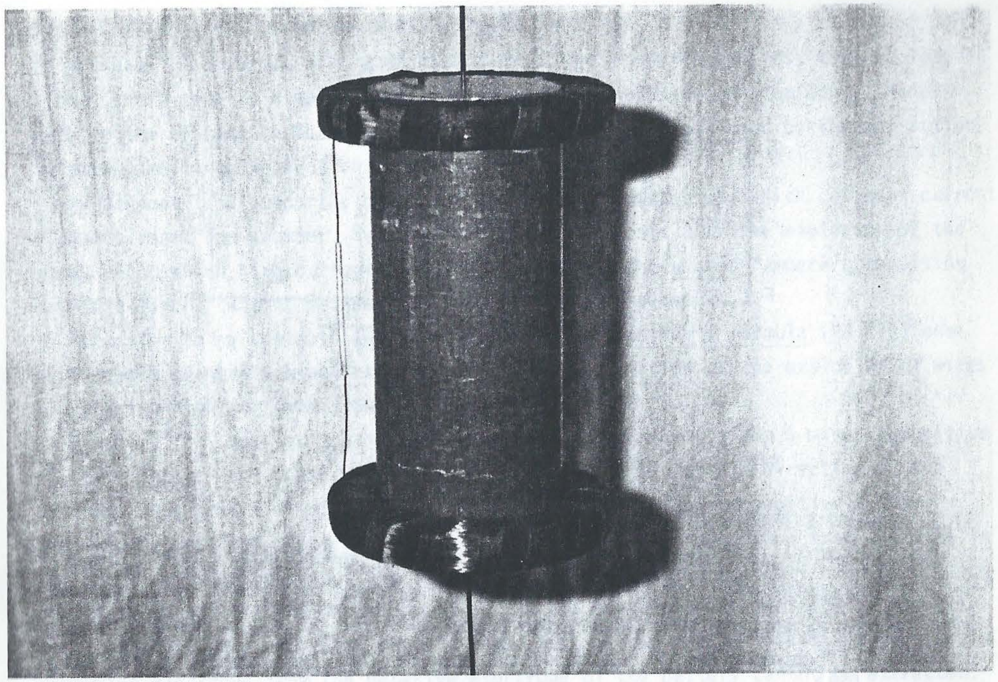

Fig. 69. The RAB-machine with "circular arms".

57. EXPERIMENTS DEMONSTRATING INDIRECTLY THE EXISTENCE OF LONGITUDINAL MAGNETIC FORCES

57.1. SIGALOV'S SECOND EXPERIMENT (fig. 70).

The wires AB and CD are solid to the laboratory. The rectangular current wire EFGH has sliding contacts at the points B and C and has a freedom to move left or right. When sending current as shown in the figure (or in the opposite direcion), the rectangular wire EFGH moves to the right sliding on the contacts B and C.

Sigalov(59) explains the motion proceeding from Grassmann's formula (24.4) as a "self-interaction" of the currents BC, EF and GH (BC and EF repel one another, while BC and GH attract one another) what, obviously, is a nonsense.

The explanation of the motion can only be done if proceeding from Whittaker's formula (24.3) (Nicolaev's formula (24.12) leads to the same result) as interaction between the currents AB and FG, on one side, and CD and HE, on the other side. Thus those are the longitudinal forces f_{FG} and f_{EH} which push the rectangular loop to the right.

The forces of reaction f_{AB} and f_{CD} are applied to the fixed wires AB and CD and point to the left.

Let me note that Sigalov's first experiment was shown in fig. 10.

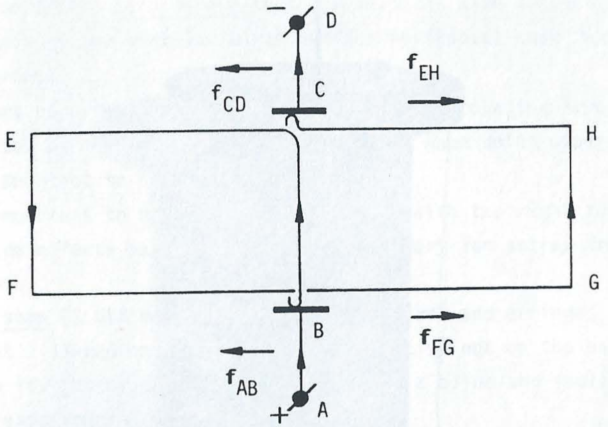

Fig. 70. Sigalov's second experiment.

57.2. SIGALOV'S THIRD EXPERIMENT (fig. 71).

The wire BC is solidly fixed to the rectangular permanent magnet EFGH. This wire has sliding contacts at the points B and C and a freedom to move up-down. When sending current as shown in the figure, the magnet with the solidly fixed wire BC moves downwards. If changing the direction of the current, the magnet moves upwards.

Sigalov[59] explains again the motion as self-propulsion because of the interection of the current BC with the horizontal magnet's currents which are indicated in the figure as EF and GH.

Meanwhile the explanation of the effect is exactly the same as in fig. 70: Those are the longitudinal forces with which the fixed currents AB and CD act on currents FG and HE producing the resulting force f_{FGHE}. These longitudinal forces point downwards, while the forces of reaction f_{AB} and f_{CD} acting on the fixed wires point upwards.

As a matter of fact, the experiments shown in figs. 70 and 71 are quite identical. To see how similar are these two experiments, rotate fig. 71 over 90^o in an anticlockwise direction and compare it with fig. 70.

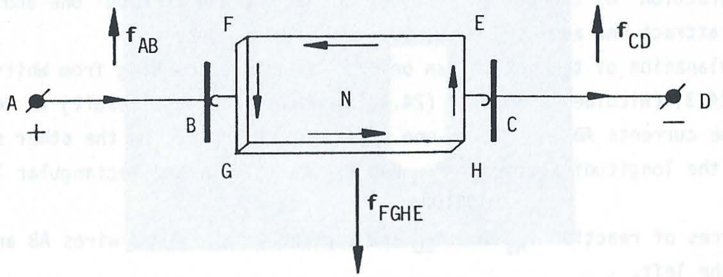

Fig. 71. Sigalov's third experiment.

57.3. GRANEAU'S EXPLOSIONS OF WIRES BY HIGH CURRENTS.

Graneau[60] observed that when high current passes through wires, they explode in a very short time in numerous small pieces. After analysing these pieces, Graneau came to the conclusion that the explosion in no way can be caused by thermal action (heating, melting, vaporation, explosion).

As Graneau is a supporter of Ampere's formula, according to which colinear current elements repel one another, he introduced the hypothesis that the explosion of the wires along which high current flows must be due to the alleged "Ampere's repulsing magnetic forces" acting between the colinear current elements.

According to my concepts (when proceeding from Nicolaev's formula (24.12)) one must reject Graneau's hypothesis as wrong. The explanation of the explosion of wires along which high currents flow is the following:

Sansbury[61] observed that when stationary current flows along a wire, a positive electric charge is repulsed from the wire, independently of the direction of the current. Thus a wire along which current flows becomes charged positively. Why? - Because the positive electrode of the battery "sucks" the electrons from the wire in its immediate neighbourhood, and the process goes on with a velocity near to c along the whole wire until the "sucking force" reaches the negative electrode of the battery. Thus a wire along which current flows must become charged positively the whole. Otherwise electrons from the negative electrode of the battery cannot be extracted. It is a stupidity to think that the charges from the positive electrode can attract the electrons from the negative electrode by their "coulomb attraction", as the distance between these two electrodes may be kilometers. The "coulomb attraction" is between every two neighbouring current elements. The propagation of a current pulse along a wire has many common features with the Ewing effect (see Sect. 54.5), however the velocity of propagation of the "electric pulse" is much higher than that of the "magnetic pulse".

When the current is higher, the depletion of electrons in the current conducting wire us higher, and the repulsive forces between the positively charged ions of the metal lattice provoke the explosions. A childishly simple explanation!

58. EXPERIMENTS DEMONSTRATING DIRECTLY THE EXISTENCE OF LONGITUDINAL MAGNETIC FORCES

58.1. HERING'S EXPERIMENT (fig. 72).

Hering[62] carried out many experiments in which longitudinal motions of straight current wires have been observed. These experiments have categorically shown that Grassmann's formula is wrong, but Hering's endeavours to persuade the world by obvious experiments that Grassmann's formula (and thus also the Lorentz equation) cannot be right remained without success. This is a clear example that official physics is not an experimental science but a dogmatic science as it was during the dark Copernicus - Bruno - Galileo epoch. Nothing has changed (and nothing will change).

Let me write, for curiosity, the following sentence from Hering's cumulative paper[62]:

> During the past fifteen years the writer has repeatedly called the attention of physicists to the experimental evidence of the present unsatisfactory state, and showed how some of our laws misled and even deceived the engineer when he tried to apply them; they were repeatedly appealed to by the writer to revise them so that the engineer could use them and depend on them as being correct, ... but there was a surprising lack of interest in correcting alleged mistakes and shortcomings, and even a determined effort to prevent the publication of the writer's investigations. In one case publication was at first refused on the ground that if the experimental evidence was correct, which was easily demonstrated, it was so serious a matter to change one of the older laws, that it ought to be kept secret! In another case the refusal was because it was, "so subversive of long established principles", the age of a law being considered more important than its correctness.

I shall analyse here only one (fig. 72) of Hering's experiments which is extremely reach on conclusions.

The wires DEFGHAB as well as the wire CG, called by Hering also vertical conductor and designated by V, are fixed to the laboratory, while the wire BD, called by Hering also horizontal conductor and designated by H, is suspended on filaments and can easily be moved in horizontal directions to the left and to the right. At the

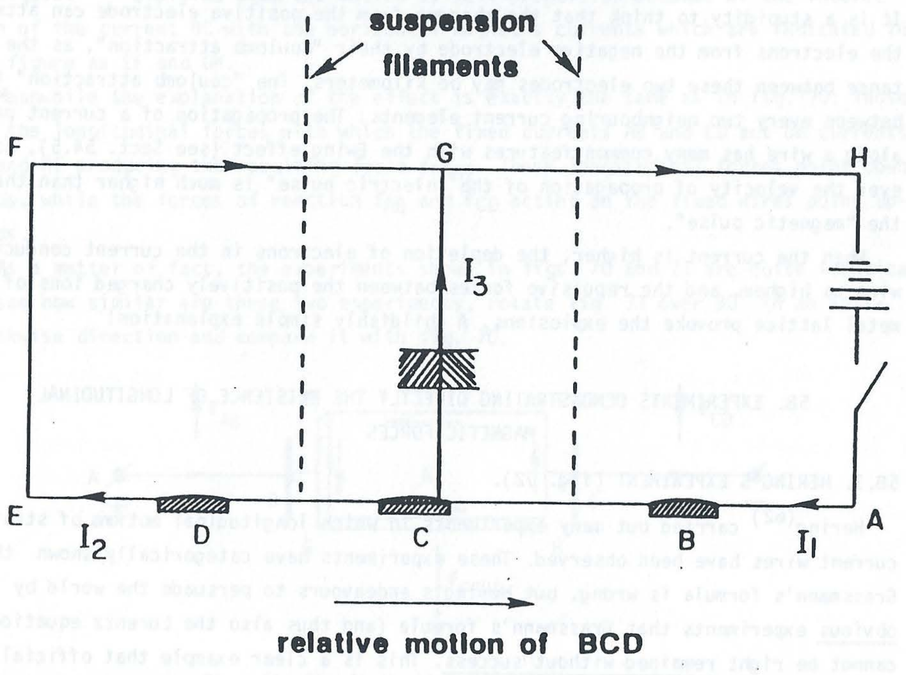

Fig. 72. Hering's experiment.

points B, C and D there are sliding contacts realized by the help of mercury troughths. The battery supplies the current I_1 in the wires ABC, which separates in the currents I_2 and I_3 at the point C, the latter unifying again to the initial current I_1 at the point D. When sending current in the indicated (or opposite) direction, the wire BD moves to the right. The motion can immediately be explained by Whittaker's formula (24.3) (Nicolaev's formula (24.12) leads to the same result).

Indeed, take in formula (24.12) the current element I_3dr' along the wire CG, the current element I_1dr along the wire BC and the current element I_2dr along the wire CD. The vector distance r points from I_3dr' to I_1dr and I_2dr.

The first term of formula (24.12) gives vertical forces which are compensated by the weight of the wire CD, as the vertical force acting on it points upwards, and by the tension of the right suspension filament, as the vertical force acting on the wire BC points downwards. The second term gives forces which point to the right for the wire BC as well as for the wire CD. The third term in formula (24.12) is equal to zero.

The experiment is extremely easily repeatable and simple, its explanation by the Whittaker-Nicolaev formulas is straighforward but <u>for almost 100 years it has been silenced</u>.

Now I shall give the presentation of Hering's experiment by his own words[62], as Hering has also transformed the <u>propulsive</u> experiment in fig. 72 to an extremely important <u>rotational</u> variation (I give the picture for the rotational variation in fig. 73).

In Hering's paper there is a <u>diagonal line</u> between the middle points of the wires CG and CD, along which, according to Ampere's formula (24.5) the forces of interaction between the respective current elements must act. I do not draw this line in my figure 72, as according to the Whittaker-Nicolaev formulas, the forces of interaction between the current elements of the wires CG and BCD do not lie on the lines joining the elements.

Thus hear now Hering[62]:

> Fig. 72 is a modified form of an old experiment attributed to Faraday or perhaps to Ampere. It furnishes a different and independent proof of the longitudinal force and one which it is difficult if at all possible to meet by the older laws. In the original a vertical conductor V was mounted so that it could move to the right or left parallel to itself. It contacted with a horizontal wire H which was stationary. When the currents were passed in the directions indicated the movable wire V moved to the left.
>
> The writer maintains that as the movement of V was caused by the current in H, then if the apparatus be reversed so that V is fixed and H has a freedom of motion in the opposite direction, the same force would move H in the direction of its length, which it did, thus showing the existence of this strongly denied longitudinal force. This must follow from Newton's third law, that for every action there is an equal and opposite reaction. It aslo must follow from the view of Ampere and others, apparently endorsed by Maxwell (Art. 527), at least not denied by him, that the force between two elements is along the line which joins them, as shown by the diagonal line (I repeat, this diagonal line is not indicated in my figure - S.M.). If so, such a direction must have com-

ponents in the directions of the lengths of both conductors.

It seems strange that although this experiment, the law of Newton, and the views of Ampere, have been known for the past hundred years, this method of proving the existence of the longitudinal force has apparantly not been considered before, or if it has it has certainly not been generally known, or had been forgotten, and is still being strongly contested.

In the writer's modification the wire V was fixed and the long wire H was suspended so that it had freedom of motion lengthwise. When the currents were passed in the directions shown, the wire H moved to the right, or when one of the currents was reversed, then to the left. The contact between the two was made with small mercury trough carried by H. When H was fixed and V allowed (by means of mercury trough) to move in the direction of its length, it so moved away from H (Nicolaev's formula leads to this result, as I noted above that the bigger force acting on BC points downwards and the lesser force acting on CD points upwards, so that the resultant force of reaction acting on CG must point upwards - S.M.). Before the experiment a current was passed through H alone to make sure that no motion was caused by the very short vertical parts that dip into the mercury dishes; moreover the final motion was again in the opposite direction to what it would be if it had been caused by these vertical parts as most physicists will claim, because the current in one pair of ends is necessarily greater than in the other.

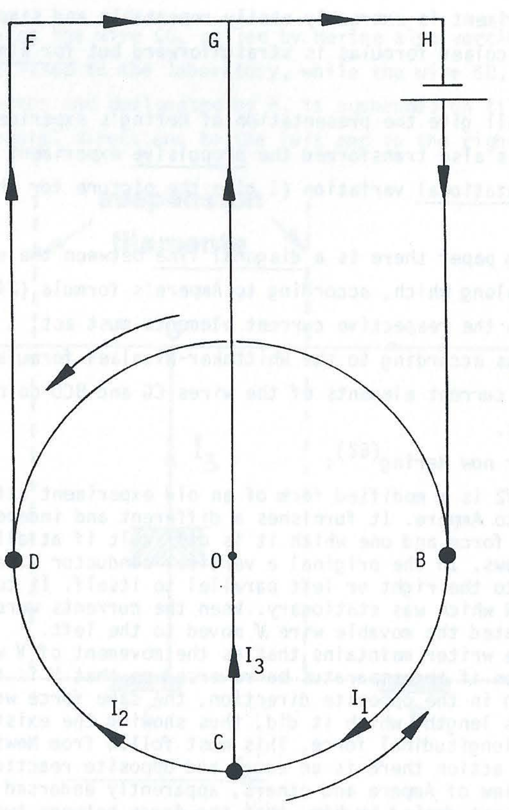

Fig. 73. Rotational variation of Hering's experiment.

It will probably not be denied that the forces involved are concentrated almost entirely at or near the corner where the conductors are nearest together; it is therefore a weak argument to make a crucial point, as has been done, of where the "rest of the circuit" is. Beyond a few inches from the corner the circuits have probably an entirely negligible effect on the forces, and it therefore does not matter where they are. Some physicists have "grabbed at straws" to uphold the older laws, instead of being helpful in trying to imrove them.

This same test was also made and exhibited by the writer some years ago, in a different way, resembling more closely the apparatus existing in many physical laboratories to show the original experiment of Faraday. H was a stationary circle and V moved around this circle. In the modified form V was fixed and the circular part moved. Sliding contacts were used to replace the usual liquid conductor and this caused much friction, but still the movement was quite decided, and was witnessed by many.

The rotational variation of Hering's propulsive experiment is shown in fig. 73 (in his paper Hering does not give a picture of the rotational variation). The conductive circle can rotate about the center O. At the points B, C and D there are sliding contacts with the wires DFHB and CG which are solid to the laboratory. When sending current as indicated (or in the opposite direction) the conductive circle will begin to rotate anti-clockwise. Thus Hering has constructed an S-motor some 100 years ago. And his fateful experiment was followed by 100 years of universal blindness, or, better to say, of acanite resistance against obvious facts.

58.2. GRANEAU'S SUBMARINE (fig. 74).

Graneau[63] carried out the following experiment: A tungsten "submarine", whose left end was "cut" and right end "pointed", was immersed in mercury. When sending current in the mercury in parallel to the submarine's length (see the figure at the left side), it moved forward with the cut end.

The explanation according to Nicolaev's formula (24.12) is straighforward: The current's filaments which arrive at the cut end of the submarine are more parallel than the current's filaments which arrive at the pointed end, as the conductivity of mercury is lower than that of tungsten, and the same current can pass from both sides of the submarine if the current at the pointed end goes through a larger cross-section, as shown in the figure. Thus the current's filaments in mercury at the cut

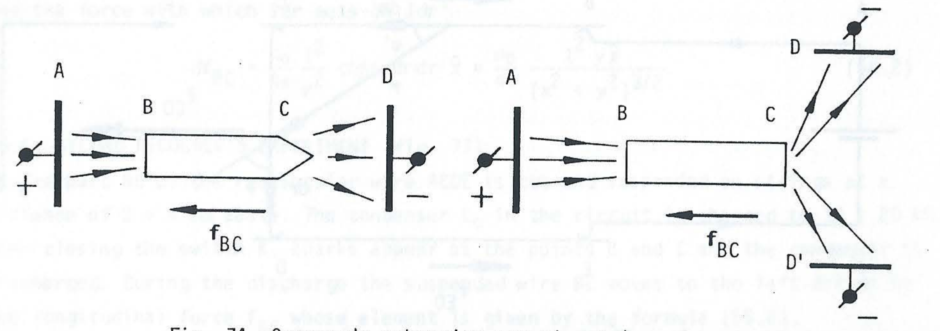

Fig. 74. Graneau's submarine experiment.

end conclude with the current's filaments in the tungsten angles near to zero, while the current's filaments in mercury at the pointed end conclude with the filaments in the tungsten angles different from zero. Consequently the vertical components of the filaments at the pointed end prevail over those at the cut end and the submarine obtains a push to the left.

Instead to point the right end of the submarine, one can cut also this end and make the submarine entirely symmetric, but then to cover the right end by an insulator or one has to remove the right electrode from the line of the submarine to two positions whose joining line is at right angles with the submarine's line, as Nicolaev[59] has done. At these variations (see the picture on the right side of fig. 74) the motion of the submarine remains in the same direction to the left.

Graneau[63] has wrongly explained the motion of the submarine by the alleged "Ampere's repulsive forces" between colinear current elements.

According to Nicolaev's formula, however, the forces between colinear current elements are null and those are the forces between the "perpendicular" current elements which provoke the motion of the submarine. Further only Nicolaev's formula will be used.

58.3. FIRST NICOLAEV'S EXPERIMENT (fig. 75).

In the rectangular wire ACDF the contacts at the points B, C, D and E have been done sliding by the help of mercury or electrolytes. Then Nicolaev observed that by sending current in the indicated (or opposite) direction, the wires BC and DE moved to the left, while the wire CD moved to the right. The calculation of the force acting on the wire BC (DE) can be found in Sect. 26.1.

The calculation of the force acting on the wire CD, as shown in Sect. 25, is a difficult mathematical problem, as at its solution singularities do appear. To make the calculation easy (as in Sect. 26.1), the sliding contacts at the corners C and D are to be done as shown in fig. 76. In such a case the exact values of the forces acting on the wires BC, CD and DE can be found and then compared with the experimental data.

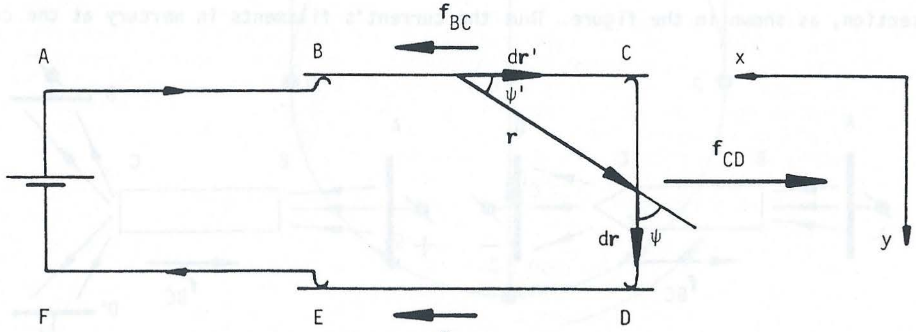

Fig. 75. First Nicolaev's experiment.

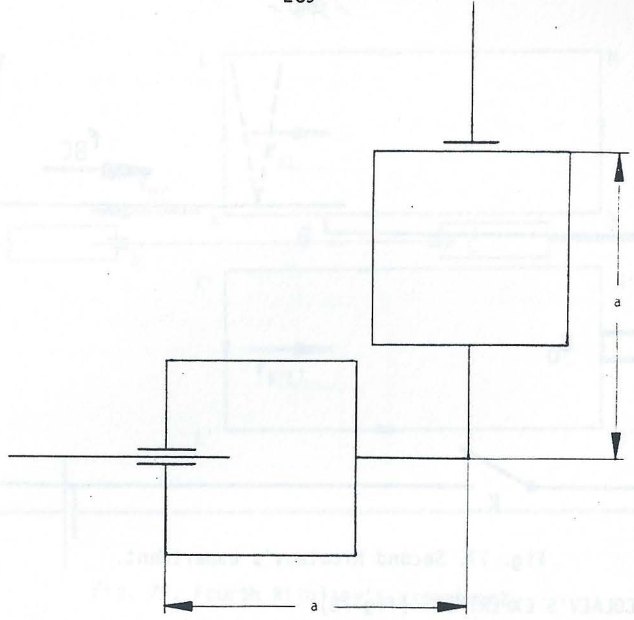

Fig. 76. Realization of the sliding contacts at the corners of Nicolaev's first experiment permitting exact calculation of the acting forces.

Obviously the force f_{CD} will be stronger than the sum of the forces f_{BC} and f_{DE}, as on the currents BC and DE only the current CD acts, while on the current CD besides the currents BC and DE also the currents AB and EF act (we assume that the last two currents are long enough).

Here I shall only calculate, by the help of formulas (24.3) or (24.12), the horizontal elementary force with which a current element Idr' with abscissa x acts on a current element Idr with ordinate y, taking the first element at the wire BC and the second element at the wire CD,

$$df_{CD} = \frac{\mu_o}{4\pi}\frac{I^2}{r^2}\cos\psi\, dr\, dr'(-\hat{x}) = -\frac{\mu_o}{4\pi}\frac{I^2\, y\hat{x}}{(x^2+y^2)^{3/2}}, \qquad (58.1)$$

and the force with which Idr acts on Idr'

$$df_{BC} = \frac{\mu_o}{4\pi}\frac{I^2}{r^2}\cos\psi\, dr\, dr'\hat{x} = \frac{\mu_o}{4\pi}\frac{I^2\, y\hat{x}}{(x^2+y^2)^{3/2}}. \qquad (58.2)$$

58.4. SECOND NICOLAEV'S EXPERIMENT (fig. 77).

The part BC of the rectangular wire ACDE is cut and suspended on strings at a distance of 2 ÷ 4 mm above. The condenser C_o in the circuit is charged to 10 ÷ 20 kV. When closing the switch K, sparks appear at the points B and C and the condenser is discharged. During the discharge the suspended wire BC moves to the left driven by the longitudinal force f_{BC} whose element is given by the formula (58.2).

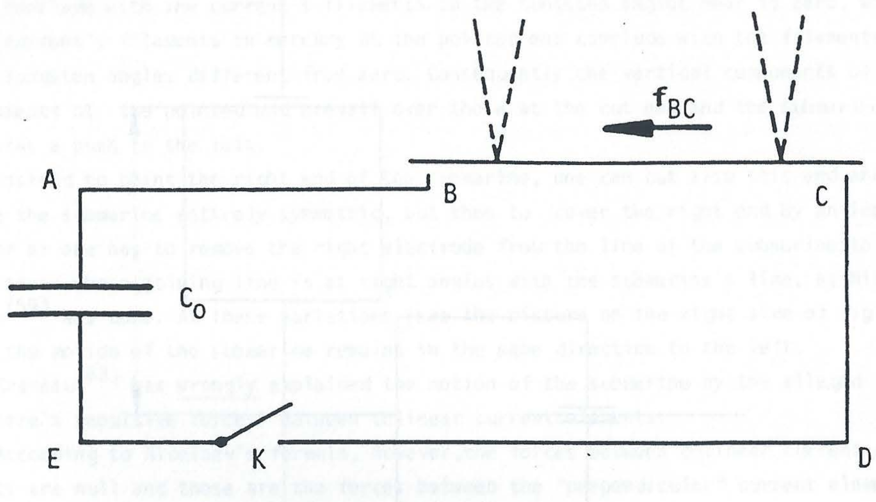

Fig. 77. Second Nicolaev's experiment.

58.5. THIRD NICOLAEV'S EXPERIMENT (fig.78).

The current in the double rectangular circuit EDCD'E'F flowing along the wire BC (which has sliding contacts at its ends) separates at the point C into the equal currents of half a value CDEF and CD'E'F. The force f_{BC} acts on the wire BC pushing it to the left. The forces of reaction f_{CD} and $f_{CD'}$, whose sum is equal and opposite to the force f_{BC} act on the wires CD and CD'.

58.6. FOURTH NICOLAEV'S EXPERIMENT (fig. 79).

The wire BC in the rectangular wire ADEF has sliding contacts at its ends and can move in the horizontal direction. When currents flow in the two small rectangles KLMN and K'L'M'N', a longitudinal force f_{BC} pushes the wire BC to the left. The forces of reaction f_{KL} and $f_{K'L'}$ whose sum is equal and opposite to the force f_{BC} act on the wires KL and K'L'.

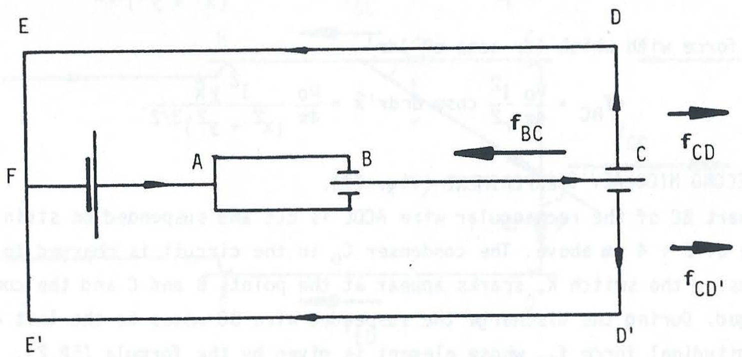

Fig. 78. Third Nicolaev's experiment.

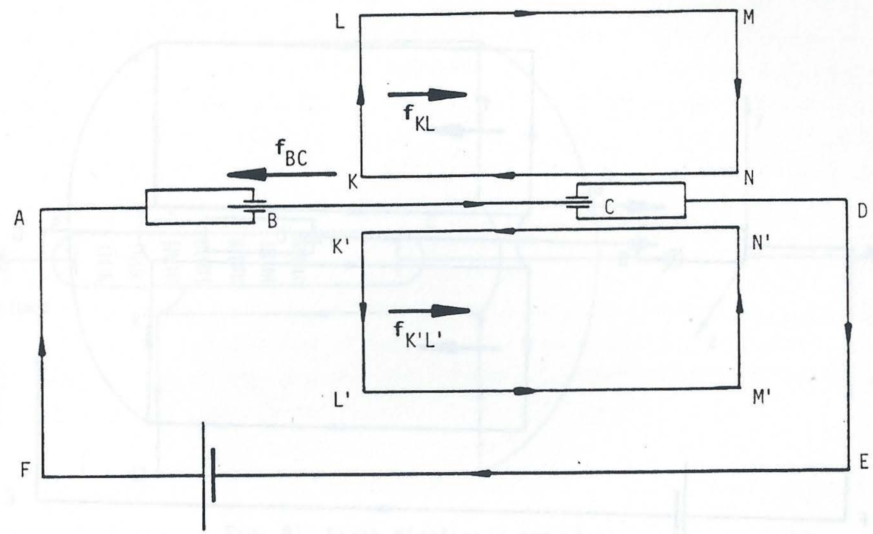

Fig. 79. Fourth Nicolaev's experiment.

If we assume that the wires KN and K'N' are very near to the wire AD and that all three rectangular loops are big enough, the only force which acts on the current wire BC will be generated by the currents in the wires KL and K'L'. Easily can be seen that when the currents flow in the indicated directions (or all currents in the opposite directions) the longitudinal force f_{BC} will push the wire BC to the left. The forces of reaction f_{KL} and $f_{K'L'}$ will act on the wires KL and K'L' pointing to the right.

The same will be the picture if only one of the small rectangular loops will be present. However when both small rectangular loops are there, the experiment is very symmetric and all non-longitudinal forces acting on the wire BC are balanced.

58.7. FIFTH NICOLAEV'S EXPERIMENT (fig. 80).

The wire AD, whose part BC has sliding contacts at its ends, goes along the axis of a toroidal solenoid. The cross-section of the torus by a plane containing its axis is shown in fig.80, where also two of the windings lying in the cross-section plane are shown with the directions of the currents flowing in the windings.

As it can be concluded from formula (18.28) for a very long cylindrical solenoid, if there is a toroidal solenoid where the relation between its radius R and the radius of the windings r is large, we can assume that the magnetic intensity B is different from zero only in the toroidal solenoid and is equal to zero outside the solenoid. Thus on a current element placed outside the torus (such is the wire BC) no magnetic (i.e., vector magnetic) forces can act.

Meanwhile Nicolaev has observed that a magnetic force acts on the wire BC pushing

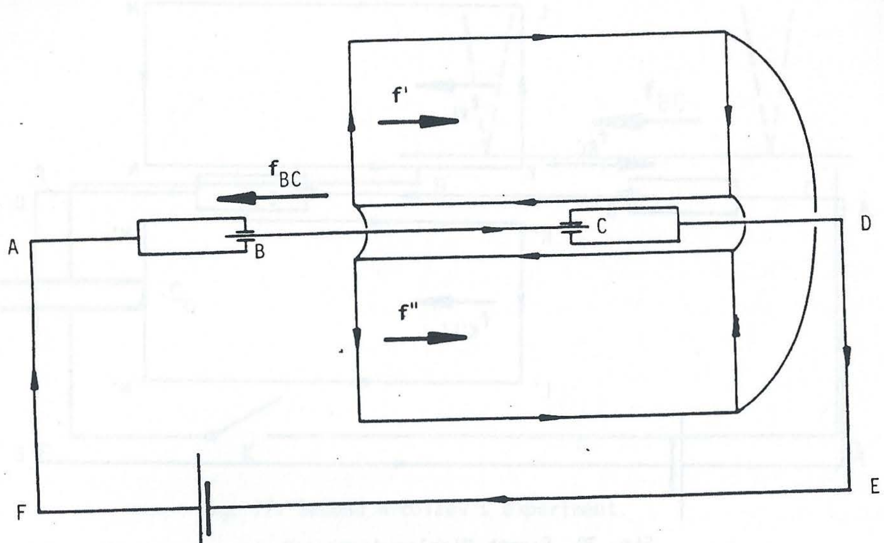

Fig. 80. Fifth Nicolaev's experiment.

it to the left. The forces of reaction f' and f" act on the current wires of the left torus base. The explanation of the effect is to be done exactly as in the fourth Nicolaev's experiment.

The fifth Nicolaev's experiment shows clearly that the magnetic field is defined not only by the vector magnetic intensity **B** given by the third formula (21.1) but also the scalar magnetic intensity S given by the formula (24.14) must be taken into account. And this experiment shows that the scalar magnetic intensity generated by a toroidal solenoid is different from zero along the axis of the toroid.

58.8. SIXTH NICOLAEV'S EXPERIMENT (fig. 81).

A high-voltage tube with glow discharge was put along the axis of a toroidal solenoid. By sending current in the solenoid and by changing its direction Nicolaev observed that the dark cathode space changes its length.

The effect is to be explained by the action of the scalar magnetic field on the electrons flying from the cathode, C, to the anode, A. As the charge of the electron, $-q_e$, is a negative quantity, by putting it in the equation (24.13) and taking into account only its last term (see also formula (24.14)), we obtain for the force acting on the electron

$$f = (-q_e v)S = -q_e vS(-\hat{x}) = q_e vS\hat{x}, \qquad (58.3)$$

where v is the velocity of the electron pointing from the cathode C to the anode A, and S is the scalar magnetic intensity generated by the toroidal solenoid. As for

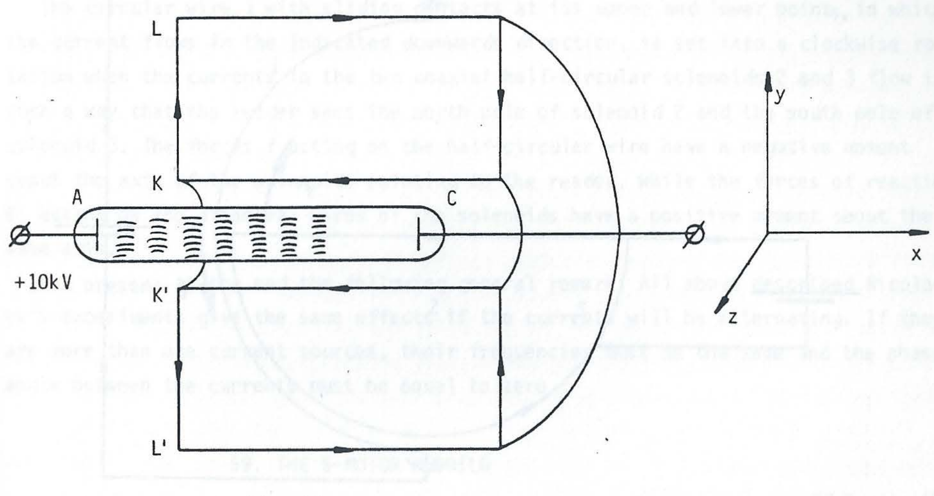

Fig. 81. Sixth Nicolaev's experiment.

the indicated direction of the current in the toroidal solenoid the scalar magnetic intensity along its axis is negative (see figs. 79 and 80), the force acting on the electron will point in the $-\hat{x}$ direction (to the left) and will thus accelerate the electrons. Consequently when switching on current in the solenoid in the indicated direction, the dark cathode space will become shorter. If we change the direction of the current in the solenoid, the velocity of the electrons will be diminished and the dark cathode space will become longer.

All these effects have been observed by Genadi Nicolaev.

58.9. SEVENTH NICOLAEV'S EXPERIMENT (fig. 82).

The half circular wire 1 with sliding contacts at its ends, in which the current flows clockwsie, is set into a clockwise rotation when the current in the coaxial half-circular solenoid 2 flows clockwise (thus when the reader looks at the south pole of the solenoid). The force f acting on the half-circular wire has a negative moment along the axis pointing to the reader, while the force of reaction f' acting on the diametral wires of the solenoid has a positive moment about the same axis.

If we should rotate fig. 82 over 90^0 in a clockwise direction and we should then compare it with fig. 73, we shall see that the rotational variation of Hering's experiment and the seventh Nicolaev's experiment have many common features. The circular currents in both experiments have the same directions but as the radial currents have opposite directions, of course, the motion of the circular wire will be the opposite one. Take into account that the half-circular current in Nicolaev's experiment belonging to the half circular solenoid (which is missing in Herning's experiment) is of no importance, as it cannot generate longitudinal forces on the half-

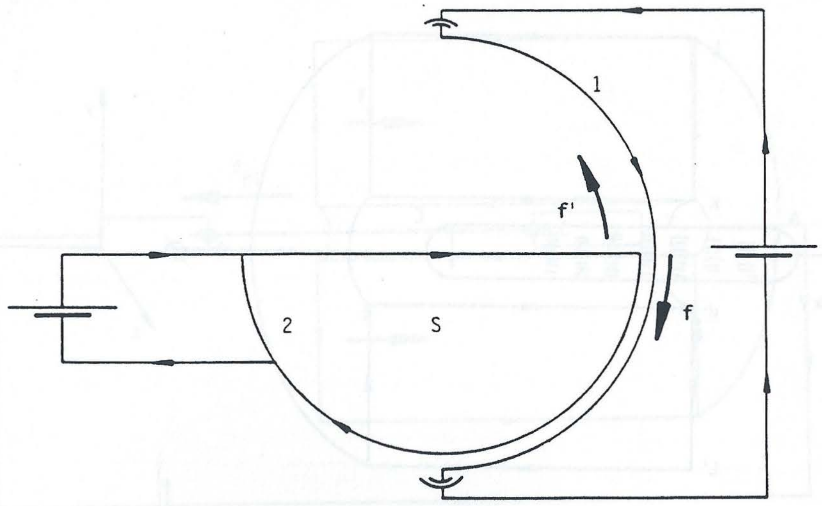

Fig. 82. Seventh Nicolaev's experiment.

circular current wire with the sliding contacts (Nicolaev's formula!!!).

The electromagnet in fig. 82 can be replaced by a permanent magnet; the effect will remain the same. If putting the north pole of the half-circular magnet to point to the reader, the velocity of the half-circular wire 1 will change to the opposite.

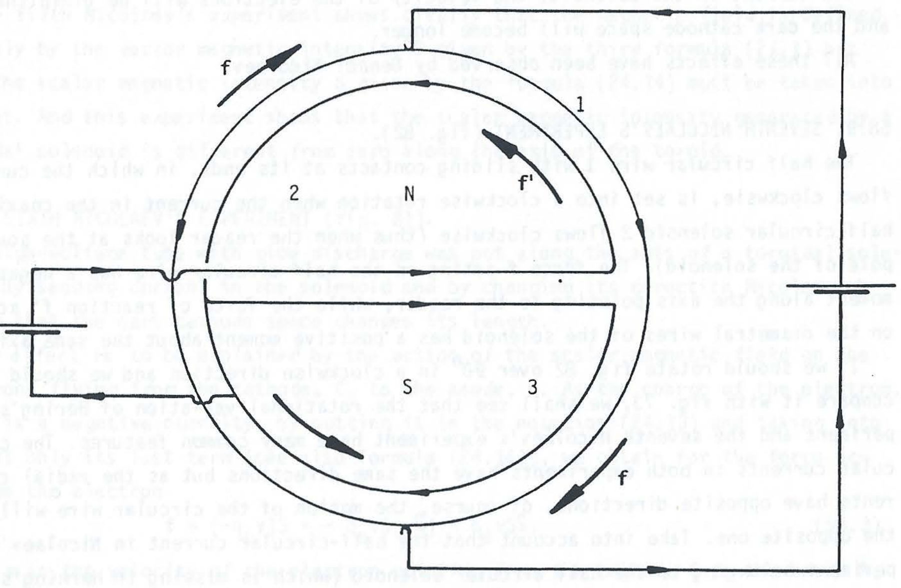

Fig. 83.Eighth Nicolaev's experiment.

58.10. EIGHTH NICOLAEV'S EXPERIMENT.

The circular wire 1 with sliding contacts at its upper and lower points, in which the current flows in the indicated downwards direction, is set into a clockwise rotatjon when the currents in the two coaxial half-circular solenoids 2 and 3 flow in such a way that the reader sees the north pole of solenoid 2 and the south pole of solenoid 3. The forces f acting on the half-circular wire have a negative moment about the axis of the solenoids pointing to the reader, while the forces of reaction f' acting on the diametral wires of the solenoids have a positive moment about the same axis.

Let present at the end the following general remark: All above described Nicolaev's experiments give the same effects if the currents will be alternating. If there are more than one current sources, their frequencies must be the same and the phase angle between the currents must be equal to zero.

59. THE S-MOTOR MODRILO

The first electromotor driven by a scalar magnetic field was constructed by me[57] and called MODRILO (MOtor DRIven by LOngitudinal forces) on the principle of Nicolaev's second experiment (see fig. 77). Its photograph is shown in fig. 84.

Direct electric tension of about 2000 V was produced by a cascade feeded by the mains (~220 V). The cascade was done by 11 electrolyte condensers of 470 μF each and 11 high-current diodes. This high tension was conducted by the horizontal (left)

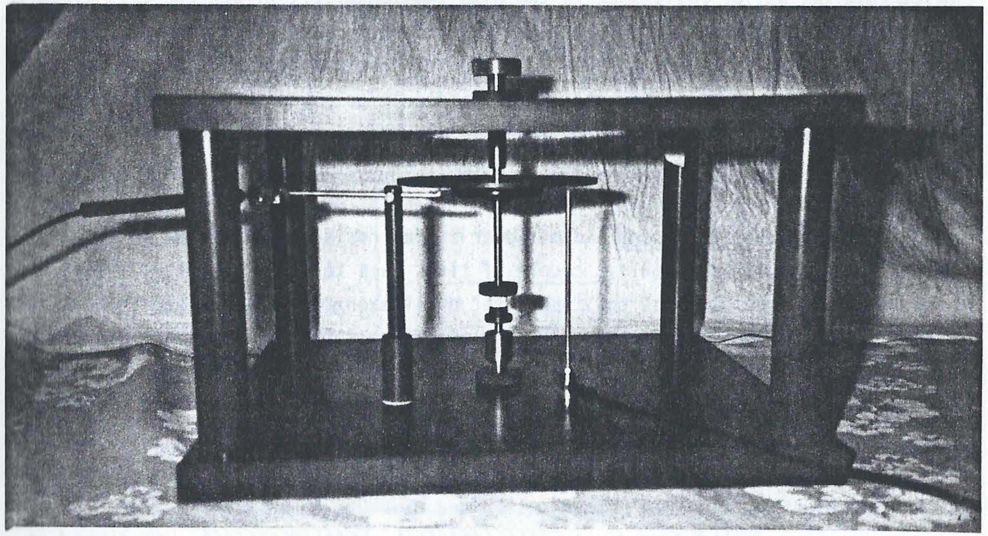

Fig. 84. Photograph of the S-motor MODRILO.

and vertical (right) wires to the end points of a chord (spanned by an angle of 45^0) of the rotating disk with radius R = 6 cm, made by plastic material (PVC) whose lower surface was covered by an Al-foil (0.5 mm of thickness). The distance between the pointed ends of the wires and the disk was maintained less than 0.5 mm, so that sparks jumped every now and then, and current flew along the disk's chord. The height of the horizontal wire was fixed. Then the height of the rotor was adjusted and as last was adjusted the height of the vertical wire which had a thread at its bottom. The drawing of the rotor is shown in fig. 85 at the left and its lower and upper suspensions are shown at the right in two times greater sizes. A small but strong enough ring magnet was fixed to the case and another one to the rotor's axle. By moving the upper magnet up-down on the axle, one settles the strength of the repulsive force, so that the rotor is practically suspended in air and the jewel bearings serve only to preserve its unstable equilibrium.

The force which will act on the chord (for very long horizontal and vertical wires) is given by formula (26.2) - according to Nicolaev's formula!!! - and it is obvious that exact calculation of this force for the geometry of my experiment was not possible.

When sparks began to jump the average current in the high-tension circuit had a certain value quasi equal to the value of the average current in the alternating circuit. The average current could be varied by varying the buffer resistance in the alterating current circuit (for which I used my cooking plate), while the duration of the direct current pulses and the respective current maxima could be varied by varying the buffer resistance in the high-tension (i.e., direct-current) circuit.

At an average current $I_{av} \cong 5$ A the disk came into rotation. If the d.c. buffer resistance was lower (i.e., the maxima of the current pulses higher), motion was observed at lower average current. It was difficult to say which were the maxima of the current pulses but (at low damping - see beneath) they were surely hundreds of amperes. On the other side, as the d.c. circuit had not only capacitance and resistance but also some inductane, the current flowing at a discharge of the condenser was oscillating damped current and at lower buffer resistance the damping was less, so that the same current could a couple of times pass through the motor. I must however note that some parts of the "opposite" oscillating currents passed through the diodes of the cascade. Thus at low damping the current through the motor was not direct but alternating or, at least, pulsating.

The way of making sliding contacts by the help of sparks was not good, as the sparks melted the metal and the Al-disk was "binded" by the pointed ends of the horizontal and vertical wires. As the disk's periphery was slightly wobbling, to evade such a binding, the distance between wires and disk was to be done greater. In such a case, however, sparks jumped only at the "lower wobbling" or no sparks jumped at all.

As shown in Sect. 29, in any electromotor driven by a scalar magnetic intensity,

i.e., in any S-motor, not back but forth tension is to be induced. Let us consider this problem once more on the example of the S-motor MODRILO.

Let us take a reference frame with abscissa pointing from the horizontal wire to the vertical wire (i.e., from left to right). Let us suppose that the current is flowing from left to right along the chord, i.e., in the +x-direction. From the first term of formula (24.12) (see also the last term in formula (24.13) and formula (24.14)) we see that we must have $S < 0$. Thus, again according to formulas (24.13) and (24.14), as **v**, the velocity of the current conducting charges which are positive, is positive pointing from left to right, the part of the disk which is near to the reader must rotate from right to left. This sense of rotation was observed in the motor MODRILO.

Now to the induced tension. When the disk rotates from right to left (I shall omit further the words "the part of the disk near to the reader"), the convection current of the current conducting charges which, I repeat, we consider as positive will point from right to left. Then the induced electric intensity, again according to formulas (24.13) and (24.14), at the condition $S < 0$ will point from left to right, i.e., along the direction in which the driving electric intensity acts. Consequently the induced electric intensity and tension will not oppose the driving electric intensity and tension but will support them.

Because of the high driving tension applied to the motor MODRILO, the induced tension could not be measured.

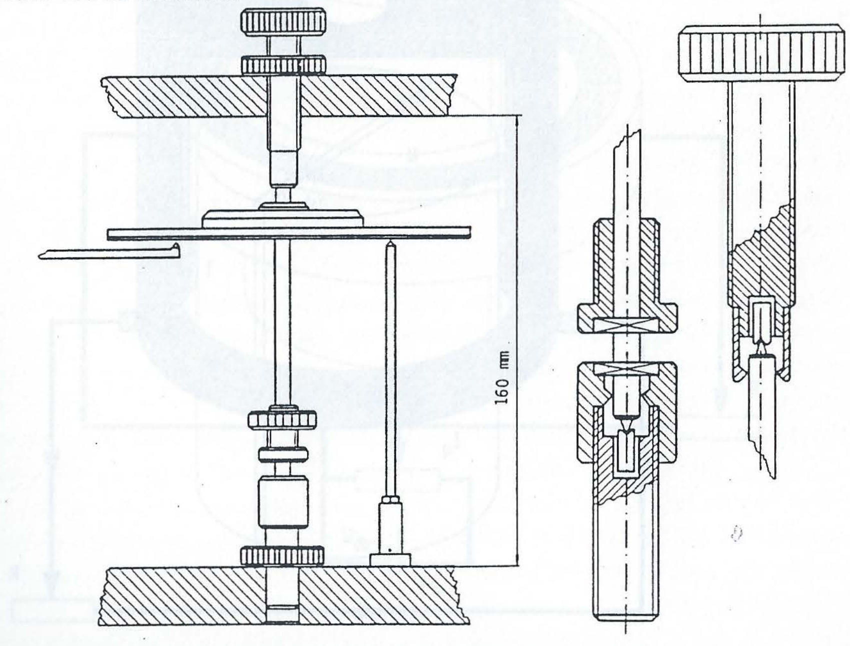

Fig. 85. Diagram of the motor MODRILO.

60. THE S-MACHINE SIBERRIAN COLIU

The perpetuum mobile which I intend to construct in the near future (after an operation I must go certain time with clutches on one leg and my experimental activity is drastically reduced) will be based on the eighth Nicolaev's experiment (see Sect. 58.10)). For honouring Nicolaev who lives in the town Tomsk in Siberia, I called this wonderful S-machine (it is motor, generator and and <u>easy</u> *perpetuum mobile*) SIBERIAN COLIU.

The <u>proposed</u> drawing of Siberian Coliu is shown in fig. 86.

A strong cylindrical permanent magnet is cut in two pices across its diametral plane and again a cylindrical magnet is built but with opposite poles on every half surface. A metal ring can rotate at the middle of this cylindrical magnet. At two diametrically opposite points, at 90^0 from the "cutting plane" of the cylindrical magnet, there are sliding contacts and the circuit is closed by the rheostat R. A Π-form "bracket" done of insulating material is fixed to the rotating ring and by one's fingers one can set the metal ring in rotation.

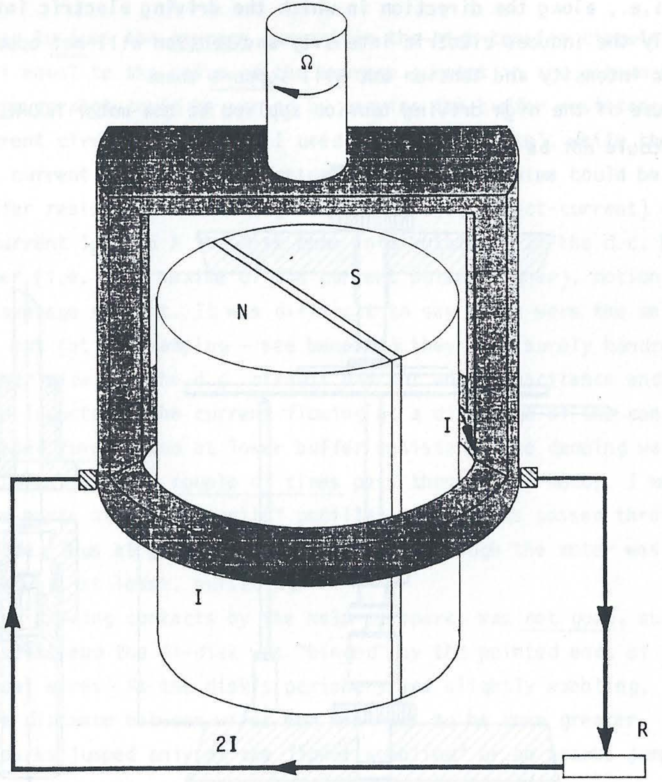

Fig. 86. The S-machine Siberian Coliu with solid rotating ring.

The machine works as an S-motor if current from an external source will be sent in the circuit. At the indicated direction of the current (anti-clockwise in the half-circle which is near to the reader) the rotation of the ring, at the indicated polarities of the half-circular magnets, will be clockwise (see fig. 83).

The machine works as an S-generator if the disk will be set in rotation by one's fingers. At the indicated rotation of the ring the induced current will have the indicated direction.

As it was calculated in Sect. 29, if the driving mechanical torque will be eliminated and the driving torque due to the induced current will be equal (and opposite) to the friction torque, the machine will rotate eternally. The produced thermal electric power will be equal to the produced mechanical power and the latter will be equal to the friction power. If the friction power is finally transformed into heat, then in the S-generators two powers will be produced: the thermal elecric power in the circuit and the thermal friction power. At equal driving mechanical and friction torques these two powers will be equal.

With the rheostat R we settle such a current in the circuit which determines this

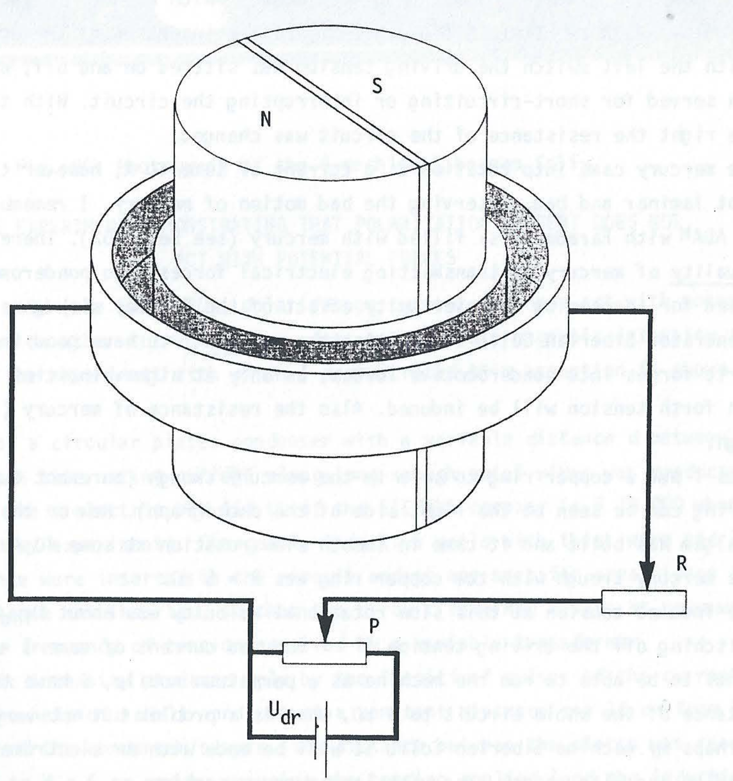

Fig. 87. The S-machine Siberian Coliu with liquid rotating ring.

angular velocity at which the driving and friction torques are equal. If, for certain reasons, the rotor will begin to increase its velocity (i.e., the generated torque will become larger than the friction torque), we introduce with the rheostat R higher resistance in the circuit and decrease the angular velocity. If the rotor will begin to decrease its velocity, we decrease by the help of R the resistance of the circuit.

Siberian Coliu can be done in the most simple way if the metal ring will be replaced by a circular trough filled with mercury (fig. 87). Then by the help of the current taken from the external source of driving tension U_{dr}, we set the mercury in the trough in rotation. With the increase of the mercury's rotational velocity we exclude gradually the driving tension by the help of the respective potentiometer P. Then the "equilibrium" angular velocity for eternal rotation is settled by the help of the rheostat R.

My realization of Siberian Coliu with mercury ring is shown in fig. 88.

The source of driving current for setting mercury in rotation was a 7.2 V Ni-Cd accumulator. The diameter of the neodymium magnet which was cut in two half-circular magnets was 3 cm. I did not use potentiometric insertion of the driving tension and with the left switch the driving tension was sitched on and off, while the right switch served for short-circuiting or interrupting the circuit. With the rheostat on the right the resistance of the circuit was changed.

The mercury came into rotation at a current of some 40 A, however the rotation was not laminar and bad. Observing the bad motion of mercury, I remembered my machine ADA^M with Faraday disk filled with mercury (see Sect. 52). There exactly the bad quality of mercury in transmitting electrical forces into ponderomotive forces was used for increasing the over unity effect of the Faraday disk generator. But in the generator Siberian Coliu I am aiming the opposite: to have good transmission of electric forces into ponderomotive forces, as only at high velocities of the mercury a high forth tension will be induced. Also the resistance of mercury (18 mΩ) was very high.

Thus I put a copper ring to swim in the mercury trough (an exact duplicate of this ring can be seen at the right side of the photograph). Now on the copper ring an amalgam was built and it came in smooth slow rotation at some 40 A. The resistance of the mercury trough with the copper ring was R = 5 mΩ.

The induced tension at this slow rotational velocity was about U_{ind} = 0.2 mV and by switching off the driving tension I induced current of some $I = U_{ind}/R$ = 40 mA. Thus to be able to run the machine as a perpetuum mobile, I have to reduce the resistance of the whole circuit to 5 µΩ, what is a problem but not very difficult.

Perhaps my machine Siberian Coliu II will be made with an electromagnet with larger radius and with copper ring with larger cross-section.

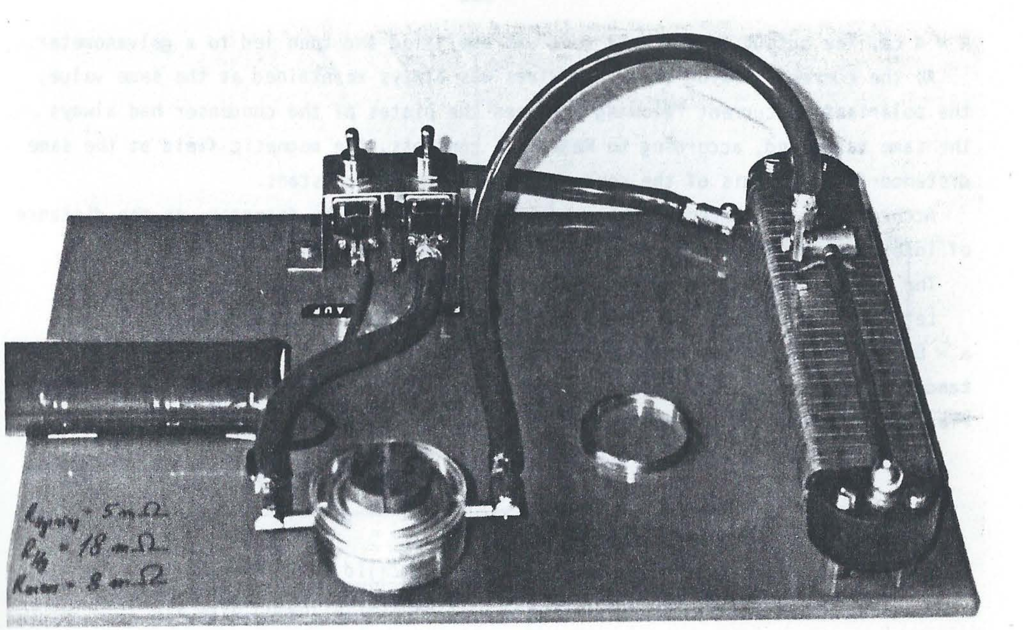

Fig. 88. Photograph of the S-machine Siberean Coliu.

61. THE EXPERIMENT DEMONSTRATING THAT POLARIZATION CURRENT DOES NOT ACT WITH POTENTIAL FORCES

As already said (see Sect. 30), polarization current does not act with potential magnetic forces on other currents, i.e., does not generate magnetic intensity field. The scheme of the experiment with which I demonstrated this assertion is shown in fig. 89.

The space of a circular plates condenser with a variable distance d between the plates, to which alternating current along long enough axial wires was conducted, was filled by the dielectric Y5U 153 UL of the SIEMENS company ($\varepsilon \cong 10{,}000$ when pressed, as in my experiment). Changeable inductive coils with thick wire and low ohmic resistance were inserted in the circuit and at any specific capacitance a respective inductance was inserted, so that the circuit remained always at resonance at the used 50 Hz frequency of tension supplied by a variable transformer.

The magnetic intensity produced only by the "positive" pulses of the current was measured by the help of a Hall sond put at a constant distance r = 10 cm from the central point of the condenser's axis. The distance between the plates was changed from d = 0 cm to d = 6 cm and by changing the tension applied (and the induction coils) the current was always maintained at I = 10 mA. The radius of the plates was

$R = 4$ cm. The output of the Hall sond was amplified and then led to a galvanometer. As the current flowing along the wires was always maintained at the same value, the polarization current "flowing" between the plates of the condenser had always the same value and, according to Maxwell's concepts, the magnetic field at the same distance from the axis of the condenser had to remain constant.

According to my concepts, the magnetic intensity had to decrease, as the distance of interruption of the conduction current increased.

The calculation of the effect can be done easily.

Let us put a straight wire of length d on the x-axis, so that its middle is at $x = 0$. The magnetic potential generated by a current I flowing in the wire at a distance y along the y-axis, according to the first formula (18.15), will be, considering the potential of the whole wire as twice the potential of its right half,

$$\mathbf{A}_d = 2(\mu_0/4\pi) \int_0^{d/2} I dx\hat{x}/(x^2 + y^2)^{1/2} = (\mu_0/2\pi)\mathrm{Arsinh}(d/2y)\hat{x}. \qquad (61.1)$$

For the magnetic intensity we obtain

$$\mathbf{B} = \mathrm{rot}\mathbf{A}_d = \frac{(\mu_0/2\pi)Id\,\hat{z}}{y(d^2 + 4y^2)^{1/2}}. \qquad (61.2)$$

Thus the magnetic intensity generated by an infinitely long wire at a distance $y = r$ from it will be (see formula (21.12)

$$B_\infty = (\mu_0 I/2\pi r)\hat{z}. \qquad (61.3)$$

If now an infinitely long wire is interrupted in the middle by a condenser, the distance between whose plates is d (fig. 89), the magnitude of the magnetic intensity at a point distance r from the central point of the condenser will be (write in formula (61.2) $y = r$)

$$B = B_\infty - B_d = (\mu_0 I/2\pi r)\{1 - d(d^2 + 4y^2)^{-1/2}\}. \qquad (61.4)$$

As the measurements were only relative, the galvanometer was not calibrated as indicator of magnetic intensity and for any distance d the ratio B/B_0 (as ratio of the galvanometer's readings) was registered, where B_0 was the indication of the galvanometer for $d = 0$ and B for distance d between the plates.

The measured ratios are given in table 61.1, where also the ratios according to Maxwell's and my concepts are presented. As the fluctuations of the galvanometer were less than 1%, the discrepancies between theory and experiment (which did not surpass 40% for $d = 1$ cm and fell to zero for $d = 6$ cm) are explained by the fact that the ratio R/d was not tending to zero (and for short distances, d, was higher).

I wrote that according to "Maxwell's theory" the ratios in table 61.1 must remain equal to unity. What signifies "Maxwell's theory" is not clear enough, but if we look at the Maxwell-Lorentz equations (30.15), we shall see that the ratio must decrease with the increase of the distance between the plates. Indeed, if the current in the

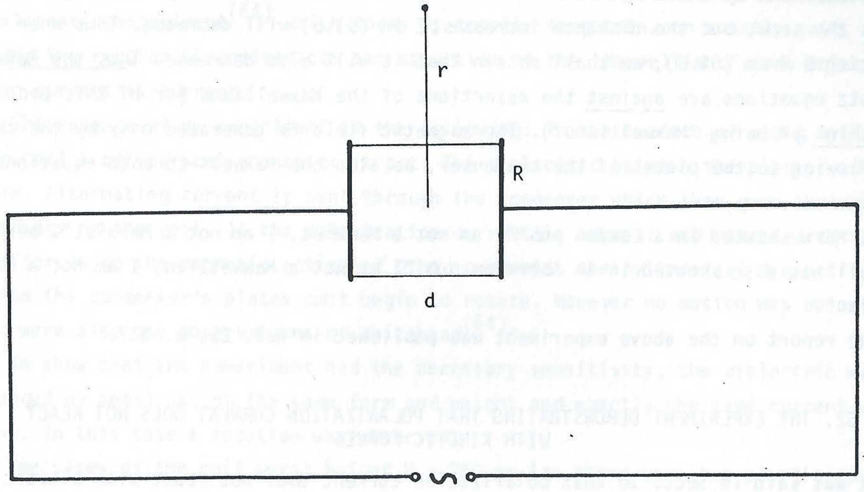

Fig. 89. Diagram of the experiment showing that polarization current does not act with potential magnetic forces on other currents.

Table 61.1

d (cm)	Ratios B/B_0 Maxwell's theory	Author's theory	Experiment
1	1.00	0.95	0.97
2	1.00	0.90	0.92
3	1.00	0.85	0.86
4	1.00	0.80	0.81
5	1.00	0.76	0.77
6	1.00	0.71	0.71

wires remains constant, this signifies that at any distance d between the condenser's plates the same amount of charges will arrive at the plates. According to equation (30.12), taking into account (30.15), we shall have

$$\oint_L \mathbf{B}.d\mathbf{r} = (\varepsilon_0\varepsilon/4\pi)(\partial/\partial t)\int_{S_0} \mathbf{E}.d\mathbf{S} + (\varepsilon_0/4\pi)(\partial/\partial t)\int_{S-S_0} \mathbf{E}.d\mathbf{S}, \qquad (61.5)$$

where S_0 is the cross-section of the cylindrical dielectric which is equal to the surface of the condenser's plates, S is a circle with radius r and L is its circumference. The electric intensity $\mathbf{E}$ is determined only by the quantity of charges on the plates and by the distance between the plates. If the quantity of charges remains the same, but the distance increases, E in (61.5) will decrease. Thus when calculating B from (61.5), we shall obtain that it will also decrease. Thus the Maxwell-Lorentz equations are against the assertiona of the Maxwellians (or of this people who think of being "Maxwellians"). The magnetic field is generated only by the charges flowing to the plates of the condenser, as also the Maxwell-Lorentz equations show.

As Marx shouted in a London pub "I am not a Marxist, I am not a Marxist", perhaps Maxwell has also shouted in an Aberdeen pub "I am not a Maxwellian, I am not a Maxwellian".

The report on the above experiment was published in Ref. 25, p. 317.

62. THE EXPERIMENT DEMONSTRATING THAT POLARIZATION CURRENT DOES NOT REACT WITH KINETIC FORCES

It was said in Sect. 30 that polarization current does not react with kinetic forces to the action of other currents. The diagram of the experiment with which I demonstrated this assertion is shown in fig. 90 and the photograph in fig. 91.

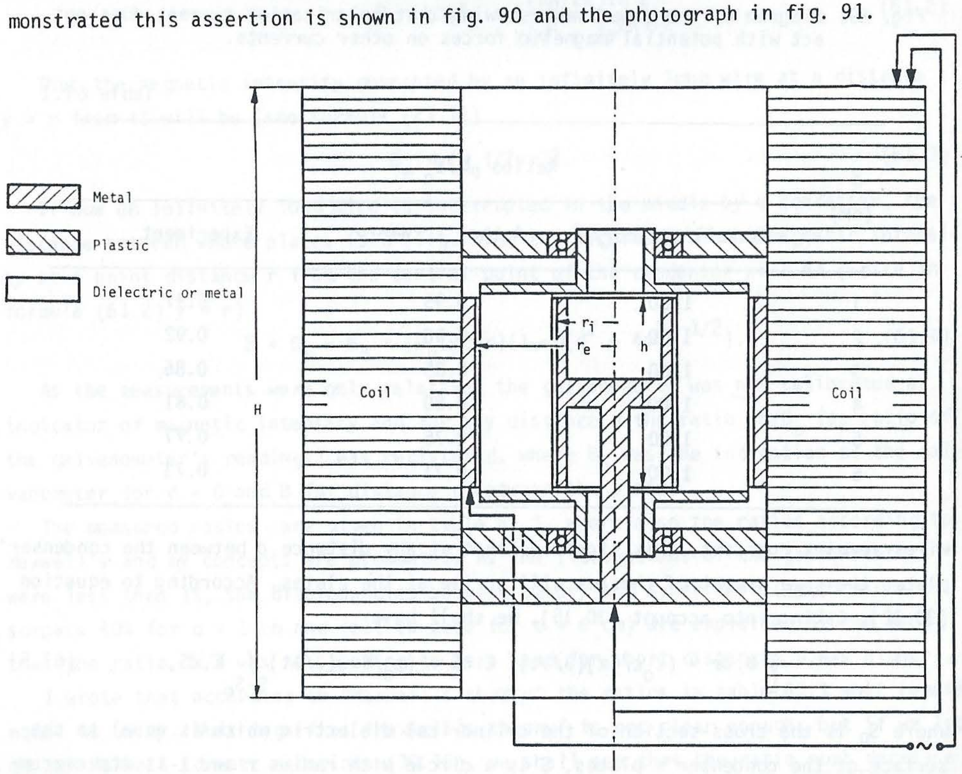

Fig. 90. Diagram of the experiment showing that polarization current does not react with kinetic forces to the magnetic action of other currents.

My experiment, as a matter of fact, was a substantially improved repetition of Whitehead's experiment[64] which today is totally forgotten, or exactly said, put under the rug, as it contradicts the assertion of the "Maxwellians" that polarization current is current.

The essence of my experiment is the following: In the orifice of a big cylindrical coil a cylindrical condenser is put. The dielectric between the plates can rotate. Alternating current is sent through the condenser which then goes through the windings of the coil. If the polarization current is current and reacts with kinetic forces to the magnetic action of other currents, the cylindrical dielectric between the condenser's plates must begin to rotate. However no motion was observed (as were also the observations of Whitehead[64]).

To show that the experiment had the necessary sensitivity, the dielectric was exchanged by metal having the same form and weight and exactly the same current was sent. In this case a rotation was observed.

The sizes of the coil were: height H = 260 mm (as there were two plastic covers with thickness 5 mm each up and down, the height of the copper was H' = 250 mm), external radius R_e = 130 mm, internal radius R_i = 64 mm (as there was an internal plastic cylinder, the internal radius of the copper was 69 mm). The applied tension was U = 300 V.

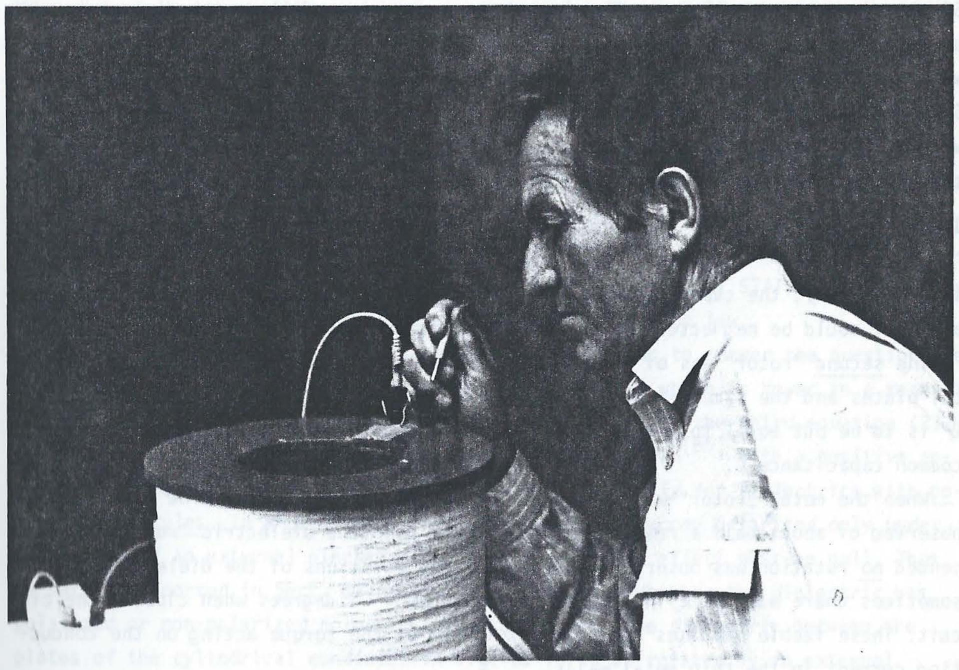

Fig. 91. Photograph of the experiment demonstrating that polarization current does not react with kinetic forces to external magnetic fields.

The coil had $N = 140{,}000$ windings of a copper wire with diameter 0.3 mm and ohmic resistance $R = 20{,}000\ \Omega$. The flowing current at resonance was thus $I = U/R = 15$ mA and the magnetic intensity generated by the coil in its internal part was, according to formula (18.28), $B = (N/H')I = 8.4\times10^{-3}$ A $m^{-1} = 0.011$ T.

The sizes of the condenser were: height $h = 80$ mm, internal radius (i.e., external radius of the internal cylindrical electrode) $r_i = 24$ mm, external radius (i.e., internal radius of the external cylindrical electrode) $r_e = 56$ mm.

Two "rotors" were made which were put in the condenser's gap and could rotate on two ball-bearings, as shown in fig. 90.

The <u>first</u> "rotor" was of <u>dielectric</u>. The powder substance Y5U 153 UL was pressed in a cylindrical box with metal cylindrical walls and plastic lids. The metal walls were pretty thin with thickness $\Delta = 1.5$ mm. The distance between these walls and the condenser's plates was $\delta = 0.4$ mm.

By applying a tension with variable frequency, it was established that a resonance took place very nearly to the frequency $\nu = 200$ Hz. As the coil had an inductance $L = 3700$ H, the capacitance of the condenser was $C = 1/4\pi^2\nu^2L = 0.17$ nF.

The capacitance C was calculated in the following way: The condenser was considered as three cylindrical condensers, having the same height $h = 80$ mm, connected in series. The first was a vacuum condenser with external and internal radii $r'_e = r_e = 56$ mm, $r'_i = r_e - \delta = 55.6$ mm. The second was a condenser filled with dielectric with permittivity $\varepsilon = 10{,}000$ and it was assumed, for simplicity, that the thin metal walls had the same permittivity. Thus its external and internal radii were $r''_e = r'_i = 55.6$ mm, $r''_i = r_i + \delta = 24.4$ mm. The third condenser was again a vacuum condenser with external and internal radii $r'''_e = r''_i = 24.4$ mm, $r'''_i = r_i = 24$ mm. The resultant capacitance was (see formulas (19.22) and (17.9))

$$1/C = 1/C' + 1/C'' + 1/C''' = (1/2\pi\varepsilon_0 h)\{\ln(r'_e/r'_i) + 1/\varepsilon)\ln(r''_e/r''_i) + \ln(r'''_e/r'''_i)\}, \tag{62.1}$$

and, obviously, the capacitance C", as very big with respect to the capacitances C' and C"', could be neglected, so that the calculation gave $C = 0.19$ nF.

The <u>second</u> "rotor" was of <u>metal</u> and had exactly the same sizes of the cylindrical plates and the same <u>weight</u> as the first one. Formula (62.1), where capacitance C" is to be put equal to infinity, obviously, will yield the same result for the common capacitance C.

When the metal "rotor" was suspended in the condenser's gap, a slow rotation was observed of about half a revolution per second. When the dielectric "rotor" was suspended <u>no</u> rotation was observed. Only at certain positions of the dielectric "rotor" sometimes there was a small displacement of about 4 -5 degrees when closing the circuit. These feeble impulses are to be explained by the torque acting on the conducting current in the thin metal walls.

The torque acting on the metal "rotor" will be

$$M = \left|\int_{r''_i}^{r''_e} \mathbf{r}\times(I d\mathbf{r}\times\mathbf{B})\right| = \int_{r''_i}^{r''_e} r(Idr)B = (1/2)IB(r''^2_e - r''^2_i). \tag{62.2}$$

By putting here $I = 15$ mA, $B = 0.011$ T, $r''_e = 55.6$ mm, $r''_i = 24.4$ mm, we obtain $M = 2.06\times10^{-7}$ N m = 2 dyne cm.

Consequently, remembering that $\Delta = 1.5$ mm was the thickness of the metal walls of the dielectric box, one shall have for the torque acting on the <u>external</u> metal wall

$$M' = (1/2)IB\{r''^2_e - (r''_e - \Delta)^2\} = IBr''_e\Delta. \tag{62.3}$$

By putting here the relevant figures, we find for the torque $M' = 0.14\times10^{-7}$ N m = 0.14 dyne cm.

The report on the above experiment was published in Ref. 65.

63. THE MACHINE BUL-CUB WITHOUT STATOR

The fact that polarization current does not react with kinetic forces to external magnetic fields (B-fields) was used by me to make the uneffective BUL-CUB machine (see fig. 30) effective in a very tricky way.

I have shown (see formulas (48.7), (48.8) and the text after (48.8)) that the torques acting on the wires ab in the magnet's gap and on the wires cd in the two yoke's gaps are equal and oppositely directed, so that the BUL-CUB machine in the form shown in fig. 30 cannot rotate; for this reason I called it the "uneffective BUL-CUB machine".

If now we exchange the conduction current in the yoke's gaps by polarization current, as there will be <u>no torque</u> on the polarization current, only the torque acting on the conduction current in the magnet's gap will remain, and the machine will begin to rotate <u>as a whole</u>. Taking into account that the BUL-CUB machine will have only rotor and no stator, I called it the BUL-CUB MACHINE WITHOUT STATOR. It is obvious that this machine violates the angular momentum conservation law.

The same machine when rotated as generator can help us to answer the question whether an electric tension will appear across a dielectric which is moved in a magnetic field, because of the action of the motional induction (see the third equation (21.1)).

Such an experiment was done for the first time by Wilson[66] with a positive answer. It is obvious that a positive effect will appear only for dielectrics with <u>polarized molecules</u>. In a dielectric where the molecules become polarized only under the action of an external electric field, of course, the effect must be null. Thus my machine reported in Sect. 62 can serve to establish whether the dielectric has polarized or non-polarized molecules. For this reason the dielectric between the plates of the cylindrical condenser in fig. 89 is to be rotated by an external torque in an alternating magnetic field of the cylindrical magnet. If an alternating tension will appear in the circuit, the dielectric has polarized molecules, if not, the molecules of the dielectric become polarized only in an external electric field.

My BUL-CUB machine without stator (figs. 92 and 93) consists of a coil wound on a cylindrical core closed by a cylindrical yoke and two circular lids. The machine can rotate on the end points of two clock axles. The sharpened extremities of the axle were immersed in cups filled with mercury (in fig. 92 the cups with mercury are not indicated!). The rotor was "suspended in air" by the help of two ring magnets as in fig. 85 (the two ring magnets are not indicated in fig. 92!).

The Faraday-Barlow disk (the disk in which the radial current flew) was of brass. The center of the disk was connected, through the lower pointed axle, with the one electrode, L, of the delivered tension (when the machine works as generator). The periphery of the Faraday-Barlow disk was fixed to a brass ring whose surface "looking down" presented the upper plate of a ring condenser. The lower plate of this ring condenser was connected via sliding contacts with the other electrode, K, of the delivered tension. The lower lid of the yoke had a ring gap in which the dielectric of the condenser was placed. One end of the coil's wire was connected through the upper pointed axle with the electrode, M, of the driving tension (when

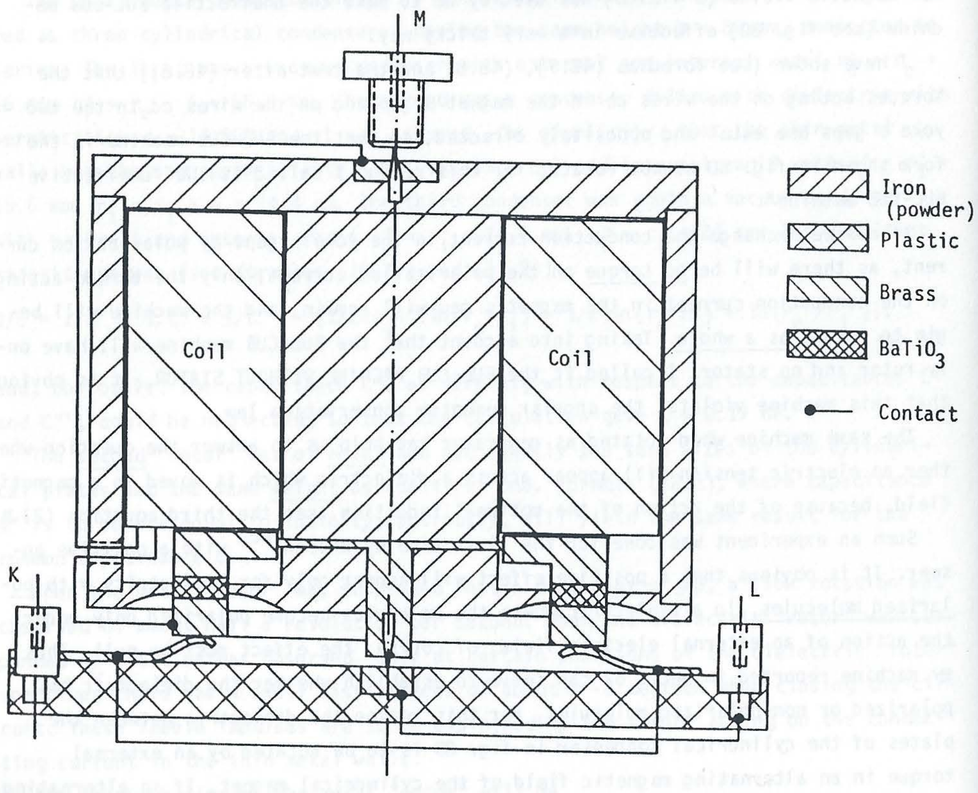

Fig. 92. Diagram of the BUL-CUB machine without stator.

the machine works as a motor), while the other end makes contact with the lower condenser's plate and thus via the sliding contacts reaches the other electrode, K, of the driving tension.

Let us see first how the machine works as a generator. If the condenser's plates will be connected by a wire, a tension will be induced there which will be equal and oppositely directed to the tension induced in the Faraday disk (see formulas (48.4) and (48.5)), and the net tension delivered to the electrodes K and L will be null. When there is a dielectric with polarized molecules in the gap of the lower lid, again null net tension will be induced. However, if the dielectric has non-polarized molecules, the net tension will be equal to the tension induced in the Faraday disk.

Let us then see how the machine works as a motor. The driving tension can be applied in parallel (in such a case the electrodes M and L are to be connected shortly) or in series (in such a case the sliding contacts must be taken away and the driving tension is to be applied to the electrodes M and L). I used only the series circuit, as the produced torque was very feeble and the friction was to be reduced to the possible minimum. As the torque on the radial currents in the Barlow disk is proportional to the product of the currents flowing along the disk's radii and in the coil, this torque is unidirectional when the driving tension is alternating.

If the upper and lower condenser's plates will be connected by a wire, the torque on this wire will be equal and opposite to the torque acting on the disk, and no rotation is possible, as already said above. However when there is a dielectric in the gap of the lower lid, no torque will act on the polarization current "flowing" in the

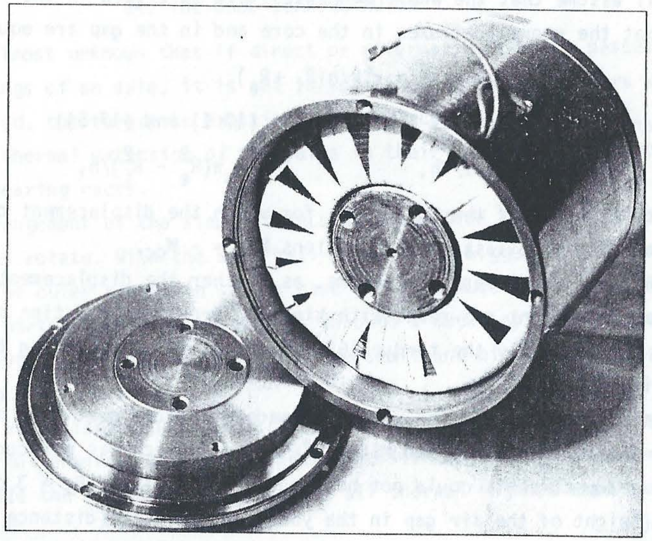

Fig. 93. Photograph of the BUL-CUB machine without stator with dismounted lower lid.

dielectric. And the body begins to rotate due to the action of "internal forces", violating thus the angular momentum conservation law.

I shall calculate the ponderomotive (kinetic) torques acting on the conduction current in the magnet's gap and on the polarization current in the yoke's gap. Let us take a reference frame with its origin at the axis of the apparatus, the x-axis pointing to the reader, the y-axis pointing to the right, and the z-axis pointing upwards. If the magnetic intensity in the core of the electromagnet is **B** pointing upwards, the radius of the core is r, and the current flowing from the axis to the periphery is I, the torque (moment of force) acting on the radial conduction current will be

$$\mathbf{M}_{cc} = \int_0^r \mathbf{r}\times(I d\mathbf{r}\times\mathbf{B}) = - IB\hat{z}\int_0^r r dr = - (IBr^2/2)\hat{z}. \qquad (63.1)$$

For simplicity sake, I shall make the calculation, supposing that the dielectric is vacuum, i.e., reducing the polarization current to displacement current. If the electric intensity between the plates of the condenser is **E**, at the above direction of the current, $\partial\mathbf{E}/\partial t$ will point downwards. Thus if the distance between the condenser's plates is h (I assume it equal to the height of the cross-section of the gap in the lower lid) and the internal and external radii of the condenser's plates (i.e., of the gap) are R_i and R_e, the torque acting on the displacement current will be

$$\mathbf{M}_{dc} = \mathbf{R}_{middle}\times\{\pi(R_e^2 - R_i^2)h(\varepsilon_0\partial\mathbf{E}/\partial t)\times\mathbf{B}'\} = (1/2)(R_i+R_r)\pi(R_e^2-R_i^2)h\varepsilon_0(\partial E/\partial t)B'\hat{z}, \quad (63.2)$$

where **B**' (pointing to the axis of the apparatus) is the magnetic intensity in the gap, and we shall assume that the whole magnetic field is closed in the iron and in the gap, thus that the magnetic fluxes in the core and in the gap are equal, so that

$$B' = r^2B/h(R_i + R_e). \qquad (63.3)$$

Taking further into account that (see formulas (17.1) and (17.5))

$$\partial E/\partial t = I/Ch, \qquad C = \varepsilon_0\pi(R_e^2 - R_i^2)/h, \qquad (63.4)$$

where C is the capacitance of the capacitor, for which the displacement current is $\varepsilon_0\partial E/\partial t$, we obtain from the last three equations $\mathbf{M}_{cc} = - \mathbf{M}_{dc}$.

The torque (63.2) is, however, fictitious, as neither the displacement current nor the polarization current can react with kinetic force to the action of the magnetic intensity B'. Thus only the torque (63.1) remains to act, setting the whole system in rotation.

In my experiment the core and the yoke were made of powder soft iron material Corovac EF 6880 delivered by the VACUUMSCHMELZE company which was not current conducting and thus eddy currents could not be induced in it. I had R_i = 3 cm, R_e = 4 cm, h = 0.2 cm (height of the air gap in the yoke), d = 0.4 cm (distance between the capacitor's plates). The dielectric of the capacitor was barium titanate with permittivity ε = 10,000 (the value was not measured). For smooth plates the capacitance is $C = \varepsilon_0\varepsilon\pi(R_e^2 - R_i^2)/d$. I etched the condenser's plates making them rough and increasing thus the surface and the capacitance, which, measured between the electrodes K and L, was C = 430 nF. A condenser with capacitance 470 nF brought the magnet coil into resonance if a 50-Hz alternating tension was applied, so that the inductivity of the coil was 22 H. By applying the mains (~220 V), the current flowing in the coil was I = 0.23 A, and thus the impedance of the coil was R = 960 Ω. The calculation of the magnetic intensity across the Faraday-Barlow disk according to the formula (see (20.11))

$$B = \Phi/\pi r^2 = \mu_0 NI/\sum(L_i/\mu_i S_i)\pi r^2, \qquad (63.5)$$

where Φ is the magnetic flux, r = 2 cm is the radius of the Faraday-Barlow disk, N = 12,000 is the number of the turns in the coil, and L_i, S_i, μ_i are the lengths, the cross-sections and the permeabilities of the different parts of the yoke (μ_{air} = 1, μ_{iron} = 200), gave the value B = 0.072 T.

First I ran the machine as a generator driving it with a d.c. motor which rubbed the upper lid. The tension which was expected to be induced along the disk's radius during a rotation with a rate N = 20 rev/sec had to be $U = \pi Br^2N$ = 1.8 mV. I measured U = 1.1 mV, but the noise of the sliding contacts was of the same order.

Then I ran the machine as a motor applying a 50-Hz tension of 1500 V from a transformer to the electrodes L and M and taking away the sliding contacts. The flowing current was I = 1.5 A and the body cameinto a very slow rotation.

The report on the above experiment was published in Ref. 67.

64. THE BALL-BEARING MOTOR

It is almost unknown that if direct or alternating current passes through the ball-bearings of an axle, it is set in rotation. In the few papers where this effect is discussed, the torque is explained as an electromagnetic effect. Yet the torque is due to thermal extension of the balls in their bearings at the points of contact with the bearing races.

The arrangement of the simplest BALL-BEARING MOTOR is given in fig. 94, where the inner races rotate. With the same ball-bearings, a bigger torque can be obtained by rotating the outer races. In such a case the axle must be made of two electrically insulated parts, and the current goes through a metal cylinder connecting the outer races of both ball-bearings. Such are the small and big ball-bearing motors presented in fig. 95.

I have established that the ball-bearing motor is <u>not</u> an electromagnetic motor but a thermal engine. Here the expanding substance leading to mechanical motion is steel, while the expanding substance in all thermal engines used by humanity is gaseous.

There is, however, another much more important difference; the motion of the conventional thermal engine is along the direction of expansion of the heated substance, while in the ball-bearing thermal engine it is at right angles to the direction of expansion of the heated substance. Consequently, in gaseous thermal engines, the gas cools during the expansion and the kinetic energy acquired by the "piston" is equal to the heat lost by the expanding gas. This is not the case in the ball-bearing motor. Here not the whole ball becomes hot but only a small part of it which touches the race at a point contact where the ohmic resistance is much higher than the resistance across the ball. Only this small "contact part" of the ball dilates; and the dilation is very small, only a few microns. (Of course, I have not measured the dilatation, I only presume that it is a couple of microns.) Since the balls and the races are made of very hard steel, a slightly ellipsoidal ball produces a huge torque when one of the races rotates with respect to the other.

Usually a push is needed to start the ball-bearing motor. However, on occasions, it does start spontaneously (with a greater probability at greater bores) because the surface of the races is not absolutely smooth. With absolute smoothness and geometrical perfection, spontaneous starting is impossible.

During rotation the ball's "bulge" moves from the one race to the other, the local overheating is absorbed by the ball and the radius of the "bulge" becomes equal to the radius of the whole ball. At the new point of contact, when current passes and ohmic heat is produced, the radius of the contact becomes again bigger than the radius of the whole ball and again a driving torque appears. Thus, as a result of the mechanical motion, the ball is not cooled; and consequently, in the ball-bearing thermal engine, heat is not transformed into kinetic energy. The whole heat which the current delivers remains in the metal substance of the machine and increases its temperature. If the ohmic resistance between balls and races is the same both at rest and in rotation, the heat produced and stored in the metal of the

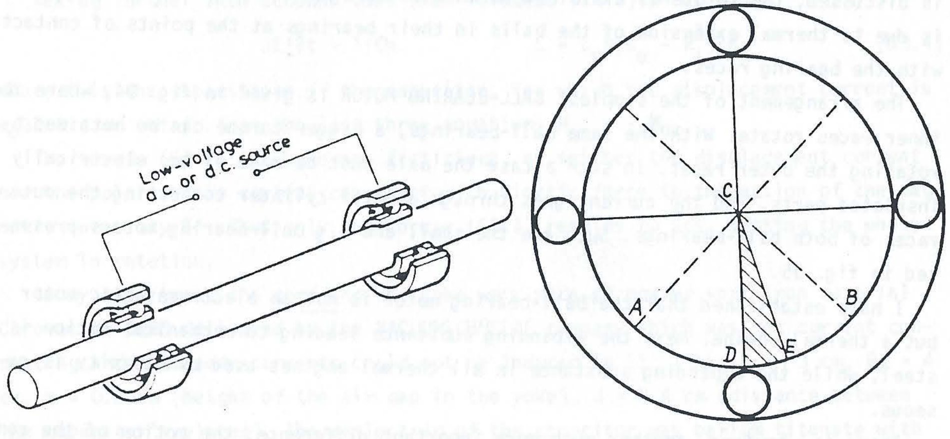

Fig. 94. Diagram of the ball-bearing motor with cross-section of the bearings.

machine will be the same at rest and rotation. This resistance, however, increases at rotation; but with further increase of the velocity the increase of resistance is very slight.

I established that the ball-bearing motor produces the same amount of heat at rest and rotation in the following manner. I measured for a definite time the temperature increase in a calorimeter in which the motor was maintained at rest, applying a tension U and registering the current I. Thus the resistance of the whole motor was R = U/I. Then I started the motor and applied a tension U' such that at the new resistance R' the current I' = U'/R' was such that UI = U'I'; i.e., in both cases I applied exactly the same electric power. According to the energy conservation law, in both cases the temperature increase of the calorimeter had to be the same, as in both cases the same amount of electric energy was put in the machine.

I recorded, however, that in the second case the temperature increase of the calorimeter was higher. Thus I concluded that in both cases the produced ohmic heat was the same; however in the second case there was also heat coming from the friction of the rotating ball-bearings. The temperature increase in the second case was about 8% while the mechanical energy produced was calculated to be about 10% of the input electric energy.

One can see immediately that the ball-bearing motor has no back tension because there are no magnets, and the magnetic field of the current in the "stator" cannot induce tension in the metal of the "rotor".

Thus the firm conclusion is to be drawn that the mechanical energy delivered by the ball-bearing motor is produced from nothing, in a drastic contradiction with the energy conservation law.

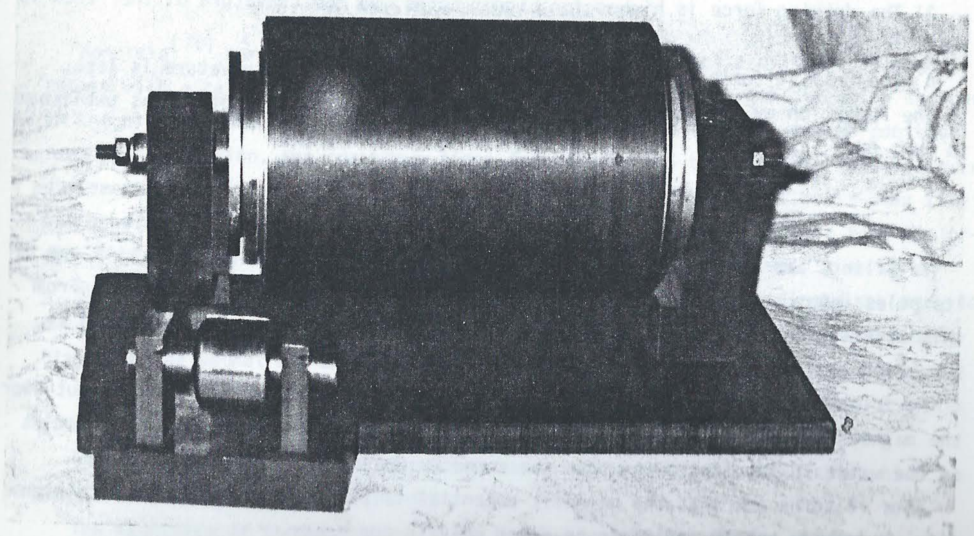

Fig. 96. Photograph of small and big ball-bearing motors.

With a direct current supply, the ball-bearing motor can rotate either left or right. Thus it cannot be an electromagnetic motor, since a d.c. electromagnetic motor rotates only in one direction, with a given direction of the current. The ball-bearing motor rotates with d.c. as wellas with a.c. With a greater current it rotates faster.

At equal applied electrical powers and equal number and size of the balls (i.e., at equal resistance), the torque is bigger for a ball-bearing with bigger bore. A ball-bearing with two times bigger bore has two times bigger torque. Fig. 95 shows two ball-bearing motors with a small and a large bore which have almost equal ohmic resistances (of course, the mechanical friction of the bigger motor is greater). By touching both motors, one can immediately feel the difference in their torques. The bigger ball-bearing has greater number of balls and consequently a bigger torque; however, its current (and power) consumption are higher.

Methods of improving efficiency in the ball-bearing motor include the following:

1) The use of balls which are harder and where a smaller amount of heat leads to larger thermal extension. We know that normally a harder solid body has a lower coefficient of thermal dilatation, so that one has to find the optimal solution which nature offers.

2) Tighter ball-bearings have a better pushing force. However, at the same time they will have more friction. A compromise is needed. But even if friction is very low, there is always a maximum velocity which the motor cannot surpass. At this maximum velocity, heat from the "bulge" cannot be absorbed by the ball, and the ball retains more or less a spherical shape. It is obvious that the maximum velocity is higher for larger balls.

3) The driving force is higher for bigger bores, as the curvature of the races is less.

4) The driving force is greater for bigger balls, as their curvature is less.

The report on my experiments with the different ball-bearing motors was published in Ref. 68.

65. DITCHEV'S EXPERIMENT

If filings are dispersed over a cardboard under which a magnet is put with one of its poles upwards, the filings form lines following the magnetic intensity **B**. From this observation official physics draws the conclusion that the magnetic field is something real as it can be "revealed by material objects".

My friend H. Ditchev[69] did the same experiment but instead cardboard he put over the magnet's pole a shallow dish filled with water. The fine filings formed circles on the water surface following thus the magnetic potential **A** (fig. 96).

Thus it turns out that the magnetic potential is as "real" as the magnetic intensity. Meanwhile both B and A can be found only in our heads.

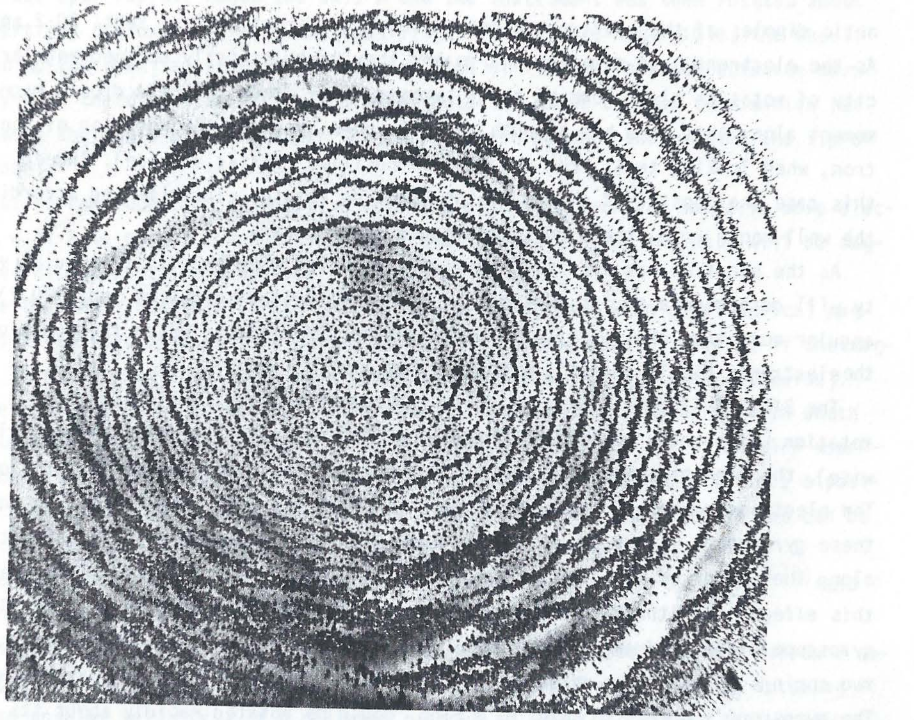

Fig. 97. Ditchev's experiment with iron powder disperced on water surface.

66. THE MONSTEIN-WESLEY EFFECT

Monstein[70] carried out the following experiment: He set a cylindrical magnet rotate with a certain angular velocity about its axis once in one direction and once in the opposite one. Monstein observed that when letting then the magnet continue freely its rotation, the coast-down times for the one and the opposite rotations were different. The differences were not big (few percents of the total coast-down time) but they were definitely asymmetric and could be clearly distinguished from the ordinary stochastic differences whose sums (for many experiments) must give zero.

When the magnet has been set to rotate positively, i.e., anti-clockwise, and looked to its south pole, the coast-down time was always longer than the coast-down time when the magnet was set to rotate negatively.

To the best of my knowledge, Monstein was the first one of having observed this effect.

This effect is of the kind of the Barnett and de Haas - Einstein effects which I should like to present first shortly.

The magnetism of the magnetics is due to the orientation of the elementary magnetic dipoles of the electrons along a preferred direction (see Sect. 20.2 and 32). As the electrons have negative charge and they have strictly defined angular velocity of rotation along some of their symmetry axes, then if their dipole magnetic moment along this axis has a south magnetic pole upwards, the rotation of the electron, when looking to it from up, will be positive (anti-clockwise). Indeed, in this case the "positive" charge of the electron rotates clockwise and according to the well-known rule, there must be a south pole upwards.

As the electron has a certain mass, its rotation with a definite angular velocity will determine also its own angular momentum, called spin (see Sect. 20.2). This angular momentum, obviously, will point in the direction in which the south pole of theelectron's dipole magnetic moment points.

The BARNETT EFFECT[71] is the following one: When a cylindrical magnetic is set in rotation, it becomes magnetized, namely, if the rotation is positive (anti-clockwise), the magnetic obtains a south pole upwards. The explanation is as follows: The electrons represent small gyroscopes and when the whole body is set in rotation these gyroscopes search to orient the vectors of their rotational velocities along the vector of the angular velocity of the whole body. Barnett demonstrated this effect[71] with the help of the gyroscopic model presented in fig. 98. This gyroscope differed from a common type of gyroscope only in the addition of the two springs SS (taken as rubber bands) and the arrangement for their attachement. The gyroscope's wheel, pivoted in a ring, could be rotated rapidly about its axis A. Except for the action of the springs, the ring and the axis A were free to move in altitude about a horizontal axis B, the axis A making thus an angle θ with the vertical axis C, while the axis B, together with the wheel and the framework supporting it and the springs, could be rotated about the vertical axis C. If the

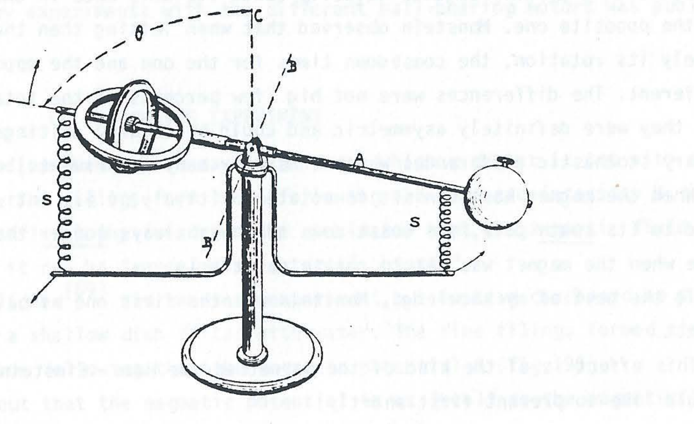

Fig. 98. Barnett's demonstrational gyroscope which is rotated as a whole.

wheel was spun rapidly about the axis A and the instrument was then rotated about the vertical C slowly, so that the centrifugal forces were negligible, the wheel tipped up (or down) so as to make the direction of its own rotation coincide more nearly with the direction of the impressed rotation about C, thus to diminish (or increase) the angle θ. Tne greater the rotary speed about C the greater the tip of the wheel.

Thus we conclude that at positive rotation of the cylindrical magnetic more electrons will have spins' components upwards than downwards and the body will be magnetized with a south pole upwards.

The DE HAAS - EINSTEIN EFFECT[72] is the following one: When a cylindrical magnet is magnetized by a current pulse, it obtains a small torque, namely, if the magnetic is magnetized with south pole upwards, the torque is negative (clockwise).

The explanation is as follows: At the magnetization of the magnetic with south pole upwards, more electrons arrange their spins upwards. The law of angular momentum conservation requires that the magnet obtains an opposite "spin", i.e., a positive torque. The same effect appears when a magnet will be demagnetized and can be called the <u>inverse</u> de Haas - Einstein effect.

The explanation of the effect observed by Monstein was given by Wesley[73] and for this reason I call it the MONSTEIN - WESLEY EFFECT.

Wesley considers the electron not as a sphere or ring of mass m_e and radius r rotating with an angular velocity ω about an axis, but as a point mass m_e rotating with an angular velocity ω at a distance r about an axis. Since then an averaging in time will be made, both these models must lead to identical results.

Let the distance of the electron from the axis of magnetization of the cylindrical magnet, which will be also its axis of rotation with the low (with respect to ω) angular velocity Ω, be R. The position of the electron as function of time in the xy-plane of a cylindrical frame of reference is given by its radius vector

$$\mathbf{r}' = \{R\cos\Omega t + r\cos(\omega \pm \Omega)t\}\hat{\mathbf{x}} + \{R\sin\Omega t + r\sin(\omega \pm \Omega)t\}\hat{\mathbf{y}}, \qquad (66.1)$$

where the upper sign is to be taken when the spins of the electron and the magnet coincide,and the lower sign when they are opposite, and for t = 0 the electron is on the x-axis.

Differentiating (66.1) with respect to time, we find the velocity of the electron

$$\mathbf{v} = -\{\Omega R\sin\Omega t + (\omega \pm \Omega)r\sin(\omega \pm \Omega)t\}\hat{\mathbf{x}} + \{\Omega R\cos\Omega t + (\omega \pm \Omega)r\cos(\omega \pm \Omega)t\}\hat{\mathbf{y}}. \qquad (66.2)$$

The kinetic energy of the electron will be

$$e_k = m_e v^2/2 = (m_e/2)\{\Omega^2R^2 + (\omega \pm \Omega)^2 r^2 + 2\Omega(\omega \pm \Omega)rR\cos(\omega {}^{+2\Omega}_{+0})t\}. \qquad (66.3)$$

The kinetic energy of the electron averaged in time (what is the effective value which can be eventually observed) will be

$$\overline{e_k} = m_e\overline{v^2}/2 = (m_e/2)\{\Omega^2R^2 + \omega^2r^2 + \Omega^2r^2\} \pm \Omega p_\phi, \qquad (66.4)$$

where

$$p_\phi = m_e \omega r^2 \qquad (66.5)$$

is the angular momentum of the electron which is independent of its model (spinning sphere, ring, or mass point rotating about an axis).

The significance of the result (66.4) is that the last term can change sign depending upon the direction of rotation Ω.

If M is the total mass of the magnet and N is the number of the spinning electrons, then the net kinetic energy of the rotating cylindrical magnet of radius R_o is given by

$$E_k = MR_o^2\Omega^2/4 \pm \Omega N p_\phi = J\Omega^2/2 \pm \Omega P_\phi, \qquad (66.6)$$

where J is the moment of inertia of the magnet about the axis of rotation, P_ϕ is the own angular momentum of all electrons which generate magnetism of the magnet as a whole and we assumed that the number of these electrons for the two opposite rotations is the same (as we shall see beneath this number is not the same).

Thus the kinetic energy of the magnet for "right" and "left" rotation with the same angular velocity Ω is not the same: If the angular velocity Ω has the same direction as the spinning velocities of the electrons, the kinetic energy of the spinning magnet as a whole will be greater. Consequently when the magnet will be rotated in this direction and then left to spin freely, the coast-down time will be longer.

As the spins of the electrons are positive when looking at the south pole of the magnet, then if rotating the magnet with south pole up in the positive (anti-clockwise) direction, the coast-down time will be longer than if the magnet will be rotated in the negative (clockwise) direction.

This effect was observed by Monstein.

When looking to the south pole of the magnet and rotating it positively, the magnetic intensity increased with 19 μT for 1 m/sec velocity of the periphery of the magnet, and the coast-down time was with 2% greater than the middle (right+left) coast-down time. When the magnet was rotated negatively, the magnetic intensity decreased with 29 μT/(m/sec) and the coast-down time was with 2% less.

In his paper[73] Wesley finds easily a formula according to which one can, proceeding from Monstein's experimental data, calculate the intrinsic angular moment of the "magnetizing" electrons P_ϕ.

67. THE PERPETUUM MOBILE TESTATIKA

The machine TESTATIKA constructed by Paul Baumann some 15 years ago is, according to the best of my knowledge, the first and still the only perpetuum mobile in our world.

The story of TESTATIKA is huge, mystic, interesting and I dedicated to it the fifth volume of the series THE THORNY WAY OF TRUTH[54]. Here only a couple of words.

Paul Baumann is the spiritual head of the Christian religious community METHERNITHA in Switzerland which has some 500 members in the European countries (since 1989 I am member of the community). Born in a poor Swiss peasant family, Paul Baumann began to earn his bread at the age of twelve (now he is seventy) and has not visited schools. God has given him an amazing intellect, or something more, as, according to me, the machine TESTATIKA is constructed rather by inspiration than by brain.

It is an electrostatic influence machine of the kind of the WIMSHURST MACHINE which maintains its motion alone and delivers huge amounts of free energy.

The first small prototypes are with one rotating wheel, as the machines shown in figs. 99 and 100. The middle and big machines are with two counter-rotating wheels (as the Wimshurst machine).

The small machines inspected by me deliver some 200 W free energy in the form of direct current, the middle machines (with disks' diameter of 50 cm) deliver about 3 kW and the gigantic machine with disk's diameter 2 m (see its photograph in Ref. 74), which is still in construction, will deliver 30 kW.

The machines are set in rotation by hand (even by finger) and then they maintain their motion alone. The rotation rate of all machines is about 1 rev/sec. The mechanical power of the machines is only a very small fraction of the delivered electrical power.

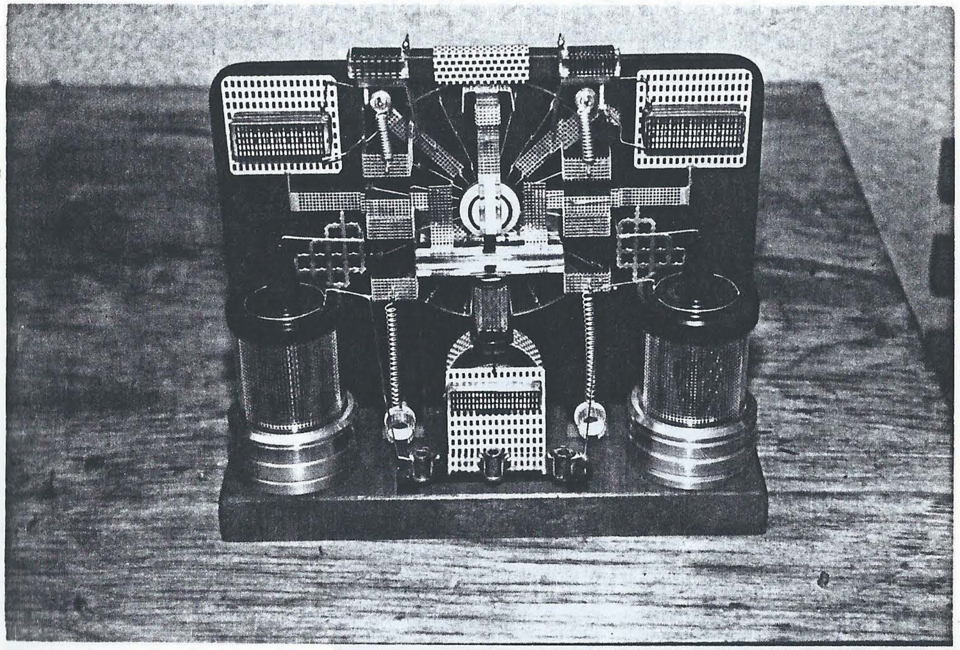

Fig. 99. Photograph of the small machine TESTATIKA with one rotating wheel.

Although having inspected two of the machines, setting the one in motion and stopping it, the secret of TESTATIKA is not clear to me. It is evident that the secret is extremely simple (of the kind of the "secret" of SIBERIAN COLIU), but nobody of the thousands of people who have seen the machines has revealed it.

The machines TESTATIKA are property of the community METHERNITHA, where people live on the principles of a pure and genuine Christian communism. In the opinion of the community, humanity is not ripe for such a source of inexhaustible energy. The secret of TESTATIKA will be made public only if humanity will grasp that the only way to survive in our highly technological epoch, when man has in his possession terrible powers, is to begin to live in humbleness, in love and solidaroty with the other people, the animals, the plants.

I tried to organize a visit of A. D. Sakharov of the community but as he was sceptical(75) that such a source of energy may exist, my endeavours did not bring fruits (see the documentation on my efforts in organizing Sakharov's visit in the last volumes of the series THE THORNY WAY OF TRUTH).

At a meeting of the active of the community, called forth by me, for discussing the problem whether the secret of TESTATIKA is to be revealed, of the 23 attending people I was the only one who voted "for".

I am for the revelation of the sources of free energy to mankind if this energy is clean and non-destructive. Free energy will solve many problems of mankind but, of course, not all. I think, it will be easier to search for God and for Christian Communism with free energy in the hands than without it.

Fig. 100. Inspecting two of the small TESTATIKA machines.

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LIST OF SYMBOLS

$\mathbf{A}$ magnetic (magretic) potential

$\mathbf{B}$ magnetic (magretic) intensity

B_{pot} potential magnetic intensity

B_{rad} radiation magnetic intensity

$\mathbf{B}_{rea}$ radiation reaction magnetic intensity (= 0)

c light velocity

C capacitance

$\mathbf{d}$ electric dipole moment

$\mathbf{D}$ electric displacement

e time energy

e_k kinetic energy

e_l low-velocity time energy

$\mathbf{E}$ electric intensity

$\mathbf{E}_{pot}$ potential electric intensity

$\mathbf{E}_{rad}$ radiation electric intensity

$\mathbf{E}_{rea}$ radiation reaction electric intensity

$\mathbf{E}_{coul}$ Coulomb electric intensity

$\mathbf{E}_{tr}$ transformer electric intensity

$\mathbf{E}_{mot}$ motional electric intensity

$\mathbf{E}_{whit}$ Whittaker electric intensity

$\mathbf{E}_{nic}$ Nicolaev electric intensity

$\mathbf{E}_{glob}$ global electric intensity

$\mathbf{f}$ kinetic force

$\tilde{\mathbf{f}}$ full kinetic force

$\mathbf{F}$ potential force

$\tilde{\mathbf{F}}$ full potential force

G conductance

G_m permeance

$\mathbf{G}$ gravitational intensity

h Planck constant

H full energy

$\tilde{H}$ total energy

$\mathbf{H}$ (magnetic intensity)

i imaginary unit

I electric current

$\mathbf{I}$ electromagnetic energy flux density

$\mathbf{j}$ space electric current

$\bar{j}$ time electric current

J moment of inertia

$\mathbf{J}$ electric current density

k circular wave number

$\check{k}$ wave scalar (wave number)

$\mathbf{k}$ wave vector

$\check{\mathbf{k}}$ linear wave vector

$\mathbf{l}$ angular momentum

L line (its length)

L inductance

m mass

$\tilde{m}$ full mass

m^* Marinov mass

$\mathbf{m}$ magnetic dipole moment

$\mathbf{M}$ moment of force

$\mathbf{M}$ magnetization

n number of particles in a system

n number of windings on a unit of length

$\mathbf{n}$ unit vector along some direction

N number

N rate of rotation

$\mathbf{p}$ (space) momentum

$\bar{p}$ time momentum

$\tilde{\mathbf{p}}$ full momentum

P power

P energy flux

$\mathbf{P}$ electric polarization

q electric charge

q^* Marinov electric charge

Q electric charge density

r distance, radius

$\mathbf{r}$ radius vector, vector distance

R radius

R resistance

R_m reluctance

S surface (its area)

S action

S scalar magnetic intensity

$\bar{S}$ density of electromagnetic energy

$\mathbf{S}$ Poynting vector

t time

T period

$\mathbf{u}$ acceleration

U space energy (electric, U_e, gravitational, U_g)

U electric tension

U_m magnetic tension

$\mathbf{v}$ velocity

V volume

$\mathbf{V}$ velocity of laboratory in absolute space

W space-time energy (magnetic, W_e, magretic, W_g)

x abscissa

$\hat{\mathbf{x}}$ unit vector along the abscissa

y ordinate

$\hat{y}$ unit vector along the ordinate

z applicate

$\hat{z}$ unit vector along the applicate

Z impedance

α initial phase

γ gravitational constant

γ conductivity

ε energy density

ε permittivity

ε_o electric constant

θ zenith angle

λ wavelength

μ mass density

μ permeability

μ_o magnetic constant

ν frequancy

$\boldsymbol{\pi}$ momentum density

ρ polar radius

ρ resistivity

$\hat{\rho}$ unit vector along the polar radius

Σ surface charge density

τ period of a particle

ϕ azimuth angle

ϕ phase angle

$\hat{\boldsymbol{\phi}}$ unit vector perpendicular to $\hat{\rho}$

Φ electric (gravitational) potential

Φ magnetic flux

χ electric susceptibility

χ_m magnetic susceptibility

ω circular frequency

Ω angular velocity

S U B J E C T   I N D E X

IMPRORTANT INFORMATION ADDED IN PROOF

In fig. 101 I present the proposal of the most simple SIBERIAN COLIU machine which, if put at low (nitrogen) tempertaures will run as a perpetuum mobile. I call this machine SIBERIAN COLIU II, while SIBERIAN COLIU I will be called the machine shown in fig. 88.

To grasp more quickly the principle of action of SIBERIAN COLIU II, compare figs. 101 and 86:

On the strong permanent magnet (which is cut along its diametral plane and then one of its halves is turned up-down) three plastic rings are put. The lower and upper plastic rings are encircled by two ball-bearings (called further "the big ball-bearings") whose outer races are encircled by copper rings (the "big copper rings") with considerable cross-section (for decreasing their ohmic resistances). The middle plastic ring supports two antipodal axles, on which two ball-bearings (the "small ball-bearings") are put, the outer races of which are encircled by copper rings (the "small copper rings") with smaller but still considerable cross-section.

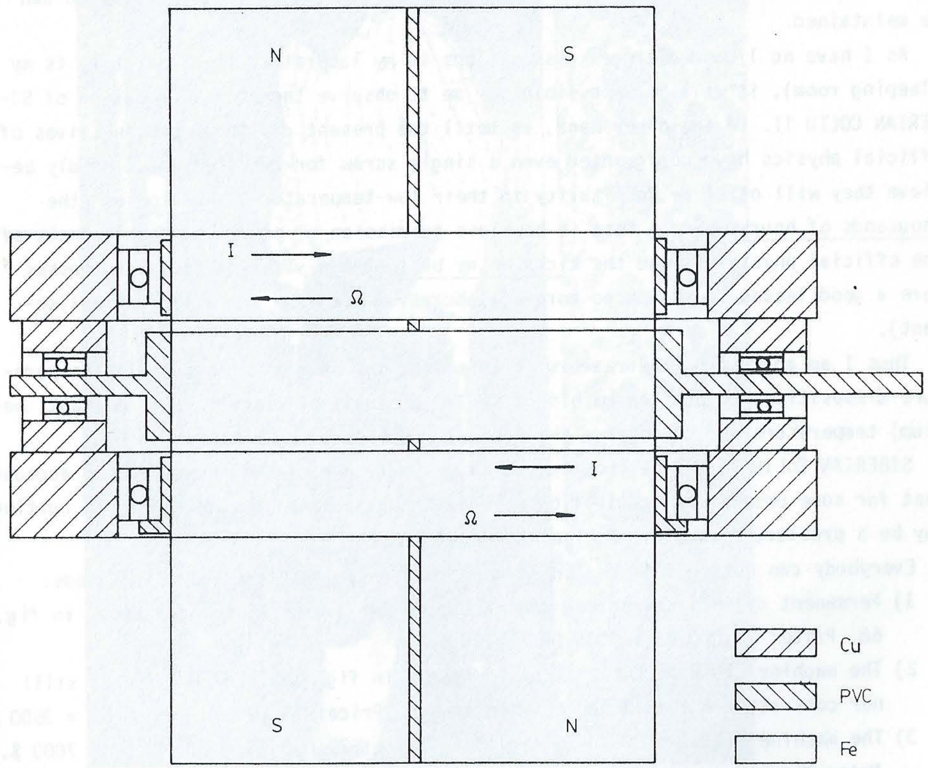

Fig. 101. Drawing of the machine SIBERIAN COLIU II (perpetuum mobile without a single screw!).

When rotating the lower big copper ring anti-clockwise, because of the friction between the copper rings, the upper copper ring comes in clockwise rotation.

As shown in Sect. 60 (see also fig. 83), at the indicated polarities of the magnets and at the indicated rotation of the big copper rings, the current induced in the two half-circular parts of the upper copper ring will be from left to right, while the current induced in the two half-circular parts of the lower copper ring will be from right to left. Any of these induced currents will support the rotation of the rings. Thus if the driving torque caused by the interaction of these currents with the "radial currents" in the magnets will be equal to the friction torque, the machine will rotate eternally.

The only condition for running this machine as a perpetuum mobile is that the ohmic resistances of the four copper rings (together with the resistances of the rolling contacts) should be low enough, so that enough current should be induced.

Thus if the machine will be put at nitrogen temperature and will be set at initial rotation by an external motor by friction (see fig. 59), then, after decoupling the driving motor, it will continue to rotate alone. The external motor can be then used as artificial "friction torque" by the help of which an eternal rotation can be maintained.

As I have no liquid nitrogen dispositions in my laboratory (my laboratory is my sleeping room), it will be impossible for me to observe the eternal rotation of SIBERIAN COLIU II. On the other hand, as until the present day the representatives of official physics have not granted even a single screw for my research, I hardly believe they will offer me hospitality in their low-temperature laboratories (the thousands of hours which I lost in hopeless submission of papers to the journals of the official physicists and the kicks on my bottom when visiting their congresses were a good lesson to search no more collaboration with the scientific establishment).

Thus I am addressing the readers of this book who have an access to low-temperature dispositions to put the machine SIBERIAN COLIU II at nitrogen (or, perhaps, helium) temperature and to observe the eternal rotation.

SIBERIAN COLIU II can be constructed in a single day. Taking however into account that for some people the acquisition of the strong permanent magnet (and its cutting) may be a problem, I make the following announcement:

Everybody can obtain from me (in no more than in a week) the following items:

1) Permanent cylindrical strong magnet cut in two pieces as the one shown in fig. 68. Price: 21,000 AS = 3000 DM = 2100 $.
2) The machine SIBERIAN COLIU II as indicated in fig. 101. The machine is still nor costructed but I can do this in a week. Price: 35,000 AS = 5000 DM = 3500 $.
3) The machine SIBERIAN COLIU I (fig. 68). Price: 70,000 AS = 10,000 DM = 7000 $. Note: Mercury is hermetically closed in its trough and there are no hygienic problems at transport and use.

I shall try to run SIBERIAN COLIU II at room temperature or putting it in refrigirator for meet (ordinary people have always generously supported my research!). The right small copper ring with its ball-bearing can be pushed to the right on its axle and so the net tension induced at the rotation of both big copper rings can be measured. The ball-bearings have to rotate loosely enough, so that the friction will be lowest possible. If the pressure on the rolling contacts will be not enough, the upper big copper ring is to be made more massive.

As, however, I tore off my Achilles tendon and can walk only with clutches (see fig. 102), my experimental activity is substantially handicapped.

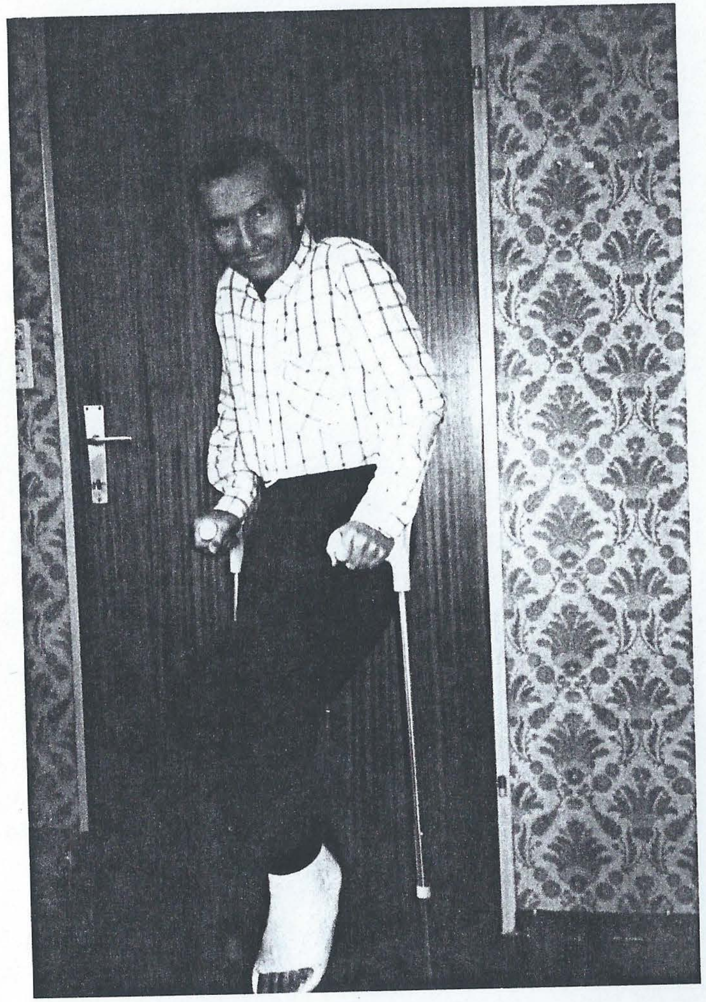

Fig. 102. On the way to eternal motion (or eternal rest!?).