The proposal came before Congress in 1946, when there was disagreement as to the form and direction it should take. According to Doctor Jewett, enactment of legislation affecting research by Congress before it set up such a foundation would dislocate the traditional excellent methods of supporting research.

The success of both basic and applied research depends primarily on personnel, and the wartime manpower shortage seriously affected research staffs. William H. Higinbotham of the Federation of American Scientists, told the committee that "the danger in science today is that we may exhaust our resources of basic scientific knowledge and of adequately trained scientific personnel."

Research Activity Continues at Oak Ridge

By the close of 1948 an electric generating plant fueled solely with atomic energy is expected to be in operation at Oak Ridge, Tenn. The plant is under construction as a co-operative venture of industry under the leadership of Doctor Charles Thomas of the Monsanto Chemical Company, St. Louis, Mo., and Doctor Harry A. Winne (F '45) of General Electric Company, Schenectady, N. Y. In Atomic Energy Plant Number 1 it is planned to employ the nuclear heat from fission of the atom in the conventional fashion by developing steam as the driving medium of a turbo-electric generator.

A 100-million-volt betatron is being built by General Electric Company for the Clinton Laboratories, operated at Oak Ridge by Monsanto Chemical Company for the Atomic Energy Commission. Shipment of the machine's final components is expected to be completed this summer.

INDUSTRY

IBEW Answers NEMA Boycott Charges. The president of the International Brotherhood of Electrical Workers, Dan W. Tracy, stated the organization is "ready to debate the allegation made by the National Electrical Manufacturers Association that the IBEW engages in so-called secondary boycotts (*EE, March '47, p 314*), if NEMA will agree to debate the effects of secondary boycotts practiced by NEMA against union products." Tracy's remarks were prompted by the announcement of R. Stafford Edwards, president of NEMA, to the effect that industry calls upon Congress to outlaw all forms of secondary boycott.

Siemens Concern Taken Over. According to a Reuter message the British Military Government has taken over the Siemens electrical concern under the provisions of Occupation Law 52 (which deals with the blocking and control of property of interest to the United Nations). Siemens, which before World War II controlled the major part of the German electrical industry, with its main subsidiary, Siemens-Schuckert, is among the Berlin industrial concerns scheduled for municipalization.

Kite Flying Leaflet. The Edison Electric Institute has sold to electric power companies more than 500,000 copies of a leaflet entitled "So You Fly Kites," which describes the dangers of kite flying with metallic string or wire. According to the Accident Prevention Committee of the EEI, electrical companies have found that the leaflet effectively supplements publicity programs on kite flying dangers.

Half Billion for Canadian Electrical Services. Within the next five years Canadian electrical utilities plan capital expenditures of some $350,000,000 for new plant, new projects, and new lines as determined from a survey by *Electrical News and Engineering* published by Hugh C. Maclean Publications, Ltd., of Toronto, Ottawa, Canada. Telephone companies plan to spend $150,000,000 thereby bringing the total to the half billion mark.

HONORS

Franklin Medal to Fermi and Robinson

The Franklin Medal, highest honor of the Franklin Institute, Philadelphia, Pa., was presented recently to Doctor Enrico Fermi, physicist at the Nuclear Research Institute in Chicago, Ill., and Sir Robert Robinson, professor of chemistry at Oxford University, England, along with other Franklin Institute awards at Medal Day exercises in Philadelphia. The institute's committee on science and the arts awarded the medal in previous years to Thomas A. Edison, Guglielmo Marconi, Neils Bohr, Orville Wright, and Albert Einstein.

Doctor Fermi received the medal for outstanding work in the field of atomic energy. Sir Robinson, generally regarded as one of the world's leaders in organic chemistry, was honored for his invaluable contributions to the present knowledge of the life processes of plants and animals.

The gold medal is awarded annually to workers, regardless of color or creed, who have done the most to advance knowledge of physical science and its applications.

First Alex Dow Awards Conferred. The Alex Dow Award, established by The Detroit (Mich.) Edison Company in 1946 to perpetuate the memory of its long-time president, was made recently to five employees of the company. Five awards, each consisting of a gold watch and a United States savings bond, will be made annually. Alex Dow, who died in 1942, was made an AIEE Honorary Member in 1937.

Noble Prize to ASME Member. Martin Goland, chairman of the engineering mechanics section of the Midwest Research Institute, Kansas City, Mo., has been awarded the 1946 Alfred Noble Prize for his paper, "The Flutter of a Uniform Cantilever Wing," published in the *Journal of Applied Mechanics.* Established in 1929, the award is made annually by the American Society of Civil Engineers to a young member of one of the four founder societies of the Western Society of Engineers for a published technical paper of unusual merit.

Lawrence Sperry Award. Endowed in 1936 by the sister and brothers of the late Lawrence Sperry, pioneer aviator and inventor, the award carrying his name was presented to Peter R. Murray "for radio controlled systems for guided missiles and pilotless aircraft." Mr. Murray is with the aircraft radio laboratory, Air Matériel Command, Wright Field, Dayton, Ohio.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Sign of Reactive Power

The following excerpts are from letters addressed to *ELECTRICAL ENGINEERING,* AIEE Standards committee, and various interested individuals, concerning the proposed change of the sign of reactive power as presented in an AIEE subcommittee report appearing in the November 1946 issue of *ELECTRICAL ENGINEERING* on pages 512–16.

. . . At the moment, the reasons seemed to me so conclusive that there should be no question but that the standard should be changed. Since that time, I understand that the college groups and those interested from an academic standpoint have submitted considerable discussion in favor of retaining the present standard. . .

. . . I believe that, basically, the move to change the sign of the quantity was based on the fact that the old standard was impractical, unworkable and substantially ignored by operating engineers, in general. Therefore, it seems to me that since the point is perhaps arbitrary from the theoretical standpoint, that we may as well adopt a standard which suits our practice and meets more nearly the effects of the flow of reactive power. . . .

R. B. MILLER (A '36)

Engineer, Iowa-Illinois Gas and Electric Company, Rock Island, Ill.)

It would seem pertinent to inquire why the "nebulous advantages of using an unwieldly standard" were not obvious and apparent 13 years ago at the time of its adoption. The "practical reasons discussed in the next section" turn out to be "advantages" which are perhaps as nebulous as our present standard . . . if the subcommittee recommendation is the result of a two-thirds vote, what considerations contributed to this lack of unanimity?

Admittedly, the concept of power factor is basic and indispensable, and the term lagging current quite generally implies specification of this current with respect to its driving voltage. Thus, the voltage becomes the reference quantity, and it is difficult to picture a concise and consistent development of circuit theory, which did not include this fundamental concept, or its equivalent. . . .

Nevertheless, after some 13 years, the suggestion is made that the current be substituted as the reference quantity, for no other apparent reason than to justify the proposed choice of the positive sign for inductive reactive power. . . .

Viewed pedagogically, the writer would feel himself at a distinct disadvantage, if he should ever find it necessary to justify to a group of critical students, the desirability and necessity of the proposed revision.

H. B. HANSTEEN (M '43)

(Associate professor of electrical engineering, Cornell University, Ithaca, N. Y.)

. . . During the last ten years I have worked with engineers in most of the power companies within 500 miles of Chicago, and I never have met one who thinks in terms of the reactive power of an induction motor flowing in a direction opposite to that of the real power. Since we in the power field are the ones who make most continuous use of this quantity, it would seem to be a definite mistake to have the standards set up with the opposite concept. The sign of inductive reactive power should be positive and not negative.

L. B. LEVESCONTE (M '43)

(Sargent and Lundy Engineers, Chicago, Ill.)

. . . I would like to add my support to the movement for reversing the sign of reactive power . . . in operation of the network calculator and in calculation of flow of reactive power on electric power systems, all of the companies with which I have been associated, have used that concept. From the contacts and experience I have had, it would appear that the operating and manufacturing companies definitely would prefer the change in the standards.

J. E. HOBSON (M '41)

(Director, electrical engineering department, Illinois Institute of Technology, Chicago)

. . . In line with our conception of supply of real and lagging power to consumers, for many years we have used the plus sign for lagging reactive power in work with the calculating board and in connection with operating the system. It is recommended that the AIEE Standards committee also adopt the plus sign.

HERMAN HALPERIN (F '45)

(Staff engineer, Commonwealth Edison Company, Chicago, Ill.)

It was shown . . . that whether reactive power is positive or negative depends on whether it is defined with respect to the series or parallel circuit. This is misleading as it gives the idea that reactive power in an inductive series circuit is opposite in sign to that in an inductive parallel circuit; an obviously false conclusion.

Whatever convention is adopted, it should not lead to mistaken concepts and, to be consistent, it must give the same sign for inductive reactive power, irrespective of the mode of connection. This ideal is possible if the convention relates, not to the sign of the reactive power, but to the more fundamental consideration of the sign of the angle between voltage and current vectors. . . .

Since the power absorbed by a circuit concerns the total current entering the circuit and the total voltage across it and is not concerned with component currents or voltages, it is no longer necessary to have sometimes voltage, sometimes current as the common reference quantity depending on the nature of the circuit. . . .

All that is necessary to avoid the confusions of series and parallel circuits is to make the convention sufficiently basic, by declaring voltage or current as the fundamental quantity.

F. DE LA CHARD

(Lecturer in electrical engineering, University of Bristol, England)

. . . I assume that the change will be effected unless there is some protest from members of the profession.

I believe it is almost universal among operating electrical engineers to consider magnetizing kilovolt-amperes as a positive quantity. We consider that an inductive load takes magnetizing kilovolt-amperes from the system and that overexcited generators, synchronous condensers, capacitors, and line capacitance supply magnetizing kilovolt-amperes to the system. . . .

I am not a sufficiently good mathematician to understand the effect of changing the sign of reactive power. I know that the present system works satisfactorily for voltage drop calculations. . . . I believe that engineers in general have adopted the existing standard of using opposite signs for real and imaginary power where current lags voltage and that considerable confusion will result from a change.

I thoroughly agree with Doctor Silsbee (*EE, Dec '46, pp 598–9*) that a better term should be invented for the quantity that is measured in vars. Doctor Silsbee suggests that "quadergy" be used for this term. "Quadergy" is derived from quadrature energy and I cannot see that this expresses the quantity any better than "reactive power." We have a satisfactory term (vars) in which to measure this quantity but we need a name for it.

I hope the committee will leave the sign of reactive power unchanged.

G. M. TATUM (A '40)

(Superintendent of operation, western division, Virginia Electric and Power Company, Charlottesville)

. . . The subcommittee's recommendation to change the sign of reactive power is one means of eliminating some of the existent confusion insofar as practical considerations are concerned. However, the change of sign will introduce difficulties in mathematical analysis involving reactive power.

. . . If the sign is changed, inductive reactive power then must be represented by an upward or positive vector which normally would be the projection of a leading current vector. This would be confusing as well as inconsistent with conventional vector analysis. We believe that the present choice of sign, based on the parallel circuit should be retained.

In order to obtain clarity in discussions and considerations involving reactive power, specific terminology should be applied to this quantity. There would be no confusion if engineers talked in terms of inductive reactive power, capacitive reactive power, inductive vars, capacitive vars instead of simply reactive power and vars. New terms for the two types of reactive power and their unit measure would fill a definite need and eliminate the difficulties resulting from vague terminology which is loosely used.

A. B. CRAIG (M '33)

(Head, meter section, transmission and distribution department, Boston (Mass.) Edison Company)

. . . To me, the significant fact is the convention that gradually has developed concerning the manner in which the system operator dispatches reactive kilovolt-amperes. Without mental effort or reasoning the operator instinctively refers to a generator as supplying more reactive kilovolt-amperes as the excitation is increased, as an overexcited synchronous condenser as supplying reactive, as an underexcited synchronous condenser as absorbing reactive kilovolt-amperes, as a capacitor supplying reactive kilovolt-amperes, or as a motor absorbing reactive kilovolt-amperes. In all these cases he unwittingly uses lagging reactive kilovolt-amperes as positive and thinks in terms of dispatching this quantity.

It is gratifying, therefore, to see the standard reversed so that it is consistent with the one convention that has real significance.

C. F. WAGNER (F '40)

(Manager, central station engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

. . . In all of our a-c network analyzer studies, we have represented lagging reactive power as $+jQ$ for reasons 3 and 4 submitted by the committee report.

However, other electrical utilities interconnecting with us make similar studies of joint interest in which the opposite standard is used. In such cases we, however, submit our data to them with reference to our standard but they in turn submit the network analyzer results in terms of their standard.

Usually no confusion arises, since the standard that is used can be determined by inspection of the results, but the adoption of a single standard would be, of course, desirable.

H. A. DAMBLY (F '42)

(Engineer, system planning, transmission and distribution section, Philadelphia (Pa.) Electric Company.)

The choice of sign for reactive power, of course, would be arbitrary if starting anew, but it is undesirable to do this. Because certain more basic concepts concerning electrical quantities involving arbitrary choices have been accepted, these provide the basis for a decided preference for the choice of sign (+) recommended by the subcommittee.

In our view the decisive factor to be considered is the concept involving the flow of reactive power in a manner analogous to the flow of real power . . . the recommendations of the subcommittee correspond with analytical studies made by the majority of the utilities. This is a factor of considerable interest from the standpoint of engineering students.

While it is true that the majority of the opinions of the 1935 subcommittee was in favor of the recommendation, their action was at variance with the preponderance of usage in the plotting of power-circle diagrams and in the analytical expressions used for obtaining the expression for power and reactive power from a voltage and a current. Now after 15 years trial, the present subcommittee recommends the sign of reactive power which corresponds with the first extensive use of power-circle diagrams and analytical expressions for obtaining the quantity $(P+jQ)$.

The experience of these two AIEE subcommittees on the sign reactive power deserves further consideration. The first subcommittee hoped to gain acceptance of a rule which was contrary to the preponderance of usage as reflected by AIEE papers and books of a pioneering nature published prior to that time. The alternative and the one being adopted by the present subcommittee is to follow usage and lend the prestige of the Standards committee for the purpose of making the practice uniform throughout the industry.

R. D. EVANS (F '40)

(Consulting transmission engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

. . . Although the article stresses the calculations of real and reactive power, in actual practice we very seldom compute these quantities since they are usually known or read on an a-c board, or the sending end value may be obtained by adding the real and reactive losses to the receiving end values. However, since the voltage drops are frequently calculated, it seems more reasonable to use the sign which will cause the least confusion in the computation of voltages. . . .

It is difficult to see the need for changing a standard which was adopted by the American Standards Association as late as 1942, and also by the International Electrotechnical Commission at some recent time, especially since it is admitted that either sign has "about equal technical validity." I see only two things to be achieved by the change in sign—additional confusion in its use, and a question from other nations about our ability to make up our minds. It seems to me that since there is no strong argument either way, and we just recently have agreed on a sign, we may as well end these arguments and retain the present standard.

R. C. R. SCHULZE

(American Gas and Electric Service Corporation, New York, N. Y.)

. . . As Mr. Schulze has pointed out, changing the sign of lagging reactive kilovolt-amperes from minus to plus when this is used in complex notation will run into difficulty in connection with calculation of voltage drop where we now use the positive sign for reactance. This comes about from the use of the vector diagram which employs voltage as a basis in ordinary voltage calculations. This is the common and, I believe, most convenient procedure. From this standpoint, therefore, there appears to be no reason whatever for changing the sign of reactive kilovolt-amperes from minus to plus but rather a good reason for not changing it. . . .

In common with most systems, our system started out many years ago with the practice of marking reactive-kilovolt-ampere meters in terms of leading and lagging with a tie to the "in" or "out" flow of kilowatts. At least 15 years ago, this practice was entirely changed and reactive kilovolt-amperes meters were marked, "Reactive kilovolt-amperes in" and "Reactive kilovolt-amperes out." At the same time, it was agreed that the only kind of reactive kilovolt-amperes that would henceforth be talked about or considered in system operation would be *lagging* reactive kilovolt-amperes, and it was also agreed that reactive kilovolt-amperes so defined would be treated as a separate quantity flowing in or out from a bus entirely independent of the direction of flow of kilowatts.

This scheme has worked beautifully on our system and is well-liked by the entire operating personnel. I believe the same method is used in a great many if not the majority of all operating systems at this time. . . .

We have been using this designation for some 18 years of network analyzer studies involving four or five different boards, and it has not been the cause of any particular inconvenience or confusion in our own experience. Actually, we believe more confusion would result from any attempt to change the reactive kilovolt-amperes sign because of the accompanying change, which would have to be made in the sign of reactance in our present expression $R+jX$.

H. P. ST. CLAIR (F' 44)

(System planning engineer, American Gas and Electric Service Corporation, New York, N. Y.)

. . . In a circuit containing inductance and resistance, or one in which the current lags in time phase with reference to the voltage, the reactive power which is the imaginary component of the total power, leads the real component by 90 degrees in phase or whether it lags 90 degrees with reference to the real power. If the imaginary component leads the real component by 90 degrees it would be considered as positive reactive power and if it lags by 90 degrees it would be negative reactive power.

The total power or the volt-amperes is the product of volts times amperes and from this one might expect it to be the algebraic product; that is, a product obtained by multiplying according to the rules of complex algebra, but this would be incorrect because power is a double frequency quantity which surges in the circuit at twice the frequency of the current and voltage. The correct result is the vector product of current and voltage. This is explained by the late Doctor C. P. Steinmetz[1] where he shows that the real power is $EI \cos \phi$ and the reactive power is $EI \sin \phi$. The reactive power therefore may be considered as positive when $\alpha > \beta$ and negative when $\alpha < \beta$ if the phase displacement $\phi = \alpha - \beta$ is positive.

However, in obtaining the vector product of current and voltage he has assumed the voltage to operate on the current; if he had assumed the current to operate on the voltage the result would have been the opposite. The sign of reactive power has been discussed by La Cour and Bragstad,[2] in which the authors conclude that reactive power may be considered as either positive or negative.

In deciding the question, reactive power in the watt triangle of real, reactive, and total power might be considered the same as reactance has in the impedance triangle in which the reactance is assumed to be positive in an inductive circuit and negative in a capacitive circuit. It may be that a study of instantaneous condition will influence a decision on the subject. . . .

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C. F. ESTWICK (M '25)

(Electrical department, George C. Sharp, Consulting Engineer, New York, N. Y.)

I warmly welcome the decision . . . to take the reactive power as positive for inductive reactive power . . . electric circuit theory for a-c networks is based on Ohm's Law in its appropriately extended sense; that means that we build the structure of electric circuit theory on the basis of the impedance relation between voltage and current. . . . The admittance relation between current and voltage is introduced in an advanced state of electrical thinking. . . . In making clear that the impedance relation between voltage and current is the fundamental relation in electric circuit theory, and the admittance concept merely a derivative from the impedance concept, we eliminate any arbitrariness in the decision on the sign of reactive power.

R. FEINBERG

(Electrotechnies department, University of Manchester, England)

Many excellent arguments have been advanced which tend to show that either the plus or minus sign is basically correct. It seems unfortunate, therefore, that the standard adopted should be opposite to commonly accepted usage of power engineers, who are the ones most concerned with the production, measurement, sale, and use of reactive power or kilovars . . .

However, in conformity with the present standard, the sign on the kilovars is negative. So the bill for electrical service should include a charge for kilowatts supplied to the load plus a charge for receiving kilovars from the load, a very unsatisfactory and artificial method of evaluating the service.

. . . Overexcitation of a generator causes it to deliver a lagging current. But overexciting a synchronous motor (the same type of machine) causes it to take a leading current. This apparent contradiction in behavior is caused by the old notion that a generator supplies current and that a motor consumes current.

Current flows in the windings of both motors and generators, and in either case just as much is supplied to the line on one side of the winding as is taken from it on the other.

A generator supplies power, not current. A motor draws power from the line. When either type of machine is overexcited, it produces kilovars; underexcitation causes consumption of kilovars, which must be produced somewhere else in the system. In this terminology there is an elegant simplicity of concept, which is lost in the emphasis on two kinds of kilovars, plus and minus. The idea of negative kilovars is as unnecessary and repugnant as negative watts or negative amperes.

J. S. GAULT (M '30)

(Professor in electrical engineering, University of Michigan, Ann Arbor)

Stanley and the Self-Regulating Transformer

To the Editor:

In an article by J. K. B. Hare, entitled "George Westinghouse — Individualist," which appeared in the October 1946 issue of *ELECTRICAL ENGINEERING*, the following statement is made: "The French engineer, Gaulard, and the Englishman, Gibbs, contributed the basic transformer; but Westinghouse (aided by William Stanley and Albert Schmid) redesigned the crude invention of Gaulard and Gibbs into a practical device." Statements which appear in the official organ of one of the major engineering societies generally are accepted by both professional engineers and laymen as factual. Without any intention on my part of detracting from the achievements of Westinghouse as an industrialist or as an engineer, I respectfully request the privilege of correcting this statement.

As will be developed in ensuing paragraphs, neither the self-regulating transformer nor the a-c system in which it is utilized was the result of redesign of the Gaulard and Gibbs apparatus or the methods of distribution they proposed, but was based upon fundamentally different principles which were developed independently by William Stanley. This is evidenced by the issuance of the self-regulating transformer patent to William Stanley and by the acknowledgment and tribute paid to him as its inventor by all Sections of AIEE in 1936, upon his transformer's 50th anniversary.

A detailed reivew of the course of events leading up to the development and demonstration in Great Barrington, Mass., in March 1886, of the self-regulating transformer and the a-c system, essentially as now employed, would be unduly long and unnecessary. It is sufficient to say that Stanley already had developed certain theories of his own in respect to the use of alternating current previous to the time he became associated with Mr. Westinghouse at Pittsburgh in 1884. . . . When the Westinghouse Company obtained the American rights to the Gaulard and Gibbs inventions, Stanley's studies and investigations of that system, long before the arrival of the apparatus in this country, led him to conclude that it had no practical value.

A brief reivew of the Gaulard and Gibbs apparatus and method of distribution follows. A number of (straight iron core) induction coils (inductoriums) were connected in series on the primary side to an alternator, designed to furnish constant current with varying potential (as compared with the constant voltage of the systems later universally utilized). The ratio of transformation generally was one to one . . . and there were no means of stepping the voltage up at the source of power. The maximum potential depended upon the limits in design of the alternator.

Stanley continued to advocate the further development of his own theories but failed to obtain the active support or interest of Westinghouse. Being a victim of frail health and yet determined to prove that his conclusions were correct, he moved his home to Great Barrington, Mass., where he could benefit from the climate and also devote his time exclusively to the development of his system. Under this arrangement Stanley continued to be associated with the Westinghouse Company and received certain equipment, with which to carry on his research and experiments. . . .

The method of distribution devised by William Stanley and put into operation at Great Barrington in 1886, employed an alternator operating at constant voltage as distinguished from constant current, and the transformers (or converters as they then were called) utilized a closed instead of an open magnetic circuit. The Siemens alternator, which Westinghouse had imported from England in conjunction with the Gaulard and Gibbs apparatus, was redesigned by Stanley to deliver constant voltage. . . .

Owing to inherent characteristics which made satisfactory regulation impossible, the system and methods proposed by Gaulard and Gibbs did not survive . . . (but) the system and apparatus developed by Stanley for transmission of alternating current at constant voltage were in all essential respects identical to that utilized today, and that they permitted a wide range of transformation and transmission. . . .

When Stanley set up and tested out his "plant" successfully in the spring of 1886, he promptly reported his accomplishments to Pittsburgh, but received no response from those whom he believed should be interested. This incident is described best by a letter dated November 25, 1922, from Colonel H. M. Byllesby, former vice-president and general manager of the Westinghouse Company, to T. C. Martin, former editor of *Electrical World*, from which I quote:

> In those days Stanley had taken up his residence at Great Barrington, Mass., where he was equipped with a laboratory and where he installed the first real alternating current plant in the United States.
>
> I had known Stanley for several years prior to joining Mr. Westinghouse's interests. There was a mutual liking between us and sometime in February or March, 1886 . . . Stanley came down to see me at New York on a Friday and impressed me with the fact that he actually did have a small alternating current station running at Great Barrington that he could receive no audience from any of his associates in the company and he implored me to go back to Great Barrington with him and look at it.
>
> This I did, and spent the following Saturday there. I found he had a complete system . . . actually performing and performing well and with relatively slight modifications could be put upon the market.
>
> I returned to Pittsburgh and reported to Mr. Westinghouse and my associates. I was enthusiastic.

All of them, even Mr. Westinghouse, were somewhat skeptical but we immediately had a thorough examination made which proved that the alternating current system had arrived successfully.

Throughout his life, William Stanley avoided personal publicity concerning his contribution to the development of the electrical and industrial arts. Knowledge that he had contributed to human progress was the major reward he sought. His work and accomplishments are to be the subject of a biography which is now in the course of preparation. Meanwhile, as is evident from the foregoing, the development of the basic principles of the self-regulating transformer—which have remained unchanged for 60 years—and its application to the transmission of alternating current was the achievement of William Stanley.

LEONARD L. STANLEY (A '37)

(Vice-president, Day and Zimmerman, Inc., New York, N. Y.)

Forces Between Moving Charges

To the Editor:

In connection with the paper "The Forces Between Moving Charges," by Professor Sard, *ELECTRICAL ENGINEERING*, January 1947, consider the following problem:

In Figure 1a, q is a charge moving with constant velocity v. The plane of a fixed turn of wire, C, passes through the path of q. Then as q passes, its magnetic field, linking C, changes, so an electromotive force is induced around C.

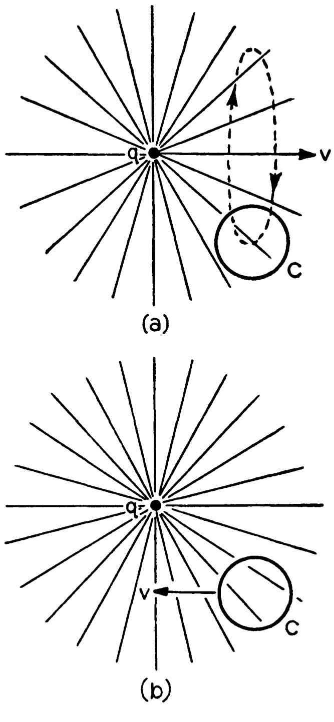

Figure 1

In Figure 1b, q is a stationary charge and the same turn C is moving with constant velocity v. Every charge in the wire experiences a force due to the electrostatic field of q, but as the line-integral of an electrostatic field around a closed path is always zero, and there is no magnetic field, there can be no electromotive force induced around the moving loop.

Since in both cases the relative velocity between q and C is the same, what is the explanation of this anomaly, in terms of the generally accepted theories of electromagnetism and relativity?

It is well known that Maxwell's theory is based on the fundamental postulate of a material medium or ether to which all velocities can be referred. Such velocities are *absolute*. Nowadays, however, it is generally accepted that only *relative* velocity has any physical meaning, but at the same time students are still taught to regard Maxwell's equations as expressions of fundamental physical truth. All goes well so long as our current circuits and magnets are stationary, however rapidly the currents may be alternating, but our credulity is stretched to fantastic limits when we apply the theory to account for the effects of moving magnets, as I have shown in the *Electrician* of October 18, 1940. So far, however, there has been little experimental evidence to show in what circumstances Maxwell's equations lead to incorrect results, so far as macroscopic phenomena are concerned.

The foregoing problem can be made the subject of an experiment. Referring to Figure 2, pairs of parallel conducting plates $a - a$ are maintained at a constant potential difference, so that the direction of the electrostatic field between the plates is opposite for adjacent pairs as shown. The dotted path b is in a plane normal to the lines of force so that if the whole system of charged plates moves with constant velocity from left to right the fixed path b will be linked by a changing electric field. Then by Maxwell's equation:

$$\nabla \times H = \dot{D} \tag{1}$$

a magnetic field should be induced around the dotted path. If the plates are properly shaped the electrostatic flux linking the path b can be made to alternate sinusoidally, so that the magnetic field around b should also alternate sinusoidally. Now place a toroidal coil to occupy the path b. The alternating magnetic flux given by equation 1 will link, if it exists, the turns and will induce an electromotive force in the coil, which may be calculated from the equation:

$$e = -\mathcal{N}\frac{d\phi}{dt} \tag{2}$$

Let $\mathcal{E}_m$ be the maximum value of the electrostatic field (at the center of the plates) and the area of the path b be A. Then the electrostatic flux linking b is given by

$$\Psi \approx \frac{2}{\pi} k_0 \mathcal{E}_m A \sin \omega t \tag{3}$$

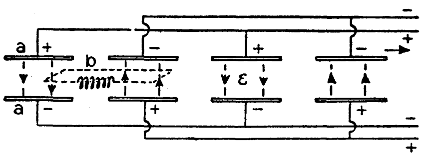

Figure 2

If L is the length of the closed path b, and B the average value of the magnetic flux density induced around the path by the changing electrostatic flux Ψ, equation 1 leads to

$$BL = \mu_0 \frac{d\Psi}{dt}$$

or

$$B = \frac{2A}{\pi L} \mu_0 k_0 \omega \mathcal{E}_m \cos \omega t \tag{4}$$

If a is the area of each of the $\mathcal{N}$ turns of the toroid filling the path b, the electromotive force induced in the coil by the magnetic flux $\phi = aB$ is

$$e = -\mathcal{N}\frac{d\phi}{dt} = \frac{2aA\mathcal{N}}{\pi Lc^2} \omega^2 \mathcal{E}_m \sin \omega t$$

which has an rms value

$$E = \frac{\sqrt{2}aA\mathcal{N}}{\pi Lc^2} (\omega^2 \mathcal{E}_m) \tag{5}$$

If p similar toroids are situated between p pairs of plates and connected in series, putting $\omega = 2\pi f$ the total generated electromotive force in this stationary "armature" is

$$E = \frac{4\sqrt{2}\pi a p A \mathcal{N} f^2}{Lc^2} \mathcal{E}_m \tag{6}$$

where c = velocity of light and $\mu_0 k_0 = 1/c^2$.

Putting in practical values, suppose that 20 pairs of plates are arranged around two parallel insulating disks rotating at 3,000 rpm. Then $f = 500$ cycles per second. If

$a = 2 \times 10^{-4}$ square meter,
$p = 20$
$A = 10^{-2}$ square meter,
$\mathcal{N} = 500$ turns per coil,
$f = 500$
$L = 0.4$ meter,
$c^2 = 9 \times 10^{16}$

and

$\mathcal{E}_m = 10^6$ volts per meter

then

$$E = 2.5 \text{ microvolts, approximately} \tag{7}$$

which is a measurable quantity at 500 cycles.

Since the passage of the coils between the charged plates will cause a fluctuation of their capacitance, there will be a fluctuation of charge on the plates and the coils which will comprise a small alternating current. This will result in a small electromotive force in the coils, whose value will be a function of the periodic change of capacitance but which is small compared with E.

The known facts of electromagnetic induction, as discovered by Faraday, give two experimental methods of inducing an electromotive force in a conductor: (*a*) when the conductor moves relatively to a constant-current system or magnet (motional electromotive force), and (*b*) when the conductor is stationary relative to a current system in which the current is changing (transformer electromotive force). For closed rigid circuits, equation 2 gives the value of the induced electromotive force for either method or for any combination of the two. It is not clear, however that either of these two necessary conditions exists in the proposed experiment. There cannot be said to be relative motion between the coils and a constant-current circuit, and, apart from the small "reaction" electromotive force, no charges are accelerating in the same way as when an alternating current flows.

And yet, by Maxwell's equations, an electromotive force should be induced. This is because, by Maxwell's hypothesis, the motion of an electrostatic system past a fixed point is supposed to cause a displacement current which is attended by a magnetic field. The proposed experiment, which is a modification of Rowland's famous experiment with a different method of detecting the magnetic field of moving charges, therefore appears to be of some fundamental interest.

E. G. CULLWICK (M '33)

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Electrical Essay

To the Editor:

A solution to the transformer problem described by Mr. Richter in the January 1947 issue, page 44, appears to be the following.

The transformer is assumed connected to two sources of alternating electromotive force, one at the left and the other at the right. When one acts as a generator, the other acts as a motor load and vice versa. When there is no load on one side, the machine on that side is adjusted to draw no current and exciting current is supplied by the other machine. Frequency is held absolutely constant and no slip is permitted.

The man in the compartment will be provided with a high resistance voltmeter of proper range, a loop of wire around the transformer core, and a local source of alternating electromotive force of the same frequency as the alternators. This local source of electromotive force should have variable voltage and a phase shifting device. Frequency can be held absolutely constant.

The principle to be used is that at no load the flux in the core of a transformer is slightly greater than at full load. Also that the flux shifts 180 degrees when exciting current is shifted from one side to the other (with due regard for polarity). The electromotive force in the loop is a measure of the flux in the core.

The procedure is to connect the voltmeter to the loop. As load changes from one side to the other, and zero load changes from one side to the other, the reading of the voltmeter will vary between two values, a high and a low. The high value indicates no load on some side which we will assume to be the right side. Under this condition, the local source of electromotive force is introduced in series with the loop and meter. Its phase and voltage is adjusted until voltmeter reads zero. We call this reading V_{0r} or no load on right. If load now appears on the right, there will be a small reading on the voltmeter called V_{lr}. If load is removed and the right side becomes primary, supplying exciting current, then the voltmeter reads a maximum called V_{0l}. If load now is put on the left, the voltmeter will read lightly less than the maximum, called V_{ll}.

We thus have four voltmeter readings, which follow in order of their relative magnitudes. (Their absolute values in volts have no significance.)

V_{0r}—No load on right, supply on left, voltmeter reads zero.

V_{lr}—Load on right, supply on left, voltmeter reads small.

V_{ll}—Load on left, supply on right, voltmeter reads large.

V_{0l}—No load on left, supply on right, voltmeter reads maximum.

After establishing the zero reading standard and making an assumption that it indicates no load on, for example, the right, our engineer in the compartment can make the following statements according to his meter readings:

There is no load on the right.
There is full load on the right.
There is no load on the left.
There is full load on the left.

Of course, right and left have no meaning to the man in the compartment. He can reverse them merely by standing on his head!

CHARLES B. SAXON (M '42)

(Consulting engineer, New York, N. Y.)

For More Practical Electrical Definitions

To the Editor:

One important advantage of the new publication policy is that more letters to the editor can be included in *ELECTRICAL ENGINEERING*. The presentation each month of a representative cross section of membership opinion would be ideal. With expanding membership adequate representation becomes more and more of a problem.

Perhaps this and other problems faced by the AIEE would be clarified somewhat if a truly representative member could be imagined. As a first approximation such a member, I think, would be alert, ambitious, resourceful, progressive, and last but not least, *predominantly practical* yet well fortified by theory. It should be possible to check the italicized attribute against such composite AIEE products as the various Standards and the "Definitions of Electrical Terms" (ASA *C42-1941*).

In general, the Standards *must* be practical because specifications based upon them often are incorporated in contracts. The following quotation from page 3 of *C42* indicates a similar objective for the definitions:

"The primary aim . . . has been to express for each term the meaning which is generally associated with it in electrical engineering. . . . When possible, the definitions have been generalized . . . , the greatest weight naturally being given to the strictly engineering applications . . . the preferred definition is a simple one . . ."

The bulk of the definitions in *C42* appear to be in accord with the quoted aim, but many in the prominent first part (Group 05) do not. For example, opposite terminal in the index is 05.21.006 which reads in part as follows:

"Point of Entry (Terminal). A point of entry for a conductor entering a delimited region is that equipotential cross section of the conductor which coincides with the bounding surface of the region." There are two more sentences and a long note in which terminal is mentioned. Compare this with the following from a dictionary:

"A device attached to the end of a wire or cable or to an apparatus for convenience in making electrical connections."

The electrical industry has been in existence long enough for the general public to become familiar with some of the terminology and this is reflected by the dictionaries. The need for specialized definitions can be met best as in the past by AIEE publications like *C42*, but the quoted aim should not be overlooked. Definitions of a theoretical nature like 05.21.006 preferably should be relegated to an appendix until the industry catches up with them.

In conclusion, it seems desirable on general principles for the definitions in the main part of *C42* to be predominantly practical and thus representative of the membership. To continue the present arrangement might affect adversely the effort to raise the status of the profession. It would be unfortunate if that portion of the public which has to refer to *C42* got the impression that the primary aim is to mystify rather than to enlighten!

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For Adoption of Metric System

To the Editor:

I was pleased to see, in the articles in your May and June 1946 issues by Nikiforoff and coauthors, on Mexico's electrification program, that quantities generally are expressed in metric units—the practice doubtless followed by the authors in their original paper. Though this policy is not followed, invariably there is free use of such units as cubic meters per second and square kilometers, with metric measures in some cases followed by English equivalents in parenthesis. Fortunately, electric units are now on the metric basis.

It appears desirable for American engineers and writers to recognize that practically the entire world, except the United States and Great Britain, utilizes the metric system. *ELECTRICAL ENGINEERING* doubtless has many readers throughout the non-English-speaking world, and it would seem wise to cater to them in some degree, rather than use English units exclusively in your articles.

Our company has used metric units for several decades in drawing engineering plans for plants in countries that have adopted the metric system. Engineers and draftsmen soon become proficient in using the metric. We therefore are interested in metric progress in this country; delay and expense result from the necessity of conversion as between systems. Personally, I hope that, over a reasonable period, the metric system may be adopted in the United States.

LOUIS ELLIOTT

(Consulting mechanical engineer, Ebasco Services, Inc., New York, N. Y.)

NEW BOOKS • • •

"Work Measurement Manual." Those interested in improving the ability of time study men to set accurate and consistent time standards will find this volume a valuable guide. The importance of time study and the procedures commonly used in making time studies are explained, as well as the work measurement investigations now being conducted by the author. A section is devoted to the use of standard motion-time data for various specific operations. Full report is given of the author's recent industrial engineering survey of 80 industrial plants. By Ralph M. Barnes. William C. Brown Company, Dubuque, Iowa, 1947, 218 pages, 8½ by 11 inches, paper, $3.75.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

SCIENCE REMAKES OUR WORLD. By J. Stokley. Ives Washburn, New York, N. Y. Revised edition, November 1946. 318 pages, illustrated, 8¾ by 5¾ inches, cloth, $3.50. In simple, nontechnical terms the author describes the scientific developments of recent years and shows how they affect our everyday life as well as the technical fields involved. The wide range of topics includes plastics, chemurgy, color photography, television, sulfa drugs and penicillin, jet propulsion, radar, and rockets. An insight into the future is provided in the material on helicopters, light that flows around corners, three dimensional movies, atomic power, and so forth.

2,100 NEEDED INVENTIONS. By R. F. Yates. Wilfred Funk, Inc., New York, N. Y., 1946. 252 pages, 7½ by 5 inches, cloth, $2.50. The first few chapters briefly describe the general subject of invention and its rewards and discuss the patenting and handling of inventions. In succeeding chapters the specific suggestions are classified in some 35 subject groups covering virtually the whole field of commercial endeavor.

VARNISHED CLOTHS FOR ELECTRICAL INSULATION. By H. W. Chatfield and J. H. Wredden. J. and A. Churchill Ltd., London, England, 1946. 255 pages, illustrated, 8¼ by 5¼ inches, cloth, 21*s*. The authors have brought together in this book a considerable amount of ordinarily scattered information. Four basic topics are dealt with: the textiles which form the supporting fabric; the impregnating varnishes; the manufacture of the treated fabrics; the properties and uses of the varnished cloths as insulating mediums. Additional information is given on methods of storage, analysis, and testing of the raw materials and the finished product.

WOMEN CAN BE ENGINEERS. By A. C. Goff. Apply to author at 153 Lauderdale Avenue, Youngstown, Ohio, 1946. 227 pages, 8¾ by 5½ inches, cloth, $2.50. In part I the author presents biographical sketches of 13 women who have achieved success in the engineering field. The emphasis is on their work and is designed to show what can be done as well as what difficulties may arise. Part II presents similar information about six other women who have done effective work in allied technical and scientific fields.

MITTEILUNGEN AUS DEM INSTITUT FÜR HYDRAULIK UND HYDRAULISCHE MASCHINEN. Eidgenössischen Technischen Hochschule in Zürich. Verlag Ag. Gebr. Leemann and Co., Zurich, Switzerland, 1946. Illustrated, 9½ by 6½ inches, paper. 1. Untersuchungen über den Einfluss der Schaufelzahl auf die Wirkungsweise eines Freistrahlrades. By H. Fikret Taygun. 82 pages, 7.20 Swiss francs. 2. Der Einfluss der Schaufelzahl des Laufrades auf den Wirkungsgrad bei Kreiselradmaschinen (Überdrucklaufräder). By M. I. Hassan. 69 pages, 7.50 Swiss francs. Two communications from the Swiss Institute for Hydraulics and Hydraulic Machinery describe the test methods and equipment, the necessary calculations, and the effective results of investigations on the following: (1) The influence of the number of blades on the mode of action of an impulse wheel (17, 20, and 23 blades respectively are considered). (2) The influence of the number of blades of the runner wheel on the efficiency of turbines (figures for 11, 15, and 19 blades are given at the end).

FUELS AND FUEL BURNERS. By K. Steiner. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 394 pages, illustrated, 8½ by 5¼ inches, cloth, $5. The nature, occurrence, and properties of fuels are treated from the viewpoint of domestic and commercial heating. Considerable space is devoted to the design, construction, installation, and operation of stokers, oil burners, and gas burners used in heating plants of residences, commercial buildings, and moderately sized steam plants. A special chapter on wood fuel is included, prepared by the United States Forest Service, and there is a rather complete discussion of automatic control methods and apparatus for heating systems, including both conventional electric and recent electronic types.

TABLES OF FRACTIONAL POWERS. Prepared by the Mathematical Tables Project under the sponsorship of the National Bureau of Standards and the Work Projects Administration for the City of New York and completed with the support of the Office of Scientific Research and Development, L. J. Briggs, director, and A. N. Lowman. Columbia University Press, New York, N. Y., 1946. 486 pages, tables, 10¾ by 7¾ inches, cloth, $7.50. The present volume of this steadily expanding series is a compilation of tables of decimal and fractional powers. In part I the values of A^x, for fixed bases and variable exponents, are given to 15 decimal places for 2-digit decimals of A and x. In part II the function X^a, for variable bases and the frequently occurring exponents $\pm 1/2$, $\pm 1/3$, $\pm 2/3$, $\pm 1/4$, $\pm 3/4$, also are tabulated to 15 places. As usual, there is a bibliography of similar tables. In the foreword to the volume various problems are suggested, the solution of which is facilitated by the use of the present tables.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS ZERO AND ONE (Annals of the Computation Laboratory of Harvard University, Volume 3). TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS TWO AND THREE (Annals of the Computation Laboratory of Harvard University, volume 4). Harvard University Press, Cambridge, Mass.; Geoffrey Cumberlege, Oxford University Press, London, England, 1947. No pagination, tables, 11 by 8 inches, cloth, $10.00 each volume. Continuing a series of publications by the Harvard Computation Laboratory, these two volumes present detailed tables to 18 decimal places for a range of argument from 0 to 100, with an argument interval of 0.001 up to 25 and of 0.01 above 25. The volume covering the orders zero and one contains also an introductory discussion of Bessel functions, a description of the computational techniques, and the method of interpolating within the tables. The computation was done by the automatic sequence controlled calculator, the operation of which was described in volume I of the series.

TABLES OF SPHERICAL BESSEL FUNCTIONS, Volume 1. Prepared by the Mathematical Tables Project, National Bureau of Standards. Columbia University Press, New York, N. Y., 1947. 375 pages, tables, 10¾ by 8 inches, cloth, $7.50. In the theoretical analysis of wave motion, solutions of various coordinate systems are necessary, and in certain ones Bessel functions are involved having orders equal to one-half an odd integer. The present volume provides tables to seven or more significant figures for the spherical Bessel functions of orders $\pm(n+1/2)$ where $n=0$ to 13 with an interval of 1, and for a range of X from 0 to 10 with intervals of 0.01 and from 10 to 25 with 0.1 intervals. The customary detailed explanatory introduction is included, and a list of the previous publications of the series is appended.

ELEMENTARY VECTORS FOR ELECTRICAL ENGINEERS. Second edition. By G. W. Stubbings. Sir Isaac Pitman and Sons, Ltd., London, England, 1945. 110 pages, diagrams, tables, 7½ by 5 inches, cloth, 6*s*/6*d*. This practical little volume emphasizes fundamentals and devotes the first two chapters to explaining the representation of a-c quantities by graphical vectors. Chapter III contains a detailed elementary treatment of the graphical solution of 3-phase problems, and the following two chapters deal with the concept and applications of vector algebra. A short, final chapter discusses the geometrical meaning of hyperbolic functions.

PAMPHLETS • • • •

Federal Communications Commission 12th Annual Report Covering the Fiscal Year of 1946. Superintendent of Documents, Government Printing Office, Washington, D. C., 20 cents.

The Use of Research by Professional Associations in Determining Program and Policy. By E. L. Brown. Russell Sage Foundation, New York, N. Y., 1946, 39 pages, 25 cents.

Symposium on Testing of Bearings. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1947, 72 pages, $1.50.

Home Food Freezers, Refrigerating Engineering Application Data—Section 37. By R. H. Bishop. *Refrigerating Engineering*, 40 West 40th Street, New York 18, N. Y., 12 pages, 30 cents.