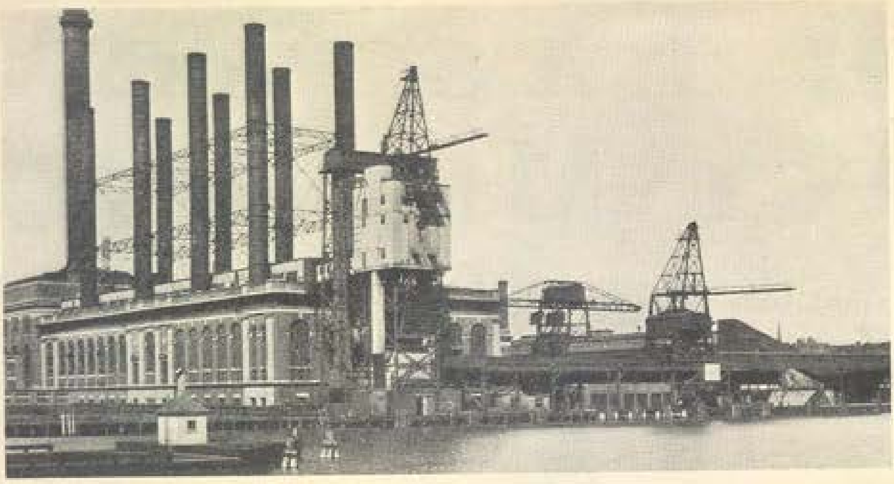
NORTH EASTERN DISTRICT MEETING

American Institute of Electrical Engineers

Providence Biltmore Hotel, Providence, Rhode Island, May 4-7, 1932

Rhode Island State Capitol

General Convention Program
Abstracts of All Technical Papers



South Street generating station of the Narragansett Electric Company, Providence, one of the largest steam plants in New England. The installed generating capacity is 225,000 hp.

General Information

THE EIGHTH annual meeting of the North Eastern District of the A.I.E.E. will be held at Providence, Rhode Island, May 4–7, 1932, with headquarters at the Providence Biltmore Hotel. The committee has arranged an attractive program consisting of four technical sessions, inspection trips, a banquet, entertainment features, and a special program for the ladies. Another important feature of the meeting will be the student program scheduled for Friday, May 6. The technical sessions cover a variety of subjects. There will be a symposium on traffic control, a session arranged by the committee on electrical machinery, one by the committee on power transmission and distribution, and a session on selected subjects.

Providence, the capital of Rhode Island and the southern gateway to New England, enjoys exceptional shipping facilities to all parts of the world. Situated at the head of Narragansett Bay, 30 miles from the ocean, it occupies a strategic position as a port for both foreign and domestic commerce as well as a point of inland distribution; it is the second largest oil distributing port on the Atlantic seaboard. The city, itself, has a population of approximately 350,000, and within 15 miles of the city hall there are more than 700,000 inhabitants. The community enjoys 59 parks and playgrounds, the Roger Williams Park with its chain of lakes being considered one of the most beautiful parks in the country.

Providence is the home of Brown University established in 1664 and seventh in age among American colleges with an enrollment of approximately 2,200 students and a faculty of 200. Pembroke College for women is a part of the university. Providence College, the Rhode Island College of Education, the R. I. School of Design, and the R. I. College of Pharmacy all are located here. R. I. State College is at Kingston.

Industrially, Providence ranks high; it is the center of a state which has 35.1 per cent of its workers engaged in machine trades. The Brown and Sharpe Mfg. Co., makers of tools, the Nicholson File Co., American Screw Co., and Gorham Mfg. Co., makers of sterling silverware, all located in this city, are the largest in the world in their respective fields. The rubber industry also has good representation by seven large plants producing rubber footwear, medical goods, and novelties. Some of the largest plants of the U. S. Rubber Company are located here.

The Narragansett Electric Company, largest unit in the New England Power Association, serves most of the entire central and southern sections of the state, the southern part being served through a subsidiary company, the South County Public Service Company. The Blackstone Valley Gas and Electric Company serves the northern section and the Newport Electric Corporation the islands of Rhode Island and Conanicut. A network of transmission lines, steam and hydroelectric stations give to Rhode Island the benefit of an abundant supply of electric current. The Providence Gas Company established in 1848 serves about 82,000 customers in Providence and suburbs.

Entertainment Features

Wednesday night will witness the "Gathering of the Clans." Provision will be made for informal get-togethers and reunions, card tables will be available, and supper dancing may be enjoyed in the Venetian Room of the Providence Biltmore Hotel.

Sock and Buskin, the dramatic organization of Brown University, is endeavoring to arrange a performance on Friday evening for the Institute members and ladies.

To the golf playing members there will be available the facilities of the Wannamoisett Country Club, a ranking course over which the Professional Golfer's Association in 1931 played off their championship. Tennis facilities will also be provided.

Banquet

The banquet will be held Thursday evening in the main ballroom of the Biltmore. Prof. William H. Kenerson of the mechanical engineering department of Brown University will act as toastmaster and William S. Lee, junior past-president of the Institute, will be the speaker of the evening. Both President C. E. Skinner and Vice-President I. E. Moultrop will address the meeting, and the District prizes awarded for papers given in 1931 will be presented. At the conclusion of these ceremonies there will be dancing until 1:00 a.m.

Ladies' Entertainment

The committee for the entertainment of the ladies has prepared what should be an interesting program. It is planned to spend one afternoon in colonial Rhode Island, a large share of which still maintains its original appearance. This will be rounded out with a tea in the historic mansion now housing the Handicraft Club. A luncheon and bridge at one of the city or nearby country clubs also is contemplated. Trips to Roger Williams Park and other points of local interest will be arranged. Golf courses and tennis courts will be made available to all ladies interested in those departments of sport.

Inspection Trips

Inspection trips are scheduled on the program for Thursday afternoon and Saturday morning. In addition, a special trip for the students is being arranged for Friday afternoon.

Full details of all trips will be announced later and posted on the bulletin board. Among the places of interest which may be visited are a generating station and substations of the Narragansett Electric Company and the Gorham Manufacturing Company. The engineering laboratories of Brown University will also be open for inspection. Several other trips also are being arranged.

Registration

All who plan to attend the meeting should register in advance by mail. A card for this purpose will be sent to all members of Districts 1 and 3 before the meeting. Members should complete their registration after arrival at the meeting so as not to miss the opening session. There will be a meeting fee of one dollar for members and fifty cents for students.

All who register in advance will be sent a road map of Rhode Island and a map of the downtown section of Providence showing headquarters and convenient parking and garage facilities.

Hotel reservations should be made by writing directly to the hotel preferred. Rates for the headquarters hotel, Providence Biltmore, as well as several other recommended hotels are given in the accompanying table.

Technical Program

Abstracts of all papers to be presented at the meeting are given on adjoining pages. Pamphlet copies of these papers are not available.

All technical sessions and the opening of the meeting will be held at the Providence Biltmore Hotel. Breakfast meetings will be announced on the bulletin board near registration headquarters and will be held daily for authors and chairmen of the technical sessions scheduled for the day.

Wednesday, May 4

9:00 a.m.—Registration

9:30 a.m.—Opening Session

Opening address—I. E. Moultrop, vice-president, North Eastern District, A.I.E.E.

Welcoming remarks—James E. Dunne, mayor of Providence

Greetings—Leighton T. Bohl, president of Providence Engineering Societies

Selected Subjects—Prof. V. Bush, *chairman*

PARALLEL TYPE INVERTER, F. N. Tompkins, Brown University

ENGINEERING FEATURES OF PHANOTRON TUBES, H. C. Steiner, A. C. Gable, and H. T. Maser, General Electric Co.

SUBHARMONIC FREQUENCIES PRODUCED IN NON-LINEAR SYSTEMS, W. M. Goodhue, Harvard University

A GENERAL THEORY OF SYSTEMS OF ELECTRIC AND MAGNETIC UNITS, V. Karapetoff, Cornell University

A PROPOSAL TO ABOLISH THE ABSOLUTE ELECTRICAL UNIT SYSTEMS, E. Weber, Brooklyn Polytechnic Institute

2:00 p.m.—Electrical Machinery—P. L. Alger, *chairman*

PERFORMANCE CHARACTERISTICS OF INDUCTION MOTORS, C. G. Veinott, Westinghouse Electric & Mfg. Co.

STRAY LOAD LOSS IN POLYPHASE INDUCTION MOTORS, C. J. Koch, General Electric Co.

TORQUE-ANGLE CHARACTERISTICS OF SYNCHRONOUS MACHINES FOLLOWING SYSTEM DISTURBANCES, S. B. Crary and M. L. Waring, General Electric Co.

FIELD TESTS TO DETERMINE THE DAMPING CHARACTERISTICS OF SYNCHRONOUS GENERATORS, F. A. Hamilton, General Electric Co.

DESIGN OF CAPACITOR MOTORS FOR BALANCED OPERATION, P. H. Trickey, Westinghouse Electric & Mfg. Co.

8:00 p.m.—Informal Reception

Thursday, May 5

9:00 a.m.—Symposium on Traffic Control—H. M. Turner, *chairman*

Address: THE BROADER ASPECTS OF TRAFFIC CONTROL, E. P. Goodrich, president, Traffic Institute

THE FLEXIBLE PROGRESSIVE TRAFFIC SIGNAL SYSTEM, H. I. Turner, Eagle Signal Corp.

ELECTROMATIC TRAFFIC DISPATCHING SYSTEM, H. A. Haugh, Jr., Automatic Signal Corp.

RECENT DEVELOPMENTS IN TRAFFIC CONTROL, H. W. Vickery and V. W. Leonard, General Electric Co.

TRAFFIC FLOW REGULATOR, C. H. Bissell and J. G. Hummel, Crouse-Hinds Co.

12:00 m.—District Executive Committee Luncheon

2:00 p.m.—Inspection Trips

6:00 p.m.—Banquet

Friday, May 6

9:00 a.m.—Student Technical Session

Address—William S. Lee, junior past-president A.I.E.E.

Awarding of Prizes

12:00 m.—Luncheon Conference of Counselors and Delegates

2:00 p.m.—Student Inspection Trip

2:00 p.m.—Transmission—P. H. Chase, *chairman*

DOUBLE CONDUCTORS FOR TRANSMISSION LINES, H. B. Dwight and E. B. Farmer, Massachusetts Institute of Technology

THREE PHASE MULTIPLE CONDUCTOR CIRCUITS, Edith Clarke, General Electric Co.

THE SOLUTION OF CIRCUITS SUBJECTED TO TRAVELING WAVES, H. L. Rorden, General Electric Co.

CORONA LIMIT, TRANSMISSION CHARACTERISTICS AND METHOD OF LOADING MULTIPLE CONDUCTOR LINES DESIGNED TO OPERATE AT VERY HIGH VOLTAGE, C. A. Boddie, Boddie Electro Physical Labs.

7:30 p.m.—Entertainment Feature
(To be announced at the meeting)

Saturday, May 7

Meeting rooms have been arranged for continued sessions of any part of the technical program.

The local committee is planning an all-day trip, details of which will be announced later.

RULES ON PRESENTING AND DISCUSSING PAPERS

At the technical sessions papers will be presented in abstract, ten minutes being allowed for each paper unless otherwise arranged or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually five minutes is allowed to each discusser. When a member signifies desire to discuss papers on other subjects or groups he shall be permitted a five-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer.

Each discusser is to step to the front of the room and announce, so that all may hear his name and professional affiliations.

COMMITTEES

District Meeting—I. E. Moultrop, *chairman*, vice-president, North Eastern Dist.; A. C. Stevens, secretary-treasurer, North Eastern Dist.; C. W. Henderson, chairman, Student Counselors, North Eastern Dist.; O. W. Briden, R. W. Graham, W. S. Maddocks, J. P. McCann, R. G. Warner, and F. C. Young.

Local—W. S. Maddocks, *chairman;* O. W. Briden, *secretary-treasurer;* R. W. Herrick, Mrs. R. W. Herrick, J. W. Keeney, L. P. Kenneally, and J. C. B. Washburn.

Hotels and Registration—O. W. Briden, *chairman;* R. W. Allen, L. P. Breault, A. S. Kirk, E. E. Nelson, R. C. Patton, O. E. Sawyer, F. N. Tompkins, and R. J. Underwood.

Finance—J. W. Keeney, *chairman;* W. W. Broadbent, and O. W. Briden.

Inspection Trips and Transportation—J. C. B. Washburn, *chairman;* P. W. Browers, P. L. Carroll, E. B. Curdts, R. W. Eaton, L. E. Fogg, J. E. Hall, C. H. Parker, and G. U. Parks.

Sports, Entertainment, and Banquet—R. W. Herrick, *chairman;* E. S. Esty, M. V. Gardner, I. W. Knight, J. J. O'Brien, W. C. Slade, T. G. Webber, and J. W. Young.

Student Program—C. W. Henderson, *chairman;* W. B. Hall, and L. W. Hitchcock.

Publicity—L. P. Kenneally, *chairman*.

Ladies Entertainment—Mrs. R. W. Herrick, *chairman;* Mrs. R. W. Eaton, Mrs. W. S. Maddocks, Mrs. W. C. Slade, and Mrs. J. W. Young.

Hotel	Single	Double
Providence Biltmore	$3.50–$7.00	$5.50–$10.00
(With bath and shower)	$5.00–$8.00	$7.00–$12.00
Narragansett	$2.50*	$4.00*
	$3.00–$3.50	$4.50–$5.00
Crown	$2.00*	$4.00*
	$3.00	$6.00
Wayland Manor (Family Hotel)	$3.50	$5.00
Apartments, 3 or 4 persons, $2.50 per person		

* Rooms without bath

The Mall—heart of the business section of Providence—looking toward the city hall from the steps of the Federal Building. The Providence Biltmore Hotel is on the right, the Union station being slightly further to the right

Abstracts

Of Papers to Be Presented at the Providence District Meeting

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Providence District meeting (May 4–7, 1932) are published herewith. Papers presented at this meeting will not be available in pamphlet form, but in response to popular demand and within its space limitations, ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

The Parallel Type "Inverter"

By
F. N. Tompkins[1]

THE DEVELOPMENT of the thyratron or three-element hot-cathode gas-filled tube with grid-controlled arc has given electrical engineeing a new tool. Many interesting and valuable applications have been devised, among the most interesting of these being the "inverter." Its purpose is the inversion or changing of direct current to alternating current, the reverse process of the more usual rectification. With the advent of the thyratron with its high efficiency, low voltage drop, and its ability to handle the comparatively large amounts of power, the inverter gives promise of becoming of commercial importance.

Inverter circuits may be divided into two main types, series and parallel. While for the former types many data have been published and many different circuits have been devised, very little beyond the fundamental circuit has been given for the latter. The purpose of this paper is to present the results of a study of the parallel-type inverter which was undertaken to secure a better understanding of the function of each part and of the operation as a whole. There is presented the information necessary to make the operation of thyratron circuits understood. The principles of operation of the inverter are developed by means of simple diagrams, and from complete sets of oscillograms the actual operation is shown.

It is demonstrated that the method of operation differs from that usually assumed, inasmuch as the capacitor performs the function of giving the correct phase relation between the input current and the induced transformer primary voltage, rather than providing a sudden reversal of potential on the anode of the tube being stopped. This reversal is provided by the induced primary voltage. The effects of low power factor loads with both leading and lagging current are shown by oscillograms and the effects of improper circuit constants when operating at low power factor are given.

The output wave form under conditions of full load unity power factor is analyzed and it is shown that with the proper circuit constants the voltage wave is a fair approximation of a sine wave. For any given set of circuit constants the output wave forms change with the character and degree of loading. When reasonably good output wave forms are secured, the voltage regulation is poor but the efficiency is high. Changes in the circuit which give better regulation cause poorer wave form so that in the design of this type of inverter circuit a balance must be chosen between these two factors. Curves of efficiency and regulation, the latter showing the effects of different values of capacity, are given and briefly discussed. (Pamphlet copies not available.)

1. Brown University, Providence, R. I.

Engineering Features of Phanotron Tubes

By
H. C. Steiner[2]
A. C. Gable[2]
H. T. Maser[2]

DURING the last few years vacuum tubes have found an ever-enlarging field in industrial applications, the more recent gas filled electron tubes providing the engineer with a tool even better suited to his needs. Among the outstanding engineering features of the gas or vapor filled electron tube (to which the name phanotron has been applied) are as follows:

1. The tubes are static devices, the complete functions of which are performed through the movement of electrons and ions.

2. The efficiency in controlling or converting power is high. Tube efficiency ranges from 95 per cent to over 99 per cent.

3. Control is flexible and the power required for control is small.

4. The speed of operations as a relay is extremely fast, and in addition, the tube may function cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.

5. Noise and vibration are entirely absent.

6. Current carrying capacity is available in the range from a few milliamperes to several hundred amperes.

In practise the name phanotron has become associated with the two-element or simple rectifying tube. The phanotron tubes in which the starting of the conduction period is controlled electrostatically by the action of one or more grids have been termed thyratron tubes. The design, characteristics, and operation of these types of tubes are described in this paper, ratings being given.

Fundamentally, applications may be divided into two classes; namely, rectifiers converting alternating current into direct current with or without voltage control, and inverters changing direct current into alternating current. Oscillograms are given in the paper for a bi-phase rectifier with voltage control, supplying loads that are predominantly resistive, inductive, and capacitive. The operation of a single phase inverter is described and oscillograms are given for the voltage and current conditions of one of the tubes, the output voltage, and the commutating condenser current. (Pamphlet copies not available.)

Subharmonic Frequencies Produced in Non-Linear Systems

By
W. M. Goodhue[3]

IN BRIDGE measurements, harmonics, due to a non-linear load being measured or due to the power supply may fail to be balanced at the same time the fundamental is balanced. This impresses on the detecting system a wave containing a large proportion of harmonics, or, at true fundamental balance, harmonics without fundamental component. The detecting system contains magnetic materials and may include a vacuum tube amplifier. Different observers have found errors which they traced to the apparent conversion of part of the harmonics into a fundamental component.

It is shown in the paper that a single non-linear device, such as a vacuum tube operating on a curved characteristic, usually converts parts of an input, consisting of third and fifth harmonics only, into a fundamental component. This is distinct from detector action which occurs at the same time and yields a second harmonic, and

2. Genl. Elec. Co., Schenectady, N. Y.
3. Harvard University, Cambridge, Mass.

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also from modulation which requires two stages of amplification, one acting as modulator and the other as detector.

For moderate amplitudes, a Taylor's theorem expansion of the characteristic of the non-linear device is employed and resulting formulas for fundamental and harmonics tabulated for an input of two harmonics of arbitrary frequency, magnitude, and phase angle. The Taylor coefficients of the power series expansion which are involved in the resulting formulas are determined graphically, as the graphic method is more informative, less troublesome, and more accurate than attempting to obtain directly the cubic equation by a three point method, etc. The effect studied is essentially a third order effect.

For large amplitudes the method is entirely graphic, and even ordinary methods of wave analysis are not suitable due to the small fundamental and large harmonics. Graphic integration is employed and comparisons made of r.m.s. value, average value, and magnitude of fundamental. Also an example is worked out with an iron alloy (linking a coil) instead of the vacuum tube amplifier. Usually the effect with magnetic materials is further complicated by eddy currents and cyclic loop effects. (Pamphlet copies not available.)

A General Theory of Systems of Electric and Magnetic Units

By V. Karapetoff[4]

GENERALLY it is conceded that the present situation in regard to the electric and magnetic units is far from satisfactory, for the following reasons:

1. Two or three systems of units are in general use (C.G.S. and practical) at least two more are employed by some prominent writers (the Gauss system and the Heaviside-Lorentz system) and new ones are occasionally being proposed.

2. The absolute magnitudes of some units fixed by international agreement or in general use otherwise are considered as being too small or too large by some investigators who urge the adoption of smaller or larger units.

3. There is an appreciable disparity between the "absolute" C.G.S. units and the corresponding "international" units.

4. The physical dimensions of the electric and magnetic quantities are believed by some scientists to be different in different systems of units. Some physicists even believe it legitimate to assign an arbitrary physical dimension to a quantity; as, to assume absolute permeability for any medium to be a numeric.

In this paper it is pointed out that a system of electric and magnetic units may be shown to be characterized by five parameters; namely, a numeric n which gives the ratio between the nominal density of electric displacement used in that system and the true density; a numeric p which gives the corresponding ratio for magnetic flux densities; a physical conversion factor k which converts a given volume of current into the corresponding magnetomotive force; the absolute permittivity κ; and the absolute permeability μ. On the basis of these five parameters, the principal fundamental equations of electricity, magnetism, and electromagnetic waves are written in what is called the general system of units without assigning definite values to these parameters. It is shown also that the five parameters must satisfy the equation $vk = \sqrt{np/\kappa\mu}$ where v is the velocity of propagation of electromagnetic waves in that particular medium to which κ and μ refer; otherwise the five parameters may be chosen artibrarily.

By giving these parameters specific values, seven different systems of units are derived; namely, the electrostatic, the electromagnetic, the practical, the Gauss, the Heaviside-Lorentz, one which the author calls the compromise system, and the ampere-ohm system introduced by him some 20 years ago. The characteristics, the advantages, and the disadvantages of each system are briefly discussed, and it is shown how to deduce a new system of units from the general system.

At the end of the article a discussion is given on the physical dimensions of various electric and magnetic units. It is stated that four fundamental units are necessary for a system so that if certain length, mass, and time intervals are taken as three fundamental units, a fourth electric or magnetic unit must be added, for example, the permittivity or the permeability. In the ampere-ohm system, two mechanical fundamental units are used, the centimeter and the second; also two electrical units, the ampere and the ohm. Physical dimensions of k are unknown. (Pamphlet copies not available.)

4. Cornell University, Ithaca, N. Y.

A Proposal to Abolish the Absolute Electrical Unit System

By E. Weber[5]

THE FUNDAMENTAL discovery that the ratio of the "absolute" electrostatic unit to the "absolute" electromagnetic unit of electric charge, predicted as velocity, was apparently identical with the velocity of light brought about an unforeseen confusion in the field of electrical units. The use of various absolute dimension systems expressing the electric and magnetic quantities by means of the three mechanical fundamental dimensions influenced the writing style of formulas and caused the introduction of arbitrary factors.

A veritable flood of articles and papers has been published in the important periodicals of the world, concerned either with a new system of electric and magnetic units or dimensions, or with a comprehensive basic system of mechanical units. None of them has succeeded as yet, because of the attitude of respect toward the classical "absolute" systems. This paper aims to prove conclusively the incorrectness of these classical dimension systems and to propose "natural systems" which, it is hoped, may finally settle the differences and put the electrical unit systems upon a sound basis.

The absolute dimension systems expressing the electric and magnetic quantities by the three dimensions of mechanics are shown to be incorrect since the consequent use of proper mathematical statements leads to impossible results. However, the definitions of the absolute units, as well as the "practical" units in electromagnetics have a sense quite independent of the dimension systems. It is shown that the simplest and, as it seems, apparently the only true solution is to extend the two mechanical dimensions systems, known as technical and physical systems, into the field of electromagnetics by adding a new fundamental electric dimension. This gives two electrical systems, the electrotechnical dimension system with all the practical units and the electrophysical dimension system with all the absolute units. (Pamphlet copies not available.)

Performance Calculations on Induction Motors

By C. G. Veinott[6]

THE MEANS given in this paper for calculating the performance of both single phase and polyphase induction motors is intended primarily for calculations from previously determined design constants. By actual trial the methods have been found to be very easy to learn and use even without a knowledge of induction motor theory, and are very rapid.

In the past many of the popular calculating methods for induction motors made use of various forms of circle diagrams, charts, families of curves, etc. Both methods developed in the present paper are arrived at by a simple straightforward use of complex algebra, and consist of the filling in of the blank spaces of a calculating sheet especially prepared for this purpose and which can be incorporated on the regular design sheet. The methods are inherently as accurate as the best methods proposed to date, and are more accurate than many of the older methods. Further, they are well suited to rough calculation, ordinary calculation, or exact calculation.

The single phase calculation method is based upon the cross-field theory, the principle being to set up and solve by the algebra of complex quantities three simultaneous equations for the currents in the three circuits of the motor; namely, primary circuit, transformer circuit of the rotor, and the secondary cross-field circuit. The new method is faster than previous graphic methods, and also is more accurate. The independent variable is the rotor speed.

The polyphase calculation method is based upon the equivalent circuit and the equivalent circuit is based upon the revolving field theory. The independent variable is the slip. As it is not necessary to compute the large number of curves required for some of the previous methods, an enormous amount of time and labor is saved. Furthermore, the method distinguishes between primary and secondary leakage. (Pamphlet copies not available.)

5. Polytechnic Institute of Brooklyn, N. Y.
6. Westinghouse Elec. & Mfg. Co., Springfield, Mass.

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Measurement of Stray Load Loss in Polyphase Induction Motors

By C. J. Koch[2]

FOR LACK of a satisfactory method of measurement, no provision is made for stray load losses in the A.I.E.E. standard efficiency tests for induction motors. These losses may amount to from 2 to 5 per cent in squirrel cage motors from 1 to 5 hp. in size, decreasing gradually with increase in motor rating until they are less than 1 per cent for motors of several hundred horsepower. Development of an easy method of measuring stray load losses would not only rectify this situation, but also would permit the losses themselves to be studied more intensively and perhaps ultimately to be reduced greatly.

All methods of measuring stray load losses may be classified as either direct or indirect. Indirect methods aim to measure the total loss in the motor, substraction of the conventional losses yielding the stray load loss. Best known among the various indirect methods perhaps is the input-output method. Direct methods of measuring these losses are based upon the following procedure: Either the rotor or stator winding is excited by direct current with the unexcited winding short-circuited; the rotor then is revolved at synchronous speed and the power required to do this is measured. The stray load loss then is determined by subtracting from the power required to drive the rotor in this manner, the friction and windage losses, and also an amount of power equal to the I^2R loss produced by the fundamental frequency current in the unexcited member.

Upon the basis of a series of tests made on both slipring and squirrel cage motors of different sizes, the following methods are recommended:

Slipring Motors

1. Measure the power required to drive the motor at synchronous speed with the primary winding short circuited and sufficient d-c. excitation applied to the secondary winding to cause full load current to circulate in the primary; designate the power required as W. From the d-c. resistance (making any corrections necessary for differences in temperature) determine the primary I^2R loss and designate this as T.

2. Repeat the test just outlined, with the primary current equal to the magnetizing current, and determine the rotational power required and the I^2R loss; these latter are designated W_0 and T_0, respectively.

3. The stray load loss, then, is equal to $W - W_0 - T + T_0$.

Squirrel Cage Motors

1. Apply d-c. excitation to the stator using two of the stator terminals and leaving the third open; the amount of direct current required is 1.225 times the full load alternating current per terminal. Under these conditions determine the power required to rotate the rotor at synchronous speed; this is designated W.

2. With the rotor at standstill apply to the stator balanced polyphase voltages of normal frequency and of sufficient value to produce full load current per terminal, and measure the starting torque thus produced. A check on the correctness of the torque obtained is given by the fact that its value expressed in synchronous watts must be somewhat less (usually from 5 to 20 per cent) than the stator watts input less the stator copper loss as calculated from d-c. resistance. Then T = Synchronous watts torque − 0.142 × Syn. Speed (r.p.m.) × Torque (lb.-ft.)

3. Repeat the test just described, determining W_0 with d-c. excitation equivalent to normal a-c. magnetizing current and calculate

$$T_0 = T\left(\frac{\text{Magnetizing Current}}{\text{Full Load Current}}\right)$$

4. The stray load loss is then equal to $W - W_0 - T + T_0$

In practise, the starting torque varies closely as the square of the primary current. It is desirable therefore to measure the value of T at only one value of current, selected to obtain the greatest accuracy of test, and to obtain the values of T at other points by proportionality. The best value of current to select for this test will depend somewhat upon the type and size of motor. If the current is too large, overheating takes place and errors arise due to incorrect determinations of conductor temperature. However, if too low values of current are used, the small torque produced in comparison with the static friction makes accurate values difficult to obtain. It is recommended that full load current normally be used for squirrel cage and ball bearing motors, while values of 150 per cent full load current are recommended for normal use on sleeve bearing motors of less than 25 hp.

It is suggested that, after confirmation or modification by other investigators, the methods outlined be taken as a basis for revision of the A.I.E.E. standards, such revision to require the inclusion of induction motor stray load losses in efficiency determination. (Pamphlet copies not available.)

Torque-Angle Characteristics of Synchronous Machines Following System Disturbances

By S. B. Crary[2] M. L. Waring[2]

THE DETERMINATION of the behavior of synchronous machines during transient conditions subsequent to a system disturbance is becoming increasingly interesting and important. In determining this behavior it is essential to know the torque-angle characteristic of the given machine under conditions resulting from disturbances of various sorts. The most important of such disturbances are variations in mechanical torque, excitation voltage, amount of external reactance, and system voltage. System voltage may vary in either magnitude or angular position.

Some of these disturbances already have been treated by various authors. It is the purpose of the first part of the present paper to establish general equations from which may be derived specific equations. Starting with the fundamental relations already developed, general equations are derived for the positive phase sequence torque of a synchronous machine subsequent to the following:

1. Switching in or out of a connecting line.
2. Occurrence of a balanced three phase system fault.

The evaluation of the torque characteristics following such disturbances is of particular importance in the determination of transient stability limits, and a step-by-step method of calculation is given so that the electrical torque of a machine having any number of rotor circuits can be determined at any time of its swing. The formulas and step-by-step method presented make it possible to predetermine the effects of amortisseur windings and high speed excitation. No attempts, however, have been made to draw any general conclusions as to the effect of these two factors.

In the second part of the paper an actual case of switching out of a connecting line is calculated, and the results compared with field tests taken on the system of the New York Power and Light Corporation. These tests are described in the companion paper, "Field Tests to Determine Damping Characteristics of Synchronous Machines." Good agreement between the calculations and test results is shown. (Pamphlet copies not available.)

Field Tests to Determine the Damping Characteristics of Synchronous Generators

By F. A. Hamilton, Jr.[2]

PRACTICAL system tests of the damping action of generators with and without low resistance damper windings, but otherwise identical, have been made. The effects of normal variations of generator field circuit resistance, field current, and loading were investigated, and data for checking calculated machine constants also were obtained. The results of the tests presented in this paper are valuable from a quantitative, as well as from a qualitative standpoint.

The field tests proved useful in providing graphic evidence of phenomena not well understood, and in obtaining data to verify available methods of analysis and upon which to build new methods of calculation and extension of existing theory.

Low resistance damper windings were found quite definitely to assist the rapid smoothing out of balanced disturbances resulting from the switching in or out of lines, synchronizing, load changes, or the tripping of loaded generators, and three phase short circuits. The test results indicate that generator field circuit resistance and generator field current may be varied within normal limits without greatly affecting the generator damping characteristics. Also, the test data verified methods of calculation presented in the companion paper, "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances." (Pamphlet copies not available.)

— NOTES —

Design of Capacitor Motors for Balanced Operation

By
P. H. Trickey[6]

THE PRESENT methods of calculating the full load performance of capacitor motors are quite long and tedious. A simple convenient method of calculating full load conditions is given in this paper, including the necessary theory and formulas.

It is agreed generally that a capacitor motor should be designed to operate under nearly balanced conditions at full load. This means that there shall be no transfer of power from one phase to the other and the rotor current shall be balanced. With such a design, each phase produces equal flux and the rotor operates as if it were in a two phase stator. The theory presented in this paper is based upon balanced conditions, the method being useful only when the starting torque required is not too great. In many cases the starting torque requirements determine the winding, and the motor must operate slightly unbalanced at full load, with the resultant circulating current and lowered efficiency. (Pamphlet copies not available.)

The Electro-Matic Traffic Dispatching System

By
H. A. Haugh, Jr.[8]

VEHICLE actuated traffic dispatching systems may be used by which the traffic in a given area controls itself. By this means the duration of the green light period at any intersection is in proportion to the volume of traffic on each approach. A smooth flow of vehicles is produced which uses the intersection efficiently.

This system of traffic control consists of three main parts; namely, the detectors, the signal lights, and the dispatcher. The detector may be any one of several types, such as a mechanical switch located in the pavement, an electromagnetic unit, or a beam of light which will be interrupted by approaching vehicles. The mechanical type has been found to be the most practical.

This dispatching device for this type of system must be of extreme flexibility, and the timing of the signal light cycle must constantly change to meet the irregular demand of traffic. This operation is secured by a group of time-delayed relays, combined with a switching mechanism. The resulting operation is similar to that which would be secured by having a traffic policeman at each corner, and the speed and amount of traffic, length of time which a car has to wait, and such factors, all are taken into consideration. The right-of-way is yielded to cross street traffic when the intersection is clear, and even when it is not clear if the cross traffic has waited for a predetermined period. However, moving traffic is never interrupted unless the right-of-way has been called to the cross street by waiting traffic or by a "pedestrian period." (Pamphlet copies not available.)

The Flexible Progressive Traffic Signal System

By
H. I. Turner[7]

A FLEXIBLE progressive traffic signal system usually makes it possible to time signals so that traffic may move east and west, as well as north and south, at predetermined uniform speeds without being obstructed by a "stop" signal after once having passed a "go" signal. The planning of such a system is a matter that requires most intelligent study and one which yields results well worth the effort. Traffic-actuated equipment seldom can be justified over pre-timed equipment, as in a great majority of congested districts the coordination of the movement of traffic through the entire district is of incomparably greater importance than the most efficient movement of traffic at any few intersections taken by themselves.

Two general types of systems are used for planning service: the first employing a central office type controller with no timing devices located at the individual intersections, and the second, that which employs a master controller at a center point and an individual controller at each intersection. All of these controllers must have facilities for adjusting the time of each cycle of operation of the signals at any intersection from a central point, the percentage of the cycle taken by "go" and "stop" signals must be adjustable over a wide range and independently, and the start of the cycle of operation at any one intersection should be completely adjustable.

The following features are important in any flexible progressive control device:

1. Minimum maintenance expense and service interruptions.
2. Facilities for manual control.
3. Facilities for shutting down the signals at each local controller and from a central point by merely throwing a switch.
4. Adjustments which can be understood easily and made over a wide range.
5. The duration of the amber light should not increase or decrease when the total time cycle is changed.
6. Means should be provided for exhibiting emergency signals by control from a central point.
7. Means should be provided for accommodating traffic during times of the day when it is very heavy on a particular street. (Pamphlet copies not available.)

A Recent Development in Traffic Control

By
H. W. Vickery[9]
V. W. Leonard[9]

A TIMING device containing new features and having extremely wide ranges of adjustment recently has been developed as a means for meeting the problems encountered in controlling present day vehicular traffic.

In the timer, a means is provided to give three progressive relations of the signals; thereby, the progressive relation can be changed remotely to give, for example, ideal progression of traffic into a city in the morning, and out in the late afternoon, with average progression in both directions at other hours of the day.

The timer is driven by a synchronous motor. Thus, accuracy of timing and timer settings is assured. A gear shift unit in which the gears can be shifted manually or from a remote point gives provision for changing the total time cycle. A solenoid operated drum containing a predetermined arrangement of cams opens and closes the signal light circuits. Any of the modern color sequences can be obtained by proper arrangement of the cams on the drum. Momentarily, by keys in a cycle percentage dial, a revolving switch is closed a given number of times each cycle. Thus, impulses are supplied to the drum solenoid and the drum is advanced through the various periods of the color sequence. By proper arrangement of the keys any desired percentage adjustment of these periods can be obtained.

A multi-contact relay in each timer, operated over the same wires used for remote shifting of the gears, gives provision for remote control of shut down, flashing amber, and fire control. (Pamphlet copies not available.)

The Traffic Flow Regulator

By
C. H. Bissell[10]
J. G. Hummel[10]

THE PRACTISE of assigning a definite period for the red and green lights of each traffic signal, and keeping these periods constant throughout the day and week, is subject to serious criticism. Needless delays and congestion are caused, and the obedience of motorists to traffic signals in general may be broken down.

Traffic surveys have demonstrated that there are very definite traffic peaks and valleys for each week day as well as for Saturdays

7. Eagle Signal Corp., Moline, Ill.
8. Automatic Signal Corp., New Haven, Conn.
9. Genl. Elec. Co., W. Lynn, Mass.
10. Crouse-Hinds Co., Syracuse, N. Y.

— NOTES —

and Sundays. Experience has shown that these variations occur with definite regularity. It has not been found practical or economical to send out officers to change the timing on every signal light. Also, the system of some sort of an electrical or mechanical device to record the amount of traffic and adjust the timing signals accordingly, entails an expense which cannot be justified.

A traffic flow regulator has been developed to vary the timing automatically through any predetermined cycle. For example, the device may be set to give a different signal at each of a large number of periods throughout the day, and the setting may be varied for different days of the week. In addition, certain special conditions frequently are encountered, and for these the timing device allows compensation. A system of extreme flexibility is thus secured. (Pamphlet copies not available.)

Double Conductors for Transmission Lines

By H. B. Dwight[11] E. B. Farmer[11]

FOR OVERHEAD transmission lines, double conductors, consisting of a second conductor hung a few inches below the first by metallic hangers, present a number of advantages over one larger conductor. With this double construction, the two conductors are electrically in parallel and form one effective conductor of large cross-section without increasing the number of insulators or crossarms. In some cases where there is a mechanical margin of safety, it may be found desirable to add a second conductor to the present single conductor.

Among the advantages which may be secured by the use of double conductors are: a reduction of 20 per cent or more in reactance, almost entire elimination of skin effect, an increase in current carrying capacity of nearly 30 per cent, an increase in corona voltage of from 10 to 25 per cent, and in some cases the opportunity to add to the conductivity and power rating without scrapping the old conductor. The advantages are to be balanced against the extra cost due to mechanical features including hangers, increased cost of stringing, and additional wind and ice load. Since the increase in ice load is possibly the greatest disadvantage, the use of double conductors is of greatest interest to southern districts where ice load is not encountered.

In this article, formulas are given for the calculation of the electrical characteristics of double conductor transmission lines, which enable comparisons with other types to be easily made. (Pamphlet copies not available.)

Three Phase Multiple Conductor Circuits

By Edith Clarke

DURING the past year, the subject of power transmission by multiple conductor circuits has received considerable attention. Therefore the formulas and estimating curves given in this paper may be of interest.

Formulas are developed for the inductance and capacitance to neutral per phase and the approximate corona starting voltage of perfectly transposed multiple-conductor three-phase transmission lines having any number of conductors per phase.

For certain special arrangements of the conductors, curves are given for the 60-cycle reactance, capacity susceptance, and corona starting voltage. Throughout their practical range these curves show the effect of variations in conductor diameter, spacing between phases and between conductors of the same phase. Two, three, four, and five conductors per phase are considered.

A comparison is made of multiple and single-conductor circuits with respect to charging current, voltage at no load, power which can be carried with the same voltage drop, and stability. (Pamphlet copies not available.)

11. Mass. Inst. of Tech., Cambridge, Mass.

The Solution of Circuits Subjected to Traveling Waves

By H. L. Rorden[12]

THE EFFECT of traveling waves upon terminal apparatus usually is most easily solved by means of Heaviside's operational calculus. Solutions have been given previously for various combinations of impedances that may be encountered in service, by considering such impedances to be contained in simple circuits. These are intended to approximate the general conditions of a transmission system. However, a purely mathematical analysis of such an involved nature often is looked upon skeptically and experimental variation of such calculation therefore is valuable.

It is the major purpose of this paper to illustrate the accuracy with which mathematical solutions of traveling wave theory are substantiated by test results. For this purpose a transmission about 2 miles long was used, this line consisting of parallel conductors placed 8 ft. apart and forming a loop so that both ends terminated at the laboratory where both the lightning generator and the cathode ray oscillograph were located. Various other arrangements were used including the direct application of the lightning waves to impedances and transformers.

Much valuable information has been obtained relative to the wave shape and other peculiarities of traveling waves. Many irregularities exist in these waves, but generally the waves may be reproduced to a sufficient degree of accuracy that their effect may be determined both analytically and experimentally. It was found that in general the test results checked the calculations very precisely. The relative importance of the various factors affecting traveling waves also are discussed, and it is pointed out that certain of these may be neglected. (Pamphlet copies not available.)

Corona Limit, Transmission Characteristics, and Method of Loading Multiple Conductor Lines for Very High Voltages

By C. A. Boddie[13]

THE OBJECTS of this paper are to discuss a simple and practical method by which the present transmission voltages may be increased greatly and to point out a method of avoiding the detrimental effects of the immense charging currents attendant on the use of very high voltages. The most formidable natural limitation which prevents raising line voltages is the formation of corona, and the paper is concerned chiefly with the overcoming of this limitation. This may be accomplished by the proper method of increasing conductor diameter and using multiple conductors. The conclusions brought out by this paper are as follows:

Transmission lines may be built for considerably higher voltage than those at present used, and the same economies available through the use of higher voltages apply to voltages above 220 kv. as apply below that value. No very serious difficulties may be expected in going to the higher voltages. Multiple conductor lines lend themselves naturally to use at very high voltages, and line charging currents may be taken care of easily by introducing air gaps in the raising and lowering transformers or by use of properly designed loading coils. Also, loading coils assist greatly in switching.

When large blocks of power are to be transmitted it is always most economical to push the line voltage up to the point where a single circuit will transmit all the power. This may always be done however great the power. The question of duplicate lines as affecting the continuity of service may in some cases tend to modify this conclusion, but in general the fewest possible number of circuits gives the most economical system. Improvement in the methods of operating large three phase lines will minimize the necessity for spares and emphasize the foregoing conclusion. (Pamphlet copies not available.)

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— NOTES —

This is a reprint from
Electrical Engineering
Published monthly by the
American Institute of Electrical Engineers
33 West 39th St., New York, N.Y.