JOURNAL OF THE A·I·E·E·

JUNE 1929

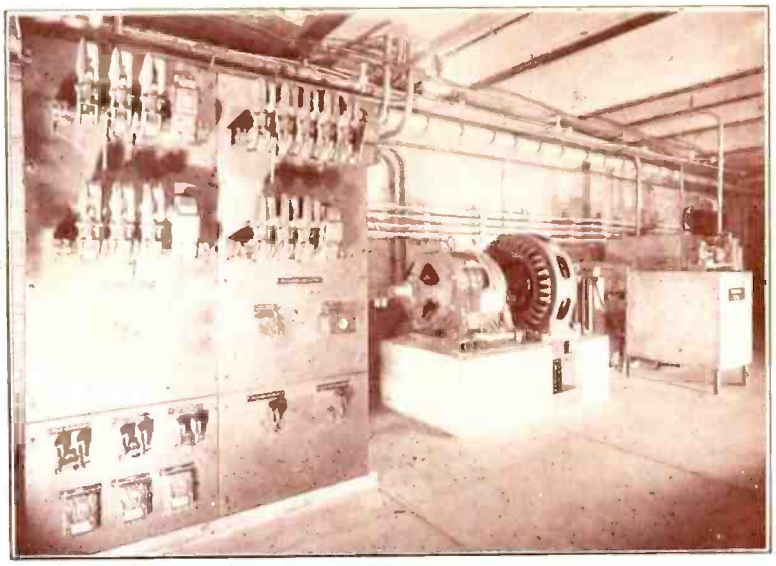
A E E I

PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

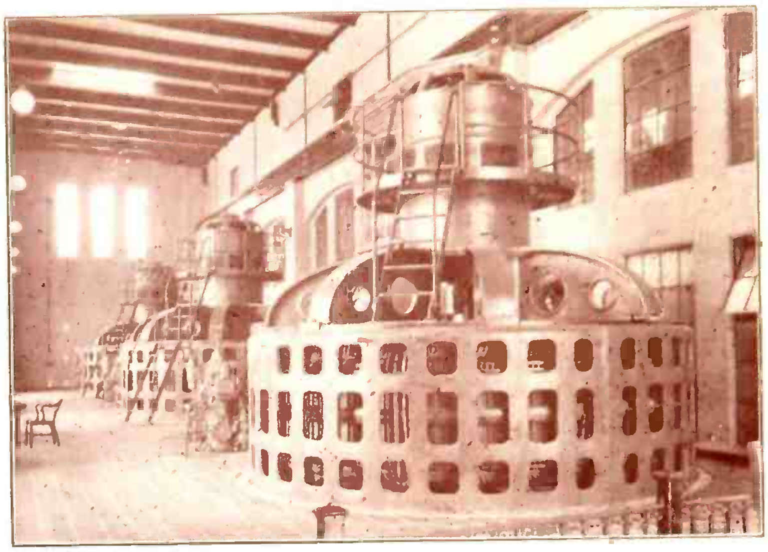
SUMMER CONVENTION, Swampscott, Mass., JUNE, 24-28

Summer Convention Headquarters and Nearby Central Stations

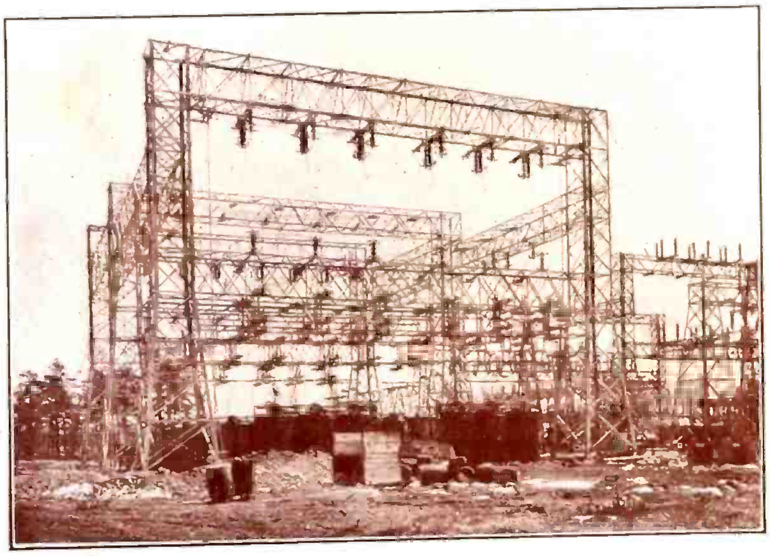
Front View New Ocean House, Swampscott, Mass.



Resonant Control Apparatus for Street Lighting Service Dorchester Substation of Boston Edison Co.

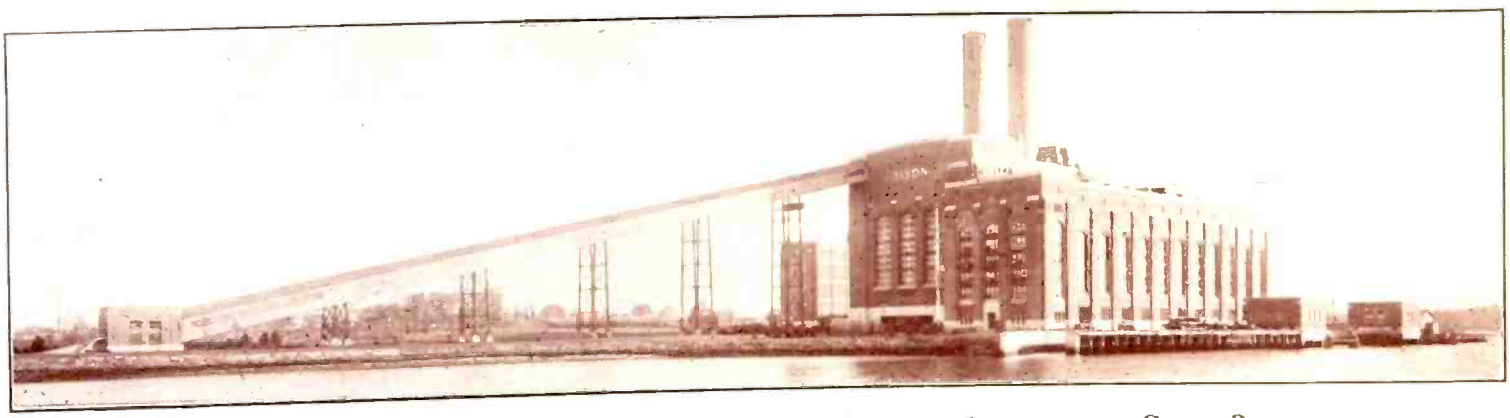


Interior Gulf Island Station of Central Main Power Co. Three 9000-Hp. Units



New 110-Kv. Switch Yard at Pratt's Junction Substation of New England Power Association

Central Main Power Co. on Androscoggin River above Lewiston



C. L. Edgar Generating Station of the Edison Electric Illuminating Co. of Boston

JOURNAL

OF THE

American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

PUBLICATION COMMITTEE

W. S. GORSUCH, *Chairman*, H. P. CHARLESWORTH, F. L. HUTCHINSON, DONALD MCNICOL, E. B. MEYER

GEORGE R. METCALFE, *Editor*

Changes of advertising copy should reach Institute headquarters by the 15th day of the month for the issue of the following month.

Subscription: $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines, $10.50 to Canada, Central America, South America, Haiti, Spain and Colonies, and $11.00 to all other countries. Single copies $1.00.

Entered as matter of the second class at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress, March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Vol. XLVIII — JUNE 1929 — Number 6

TABLE OF CONTENTS

Papers, Discussions, Reports, Etc.

Institute and Related Activities

A REQUEST FOR CHANGE OF ADDRESS must be received at Institute headquarters at least ten days before the date of issue with which it is to take effect. Duplicate copies cannot be sent without charge to replace those issues undelivered through failure to send such advance notice. With your new address, be sure to mention the old one, indicating also any changes in business connections.

(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

American Institute of Electrical Engineers

—*Some Activities and Services Open to Members*—

To Members Going Abroad.—Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societe Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Denki Gakkwai (Japan), Norsk Elektroteknisk Forening (Norway), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia), and The Institution of Engineers, Australia (Australia).

Conventions.—The Institute holds three national conventions each year; the Winter Convention in January, the Summer Convention in June, and the Pacific Coast Convention usually in September.

The Summer Conventions are designed to be less strenuous than the Winter Convention and they are usually held in various parts of the country at summer resorts, where the technical activities and the recreation features can be about evenly balanced. Several years ago the Board of Directors, recognizing the benefits to be derived by members from personal contacts and social intercourse, ruled that the technical sessions be confined to the mornings, leaving the balance of each day free for social and entertainment purposes, and in recent years the Summer Convention programs have been formulated upon this ruling. The same high grade is maintained in all convention papers, wherever presented, but the number of papers placed on the Summer Convention programs is reduced in proportion to the smaller number of technical sessions scheduled. An important feature of each Summer Convention is the presentation of the Technical Committee reports, each of which covers a distinct phase of electrical engineering and brings the advances and improvements in the art thoroughly down to date.

Presentation of Papers.—An important activity of the Institute is the preparation and presentation of papers before meetings of the Institute. Opportunity is offered for any member to present a paper of general interest to engineers at an Institute meeting, or of having shorter contributions published in the Journal without verbal presentation. In preparing a paper for presentation at a meeting, the first step should be to notify the Meetings and Papers Committee about it so that it may be tentatively scheduled. Programs for the meetings are formulated several months in advance, and unless it is known well in advance that a paper is forthcoming, it may be subject to many months delay before it can be assigned to a definite meeting program. Immediately upon notification, the author will receive a pamphlet entitled "Suggestions to Authors" which gives in brief form instructions in regard to Institute requirements in the preparation of manuscripts and illustrations. This pamphlet contains many helpful suggestions and its use may avoid much loss of time in making changes to meet Institute requirements.

Manuscripts should be in triplicate and should be submitted at least three months in advance of the date of the meeting for which they are intended. These manuscripts are submitted first to the members of the technical committee covering the subject of the paper, and if approved will next go to the Meetings and Papers Committee for final disposal. After final acceptance, the paper goes to the Editorial department for printing which requires usually from two to three weeks. Advance copies are desired about ten days prior to the meeting in order to distribute the paper to members desiring to discuss it. Considering the routine through which all papers must pass, the advantage of prompt notification and early submission of manuscripts will be apparent.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII — JUNE, 1929 — Number 6

Come to Swampscott!

THE Summer Convention of the Institute offers an opportunity for delightful fellowship with brother members, for hearing excellent technical papers, reports and discussions, and taking part, and for enjoying pleasurable recreation. But more— it also offers opportunity for advancing our profession still further.

The strength of the electrical engineering profession in America is reflected by the strength of our Institute. The more successful the Institute is in its service to the members, the higher will be the general standing reached by the profession.

The first day of the Convention is in many ways the most important day because then is held the conference of officers, Section delegates, and Branch Counselors. The subjects discussed at these conferences relate to means for making the Sections stronger, for increasing interest and service, and for cooperation between Sections and Branches; to questions pertaining to membership, to publications and other important matters.

This conference is not limited to the officers and the delegates. All members are invited, not only to attend, but to take part in the discussions.

While a program of subjects has been outlined by the committee, additional items of importance in the conduct of Institute affairs may be presented by anyone, as far as time permits. However, the outlined program covers a wide range of activities and interest.

Many of the Institute policies which are in effect today are the direct result of these Monday conferences, and judging from the wide interest evidenced on every side, this coming one will be no exception.

It is, therefore, hoped that all members who have given thought to the problems of the Institute, such as relate to Conventions, to Regional Meetings, to Sections or to Branches will attend the Monday meeting. The deliberations of that day will help to develop more traditions to enrich the Institute and will be a material factor in making our society advance to still greater heights of service.

R. F. Schuchardt

President.

Some Leaders of the A. I. E. E.

Severn D. Sprong, Manager of the Institute 1909-1912 and one of its Vice-Presidents 1912-14, is a native of Renssalaer County, New York. After completing the work of the common schools, he continued his studies for several years under special tutors. In 1893 he finished the General Electric Test and from then until 1898 served in various subordinate capacities in utility and special work. He then became Superintendent of the Electric Department of the Consolidated Gas Company of New Jersey at Long Branch, holding this position until 1900, when he was made Chief Engineer of the Central Electric Company, covering erection of central high-tension generating stations, transmission lines and four substations,—at Rahway, Perth Amboy, New Brunswick and Bound Brook,—replacing steam generating stations. Two years later he was chosen Assistant Chief Electrical Engineer of the New York Edison Company, remaining there until 1906, in responsible capacity engaged on the design of Waterside Station No. 2, numerous substations and transmission and distribution systems; also in the Williamsburgh Generating Station and several substations of the B. R. T. System, Brooklyn. From 1906 to 1909 he was associated with the design and construction of substations, transmission and distribution, and in charge of operations as Assistant Electrical Engineer for the United Electric Light & Power Company. Then for three years he was Chief Electrical and Mechanical Engineer for J. G. White & Company in charge of responsible direction of design and construction of numerous steam, hydro and transmission and distribution systems in the United States and Canada, also acting as advisor on various other projects along these lines. From the completion of this service until 1922 he was Chief Electrical Engineer for the Brooklyn Edison Company, in responsible charge of electrical engineering stations, substations, transmission and distribution, and all electrical construction of stations, substations, and street transmission and distribution; he was also in charge of the Meter Department and the purchase of all electrical machinery and equipment. From 1922 until 1925 he was Vice-President and General Manager of the Orange County Public Service Corporation, the Orange County Hydro Electric Corporation, Pike County Light & Power Company, and the Cape May Illuminating Company, in executive control of these properties including their development and operation, as well as the construction of hydroelectric plants. He was also President of the Port Jervis Traction Company during this period. This entire group of properties included also three gas plants and the distribution systems.

In 1922 Mr. Sprong established his own consulting engineering practise, acting at the same time as consulting engineer for the General Electric Company.

He became an Associate of the Institute in 1903 and was made a Fellow in 1912. From time to time he has been active on various Institute Committees and is at present on the Board of Examiners.

He holds membership in The American Society of Mechanical Engineers, is a member of the Society of Colonial Wars, and of the Sons of the Revolution. His clubs are the Crescent, Montauk, the Engineers and the Lawyers.

Technical Changes in Industry

The great advance made in recent years by central stations generating electric power in the more economical consumption of fuel per kilowatt-hour generated is emphasized in the survey of the National Bureau of Economic Research conducted for the Committee on Recent Economic Changes of the President's Unemployment Conference.

Data on central station efficiencies were gathered by L. P. Alford, who points out that central stations had succeeded in 1927 in reducing the consumption of fuel to 57 per cent of what it was in 1919 per unit of electrical energy generated. During that same period, the output of energy had more than doubled.

The advances in the design, construction, and operation of large steam central stations in the last decade have been principally along three lines; (1) larger generating units using steam turbines exclusively as prime movers, and larger boilers; (2) higher steam pressures and superheat temperatures; and (3) greater use of waste-heat recovery apparatus. To these may be added improvements in all auxiliary machinery to the advantage of the over-all efficiency of operation. A rough idea of the advance in efficiency may be had from the fact that for a station generating from 20,000 to 100,000 kilowatts, the present rate of coal consumption is about two pounds per kilowatt-hour as against 3.5 pounds per kilowatt-hour ten years ago. Heat economies have also been introduced all the way from the furnaces to the last expansion stage of the turbine.

Higher efficiencies than now obtained by the best, about 13,000 B. t. u. per kilowatt-hour or better than 26 per cent, are expected and can be produced; but not a great deal higher for the best all-round results.

Central station pressures are to be found in three ranges for modern installations; (1) a range around 400 pounds per square inch; (2) a range from 550 to 750 pounds; (3) a range from 1000 to 1400 pounds. The greatest activity at present is in the first and third ranges, the intermediate one being proportionately neglected. The choice between these two, the basis of selection, is partly a matter of load, but more a matter of coal price. For a cheap coal with a small average load, the 400 pound range is preferred; with a higher priced coal and a high average load the 1000 pound range is preferred; and usually we find both in the same station.

An Electrified Railway Substation
Of the Pennsylvania Railroad

BY J. V. B. DUER[1]
Associate, A. I. E. E.

Synopsis.—This paper contains a description of one of the outdoor substations of the Philadelphia-Wilmington electrification of the Pennsylvania Railroad, recently placed in service. It describes the initial installation of apparatus provided in the substation for the present suburban electrification, as well as the steps taken to accommodate the additional apparatus necessary for the through electrification when it takes place.

The location and control of the substation is described as well as the types of protective apparatus utilized and the method of operation. Attention is called to certain operating necessities which control the design and location of a substation of this character. The means provided for handling the heavy apparatus into and out of a substation of this character and the facilities for handling, cleaning and restoring oil to the different pieces of apparatus are described in some detail.

* * * * *

As a preliminary to this description, it is necessary to state that the Philadelphia-Wilmington electrification at its present stage of construction is designed for the multiple-unit suburban service only, but that everything has been so constructed that expansion to care for the handling of through electric locomotive hauled service, both passenger and freight, may be accomplished by adding to the existing facilities, without necessitating the replacement of existing electrical facilities. For complete electrification of main line territory, four single-phase 132-kv. transmission circuits on two tower lines are proposed; with four step-down transformer units at each typical trolley supply substation. The initial installation, for multiple-unit service only, has required but two single-phase 132-kv. transmission circuits, each on its own supporting structures; and at each typical trolley supply substation, but two step-down transformer units.

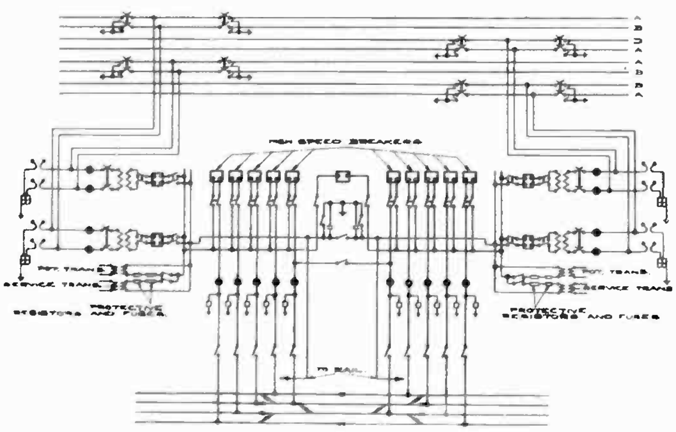


FIG. 1—TROLLEY SUBSTATION—WIRING DIAGRAM

It is then evident that the existing typical trolley supply substation is a structure which at present accommodates two single-phase transmission circuits, allowing for the sectionalization of each of these circuits by air-break motor-operated disconnecting switches. The structure further accommodates a tap from each of these transmission circuits, each of these two taps passing through another air-break motor-operated disconnecting switch to the high-voltage side of a 132/12-kv. step-down transformer, the tap being provided with choke coils and lightning arresters. The low-voltage side of each transformer unit is carried through a suitable two-pole oil switch and the requisite isolating switches to one section of a 12-kv. trolley bus. Ultimately, there will be four transmission circuits, four taps, (one from each circuit), and four transformers; but there will be only two trolley bus sections, as at present, each with two transformers connected to it instead of one.

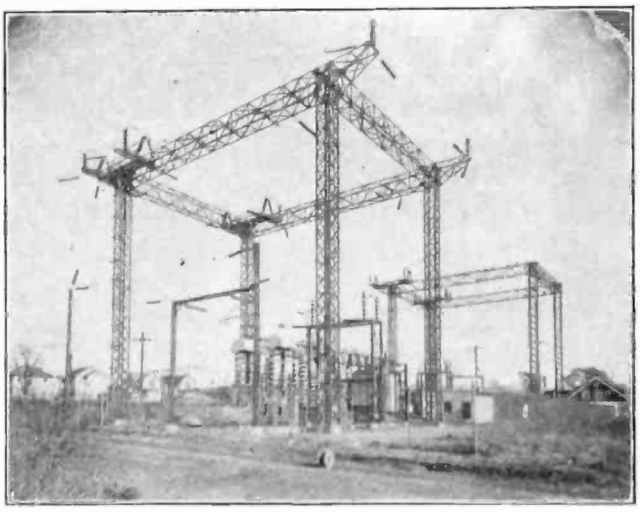


FIG. 2—TYPICAL TROLLEY SUPPLY SUBSTATION, GENERAL VIEW

Each bus section consists of a trolley and a rail bus. The two trolley bus sections are connected through a suitable single-pole breaker and the requisite isolating switches. The two rail bus sections are arranged so that they may be connected together through disconnecting switches, and further, so that either section or both may be connected to actual ground if desired.

1. Electrical Engineer, Pennsylvania Railroad Co., Philadelphia, Pa.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

From the trolley bus section, taps are taken, each of which pass through a single-pole high-speed trolley circuit breaker and the requisite isolating switches to a trolley. The trolleys passing by the substation are sectionalized so that those on one side are electrically separated from those on the other side of the substation. The trolley bus taps from one section of the trolley bus feed the trolleys on one side of the substation, and those from the other section of the trolley bus feed the trolleys

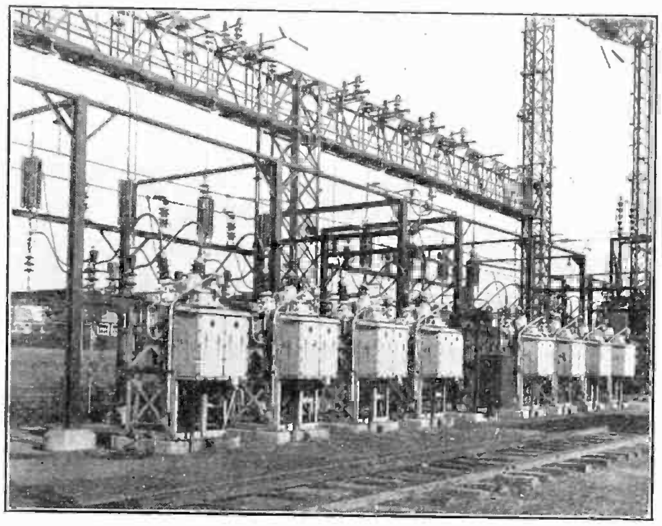


Fig. 3—Typical Trolley Supply Substation—Trolley Bus and Oil Circuit Breakers

on the other side of the substation. Each trolley bus tap is supplied with a choke coil and a lightning arrester and feeds into a different trolley from that fed by any other tap.

The railroad is equipped with interlocking cross-over

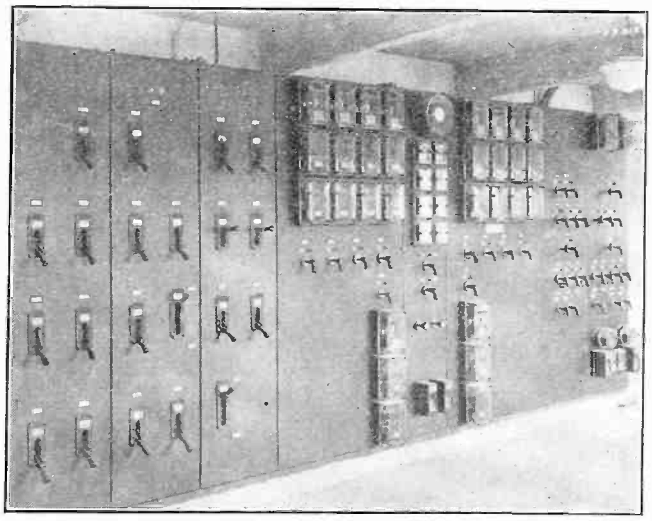


Fig. 4—Typical Substation Control Board in Control House

stations for the purpose of crossing traffic from one track to another at frequent intervals. These intervals are such that it is usually possible to locate the substations at certain of the interlocking cross-over stations. At one of these cross-over stations, the cross-overs between tracks are located between signal bridges, usually some 1200 to 2000 ft. apart. There is a signal and switch tower, more generally called an interlocking or block station, with an operator to control the cross-over movements. This tower is connected with the dispatcher's telephone circuit and with the emergency telegraph circuit. There are usually certain signal maintenance men working in the vicinity of the block station. If the telephone circuit of the load dispatcher or power director be run into the block station, and if the block station be equipped with a control board and the necessary signal lamps, the operator can well perform such substation switching operations as the power director may request, keeping the proper record of such operations. Further the operator can call by whistle or horn such signal maintenance man as may be within hearing and request him to perform such emergency operations within the substation as may become necessary prior to the arrival of a regular substation maintenance man. It is also evident that the trolleys covering the cross-over movements should be independently fed

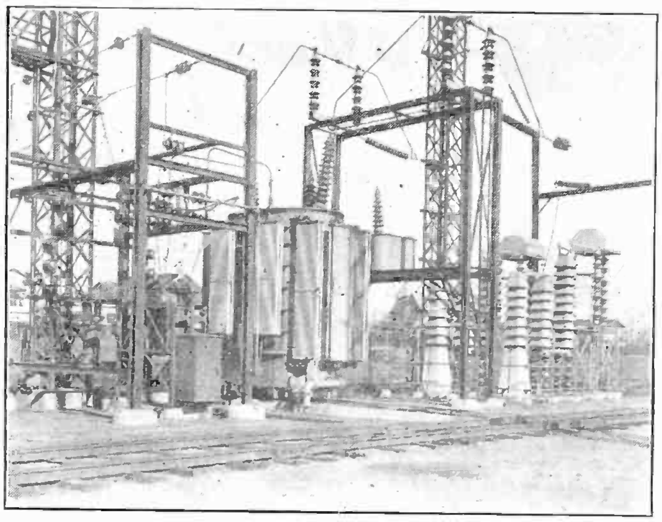


Fig. 5—Typical Trolley Supply Substation—4500-Kv-a. Transformer

from those extending beyond, so that a dead trolley beyond will not hazard the making of a cross-over movement to another track to avoid the dead trolley. If the substation be located near the cross-over station, the cross-over trolleys may be readily fed independently, directly from the substation trolley bus sections. Cross-over stations not at substations require a special bus and switch arrangement to secure this independent cross-over trolley feed feature. We may state, therefore, that in so far as is possible, the typical trolley supply substation is located near a cross-over station and the substation switching operations are controlled from the block station by the block station operator under direction from the power director.

Within the fenced in enclosure of the substation is located a small control house. In this house there is located a control and relay board, a control battery and charging facilities, such signal supply motor-generator sets and switching as may be required, the substation oil treating plant with its purifiers, filters and valves, and a telephone connected with the power director's circuit.

When the regular substation maintenance men are at work within the substation enclosure, by throwing a switch, they may take over the control of the substation switches from the block station operator's board to the control board in the control house. This operation is made upon direction from the power director and the block-station operator is informed and also receives a signal on his board when the control passes from his board to the control house board, or the reverse.

The entire relay layout for the station is on the control house board. All control operations and signals are at a control voltage of 125 volts, direct current supplied from the control battery. The control circuits are segregated for protection and for the easy location of grounds. Ground detecting apparatus is supplied.

In each substation are two service transformers, one on each section of the trolley bus, which give 230/115-volt, 25-cycle circuits from which the control battery is charged, the oil pumps operated, and the normal lighting obtained. A separate transformer supplies the signal motor-generator set or sets when such are installed at the substation.

Certain emergency lighting is supplied from the control battery.

Into each substation enclosure is run a railroad siding, and the apparatus is so located as to be readily loaded or unloaded to or from cars on this siding by a locomotive derrick or otherwise, as may be necessary.

The relay protection is such as to give the following protective functions:

Trolley high-speed breakers; high-speed impulse for short circuit; normal controlled speed relays for overload.

Each trolley bus section is differentially protected as to all breakers connected thereto for protection against bus faults.

Transformer Breakers; reverse power protection for transmission line-to-line faults; differential protection for transformer faults. Voltage relays for transmission line to ground faults supplied from a 66-kv. potential transformer connected from the midpoint of the high-tension winding of the main transformer to ground, the step-up transformers at the station supplying energy to the high-tension transmission having their midpoint grounded through resistance.

Buried oil tanks are provided in each substation for both transformer and switch oil. The piping system is such that breaker oil may be drawn from a dirty oil tank and purified and run into a clean oil tank and run into a breaker. The transformer oil may be run from the transformer through the purifier and back to the transformer, or from the transformer into the tank and thence through the purifier and back to the transformer.

The oil purifier is a combined centrifuge and filter with provision for by-passing either or both, the latter for use when oil is drawn from the clean oil tank and passed to a breaker.

The step-down transformers necessary in our eastern territory for the eventual complete electrification are of 4500-kv-a. normal continuous rating, immediately followed by 150 per cent load for two hours, immediately followed by 300 per cent load for five minutes. Thus, these transformers are much larger than normal commercially rated units of the same nominal continuous rating. They are self-cooled and self-protecting and every attempt has been made to insure serviceability. The number of these units installed initially and ultimately in a typical Philadelphia-Wilmington substation has been previously mentioned as two and four respectively.

The above describes the requirements of the substation layout. The actual physical structure which fulfills these requirements need not always be the same. It depends, naturally, upon the land available and upon other considerations which influence its design.

Typical views of a step-down transformer station are shown.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

May 28, 1928.

I appreciate the very efficient way in which employment problems are handled by you and beg to thank you for many kindnesses and courtesies in connection with the vacancies in this office.

May 28, 1928.

I want to express my appreciation of the effort that you made to locate the right man for this position and the discrimination that you showed in the applications that you sent me. I shall certainly bother you again when I have an opening as I believe you are doing a good service for our membership.

May 26, 1928.

We would not fail to comment on the high qualifications of all your applicants, and wish to thank you for the kind interest you have shown in this matter.

April 14, 1928.

We certainly appreciate your help and the high grade men you have referred to us. You may be interested to know that the only two men hired were applicants through your service, although we did receive some very good applications from our ad in a daily newspaper.

April 12, 1928.

We have employed Mr. .... to fill the position of Chief Engineer at ....

We appreciate keenly the assistance rendered by your organization and trust that we may find the means to reciprocate the courtesies you have extended.

Electrification of Oil Pipe Lines
in the Southwest

BY D. H. LEVY[1]
Associate, A. I. E. E.

Synopsis.—This paper briefly reviews the history of electricity as motive power for oil pipe line operation and notes some of the reasons for, and the results of, its rapid development in the Southwest. Some attention is paid to the method of serving these loads from transmission lines and the tendency of modern pipe line practise is shown. The last five years have seen rapid advances in the methods of underground transportation of petroleum and the paper reviews some of the present tendencies in design of the modern oil pipe line station.

* * * * *

Introduction

DURING the last two decades, most of the crude oil produced in the United States has been moved to the refineries, ports, and markets through underground steel pipe lines. The oil was forced through these lines by means of reciprocating pumps driven by steam engines or oil engines.

About three years ago, a number of factors developed which allowed, and in fact required, the extensive employment of electric power for pipe line pumping and this system has now proved highly successful.

The chief factor in this adoption of electric drive was the recent discovery of vast quantities of oil in new fields in Texas and Oklahoma. This required immediate and quick construction and operation of more and larger pipe lines.

Electrical pumping was the solution for several reasons. The proposed pipe lines were to pass through rough and dry territory having few highways and fewer railroad facilities. This condition was favorable to the electrical equipment as it is lighter and more easily transported than Diesel or steam equipment. Furthermore, the available water was generally unsuitable for Diesel engine cooling. Steam for heating the oil was not necessary in the moderate climate in this region. Moreover, electrical equipment had given very satisfactory service in other applications in producing oil.

Considering all these conditions, one pipe line company electrified 150 mi. of 10-in. line and the results were very satisfactory. Later, when the immense Permian Basin fields in southwest Texas were discovered, electrical pumping was installed by several companies operating in that area.

One of the companies electrified 400 mi. of 10-in. line, extending from McCamey, Texas to Healdton, Oklahoma. This line is served by the transmission systems of three power companies and at this writing has been in successful operation for six months, meeting all expectations as to continuity of service and economy of operation. A second company built and electrified 125 mi. of line from McCamey to Del Rio, Texas with the same satisfactory results. A third company extended their lines from Crane through DeLeon, Texas to the Gulf, a distance of 650 mi. This line has 19 stations, 14 of which are completely electric-driven, and the remainder partially so. A fourth company has now under construction 450 mi. of 10-in. line with 11-motor-driven centrifugal pump stations and this line has been in operation since January 1, 1929.

The first pipe line company mentioned is now engaged in building a line from McCamey in West Texas to tide-water at Houston, a distance of approximately 425 mi. According to present information, this line is to be motor-driven.

In most of the cases a specially developed centrifugal pump is used. The centrifugal pump has the advantages of non-pulsating delivery, ability to handle oils of various viscosities, ideal characteristics for booster service, and low first cost.

Several years ago, before this type had been developed for oil-line pumping, the only available centrifugal pumps for the deliveries and heads required were boiler-feed pumps. These were tried and it became immediately evident that they were unsatisfactory. Pump efficiencies were 55-60 per cent and this alone precluded their use in oil line pumping. The centrifugal pump manufacturers attacked the problem from all angles and the so-called "high efficiency" type of multi-stage centrifugal pump came into being. New theories of centrifugal pump design were developed; casings and impellers were redesigned; internal losses were analyzed and reduced as far as possible and the mechanical details received much attention. Stuffing boxes and bearings were redesigned, and from it all, came the present oil line centrifugal pumps with higher efficiencies than had even been hoped for just a few years previously.

As to the electrical features of the typical motor-driven pipe line station, there is no departure from modern substation practises. A wiring diagram of a typical station is shown in the accompanying illustration (Fig. 1). Greater attention perhaps has been paid toward the construction of flame-proof installations. Some of the companies favor separating the motor from the pump by means of metal fire walls; others install

1. Electrical Engineer, Magnolia Petroleum Co., Dallas, Texas.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

them all in one room. It seems that personal opinion of the engineers of each company determines the policy to be pursued.

Squirrel-cage induction motors are used in all cases. Motors have been of all standard voltages but the present trend is toward the use of 2200 volts on all motors above 50 hp. Oil circuit breakers are usually installed on incoming lines and these are provided with the usual overload, undervoltage, and over-pressure protection.

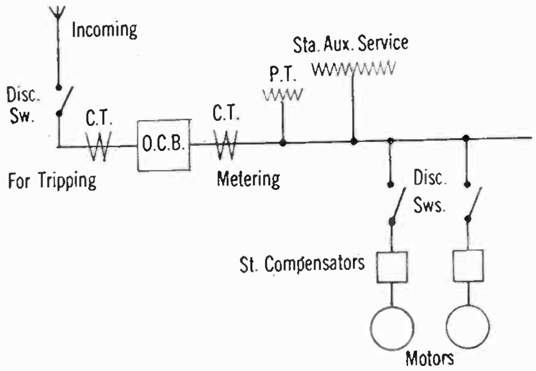


FIG. 1.—TYPICAL OIL PIPE LINE PUMP STATION

Oil line wiring diagram

As to the actual cost of moving oil through pipe lines by means of electric power, it is impossible to give any accurate figures unless all the conditions of service are known. The various factors, such as efficiency of motors, efficiency of pumps, friction of station piping, rate schedules, discharge pressures, etc., all enter into the final analysis.

Below will be found a tabulation of electric pipe line station performance, based on crude oil of 80 Sec. Saybolt Universal viscosity at 60 deg. fahr. and at a discharge pressure of 700 lb. per sq. in.

PIPE LINE "A"
Reciprocating Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
1	9	7,625,286	1,959,700	3.88
2	9	7,658,579	1,959,500	3.91
3	9	7,633,049	1,829,900	4.17
4	9	7,653,154	1,819,500	4.22

PIPE LINE "B"
Reciprocating Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
5	6	4,756,768	1,202,900	3.96
6	10	6,538,992	1,634,000	3.98
7	6	4,480,040	1,122,600	4.05
8	10	6,519,459	1,616,100	4.03

PIPE LINE "C"
Centrifugal Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
1	12	6,761,903	2,618,800	2.58
2	9	7,138,178	1,652,700	4.32
3	12	8,132,583	2,444,600	3.31

To meet the demands on their various generating stations and transmission systems, power companies serving the Southwest have had to make extensive additions, improvements, and extensions. Interconnections have been worked out and the service rendered has been, as a whole, very satisfactory to the pipe line companies.

In laying out transmission lines to serve pipe line loads, the importance of the absolute necessity to maintain continuous service must be considered. Pipe line systems having small ballast or surge tanks at each station do not provide storage capacity sufficient for an appreciable shut-down and a continuous supply of energy must be maintained at all times. To supply this demand, if at all possible, pipe line services should be supplied from a system having a two-way feed, with necessary switching apparatus to quickly sectionalize all transmission line faults.

As a source of constant revenue, pipe line loads are very desirable to the power companies. Revenues are the maximum on account of the high load factor. The average monthly load factor of one of the southwestern pipe lines for the last twelve months has been 86.6 per cent and from present indications it will continue as high for the next four years. These loads are desirable also on account of the ease of service. No extensive distribution facilities are necessary to secure the revenue. In many cases in Texas and Oklahoma, station locations are within sight of the transmission lines. As to the power factor of these loads, if the station is correctly designed, the motors driving the pump should be fully loaded and the power factor should be between 76 per cent and 87 per cent. Certain high-speed centrifugal pump motors, tested under field conditions, showed a power factor of 87 per cent. If the rate schedules contain a power factor clause with a penalty and premium rider, the use of condenser equipment by the pipe line company would be justified in most cases.

CONCLUSION

It is felt that the electrification of oil pipe lines is completely justified by the success of present installations. The time of installation is only half that required for Diesel engine equipment. The operators are easily trained to handle the electrical installations. Their operation on units of a transmission system having several sources of power is just as satisfactory as the present oil engine-driven stations. In general, shut-downs due to transmission line faults are less frequent than shut-downs due to failure of mechanical equipment. Cost of operation compares favorably with oil-engine driven stations. The near future will see many advances in pump construction and in electric pump station design and a consequent increase in over-all efficiencies.

Standard Voltage A-C. Network

BY JOHN ORAM[1]

Non-member

Synopsis.—The object of this paper is to present a description of the Dallas, (Texas,) underground network system. This system is of interest since it is directly opposed to the general trend of furnishing non-standard voltages in underground systems. The reasons for its selection and its advantages over the three-phase four-wire system are presented. A brief description of the installation of equipment in vaults and manholes is given. Another feature of this system is the use of standard reactance transformers together with an external reactor, shunted by a fuse, for purposes of overload protection to the transformers. In addition to the regular network this system has a single-wire manhole and vault lighting network which is also used as as a control wire for turning on and off multiple street lamps.

Another feature of this system is a complete underground telephone system with a telephone outlet in each manhole and transformer vault. This telephone system is also connected to float switches in transformer vaults which automatically notify the trouble office in the event of high water in a transformer vault. The routine tests made in connection with the operation of the network system are described and the method of locating primary faults is given in detail. Complete records are kept of the installation of conduit and cable. Photographic records of construction, operation, and cable failures, etc., are also kept. The record of this network system both as to efficiency and as to continuity of service is excellent.

* * * * *

THE principal characteristic of the Dallas, (Texas,) underground secondary network system is that it provides standard 115-volt service for lighting consumers and 230-volt three-phase service for power consumers. This is done by adding an 18-volt secondary coil to the standard 115-volt transformer coil and bringing out three leads on each transformer. With three transformers connected in "Y", the arrangement gives 115 volts for lighting and 230 volts for power service with a common symmetrically grounded neutral.

On account of the high primary voltage used and the relatively short distance of approximately one mile from generating station to load center no feeder regulators are required. The range of voltage regulation is about five per cent from no load to full load and the control of the generating station busbars by Tirrill regulators is adequate for this purpose. Since the major portion of the load follows quite closely that of the underground system and all other lighting service is controlled by individual feeder voltage regulators in substations, no interference with the remainder of the system is caused.

The Dallas network system covers an area of approximately 0.75 sq. mi. and consists of five 13-kv. underground feeders serving eighty-two 300-kv-a. transformer banks which supply two sets of secondary network cables, one being the lighting network and the other the power network. Automatic network units are used between transformers and the secondary network system. The principal load in the underground district consists of office buildings, theaters, department stores, and hotels. The average load density is 20,000 kv-a. per sq. mi. The greaest concentrated load is a hotel which consumes an average of 10,000-kv-a. hours every 24 hr.

The network system at present is designed for a normal maximum loading of 80 per cent on each transformer bank and an emergency loading of 100 per cent. This arrangement will permit the removal from service of any one of the five feeders without overloading the remainder of the system. The normal voltage in the secondary mains is 115 volts for lighting and 230 volts for power. The emergency voltage will average 110 and 220 volts for lighting and power, respectively.

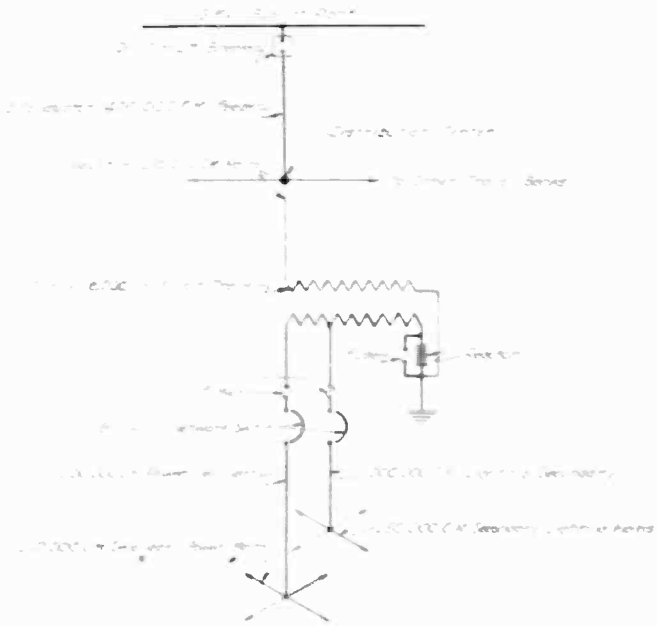


FIG. 1—SCHEME OF DESIGN OF DALLAS UNDERGROUND NETWORK

The system is composed of three-conductor, 400,000-cir. mil 13-kv. primary feeders, 250,000-cir. mil 13-kv. primary mains, 100-kv-a. 8000-115 133-volt transformers, automatic network units, 250,000-cir. mil secondary power cables, 250,000-cir. mil. secondary lighting cables, and a 500,000-cir. mil bare neutral.

The decision to use two sets of mains was made after a careful consideration of investment costs, operating costs and quality of service to be rendered. It was primarily because of the superior quality of service provided that the seven-wire system was adopted

1. Chief Engineer, Dallas Power & Light Company, Dallas, Texas.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

Previous to the installation of the underground network system the customers of the Dallas Power and Light Company had been furnished with standard 110-volt lighting and 220-volt power service. With the thought of good service and public relations in mind, some secondary network system was sought which would

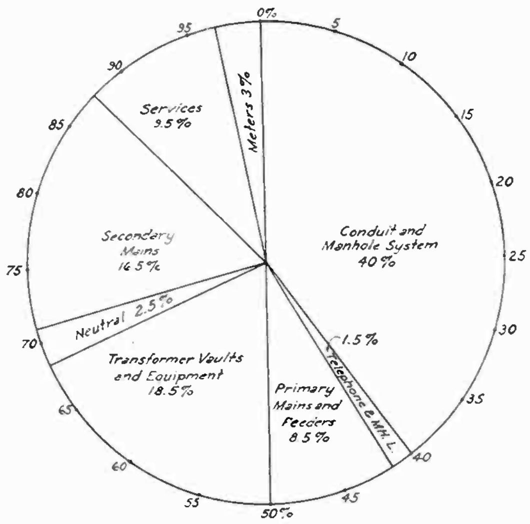


FIG. 2—CHART SHOWING DISTRIBUTION OF COSTS OF DALLAS UNDERGROUND NETWORK SYSTEM

continue to furnish normally standard voltages on both light and power mains. Investigation showed that the additional costs of the secondary portion of the system were offset by the better service provided and the saving in customers' equipment. Fig. 2 shows the comparative investment costs between the several major portions of the underground network system.

In addition to furnishing standard voltage to both lighting and power services the seven-wire system has the advantage that, since two separate sets of mains are used, fluctuations due to the power loads do not

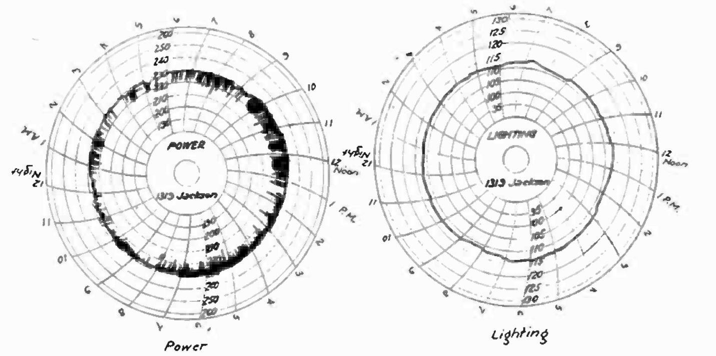


FIG. 3—TWENTY-FOUR HOUR VOLTAGE CHARTS ON POWER AND LIGHTING MAINS TAKEN AT SAME LOCATION

cause flickering of the lights. The absence of flicker on the lighting system may be observed from the voltmeter charts shown in Fig. 3, taken simultaneously on lighting and power services in the same distribution box. There is no limit to the size of motor that may be operated from the network system, and motors up to and including 30 hp. may be started directly across the line without the use of starting compensators. In this way the economy resulting from the simplicity, high performance, and balanced design of the common squirrel-cage motor is retained, together with greater flexibility in application where remote control is desired.

Another feature of this system is that standard reactance transformers are used with an external reactance installed in the neutral leg of each transformer, so arranged that the reactor is normally shunted by means of a fuse, thereby providing good regulation and lower secondary losses during normal operating conditions. When, however, an overload occurs on a transformer bank, due to feeder outage or other abnormal conditions, the fuses blow and thereby insert the external reactance in the circuit and relieve the transformer of part of its load.

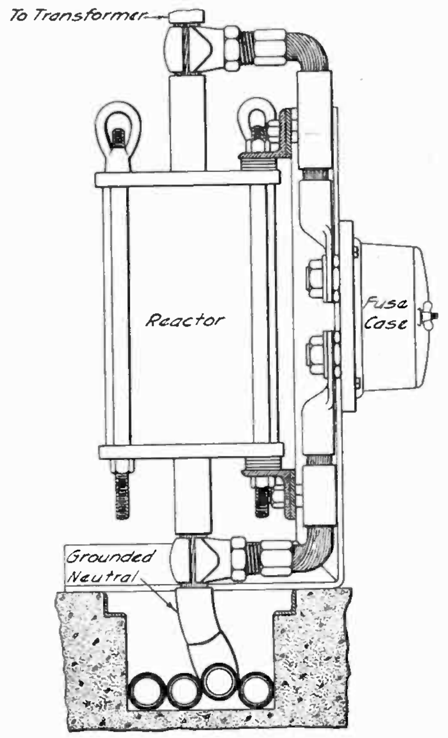


FIG. 4—FUSED REACTOR FOR TRANSFORMER PROTECTION

The transformers are installed in vaults either built by the Dallas Power and Light Company, or if in building basements they are in accordance with Dallas Power and Light Company specifications. In either case the only opening to the vault is through a manhole cover, 20 in. in diameter, built into a removable concrete panel 4 ft. wide, by 5 ft. long, placed in the sidewalk next to the curb. The castings in the panels allow men and small equipment to enter the vault with ease. If necessary to replace transformers or network switches the panel is removed. Each vault is ventilated by two 28-in. square ducts with openings in opposite ends of the vault, one near the ceiling, the other near the floor. Both ducts terminate on the sidewalk next to the curb and are covered with gratings.

The equipment in a transformer vault consists of three transformers, two network switches, primary cables, secondary cables, three reactors, a condulet each for telephone and lighting service, and miscellaneous equipment such as a ladder, manhole guard, and covering for cable trenches. The primary cables enter the vault in one of the lower ducts and are racked on wall insulators to the transformers. The transformers are placed on T-rails imbedded in the concrete floor. The secondary leads are trained vertically from the transformer terminals to the secondary cable trench in the floor. The secondary power and lighting cables extend in separate trenches to the wall on which the network switches are installed. The 1,000,000-cir. mil secondary cables are extended from the upper

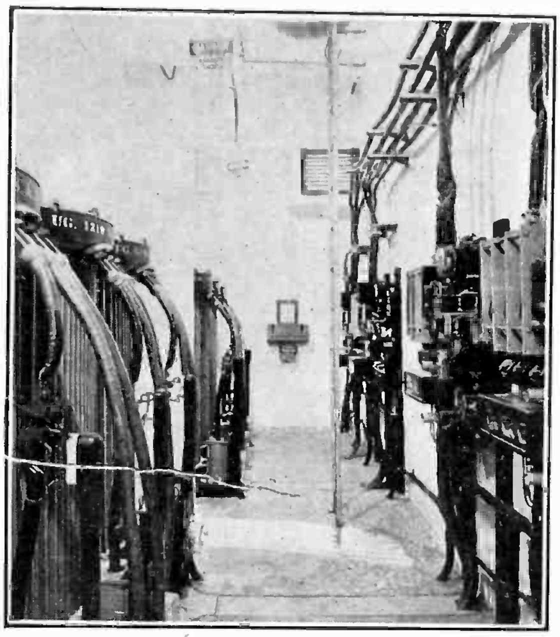


Fig. 5—Typical Double Transformer Vault

terminals on the network switch to the secondary network in the street. The secondary cables are racked separately from the primary cables.

There are at present 84 submersible and 80 non-submersible network switches in operation on the Dallas system. Of the submersible units 72 are solenoid operated and 12 motor operated; all use single-phase relays in air bells which are mounted on the wall of the vault. This arrangement facilitates maintenance and provides better ventilation of the relays. No phasing relays are used on the foregoing units. Of the non-submersible units 78 are solenoid operated equipped with single-phase relays and phasing relays, and two are motor operated equipped with three-phase relays and phasing relays. Few difficulties in the operation of the network switches have been en-encountered from unbalanced loads and elevator re-generation. These have been overcome by using three-phase relays or otherwise.

Although secondary network system in general consists of 250,000-cir. mil lead covered cables on cross streets or between important loads, additional 500,000-cir. mil cables are sometimes installed. The secondary neutral is grounded in each transformer vault and serves as a primary neutral.

The secondary services are extended to the customers building line in 4-in. fiber conduits, one each for power and lighting services where both are required. The conduits are terminated in a distribution box placed in the outside building wall, or iron conduit of reduced size is carried up the building wall about 12 ft. and terminated with a condulet. A panel is installed in the distribution box and both power and lighting services are connected to this panel. If it is not possible to install the distribution box, the customers' outlets are grouped on the outside wall at the first floor ceiling line. The cables used for services are single-conductor, 600-volt, paper insulated, and vary in size from No. 6 A. W. G. to 500,000 cir. mil.

In addition to the secondary and primary mains in the duct lines there are telephone and manhole lighting cables with outlets in each manhole and vault. The manhole lighting cables are No. 6 A. W. G. and form a secondary network with 115 volts to ground which is used by the workmen for lights, blowers, soldering pots, and other general conveniences. This network is connected to the main secondary lighting network through a fuse and switch, and is so arranged that in addition to serving as a manhole lighting system it will also serve as a pilot wire for controlling a proposed multiple street lighting system in the underground area.

The telephone system is in the same conduit as the manhole lighting cable. It consists of two 26-pair cables which extend from the switchboard in the Trouble Division's office to central locations, and branch out into two-conductor No. 14 lead covered cables. These two-conductor cables are installed on the main streets so that each manhole and vault has a telephone outlet.

The telephone system is also used as a signal system to give warning of water in transformer vaults. This is accomplished by connecting a coil of No. 4 bare copper wire in a porcelain housing to the ungrounded side of the telephone circuit. The device is installed in transformer vaults about six inches above the floor. When water reaches a level of six inches or more the telephone cable is short-circuited and a light signals the operator in the Trouble Office.

In the operation and maintenance of the network system certain routine tests and inspections are made. The vaults are inspected regularly and all dirt, paper, and other accumulations removed from the ventilator pits and floor. Oil samples from all transformers are taken once each month and tested for dielectric strength. The oil level in the transformers is observed and if necessary oil is added. The oil in each transformer is filtered at least once a year regardless of its dielectric strength. Each network switch is inspected weekly and the number of operations recorded. An inspection of network switches is made each month.

They are cleaned and adjusted, and repairs are made if necessary.

To test the operation of network switches, feeders are removed from service once each week during the light load period, by opening the circuit breakers at the Generating Station. If the feeder is not automatically deenergized when the breaker is opened, a trouble man is sent out to see which network switch has failed to open. A signal system installed in each vault saves the trouble man much time in locating the faulty switch. This signal system consists of a 125-volt lamp installed in the ventilator so that it can be seen by the trouble man without getting out of his car. One terminal of the lamp is connected to ground and the other to a lighting phase through an auxiliary switch that closes only when both network switches are open. A signal lamp not burning indicates that a network switch is closed. If faulty the switch is locked open until repaired.

In the location of primary faults special equipment is used. The apparatus is installed at the Generating Station and consists of a 50-kv-a. 440/8000-volt step-up transformer and 8000-volt, 15-ampere reactor. The procedure followed in locating a fault is to manually lock open each network unit on the feeder in trouble, disconnect the feeder at the Generating Station and connect the reactor to the faulty conductor until it is broken down to ground. With a split-core instrument transformer and low reading ammeter the current sent out over the cable is traced to the fault location.

Detailed records of underground installations are kept under five general classifications, *viz.*: (1) Duct Line Records, which are in the form of drawings showing a plan and profile of the duct lines together with the location of all substructures adjacent thereto; (2) Manhole Records, which are also drawings giving the location and details of construction of each manhole; (3) Cable Records, which give the location, size, date installed, and other data pertaining to each cable in each manhole; (4) Transformer Records, which gives the purchase specifications together with a complete history of each transformer; and (5) Service Records, which is a section map of the city showing the location and size of each lighting and each power service.

Records are kept of all equipment failures which includes a detailed description of the failure together with a photograph of the faulty apparatus where possible. Included in these records are cable failures, transformer failures, network unit failures, etc.

During the year 1928 the average efficiency of the underground network system, as calculated from watt-hour meter readings at the Generating Station and those on customers' premises, was 95.5 per cent. The average annual power factor was 0.90 and the load factor 0.50. Approximately 36 per cent of the energy distributed was power and 64 per cent lighting.

The operation of the system since its installation has been successful. The voltage regulation has been good and there have been practically no complaints. The record with reference to continuity of service, like that for voltage regulation, has been satisfactory. The completed network system has been in operation nearly two years and during that time no customer has been out of service. A number of faults on primary cables has occurred, but in each instance the trouble has been automatically and successfully cleared without interruption to service. Secondary cable faults burn clear without noticeable effect on the service.

STUDENT ENGINEERS SHOULD STUDY PSYCHOLOGY

Though an engineer now occupies the White House and the present is often referred to as the engineer's age, engineering graduates are earning small salaries. At the same time, the feeling of a lack of engineers all over the country persists.

Speaking about this puzzling situation, C. F. Kettering, general director of the General Motors Research Laboratories, stated in a recent talk before the Cleveland Section of the Society of Auomotive Engineers that engineering education fails to prepare the student for his real work because it does not teach him enough of economics and psychology. As a result, the young engineer cannot sell his ideas; he becomes discouraged and drifts into other lines of work where the rewards seem to be greater and more immediate. For instance, only 6 out of 37 graduates in electrical engineering in a single class were found to be practising electrical engineering 10 years after graduation.

To fit engineering graduates into industry, they should be put on a job that is similar to what they were studying in college, Mr. Kettering suggested, and be given a chance to become acclimated to industry and to assume a more important position.

Many engineers have not yet learned to use their imagination. We find in industry a question as to what the future demand will be, and the engineer should have enough imagination to see that the thing of tomorrow will be different from that of today.

Bankers, said Mr. Kettering, are interested in the engineer as never before, because they say that he is upsetting the stability of business, but the whole object of research is to keep everyone reasonably dissatisfied with what he has in order to keep the factory busy making new things.—*S. A. E. Journal.*

J. Tribot Laspière, director of the International Conference on Large Electric High-Tension Systems, which will hold its biennial meeting this year at Paris on June 6 to 15, reports that 380 members from 21 countries have already been enrolled. It is anticipated that the attendance of the 1927 session will be exceeded.

Abridgment of

Automatic Transformer Substations
Of the Edison Electric Illuminating Company of Boston

BY WILLIAM W. EDSON[1]
Member, A. I. E. E.

Synopsis.—*The Edison Electric Illuminating Company of Boston has adopted a policy of numerous relatively small automatic a-c. substations located at the various individual load centers, this policy being enhanced by the development of a new method of automatic control and by the standardization of the station design.*

The rating of a substation is based on the sum of three specially designed transformers each having an inherent 50 per cent overload capacity. Thus, the maximum load is normally carried by the three units operating at their nominal 100 per cent rating, but in emergencies the load can be handled by two banks, the transformer out of service, representing only 33 per cent of the station capacity instead of 50 per cent as in the usual case.

The automatic control consists essentially of load-current relays which switch in or out the follow-up transformers as needed. This operating point for maximum station efficiency equals $\sqrt{\dfrac{2 \times \text{core losses per bank}}{\text{copper losses}}}$. *Serious trouble on any bank will bring in the succeeding transformer. Each transformer has its own sequence switch so that it may be made leading, follow-up, second following, or manual, irrespective of the set-up for the remaining units. The simplicity of this control equipment is particularly interesting, in fact only the current control and one auxiliary relay are directly chargeable to the automatic control. The circuits and apparatus have several special features promoting safety and reliability.*

The construction of these stations has been standardized by the development of standard "blocks" complete in themselves and suitable for being arranged or added, as desired. Thus, for each transformer section there are four types of blocks—high-tension, low-tension, regulator and switchboard. Such an arrangement offers the advantages of complete segregation of equipment, flexibility in station layout, efficient provision for growth, standardization of engineering and construction, and the satisfactory use of complete bills of material.

This system of control and standardization of construction has been applied to five new automatic transformer substations in the last two years, and the results have been very satisfactory.

* * * * *

THE rapid growth and expansion of the electrical distribution system of The Edison Electric Illuminating Company of Boston has dictated a policy of numerous relatively small automatic a-c. substations located at the various individual load centers. Such an arrangement results in reduced line and feeder losses, better voltage regulation, improved reliability of service, closer balance between the load and the transformer capacity in service, and in a more efficient building program for the substations.

The value of this policy was materially enhanced by the development of a new method of automatic control which was much simpler in both design and operation than the previous schemes. In the last two years, the adoption of this control, along with the standardization of station design, has been applied to five new automatic transformer substations and the advantages are quite apparent.

Station Capacities

The ratings of these stations are based upon an ultimate of three units, and vary from 5000 to 15,000 kv-a. depending on local requirements, these differences being easily met by selection of the number and sizes of the transformers without detracting from the principles of standardization. Closely associated with this question of unit sizes is the special design of transformers developed some years ago for the Edison Company.

First of all, it is essential that a station be able to carry its full load in event of failure of one of the units. Formerly this contingency was met by installing the three transformers of such size that two at full rating could carry the load. This meant that under normal conditions one unit (50 per cent of station rating) and its switching equipment was out of service, which represents an economic loss.

Under the Edison Company's arrangement this situation is met by selecting a smaller size, such that all three would be used in carrying a full load. At a slight additional unit cost these transformers are given a 50 per cent overload capacity by increasing the copper and the cooling surface, so that if necessary any two could carry the full load without exceeding the normal 55 deg. cent. temperature rise. Of course the efficiency of these units would be reduced somewhat during this overload, but as this is an emergency condition the loss in kilowatt-hours is negligible.

Description of Station

For a 10,000-kv-a. station, for example, there are three 3500/5250-kv-a., three-phase, delta-star transformers having their maximum efficiency at 75 per cent (probable normal load) of their nominal rating of 3500 kv-a.; that is, at 2600 kv-a. Each bank has a high-tension bus section supplied by two 13,800-volt lines, these sections being connected by bus-tie breakers normally closed. The bank supplies a main and auxiliary bus having six 4000-volt, four-wire ungrounded neutral, regulated, automatic reclosing feeders. The low-tension bus-tie breakers are normally closed, but they trip automatically in case of a feeder fault if all

1. Station Engineering Dept., Edison Electric Illuminating Co. of Boston, Boston, Mass.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

29-76

three banks are in service, thereby, reducing the rupturing duty on the feeder oil circuit breaker.

Only two of these banks, however, are installed initially as the station load at first can be carried by one bank in an emergency.

Automatic Transformer Control Design

In designing the automatic operation of an automatic transformer substation the following procedure may be followed: (applies equally well to any type of automatic control)

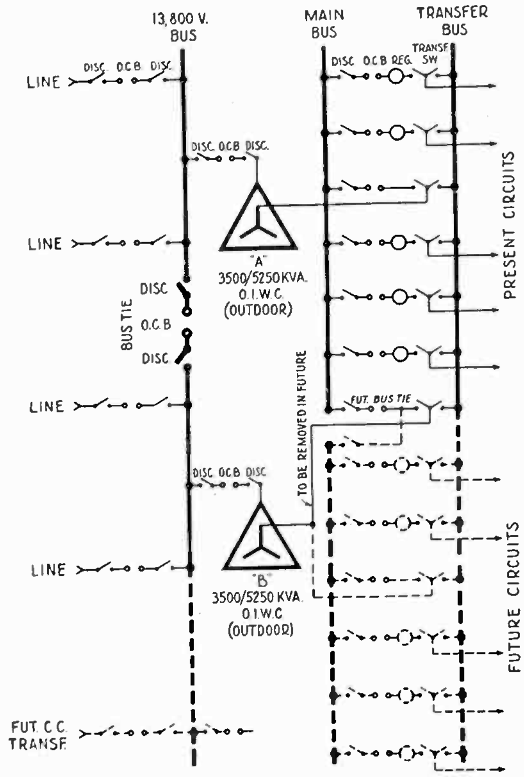


Fig. 1—Single-Line Diagram of Humboldt Avenue Station

1. The size and number of the various units and the one line diagram of the station are first established.

2. A list of the desired operating features is then discussed and agreed upon by the various interested departments of the company. Incidently, as for any type of automatic equipment, this is the real deciding factor leading to successful operation.

The equipment must be able to perform in general the duties of an operator in an accurate, safe and reliable manner, but there is a surprisingly large number of requirements which may safely be eliminated.

3. The third requisite in the designing of an automatic station is the collecting of the individual relay circuits into a combined diagram which is simple, efficient and safe. Three items must be kept in mind while studying this completed diagram.

a. Does it meet all of the operating features and control requirements?

b. Are there any short circuits or stray currents under any possible combination of relay or switch operations? Any amount of time spent on this study will be amply repaid when the set goes into operation. Even then, actual service will develop unexpected stray circuits, but these can be mitigated.

c. Can the installation be simplified, such as by assigning several duties to one relay, collecting various circuits to the same set of relay contacts, or by arranging the contacts so that the number of wires leading to an item of equipment is reduced to a minimum?

The schematic diagram is essential as each individual relay circuit can easily be followed and studied.

Some form of sequence chart is also of great help as it serves as a "slow motion" picture of the status at any operating step; that is, it shows the cause and result of each operation.

Operation

The system developed and adopted by the Edison Company performs as follows:

a. For light-load conditions, one transformer carries the load. As the load increases, the other banks cut-in automatically as required. The two properties available to control such operation are the transformer temperatures or the station load. The first is not entirely suitable as the temperature usually lags too far behind the load, it is not independent of the weather conditions, and the present temperature relays are somewhat delicate and difficult to keep in adjustment.

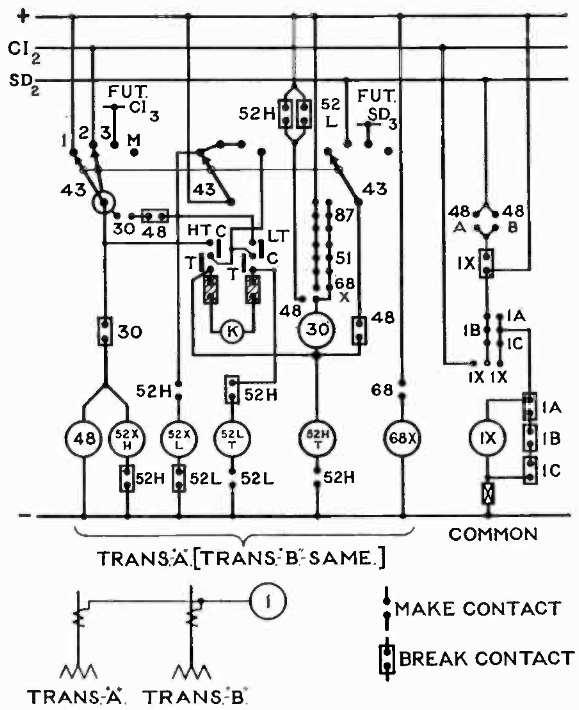


Fig. 2—Schematic Diagram of Transformer Control

The second method (station load) offers better results as the current relays already developed are quite accurate and reliable. Another important advantage is that the transformers can be operated nearer the best over-all efficient point. For example, these cut-in relays can be set at a point where the core and copper losses of one transformer equal the total losses of two transformers. Expressed mathematically this most efficient point to bring in the second bank equals $\sqrt{\frac{2\ L_i}{L_c}}$ where L_i is the core or zero load losses of one transformer and L_c is its full load copper losses.[2] This point averages

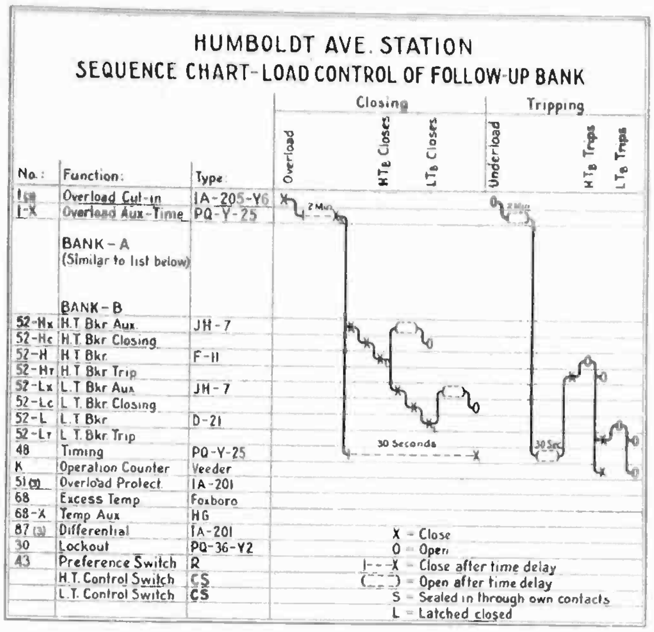


FIG. 3—SEQUENCE CHART—AUTOMATIC STARTING

approximately 105 per cent of the nominal rating (70 per cent of total) for the transformer used, which means the banks are always cool and available for unusual demands.[2] Since there is little occasion for the transformers to be overloaded (which often occurs with temperature control) the voltage regulation is materially improved.

The relays used for this control (one in each phase) are the G. E. Type IA, the overload contacts being connected in parallel and the underload, or back contacts, being in series. The latter operate at about 90 per cent of the cut-in value. An auxiliary timing relay, Type PQ set for two minutes is used to prevent too frequent operation on a surging load and to reduce the wear on the contacts of the current relays.

In case of overload the cut-in bus is energized, which will bring in any bank or banks whose preference switch is connected to this bus. The auxiliary closing contactor is energized and the high-tension oil circuit breaker closes, which in turn sets up the closing circuit for the low-tension breaker. It will be noticed that when the cut-in bus was energized the protective timing relay No. 48 began to close. By the time it completes its stroke, the high- and low-tension breakers should be closed but if not, or if one drops out due to latch trouble, a tripping circuit is set up and the transformer is locked out.

When the station load decreases the shut-down bus is energized. At the same time the cut-in bus is deenergized which allows No. 48 timing relay to open. When it completes its operation the tripping circuit for the high-tension breaker is completed and this breaker opens, followed in turn by the low-tension breaker.

A similar set-up would be used to control the third bank through a second set of cut-in and shut-down busses.

b. The question of safety and reliability assumes special importance in a non-attendant station. These are met in the Edison system by providing each transformer with differential protection relays, excess overload relays, maximum oil temperature relays and an over-all checking relay to insure that the circuit breakers do not drop open or pump. Any of these faults operate the lock-out relay No. 30 and trips both breakers.

There are also several inherent features of design which promote safety; such as, only one polarity is taken to the circuit breaker auxiliary switches or to the relay contacts, all relay coils are for continuous duty, no contacts are subjected to unsafe carrying or breaking currents, interlocks are included to make the high-tension breaker close or open before the low-tension breaker, thereby reducing high-tension voltage stresses, the various circuits are arranged so that improper operation of set-up or manual control switches cannot do any harm, and the number of relays is reduced to a minimum.

c. A second operating requirement calls for the

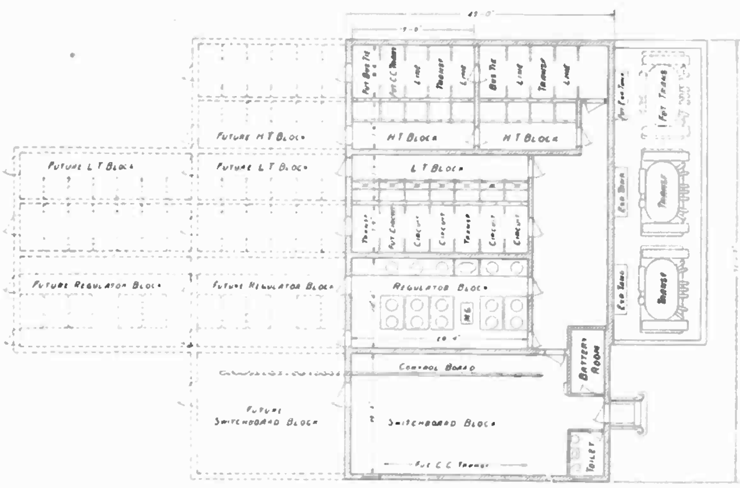


FIG. 4—PLAN OF HUMBOLDT AVENUE STATION

transfer of load to another transformer in case one of the banks is in trouble. This is accomplished by energizing one of the above mentioned cut-in busses by means of the transformer lock-out relay. Here again time is introduced (approximately 30 sec.) before the alternate bank restores the system for the same reasons that timing is used on the automatic reclosing breakers on the low-tension circuits.

Lock-out relay No. 30 removes potential from relay No. 48 which after a time delay drops open. This completes the circuit through the preference switch to energize the cut-in bus which will bring in the next transformer in a similar manner as above.

2. See appendix, complete paper.

d. Full selectivity is provided by giving each transformer its own sequence switch so that any bank may be made first, leading; second, follow-up; third, alternate; fourth, out. Manual control switches are connected to this fourth position as a matter of uniformty in operation between stations otherwise they could be omitted. It will be noted that any of the transformers can be operated independently of the others. For example, one may be under manual control and the rest automatic, or if desired, two may be set up to operate in parallel as a group thereby permitting two smaller banks to operate as a unit and reducing the number of operating cycles.

1. A high-tension block for the two incoming lines, the 13,800-volt bus and its tie breaker, and the transformer high-tension breaker.

2. A low-tension block for the transformer low-tension breaker, the main and transfer busses with their breakers and disconnects, and the 4000-volt feeders.

3. A regulator block for the feeder induction voltage regulators. The battery motor-generator set and the station power and lighting transformers are located in the space opposite the bus-tie cell.

4. A switchboard block for the control switchboard, battery room, toilet, and the constant current lighting transformers if used.

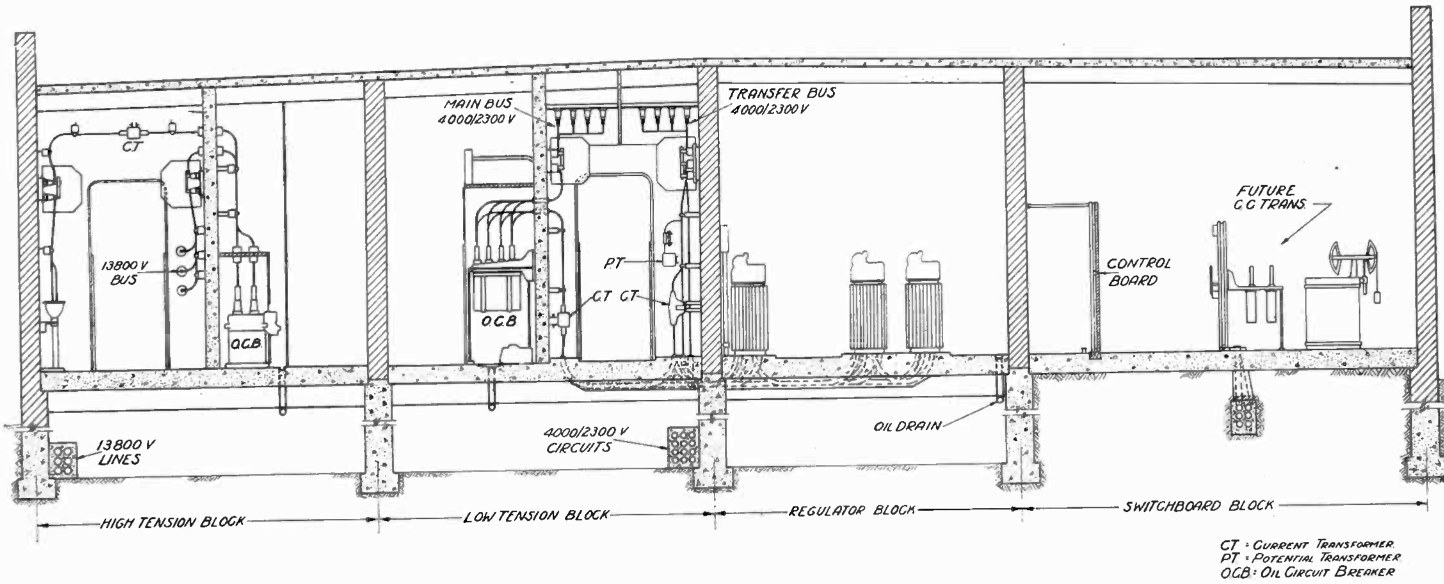


FIG. 5—CROSS-SECTION OF HUMBOLDT AVENUE STATION

MISCELLANEOUS AUTOMATIC FEATURES

The manufacturer's method of automatically reclosing feeder circuit breakers has been revised somewhat to include the safety features and simplicity referred to above.

The battery charging motor-generator normally floats on the control battery, but it will shut down in case of certain faults and will restart when conditions become normal.

A signal is sent over leased telephone wires to the nearest manually controlled station to indicate the opening of any line or feeder circuit breaker, the lock-out of any transformer, or a ground on the 4000-volt system. This latter indication is accomplished by means of a CV voltage relay connected between the system neutral and ground.

STATION DESIGN

The construction of these automatic substations has been standardized as far as practicable. The basic feature which permits this standardization of construction is that the station is divided into "blocks," complete in themselves and suitable for being arranged or added as desired.

For each transformer section there are four such blocks:

ADVANTAGES OF THE BLOCK DESIGN

a. Complete segregation, the blocks themselves forming natural fireproof subdivisions.

b. Flexibility in arrangement to meet land or neighborhood conditions.

c. Efficient provision for the growth of the station by the addition of blocks as needed.

d. Standardization of construction, resulting in the simplification of the preliminary load, land and cost estimates as similar information from previous stations is at hand, the betterment of the price and delivery for the purchase of the equipment due to duplication of former orders, and the decrease in the time and cost of the design installation and operation of the station. Incidently, it is an advantage to know in advance that the completed station and its operation will be satisfactory to the various departments concerned as the individual standards have already been tried in service and approved.

e. Satisfactory use of an itemized bill of material, this list being grouped in accordance with the station blocks and giving such information as may be needed during the various stages of engineering or construction.

MISCELLANEOUS CONSTRUCTION FEATURES

Each high- and low-tension block is divided by an eight-inch concrete fireproof wall so that the oil circuit breakers are in one compartment while the busses disconnects and instrument transformers are in the other. Metal lath and plaster cell walls two inches thick separate the equipment per circuit. The regulator room and breaker cells are drained to prevent spreading of any possible burning oil. There is no reinforcement or other steel work carried over between cells. The ground busses are run on insulators to prevent fault currents passing through the structure.

The cell wiring is flame-proof varnished cambric cable. The high- and low-tension cables running to the outdoor transformers have oil-filled potheads to prevent leakage of oil from the transformers which are of the "industrial" oil pothead entrance type. This latter construction eliminates all outdoor structure.

An individual ventilating fan is provided for each compartment so that any room can be quickly cleared of smoke or gases after a fire.

Individual automatic electric heating units with circulating fans are installed in each room for general heating and for preventing condensation.

The general illumination is by alternating current, but floodlights and certain lighting circuits are on a manually operated change-over switch to the battery for emergency use.

Figs. 1, 2, 3, 4 and 5 apply to the Humboldt Avenue automatic substation but the other four stations follow the same general design except for variations in assembly of the "blocks." For example in the Arlington Substation the switchboard and regulator blocks are located on the second floor.

The construction and operation of these stations have been very satisfactory and it is expected that this type of design will be continued in future stations.

Abridgment of

Guarding and Shielding for Dielectric Loss* Measurements on Short Lengths of High-Tension Power Cable

BY E. H. SALTER[1]

Associate, A. I. E. E.

Synopsis.—*This paper presents the results of investigations made to explain the wide differences found between dielectric loss measurements made on full-reel lengths of cable and on samples (10 ft. net length) removed from these reels. At least one source of such differences is found in losses occurring at the ends of the cable, these losses being insignificant in the case of the full reel but amounting to as much as 100 per cent of the loss in the normal sample. Methods of determining, controlling and eliminating these end losses are described.*

* * * * *

Introduction

WITH the advent of low-loss insulations, it has become necessary to make measurements of dielectric loss and power factor of power cables with greater accuracy and refinement. Since a large proportion of the measurements of this nature are made on comparatively short lengths of cable (10 ft. net length under sheath), the question has often been raised as to what influence the end conditions in these specimens might have on the results obtained.

General

At the Regional Meeting held in Pittsfield, Mass., May 25-28, 1927, Mr. C. L. Kasson presented a paper entitled *High-Voltage Measurements on Cables and Insulators*[2] in which he pointed out that in measurements with high continuous potentials and high single-phase alternating potentials, very large errors might occur due to corona formation at the cable ends and on the lead wires. He showed how, by complete electrostatic shielding and guarding of the sample under test and the instrument circuit, these losses might be eliminated from the measurements.

Such shields and guards have been in use for some years in laboratories making dielectric loss and power-factor measurements on short lengths of cable, where, to accomplish this end, it has been the practise to use the tank of the supply transformer as a shield for the transformer, to use lead-covered power cable for high-voltage leads wherever practicable, to screen the cable sample (and the air condenser, when used) and to use shields on all leads to the measuring instruments, these shields often surrounding the instruments as well. The proper use of such precautions eliminates practically all effects due to direct leakage (conductance leakage) and to capacitance connections between high- and low-voltage circuits. All of the above mentioned have to do chiefly with the equipment for making dielectric loss measurements. It is the purpose of this

*Part 4 of a Symposium of six papers on Shielding in Electrical Measurements.

1. Engineer, Cable Research, Electrical Testing Laboratories, New York, N. Y.

2. A. I. E. E., TRANS., Vol. XLVI, 1927, p. 635.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

paper to discuss certain conditions relative to the samples, as such, which have been found to play a large part in the results obtained in these measurements.

In test work, power cables fall into two general classifications; *i. e.*, single-conductor cable and multi-conductor cable. For power service, most multi-conductor cable is three-conductor. There are then two general types of three-conductor cable, according to construction; *i. e.*, the belted type and the shielded-conductor type. Each of these three groups represents a slightly different problem in preparation for test. They will be dealt with here in the order named.

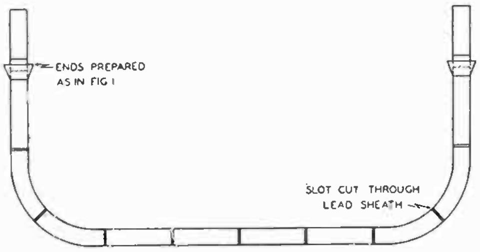


Fig. 2—Distribution of Sections for Power-Factor Survey Along Normal Sample

Guarding the Single-Conductor Test Specimen. Tests on a number of samples in which lead sheath was slotted at 1-ft. intervals throughout its length, as shown in Fig. 2, showed the end sections to have extremely high power factor and ionization factor. This condition, while not always serious before heating the sample, was found to be quite pronounced after heating to 100 deg. cent. and cooling to room temperature. This condition is illustrated by Figs. 4 and 6 showing the results of tests at room temperature before and after heating to 100 deg. cent.

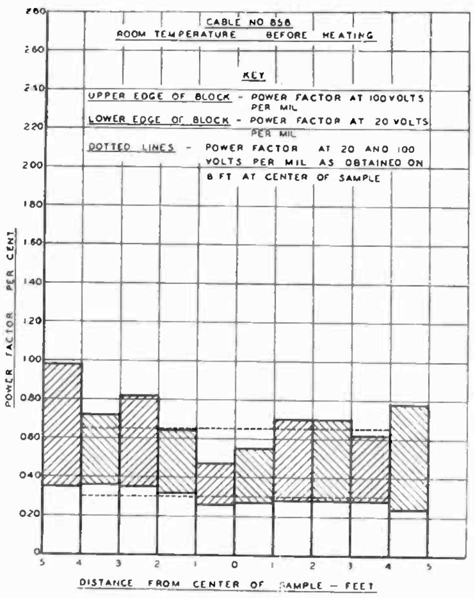


Fig. 4—Single-Phase Dielectric Loss Measurements

Power-factor variation along length of cable

It will be noted from Figs. 4 and 6 that the 1-ft. sections at the ends of the specimen are for the most part the only ones showing any considerable change in power factor. In these end sections, the impregnating compound is, to a certain extent, open to the air so that the increases found are likely due to air absorption with possible oxidation of the compound while at the higher test temperatures.

The method of eliminating these end losses from measurements on a length of cable is almost self-evident in an examination of the results shown; *i. e.*, eliminate these 1-ft. sections at the ends from the test circuit by making them a part of the guard or shield circuits. This, then, means that in preparing such a sample for dielectric loss tests, circumferential slots are cut through the lead sheath at least 12 in. from each end. These slots are filled with insulation and sealed against loss of oil when the cable is heated. The central section of lead sheath then forms the test electrode while the isolated sections at the ends are used as guards.

Guarding the Belted Three-Conductor Test Specimen.

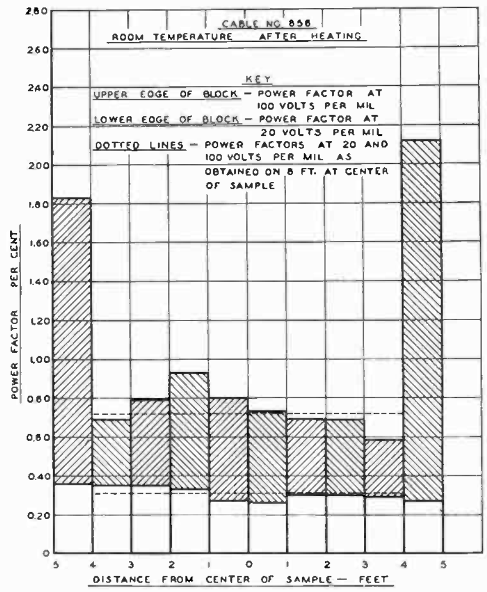


Fig. 6—Single-Phase Dielectric Loss Measurements

Power-factor variation along length of cable

Dielectric loss tests may be made on three-conductor cable with either three-phase potential, obtaining the loss directly, or with single-phase potential, computing the loss from the results of a series of tests. While the tests described below were all made with three-phase potential, it is felt that the findings are equally applicable to tests made with single-phase potential.

In addition to end losses of the type found in the single-conductor cable, and which it is felt must likewise be found in the three-conductor cable, there is the loss due to the inter-phase capacitance of the end connections. This loss has become increasingly significant, particularly in the case of the higher-voltage cables where ionization of the air in the crotch space of the cable gives visible signs of the loss in the form of corona.

In order to determine the magnitude of these crotch losses and to find the most effective method of preparing the ends of specimens to render these losses negligible, a series of specimens was prepared and tested as follows:

A. With the ends prepared as shown in Fig. 7.

B. With the cambric joints and cable ends covered with metal foil down to the old band guards.

C. With the belt insulation cut back even with the end of the lead sheath and the guards used in B extended all the way down into the crotch.

D. With a sheet metal guard, about four inches long, placed around each conductor and well down in the crotch space.

The results of measurements under the above conditions are shown in Fig. 12. Apparently, shielding against corona loss in the crotch space (the four inches adjacent to the end of the sheath) reduces these end losses to a point where their significance in commercial measurements is negligible.

Guarding the Shielded Three-Conductor Test Specimen. The problem of guarding the ends of the short specimen of shielded three-conductor cable is much the same as that of guarding the ends of the belted three-conductor cable. In both cases the problem is to prevent corona formation in the crotch and to reduce the loss between conductors. The studies of end conditions in the shielded conductor cable followed much the same lines as the studies of the belted cable. Due to the type of construction, the crotch losses are much more readily controlled, however.

Conclusions

The investigations of end losses in dielectric loss tests of short specimens of high-tension power cable

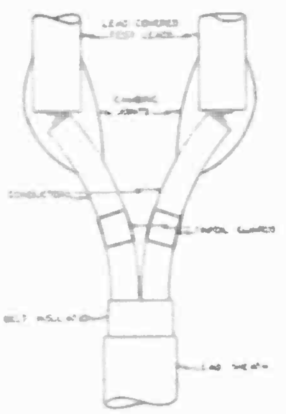


Fig. 7—A Method for Testing Crotch Losses

appear to indicate that the most satisfactory methods of minimizing these end effects are to be found in the following methods of preparing the test ends.

1. Single-conductor cable is most effectively guarded against end losses by isolating about 12 in. of cable at each end of the specimen for use as guards. When making temperature runs, the slots in the lead sheath incident to this preparation must be filled with insulation and sealed against oil leakage. The best slot width is approximately 1/8 in., narrower slots being difficult to maintain and wider slots affecting the loss measurements due to the fringing field from the slot edges.

2. Three-conductor belted type cable is practically free from corona loss in the ends if the samples are prepared with the belt insulation cut off even with the sheath end and guards 4 to 6 in. long are placed well down in the crotch. For most effective placing of the guards, it is advisable to make them of tin-plate or some similar stiff material which can be driven down into the crotch. A thin layer of varnished cambric

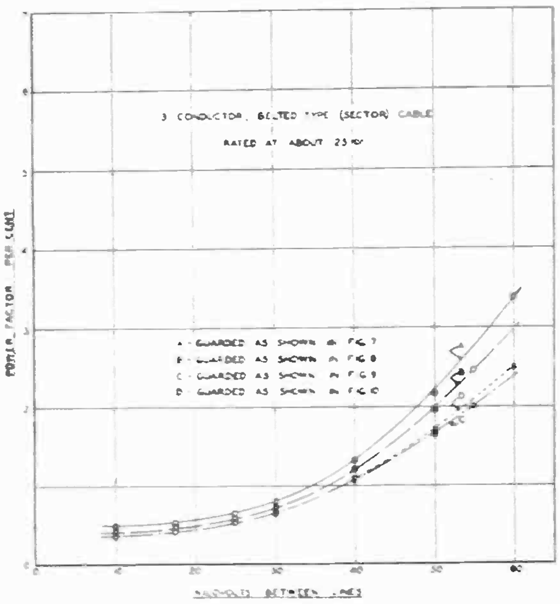


Fig. 12—Variations of Power Factor with Voltage

placed over the guards before inserting serves to insulate them one from the other.

3. The simplest scheme of preventing crotch losses in the shielded three-conductor cable is to leave the metal-foil on the individual conductors beyond the crotch space, a matter of 4 to 6 in. Narrow band guards placed above the ends of the metal foil then take care of surface leakage.

RADIO PERMITS TALKING FROM MOVING TRAIN

A new method of radio-telephonic conversation between a moving train and a stationary instrument is announced from Canada, where it has been successfully carried out on the Canadian National Railway lines. The new device throws the voice from the train to the telegraph wires which line the right-of-way of every railroad. It is then carried to the terminal point and there connected with the ordinary telephone lines. This process is reversed as regards the other participant in the conversation. As the system now stands, the terminal points must be not more than about 150 miles apart or the voice is lost. A two-hour conversation was held in this way on May 5, and several points of advantage over the German system are claimed. Experiments in perfecting the system were carried on by J. C. Burkholder, formerly with the Bell laboratory at Newark, N. J.—*Electrical World.*

Abridgment of

Precautions Against Stray-Field Errors in Measurements with Large Alternating Currents*

BY FRANCIS B. SILSBEE†

Member, A. I. E. E.

Synopsis.—In electric power stations it is often necessary to make accurate measurements of current or power when the instruments are located near to the cables carrying large alternating currents. The magnetic field produced by these currents may constitute a serious source of error in the measurements unless careful precautions are taken to guard against such disturbing effects. This paper summarizes the various principles and methods for detecting and minimizing the errors which may arise from this source. The principal methods are: (1) To so arrange the cables carrying the large currents that they produce as little stray magnetic effect as possible; (2) to use instruments of the shielded or of the astatic type; (3) to repeat readings with the instrument connections reversed; and (4) to avoid all loops in the connecting leads.

* * * * *

I. Introduction

It often becomes necessary in the central station or the laboratory to make precise electrical measurements with apparatus which is unavoidably located near conductors which are carrying large alternating currents. The magnetic field produced by such currents may become a source of serious error in the measurements, either because of the direct effect of the magnetic field in adding a ponderomotive force to the moving element of the instrument used in the measurement, or because of the electromotive forces induced in the measuring circuits by the alternating magnetic field.

It is the purpose of this paper to summarize the various principles and methods which have been suggested for detecting or minimizing the errors which may arise from the presence of stray alternating fields. This treatment, however, will be limited to those methods which are applicable in the range of frequencies used in power generation and distribution, though many of these are also applicable to audio- and even radio-frequency measurements.

The more important methods are (1) proper arrangement of the conductors carrying the large current, (2) proper choice and arrangement of measuring apparatus, (3) repetition of readings with reversed connections, and (4) proper location of connecting leads. These methods will be discussed in order.

It should be emphasized that no one of them constitutes a panacea for all stray-field troubles but that the obtaining of correct results usually requires the judicious application of several of these principles.

II. Arrangement of Current-Carrying Parts

Whenever it is possible to do so the conductors carrying the heavy currents should be so placed as to minimize the stray field which they produce. While exact computations of the field produced by various possible arrangements are both difficult amd unnecessary, it is often desirable to obtain a rough estimate of such fields, for instance in judging the relative merits of two alternative conductor arrangements. Such estimates may be based on the following approximate relations.

The field at a point P, a considerable distance from a flat loop of cable, is roughly $H = \dfrac{0.2\,A\,I\,N}{D^3}$, where H is the field strength in gausses, $I\,N$ is the ampere-turns in the loop, A is the area of the loop in sq. cm. and D is the distance in cm. from the center of the loop to the point P. When the point P lies near the axis of the loop or in the plane of the loop the direction of the magnetic field is parallel to the axis of the loop. At points which lie in other positions with respect to the loop, the direction of the field is of course quite different but can be estimated by reference to a sketch of the lines of force around such a loop (*e. g.*, Fig. XVIII in Maxwell, Electricity and Magnetism, Vol. 2, 3rd edition).

The field caused by a long straight conductor carrying a current which returns at a great distance is $H = \dfrac{0.2\,I}{D}$ and obviously drops off much less rapidly with distance than that caused by a loop. The lines of force are everywhere perpendicular to the conductor and to the line joining the point considered to the nearest point on the conductor.

Fortunately, however, the return circuit is usually not very distant. If two long straight conductors are at a distance g apart, the field H at a point P located at a considerable distance D (measured from a line midway between the conductors) is $H = \dfrac{0.2\,I\,g}{D^2}$. The magnitude of the field for a constant distance D is nearly independent of the location of P with respect to the plane containing the two conductors, although, as in the case of a loop, its direction varies greatly from

*Part 5 of a Symposium of six papers on Shielding in Electrical Measurements.

†Physicist, Bureau of Standards.

Publication approved by the Director of the Bureau of Standards, Department of Commerce.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

point to point. Since the stray field is proportional to the spacing g, it is very desirable to make this as small as possible. When the conductor section must be large it is well to use thin strips or slabs placed close together. The effective spacing g is then approximately the distance between center lines of the slabs and may be made much less than the width of the slabs or the diameter of a circular rod of the same conductance. This arrangement has the further advantage of minimizing the self-inductance of the circuit and hence lessens the reactive volt-ampere capacity of the apparatus required for supplying large currents for testing purposes. In the equipment recently installed at the Bureau of Standards for current transformer testing bars 20 in. by ½ in. have been used.

From the point of view of minimizing stray fields the ideal construction for the heavy conductors is to use a pair of coaxial cylinders. Such a return circuit produces no magnetic field at points outside the outer tube, provided the current distribution is symmetrical about the common axis of the cylinders. While this form of construction has been used to some extent in shunts[2] and certain types of instrument,[3] it tends to introduce considerable mechanical difficulty especially in arranging terminal connections.

It is not generally appreciated how closely the ideal concentric construction can be simulated by subdividing the conductor and placing its parts symmetrically around the other bar. If the return conductor consists of four wires connected in parallel placed 90 deg. apart around the central outgoing conductor and at a distance g from it, the field at a distance D from the central rod has the value $H = 0.2\ I\ g^4/D^5$. The direction of the field is tangential at positions which are on lines drawn through the central rod and each of the returns and is also tangential but in the reversed sense at positions on lines making 45 deg. with these axes. The direction of the field is radial at positions on lines making an angle of 22.5 deg. with the axis. When D is as great as 10 g, the stray field with this arrangement is only one one-thousandth as great as that caused by an ordinary two-wire circuit with the same spacing.

Table I summarizes the formulas given in the preceding paragraphs and indicates by the numerical values computed for a typical case the magnitude of the stray field to be expected.

An unshielded electrodynamic wattmeter can be used to detect and measure stray magnetic fields by applying rated voltage to the moving coil circuit while the current circuit is left open. When the orientation of the instrument and the phase of the applied voltage have been adjusted to give a maximum deflection, this deflection is proportional to the stray field present at the point where the wattmeter is located. The instrument may be calibrated by placing it at the center of a loop of large radius (R centimeters) carrying a known current (I amperes) in phase with the voltage applied to the wattmeter. The field (H in gausses) at the center

TABLE I

Effective value of stray magnetic field in gausses at a distance of D cm. from the axis of symmetry of a group of long straight conductors carrying a current of 10,000 amperes and arranged as indicated in column 1, with the spacing between adjacent conductors 10 cm.

Arrangement	Formula	Stray field $D = 50$	$D = 100$	$D = 200$	$D = 500$
Single conductor, return at great distance	$\frac{0.2\ I}{D}$	40	20	10	4
Return at distance g . . .	$\frac{0.2\ I\ g}{D^2}$	8	2	0.5	0.08
Return in two wires on opposite sides	$\frac{0.2\ I\ g^2}{D^3}$	1.6	0.2	0.025	0.0006
Return in four wires at corners of square	$\frac{0.2\ I\ g^4}{D^5}$	0.064	0.002	0.000625	.00000064
Return in coaxial cylinder		0	0	0	0
Three-phase circuit conductors in a plane	$\frac{2\sqrt{3}\ g\ I}{10\ D^2}$	13.8	3.5	0.87	0.138
Three-phase circuit conductors in a triangle	$\frac{\sqrt{3}\ g\ I}{10\ D^2}$	6.9	1.73	0.43	0.069

of such a loop is $H = \frac{2\pi N I}{10 R}$ when N is the number of turns in the loop.

III. Choice of Measuring Apparatus

The second line of procedure in avoiding stray-field errors is the proper choice of type and arrangement of measuring apparatus.

When it is feasible, use should be made of magnetically shielded instruments. In these instruments the windings are enclosed in a thick shield of high-permeability iron, which serves to greatly reduce the intensity of the stray field in the interior of the instrument. The protection thus afforded of course varies with the nature of the instrument and the design of the shield. A more detailed discussion of such magnetic shielding will be found in the papers of Curtis and Gokhale, Parts 1 and 6 of this symposium.* The literature[1,5,6] contains data showing a reduction of the stray-field error by factors which vary from ⅓ to 1/60 in different cases. As is often the case with any type of shielding there is always the danger that the presence of the iron shield may somewhat affect the action of the instrument and it is customary to laminate such shields so as to minimize the eddy currents which would otherwise be produced by the field from the instrument windings themselves. There is also a possibility of the shield acquiring a certain permanent magnetization which may affect the operation of the instrument on direct current. This effect can be eliminated, however, by taking the

*Symposium on Shielding in Electrical Measurements A. I. E. E. Summer Convention, Swampscott, Mass., June 24-28, 1929.

For all references see end of paper.

mean of readings with the currents direct and reversed.

The operating torque of many electrical instruments is the result of the interaction of two magnetic fields, one of which is much stronger than the other. This is the case, for example, in a separately-excited electro-dynamometer or in a vibration galvanometer. In such types of instrument, it is desirable to so arrange matters so that the moving element of the instrument is the one which produces the weaker of the two magnetic fields. The ponderomotive force on the moving element resulting from its reaction with the stray field (which is of course fixed in space) is thereby made less than with the converse arrangement. Thus, an electrodynamic instrument should be used with the separate excitation applied to the fixed coils; and a vibration galvanometer of the fixed magnet-moving coil type should be preferred to a moving magnet instrument, unless, of course, some additional shielding is used with the latter.

Certain types of apparatus, such as electrodynamic instruments and mutual inductors, can be built in astatic form by using duplicate coils wound in opposite directions whose effects are additive as regards the currents to be measured but subtractive as regards stray field effects. Apparatus of this type is very much less subject to stray field errors than is ordinary non-astatic equipment, and should be used whenever possible. However, it is well to bear in mind that astatic construction does not entirely eliminate all possibility of stray field error. The two coils of an astatic instrument seldom have exactly the same area turns, and even if the construction is perfect, the compensation is complete only if the stray field is uniform in direction and intensity throughout the space occupied by the instrument. The field around a laboratory or power station is usually far from uniform and may be materially different at the two coils of an astatic instrument.

IV. Reversal of Connections

A further method which is almost always applicable even in cases where the circumstances have not allowed the experimenter any leeway in the arrangement of either the current-carrying conductors or the measuring apparatus is to make two sets of measurements between which the connections of part or all of the apparatus have been reversed. The most desirable procedure is first to make such changes in connections as will reverse the direction of all currents in the measuring circuits except the heavy currents which are suspected of producing a stray field. This may usually be done by reversing the secondary connections of the current transformers. If the results of the repeat measurement made after this reversal show only a slight difference from the original results, one-half this difference may be taken as a measure of the stray field error and the mean of the two results may be considered to be correct. If the difference is large, it indicates the need for locating and removing the source of error. The same principle may then be applied further by studying each piece of apparatus separately and taking a pair of readings before and after reversing its connections. In most cases it is of course necessary to reverse two pairs of terminals as for instance the primary and secondary circuits of a mutual inductor or transformer, or the fixed and moving coil circuits of an electrodynamic instrument. After a survey of this nature has shown which parts of the network are introducing the errors, these parts should be so moved or modified as to reduce the error to a reasonably small value. A final pair of readings should then be taken to give the correct mean value.

V. Connections to Current Circuit

The coupling between the measurement circuit and that carrying the large currents is usually made through a current transformer. There is unfortunately a dearth of experimental data on the effect of stray magnetic fields on the ratio and phase angle of current transformers.[7] One would expect, however, that the effect would not be greater in magnitude than the differences observed when the primary conductor is placed in different positions with respect to a hole type current transformer.[8] With most transformers, these differences amount to only a few parts in ten thousand in ratio, but with certain unfavorable combinations of construction and conditions of use, may be as great as one-half per cent.

It occasionally happens that the coupling between the measuring circuit and the heavy current circuit must be made by a direct connection of potential leads, so as to measure the impedance drop in a run of bus or across some piece of apparatus carrying the large current. In such cases it is important to recognize clearly that the impedance drop may be very different from the resistance drop and to place the potential leads so that the resultant e. m. f. at the measuring instrument may approximate as closely as possible to the desired quantity. If the total impedance drop is desired, the potential leads should be brought off separately at right angles to the heavy conductor in such a direction as to avoid so far as possible the magnetic effect of other parts of the heavy current circuit. In other words, the mutual inductance between the potential leads and the current circuit should be zero. On the other hand, if the resistance drop only is desired, a potential lead should be laid back tightly against the conductor throughout the span from its point of attachment to that of the other potential lead. From the point where the two leads meet, they should be kept close together and preferably twisted throughout the run from the conductor to the instrument. The theoretically perfect condition is to place the potential leads so that they are linked with a magnetic flux of the same amount as that which links the main conductor. In the case of round conductors this would require the impracticable condition that the lead lie in a hole or groove inside the current carrying rod. In the case of thin rectangular bars, however, the requirement can be met by placing the potential lead close to the bar at a distance from the center of its long side equal to 0.3 of the total width of the bar.

In cases when the conductor arrangement is such that the potential leads cannot be placed in the desired location, it is often possible to correct the experimental results by computing the various mutual inductances involved. Formulas are available[9] for such computations for a great variety of shapes and arrangements of conductors.

References

1. Keinath, G., Die Technik Elektrischer Messgerate, 3d ed., 1928, Oldenbourg, Berlin, Chap. I, p. 90, et. seq.
2. Paterson, D. C. and Rayner, E. E., "Non-Inductive Water-Cooled Standard Resistances," *Inst. El. Eng. Journ.*, Vol. 42, 1909, p. 455.
3. Agnew, P. G., "A Tubular Dynamometer for Heavy Currents." Bu. of Standards Scientific Paper No. 184, 1912.
4. Brooks, H. B., *The Accuracy of Commercial Electrical Measurements*, TRANS. A. I. E. E., Vol. 39, 1920, p. 520.
5. Farmer, F. M., "Electrical Measurements in Practice," 1st ed., 1917, McGraw-Hill Book Co., New York, p. 158.
6. Drysdale and Jolley, "Electrical Measuring Instruments," Ernest Burn, Ltd., London, 1924, p. 280.
7. Keinath, G., 3d ed., p. 545.
8. Price, H. W., and Duff, C. K., "Through-Type Portable Current Transformers," Univ. of Toronto, Faculty of Applied Sciences and Engineering, Bull. No. 2, 1921.
9. Bureau of Standards Scientific Paper No. 169, and Circular No. 74.

Abridgment of

Some Problems in Dielectric Loss Measurements

BY C. L. DAWES,[1] Member, A. I. E. E.
F. L. HOOVER[2] Associate, A. I. E. E.
and
H. H. REICHARD[3] Associate, A. I. E. E.

Synopsis.—*The measurement of dielectric loss in high-voltage cables presents many problems which are not simple, and their solution is obtained only after considerable effort and research. This paper presents some of the problems that the authors have encountered in this type of work, together with the methods used for their solution.*

The bridge method, which is used for the measurement of dielectric loss, is described in some detail. Details of the auxiliary equipment, such as galvanometer, amplifier, air condenser, shielding and special methods of bringing the shielding to the proper potential are also given.

If accurate results are to be had in dielectric-loss measurements, the entire bridge, including cable, air condenser, and leads must be properly shielded, and the capacitance between leads and shielding should be made small. It is entirely insufficient to shield the bridge and ground the shielding directly. At times, shielding cables may increase the measured losses.

In measuring the capacitance of the air condenser, all stray capacitance to its guard rings and to surroundings must be eliminated.

The voltage across the voltmeter coil of a high-voltage transformer is frequently taken as a measure of the voltage across its secondary. In some methods of measurement, this voltmeter-coil circuit is an integral part of the measuring circuits. Methods of measuring the ratio of primary to secondary voltage and the phase angle between them are described, and in the complete paper considerable quantitative data are given for typical testing transformers under various conditions of load.

The accuracy of the bridge as a power-measuring device may be determined by inserting known resistances into its arms and comparing computed results with observed results. Due to unsuspected leakage and stray-capacitance currents, however, the introduction of such resistances may cause large errors. Methods of minimizing such currents are given, as are analyses of proper and improper methods of making such measurements and observed data and results. Harmonics probably do not introduce error in this type of measurement, but at times they are troublesome in that they produce anomalous effects in the measuring apparatus.

INTRODUCTION

IN conducting research on ionization in impregnated paper insulated cables at Harvard University under the auspices of the Joint Committee on Paper Insulated Cables of the N. E. L. A., A. I. E. E., and A. E. I. Co., the authors have encountered many interesting problems in making the rather difficult measurements of very small amounts of power at high voltage and extremely low power factors,—a most difficult combination. We believe that as a result of this type of research, which has been stimulated by cable manufacturers and users, the technique of making these refined measurements has been advanced by many years.

In this type of measurement, many factors which in other types of measurements are not even considered introduce large errors. In order that others may be forewarned of the sources of errors encountered, and further, to give opportunity for discussion from which all will derive benefit, the authors have been requested by engineers who have been in touch with this work to publish their experiences.

There is probably no type of measurement in which one may be more easily deceived than these dielectric-loss measurements. The losses vary with temperature, with the time of electrification, the cycle of electrification, and with the handling of the specimen. Hence, accurate checks of measurements on cable samples among different laboratories cannot be expected.

Curves obtained with certain measuring apparatus may appear perfectly rational, and yet, because of phase-angle defect or wrong transformation ratio, both of which may be constant in magnitude, the curves are actually in error. As will be shown later, it is most diffi-

Part 2 of a Symposium of six papers on Shielding in Electrical Measurements.

1. Assistant Professor of Electrical Engineering, Harvard University.

2. Assistant Professor of Electrical Engineering, Case School of Applied Science.

3. Graduate Assistant in Physics, Lehigh University, formerly Research Assistant in Electrical Engineering, Harvard University.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

cult to check a given apparatus by the introduction of known losses in the circuits. The calibrated Leyden jars, which are now available at the Electrical Testing Laboratories, have in large measure overcome some of these difficulties.

The Bridge Method

The authors use the mutual inductance bridge, which has already been described by them.[4] The complete bridge with its shielding and guard connections, as now used, is shown in Fig. 1.

The bridge proper consists of a high-voltage air condenser C_1 in series with a resistance R_1; the cable or dielectric C_2 is in series with the primary of a mutual inductance M and the resistance R_2. The detector D, which consists of a tuned iron-vane galvanometer, is connected between points a and b in series with the secondary of M. The bridge is entirely shielded by chicken wire, connected to the shielding of the air condenser. This shielding is brought to the same

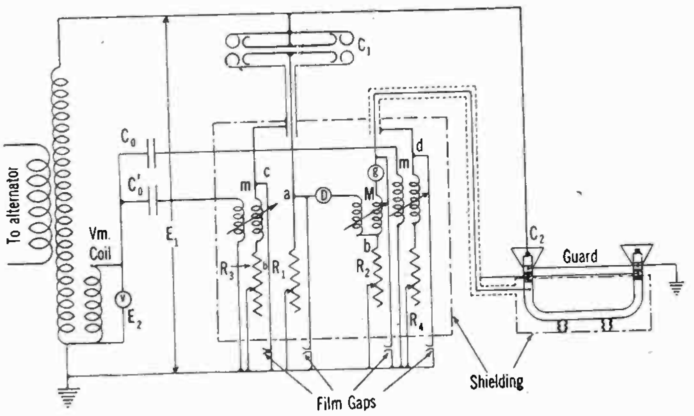


Fig. 1—Complete Connections of Bridge Circuit

potential as a by adjusting the resistance R_3, the mutual inductance m' and the capacitance c_0'. The sheaths of the cables are cut twice at each end for guards and then are completely shielded. This shielding and the inner guards are brought to the same potential as b by adjusting the resistance R_4, the mutual inductance m and the capacitance c_0.

When the bridge is in balance the power factor of the cable

$$\cos \theta = \sin \Psi = \frac{M\,\omega}{R_2} \tag{1}$$

for small values of power factor. Ψ is the angle of defect of the dielectric, M the mutual inductance in henrys, and ω is $2\,\pi$ times the frequency.

The capacitance

$$C_2 = C_1 \frac{R_1}{R_2} \tag{2}$$

The power

$$P = \frac{E^2\, C_2\, \omega^2\, M}{R_2} = \frac{E^2\, C_1\, R_1\, \omega^2\, M}{{R_2}^2} \tag{3}$$

4. C. L. Dawes and P. L. Hoover, *Ionization Studies in Paper Insulated Cables.* Trans. A. I. E. E., Vol. XLV (1926), p. 141.

The Detector

Without a sensitive detector the bridge loses most of its advantages as a precision instrument. The iron-vane vibration galvanometer with electromagnetic excitation has proved the most satisfactory detector. The impedance of our instrument at 60 cycles is 2200 $+ j\,280$. The degree of sensitivity is increased tremendously by the use of an amplifier. The galvanometer must be shielded from dielectric, magnetic and mechanical disturbance.

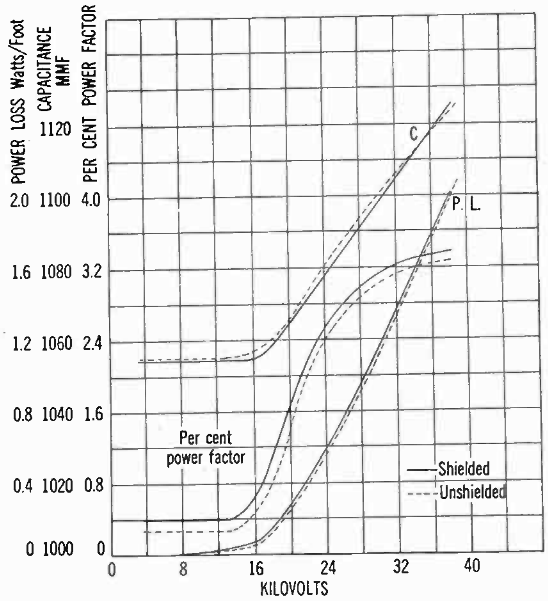


Fig. 2—Effects of Shielding 10-ft. Length Single Conductor Cable at 60 Cycles and 20 Deg. Cent

Shielding the Air Condenser, its Leads and the Bridge

It is absolutely necessary to shield the low-voltage plate of the air condenser. If the guard is grounded, it gives the condenser the equivalent of an angle of defect of some magnitude. Hence, the guard should

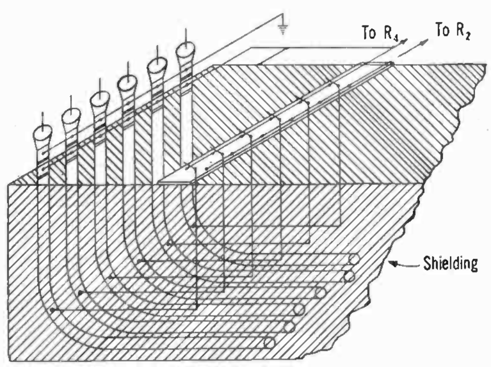


Fig. 3—Connections of Cables in Cable Rack

be brought to the same potential as the low-voltage plate. (See Fig. 1). The lead from the condenser to the bridge should likewise be shielded and should be constructed so as to have very small capacitance. This shielding and the shielding about the bridge are connected together and to the condenser guard, and brought to the potential of a, that of the low-voltage plate of the condenser.

Shielding the Cable

The cable sheath should be shielded, not only to give opportunity for eliminating capacitance to ground, but also to prevent leakage and induced charges from entering the sheath and causing errors. Also, the lead from the cable sheath to the bridge must be shielded. This shielding is all connected together and brought to the potential of point b (Fig. 1) by means of the resistance R_4, the mutual inductance m and the condenser c_0.

We have found that shielding may increase the measured loss in a cable, as shown in Fig. 2. This matter is still under investigation.

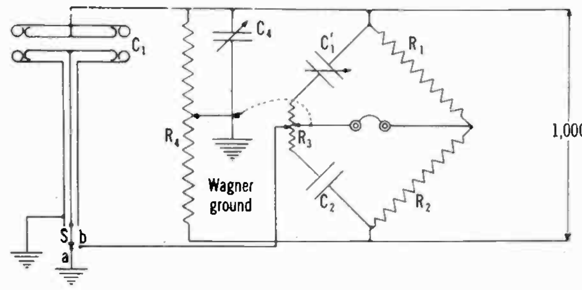


Fig. 4—Connections for Measuring the Capacitance of a Shielded Condenser

To prevent discharges to end-bells disturbing the guard-circuit balance a system of double guarding the cable ends is used. The end-bells and a short length of sheath are grounded directly (Fig. 1). A short length of lead sheath between these ends and the test length of sheath connects to the shielding as already described. Our shielding and the method of connecting six cables for test is shown in Fig. 3.

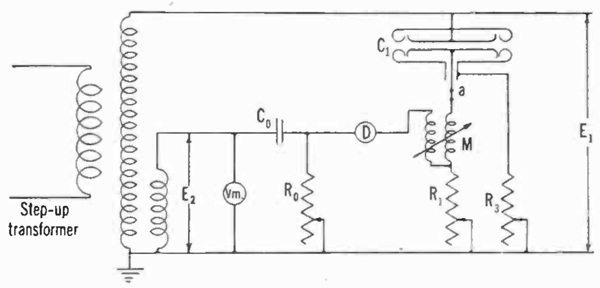


Fig. 5—Connections for Determining the Ratio and Phase Angle of Voltmeter Coil

Measurement of the Air Condenser

In measuring the capacitance of the air condenser the shielding about the low-voltage plate must always be at the same potential as the low-voltage plate but must not be included in the measurement. The measurement is made at a frequency of 1000 cycles per sec. The connections are shown in Fig. 4. With the switch S at a, the bridge is first balanced. The switch S is then thrown to b and a second balance made. The Wagner-ground balance must be made each time. The capacitance C_1 is then the difference in the settings of the condenser C_1'.

Transformer Ratio and Phase Angle

It is possible to measure the ratio and phase angle of the test transformer by using the connections shown in Fig. 5. C_1 is the high-voltage air condenser, M the mutual inductance, R_1 a resistance, D the detector, C_0 a low-voltage air condenser, and R_0 a resistance. The shielding is balanced by R_3 (also m' and c_0' may be used Fig. 1).

When the bridge is in balance

$$\frac{E_1}{E_2} = \frac{C_0 R_0}{C_1 R_1} \qquad (4)$$

The angle between E_1 and E_2

$$\beta = \frac{M\,\omega}{R_1} - \omega\, C_0\, R_0 \text{ (nearly)} \qquad (5)$$

(Data taken with three different test transformers without and with load are given in the complete paper.)

It is found that when the voltmeter coil is properly located, the ratio is little affected with change in voltage or load. The angle β changes considerably with load.

Checking the Bridge

It is possible to check the accuracy of the bridge in reference to both the measurement of current and the measurement of power. For example, by connecting a deflecting dynamometer at a, Fig. 5, the current

$$I_1 = E_2\, C_0\, \omega\, \frac{R_0}{R_1} \qquad (6)$$

when the bridge is in balance.

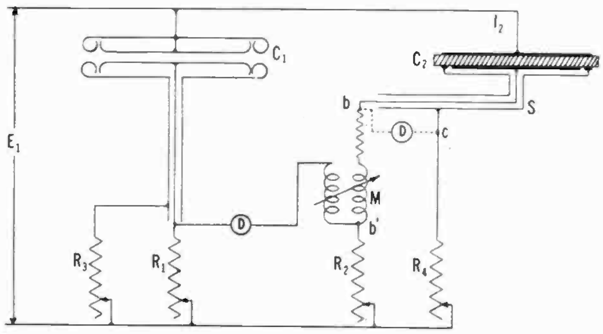


Fig. 6—Correct Method of Connecting Resistance in Series with Low-Voltage Plate

Below are representative data which we have taken

ω	E_2 kv.	R_0	C_0 μ f.	R_1	I_1 (ma.) from (6)	I_1 (ma.) (Observed)
377	25.0	1004	0.015	109	1.300	1.295

A known resistance r may be inserted in series with one of the capacitances, C_2, and the power dissipated in it calculated. (Fig. 6). If the measured power factor before the introduction of the resistance r is $\sin \Psi_1$ and the power factor after the introduction of the resistance r is $\sin \Psi_2$, then

$$\sin \Psi_2 - \sin \Psi_1 = r\, C_2\, \omega \qquad (7)$$

There are many opportunities to make large errors in this measurement. For example, in Fig. 6 the guard-circuit balance must be made between points b and c and the capacitance of the resistance r to its surroundings must be very small.

With a plate-glass condenser, the measured loss without r was 7.73 watts, with r, 10.28 watts, the difference being 2.55 watts. The computed power was 2.51

watts, a close check. Also, sin Ψ_2 − sin Ψ_1 was 0.00935 as compared with the computed value of 0.00914.

With an E. T. L. standard condenser, the measured increase of power was 0.1196 watt as compared with a computed value of 0.1178 watt.

Harmonics

Even with a sinusoidal e. m. f. wave impressed across the bridge, harmonics occur in the current wave when ionization commences. Since, with a sinusoidal e. m. f. wave, these harmonics cannot contribute power, the bridge when balanced with a tuned galvanometer ordinarily measures the power correctly. At one time when a slight third harmonic occurred in the impressed e. m. f. wave and the galvanometer was inadvertently tuned to this harmonic, the bridge balanced with a negative value of the mutual inductance. This was due to the fact that the third-harmonic voltage drop across R_1 (Fig. 1) was balanced in part by the third-harmonic drop in R_2 due to ionization in the cable and the phase relation of the third-harmonic voltage drop across one of these resistances has no particular relation to the third-harmonic voltage drop across the other.

The authors are indebted to P. H. Humphries of the Harvard Engineering School and to L. E. Cirella of the Simplex Wire & Cable Company for their assistance in obtaining data given in this paper; and to Prof. H. E. Clifford of the Harvard Engineering School and D. W. Roper, F. M. Farmer, and W. F. Davidson of the Joint Committee for their suggestions in its preparation.

Abridgment of

Shielding and Guarding Electrical Apparatus Used in Measurements—General Principles*

BY HARVEY L. CURTIS†

Fellow, A. I. E. E.

Synopsis.—Electrical measuring apparatus is shielded and guarded to protect it from the following external influences; namely, leakage currents, electrostatic fields, magnetic fields, and electromagnetic waves. Apparatus is guarded against leakage currents which may flow over or through the solid insulators on which the apparatus is supported. It is shielded against leakage currents which flow through the fluid in which the instrument is immersed. By a proper arrangement of guards and shields any apparatus can be completely protected against leakage currents.

Any apparatus can be completely shielded from electrostatic fields by placing it in a metallic case. However, there may be electrostatic reactions between the apparatus and the shield, thus introducing errors in the measuring apparatus.

Shielding apparatus from magnetic fields requires that the apparatus be surrounded by a thick enclosure of magnetic material. The theory of this magnetic shielding has been developed and formulas for producing the most satisfactory shielding are given.

The shielding of an apparatus from electromagnetic waves is largely accomplished by means of eddy currents which these waves set up in the shield. The theory for the production of these eddy currents has been developed and the best location of shields is discussed.

Some attention is given to the errors which may be introduced by shielding and some methods are outlined for obviating the necessity of shielding.

* * * * *

I. Introduction

GUARDS and shields are used with electrical measuring apparatus either to simplify its theory or to protect it from external influences. The simplification of theory has generally resulted from a rearrangement of the electric or magnetic field so that the resulting field can be more easily subjected to mathematical analysis. The external influences from which apparatus must be protected are: (1) Leakage currents, (2) magnetic fields, (3) electrostatic fields, (4) electromagnetic waves.

It is the purpose of this paper to discuss the general principles underlying the guarding and shielding of electrical apparatus.

The protection of apparatus from external influences has sometimes been called guarding the apparatus and sometimes shielding it. The following definitions seem to represent the best practise: A shield protects apparatus from those outside influences which may penetrate to the instrument through the medium by which it is surrounded. A device for the protection of apparatus from leakage currents which, for the most part, flow over the surfaces of the solid insulators used to support the apparatus is called a guard. The term "guard" is also applied to those devices the purpose of which is to rearrange the electric or magnetic field. For example, the earthed plates which are sometimes put under the insulating supports of an electrometer to prevent leakage currents are called guard plates, while if the electrometer is surrounded by a metal covering to protect it from the ionization currents of

*Bureau of Standards, Washington, D. C.

*Approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

†Part I of a Symposium of six papers on Shielding in Electrical Measurements.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

the air, this covering is a shield. Also, if a parallel plate condenser has one plate surrounded by a ring to diminish edge effects, this ring is a guard ring. However, if the back of the guarded plate is surrounded by a housing to prevent any electrostatic lines from reaching the back of the plate, this housing is a shield. While these usages of the terms "shield" and "guard" might, to advantage, be modified, they will be adhered to throughout the paper.

II. Guarding and Shielding Apparatus Against Leakage Currents

Guarding apparatus against leakage currents is necessary whenever the solids used in the insulation of the apparatus have so low a volume resistance or surface resistance as to allow a leakage current to flow which will influence the measuring apparatus. Shielding apparatus against leakage currents is necessary whenever the fluid (air, oil, etc.) in which the apparatus is immersed permits a measurable current to flow. In ordinary measurements, guarding against leakage is required more often than shielding.

The leakage currents against which apparatus must be guarded may flow through the material of which the solid insulators are made or through a film of moisture or dirt on the surface of the insulators. With some insulating materials (amber, ceresin, hard-rubber, paraffin, silica-glass, sulphur, etc.), the leakage current through the material of the insulator is, in well designed apparatus, negligibly small. Surface leakage on the other hand is often troublesome, especially since it may be quite variable. The method of guarding, however, is the same for both volume and surface leakage.

To guard an apparatus as completely as possible every insulator is made in two parts. One part of each insulator supports a piece of metal (the guard) on which is mounted the second part that in turn supports the measuring apparatus. An auxiliary electric circuit, similar to the one in the measuring apparatus, is then set up and so connected to the guards that the potential of each guard is substantially the same as that of the conductor in the measuring apparatus which it supports. Hence there is no tendency for a leakage current to flow through or over the second part of the insulator which is between the measuring apparatus and the guard.

Shielding air-immersed apparatus against leakage currents is necessary only when the apparatus is sensitive to exceedingly small currents or when the number of ions is unusually large. No general statement can be made as to the sensitivity of apparatus that requires shielding. It is customary and usually necessary to shield the essential portions of a circuit when an electrometer[3] in employed as the measuring instrument. It is usually unnecessary to shield when using a galvanometer unless the instrument is exceedingly sensitive or the surrounding air highly ionized.

III. Guarding Apparatus to Simplify Its Theory

In some types of measurements, it is desirable to determine the constants of the apparatus from the known properties of the surrounding medium. In such cases a guard may be employed either to confine the field of the measuring apparatus to that portion of space where the properties are known, or to modify the field so that the constants of the apparatus can be computed from its dimensions. In many cases one guard may perform both of these functions. A well known example is a guard-ring air condenser. Here the guard ring is useful not only to confine the lines of force to the air so that the dielectric loss is negligible, but also to make the field between the plates uniform so that the capacitance can be readily computed.

While guards are often useful, they should be used with care lest they introduce errors which are greater than those they are supposed to rectify. The possiblity of errors is well illustrated by the guard-ring condenser. When it is used as a standard having zero power factor in a-c. measurements, the assumption is tacitly made that the potential of the guard ring is at *every instant* the same as the potential of the guarded plate. This requires not only that the two alternating potentials shall have the same magnitude and be in the same phase, but also that they shall have the same wave form. Hence, not only must the impedance of the guard circuit be properly adjusted, but also it must be protected from corona and other effects which would change its wave form. Again, when the guard ring is used to simplify the computation of the capacitance, the edge correction is not zero unless the gap between the guard and plate is infinitely narrow. Hence, a correction[4] must, for precise work, be applied to the computed capacitance to allow for the finite width of the gap.

IV. Shielding of a Space from Electrostatic Fields

A given space can be perfectly shielded from external electrostatic fields by surrounding the space with a continuous metallic enclosure which is maintained at a definite potential, usually at earth potential. Provided this could always be used, nothing further would have to be written concerning electrostatic shields. The shield however, may react unfavorably on the apparatus that is being shielded. In such cases it may be necessary or advisable to omit the shield entirely, or to use less effective methods of shielding.

The most troublesome reaction between apparatus and shield is caused by capacitance. The placing of a grounded shield close to a piece of apparatus will very markedly increase not only the capacitance to earth but also the capacitance between parts of the shielded apparatus. As an example consider a shielded resis-

1, 2. For references see Bibliography.

*Here the current which flows over the surface of the insulation is, by means of the guards, shunted around the measuring instrument.

tance coil. Often such a shield is used to make definite the capacitance between the different parts of the coil, particularly that between the terminals. However, if the shield is placed very close to the terminals, slight changes in the position of the shield (such as those produced by changes in temperature) may cause changes in the capacitance between the terminals greater than the changes which would have occurred had no shield been present. This difficulty can readily be overcome by making the shield larger.

V. Shielding of a Space from Magnetic Fields

A given space can be shielded from a constant magnetic field only by surrounding the space by magnetic materials. Perfect shielding is not possible but good results can be obtained by the use of suitable materials provided they are in the most efficient shapes.

The shielding of spaces against the earth's magnetic field is probably the oldest problem in magnetic shielding. It early became of importance in the design and use of needle type galvanometers. Here the shielding might not be important if the earth's field were perfectly constant. However, the changes are of such long period that the effect of these changes can be made negligible only by reducing the entire field to a very small part of its original value.

The early attempts at magnetic shielding consisted in enclosing the space in a single shell of iron.[6] Later it was shown that two or more shells could be used to advantage. This problem was first treated theoretically by Rücker[7] for two and for three spherical shells. Later DuBois[8] gave a more complete treatment for two spheres and for two cylinders. Wills[9] extended this to cover three spheres and three cylinders. More recently Esmarch[11] and Dye[14] have given the general expression for the shielding produced by any number of cylinders provided their successive radii form a geometric progression.*

All of these derivations have assumed that the external field is uniform and of such a small value that the permeability of the shields can be considered constant. Also the shields are assumed to be concentric and the axes of the cylindrical shields are assumed to be perpendicular to the lines of magnetic force. The cylindrical shields are assumed to be sufficiently long so that end effects can be neglected. In practise this means that the length should be twice the diameter.

The important results of the theoretical investigations can be stated as follows:

1. The shielding ratio (defined as the ratio of the external to the internal magnetic field) is approximately proportional to the permeability of the material of which the shields are constructed.[8]

2. The thickness of the shields should not be great. For example, a single spherical shield, the thickness of which is greater than $\sqrt{2\, r_1^2/\mu}$, (r_1 = internal radius of shield and μ is permeability), will be improved by removing a spherical lamina, and thus reducing the total amount of shielding material.[7]

3. For both spheres[7] and cylinders[9] the best thickness and spacing is that in which the radii of the successive bounding surfaces of the shells are in geometric progression. From this it follows that any increase in the volume of the space to be shielded requires the same relative increase in the volume of the shields.

Within a few years some experimental work has been done to determine the shielding effect of spirals made from high permeability material. In some cases the shield was made by winding in a tight spiral a single sheet of magnetic material. In other cases, a sheet of magnetic material and a sheet of non-magnetic material (copper or paper) were placed together and wound into a spiral so that in the resulting shield the magnetic material was interleaved with non-magnetic material. Characteristic results are given in Table I. These results show the value of inter-leaving, though the exact thickness of the inter-leaving does not seem to be important.[15] The increased shielding that can be obtained by the use of the high permeability alloys of nickel and iron is well illustrated by the values of Hill[15] for mumetal.

VI. Shielding a Space from Electromagnetic Waves

The problem of shielding a space from electromagnetic waves depends on the frequency of these waves. When the frequency is very low, the electric and magnetic fields change so slowly that the shielding problems are nearly identical with those for stationary fields. When the frequency is very high, shielding becomes a problem in the optical opacity of materials. For intermediate frequencies, consideration must be given not only to the instantaneous values of the electromagnetic and electrostatic fields, but also to the rate at which these fields are changing.

Since in any particular case the waves emanate from a single electric circuit, the electric and magnetic vectors at a given place have a definite direction. In the nomenclature of optics, the waves are polarized. The three vectors which determine (1) the direction of motion of the wave, (2) the direction of the electric field, and (3) the direction of the magnetic field are mutually perpendicular. Hence, they may be taken as

---

*Assume there are n shields of permeability μ, the successive radii (starting from the smallest) are $r_1, r_2, \ldots \, r_{2n}$. The odd subscripts give the inside radii and the even subscripts the outside radii. The shielding ratio, g, ($= H_e/H_i$ where H_e is the external field and H_i is the field inside the shield) is given by the formula

$$g = K_n\, r_1^2/r_{2n}^2 \text{ where}$$
$$K_n = \{ 2\beta + [\beta - 1]^2 \mu/4 \}\, K_{n-1} - \beta^2 K_{n-2}$$

in which

$$\beta = \frac{r_2^2}{r_1^2} = \frac{r_3^2}{r_2^2} \;\ldots\ldots = \left(\frac{r_{2n}^2}{r_1^2} \right)^{\frac{1}{2n-1}}$$

Since K_n depends on K_{n-1} and K_{n-2}, the values for K_1 and K_2 are not given by this formula. They are

$$K_1 = 1 + (\beta - 1)\, \mu/4$$
$$K_2 = \{ 2\beta + [\beta - 1]^2 \mu/4 \}\, K_1 - \beta$$

Dye[14] gives curves to aid in computing the shielding ratio.

TABLE I
SHIELDING RATIO OF DIFFERENT MATERIALS

Reference	Kind of magnetic material	Thickness—cm. Magnetic material	Thickness—cm. Interleaves	Weight kilos	Inner diam. cm.	Outer diam. cm.	Shielding ratio S H_e/H_i
13	Transformer steel	0.26	0.14		4.	8.	180
		0.26	0.		4.	8	50
	Cast iron	4.	...		4	8.	20
15	Mumetal	0.15	0.25	0.5	10.	12	10,000

the axes of a rectangular coordinate system. The effect of a shield will depend on its orientation relative to this coordinate system.

The eddy currents which are set up in the shield may be produced either by the electric field of the wave or by the magnetic field, or by both.[17] The method by which waves produce eddy currents can be made clear by considering some particular cases. In the complete paper, two cases are considered; *viz.*, a system of parallel wires, and a laminated cube.

In order to compute the shielding which will be produced by any arrangement of solid metallic bodies, it is necessary first to compute the eddy currents that will be produced in the metal. The formula for determining the current density in a particular case is generally determined by the solution of Maxwell's differential equations of an electromagnetic field. It results that the eddy currents in a massive conductor are always a function $\sqrt{\dfrac{f\,\mu}{\sigma}}$, where f is the frequency of the wave, μ the permeability of the material, and σ its resistivity. This shows that the most effective shielding materials are those having high permeability and low resistivity.

Formulas for computing the eddy currents produced by electric waves have been derived in certain cases.[16] However, in relatively few cases have the theoretical deduction been carried to a point where the shielding power can be computed. Some experimental work[18] has shown that there is a qualitative agreement between theory and experiment.

VII. Limitations of Shielding

In a previous section, the effect on any measuring apparatus of an electrostatic shield in which it is enclosed was discussed. In any given case, the reaction between the shielded apparatus and an electrostatic shield can be expressed in terms of the coefficients of capacitance. Likewise a magnetic shield or a shield which protects against electromagnetic waves reacts with the apparatus which it is shielding. However, in neither of the latter cases can the amount of reaction be expressed by a simple formula.

It has already been pointed out that an electrostatic shield may introduce errors in a measuring apparatus for which it is difficult to make a correction. With a magnetic shield, on the other hand, the effect of the reactions is to change the sensitivity of the apparatus. As the apparatus is calibrated with the shield in place no error results from the use of the shield. However, the reactions are so complicated, involving eddy currents, hysteresis, permeability, etc., that each separate type must be subjected to an experimental investigation.

In absolute electrical measurements, where the constants of an apparatus are computed from the mechanical dimensions, shields must generally be avoided. As an example, the inductance of a coil can often be accurately computed from its dimensions. However, the formula for making the computation is developed on the assumption that the permeability of the surrounding space is unity; that is, that there are no magnetic bodies in the surrounding region. Evidently a magnetic shield would vitiate this fundamental assumption. Moreover, the derivation of the formula takes no account of the capacitance between the parts of the inductance. While this generally produces a negligible effect, yet the presence of an electrostatic shield will so increase the capacitance between parts that an appreciable effect is produced. Hence, an electrostatic shield must be avoided.

VIII. Methods for Obviating the Necessity of Shielding

Astatic instruments are often used for obviating the necessity of shielding. In an astatic piece of apparatus two similar parts are constructed. In the finished apparatus these parts are rigidly connected mechanically, but the electric and magnetic circuits are so arranged that an external electric or magnetic field will produce equal and opposite effects in the two parts. When the apparatus is placed in an electric or magnetic field which is uniform throughout the region which the apparatus occupies, then changes in the magnitude of this field will not affect the indications of the instrument. This method has been applied to galvanometers and inductors.

IX. Conclusion

In conclusion it may be said that the general principles underlying the shielding and guarding of electrical apparatus are well known, but that their quantitative application by means of mathematical analysis is often difficult or at present impossible. Hence, shields and guards should be used with care. Whenever possible the shielded or guarded apparatus should be subjected to special experiments to show that the effect on the apparatus is not determental.

Bibliography

1. Price, W. A. First use of a guard in measuring insulation resistance. *Elec. Rev.*, London, 37, p. 702; 1895.

2. Ayrton and Mather. Develops Price's method. *Phil. Mag.* 49, p. 343; 1900.

3. Curtis. H. L. Uses guards, and when necessay shields, in measuring insulation resistance. *Bul. Bu. of Standards*, 11, p. 359; 1915.

4. Rosa and Dorsey. Develops formula for a guard ring condenser *Bul. Bu. of Standards*, 3, p. 537; 1907.

5. Mascart and Joubert. Theory of Dielectric Shields. Electricity and Magnetism. London, 1883, Vol. 1, Arts. 164-166.

5a. Maxwell. Theory of a Grating of Parallel Wires. Electricity and Magnetism, *Oxford*, 1892, Vol. 1, Arts. 203-206.

6. Stefan. Theoretical treatment of a single spherical shell. *Wied. Ann.* 17, p. 928; 1882.

7. Rücker. Theoretical treatment of two and three spherical shells. *Phil. Mag.* 37. p. 95; 1894.

8. DuBois. Theoretical treatment for two spherical shells and for two cylindrical shells. *Wied. Ann.*, 63, p. 348, 1897 and 65, p. 1, 1898.

9. Wills, A. P. Theoretical treatment for three spherical shells and for three cylindrical shells. *Phys. Rev.* 9, p. 193, 1899 and 11, p. 243, 1907.

10. Nichols and Williams. Experimental verification of the theory of Wills. *Phys. Rev.* 27, p. 250; 1908.

11. Esmarch. Develops theory for any number of concentric shields. *Ann. der Physik.* 39, p. 1540; 1912.

12. Coblenz. Experimental results with six shields. *Bul. Bu. of Standards*, 13, p. 423; 1916.

13. Benedicks. Experimental results on shields of transformer iron. *Ann. der Physik* 377, p. 236; 1923.

14. Dye. Formula for multilamellar shielding and experimental results on stalloy rings. *Jl. Sci. Instr.* 3, p. 65; 1925.

15. Hill, A. V. Experimental results with a laminated shield of "mumetal." *Jl. Sci. Instr.* 3, p. 335; 1925.

16. Thompson, J. J. Develops formulas for eddy currents produced by waves. Recent researches in Electricity and Magnetism, *Oxford*, p. 259; 1893.

17. Barfield. Experimental results with different kinds of screens. *Inst. Elec. Eng.* 62, p. 249; 1924.

18. Morecroft and Turner. Experimental and theoretical discussion of certain phases of shielding. *Proc. Inst. Radio Eng.* 13, p. 477; 1925.

Railway Train Signal Practise

BY P. M. GAULT[1]

Non-member

Synopsis.—*This is a description of an automatic block signal system used on single track. Signals are located over or to right of track governed. Cab signals are a development of recent years. Indications must be easy to read. Three colors are used—red, yellow, and green. Signals are dependent upon track circuits for proper control and operation. Energy for operation is supplied by storage batteries trickle charged from commercial sources of alternating current. Current for lamps is taken directly from a-c. lines with automatic cut over to storage batteries in case of failure of supply line. Lens unit of light signal is a doublet combination with a special lens for use on curves. Absolute permissive block system provides head-on protection from station to station and permits following movements with clear signals with intermediate blocks between stations. Tonnage markers permit heavy trains to pass red signals on grades where, if stopped, these trains could not be started.*

Signal circuits are designed on the closed circuit principle. An organization for construction and maintenance of a Signal Department is outlined.

THE systems of signals installed along railroads for the protection of train movements is the general subject covered in this paper. Though the information given here applies particularly to signals used on the Missouri Pacific Lines, the principles and general applications hold true regardless of the individual railroad.

An automatic block system may be defined as a series of consecutive blocks governed by block signals operated by electric, pneumatic, or other agency actuated by a train, or by certain conditions affecting the use of a block.

A block is a length of track of defined limits, the use of which by trains is governed by block signals.

Automatic block signals may be divided into four general types:

1. Semaphore signals which give their day indication by the position of a semaphore arm, in the right-hand upper or lower quadrant for steam roads and usually in the left-hand upper quadrant for electric lines. The night indication is given by colors.

2. Color light signals which give the indication by the color of a light, day or night.

3. Position light signals which give the indication by the position of a row of lights day or night. Aspects of position light signals have the same position as the day aspects of semaphore signals.

4. Color position light signals which give their indications by a combination of color and position of lights.

Signals are located preferably over or to the right of the track which they govern. In recent years there have been several installations of cab signals placed in operation. These signals may be of any of the above four types, in miniature, and are located on the engineman's side of the cab where they will, at all times, be within his range of vision. If desired the signals may be duplicated and one placed on the fireman's side of cab as an extra precaution.

A cab signal, like a wayside signal, to be of any value as protection against the accidents which automatic signals are designed to prevent, must at all times be directly responsive to conditions ahead of a train which may affect its movement. The particular advantage of a cab signal is that it goes right along with the loco-

1. Signal Engineer, Missouri Pacific Lines, St. Louis, Mo.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

motive and gives immediate warning in case of a dangerous condition ahead.

The cab signal has been developed in connection with the continuous systems of automatic train control, which have been installed within the past five years as a result of certain orders of the Interstate Commerce Commission. To describe this development fully would require more time than we have available so I will confine my remarks to the automatic block system using wayside signals.

The indications given by automatic signals are comparatively easy to read,—in fact, this is a fundamental requirement for the reason that the engineman of a high-speed train must know immediately, exactly what information it has to impart so that he can act at once to properly control his train.

In all of our new installations on the Missouri Pacific Lines we are using the color light type of signal. Three colors are provided which, unless otherwise modified, are:

Red —*Stop*
Yellow—*Proceed at Restricted Speed*
Green —*Proceed*

These are the indications to the engineman and tell him what he is to do. Stated in another way, the red light indicates that the block immediately ahead is not clear, either it is occupied by a train, a switch is open, a car is not in the clear on a turnout, a rail is broken, or there is some other condition existing which requires restriction of movement. A yellow light indicates that the first block ahead is clear, but the next signal is red so that the engineman must have his train under control and be prepared to stop before the next signal is reached. A green light indicates that the next two blocks ahead are clear; the way may be clear for a greater distance but this is a minimum. In locating signals it is always best where conditions will permit, to space them not less than braking distance apart for the train which requires the greatest distance to stop. If it is not practicable to do this, it is necessary that control of signals be arranged so that trains will receive a so-called caution indication at a point which is braking distance or greater from the stop signal.

Various means of controlling signaling devices had been tried out in the early days of the art. Some made use of time elements which were actuated by a train as it passed; others provided a trip device, which counted a train into a block and then counted it out at the other end. All of these schemes were open to serious objections, for if a train stopped in a block, or left cars in a block, or if a wire was broken, a following train would receive a clear signal.

Beginning about 1867, William Robinson entered actively into the development of a signal system. After realizing the serious objections to the various schemes proposed, he developed a closed rail track circuit substantially as it is today, and in 1871, applied for a patent to cover; this patent was issued August 20, 1872 and reissued July 7, 1874.

All automatic block signals depend for their proper functioning upon a track circuit. It is the most important part of the system; upon it we depend to coordinate the signal system with the moving train.

The Signal Section, A. R. A., defines a track circuit as "an electrical circuit of which the rails of the track form a part."

Most steam roads use the direct current track circuit although alternating current is used on a goodly mileage and must be used on electric lines where d-c. propulsion is used.

The essential parts of a track circuit are a source of electrical energy, rails, bonding, relay, and insulated joint.

For d-c. track circuits, various types and arrangements of batteries are used to supply energy. A few years ago gravity batteries were largely used for this purpose; then followed the caustic soda cell, which has been and continues to be very popular. Of recent years the storage battery, trickle-charged, has been used in many installations.

The rails of a track circuit provide an easy path for the flow of current from the battery, but it is necessary to provide some sort of bond around the angle bars which are used to splice the rails together. Various types of bonds are used, ranging from two No. 8 B. W. G. EBB. galvanized wires, fastened to the rail with channel pins, to a short copper stranded bond which is welded to the rail.

The relays used with d-c. track circuits must operate on comparatively weak currents which flow through the rails. Various resistances have been used but the Signal Section of the American Railway Association recommends that relays be 2 or 4 ohms.

The operating characteristics of a standard new track relay of four ohms resistance are pick-up maximum 0.078 amperes, working current maximum 0.120 amperes, drop-away minimum 0.037 amperes. This is a relay having four front contacts and two back contacts.

The condition of the ties and ballast have considerable bearing on the operation of the track circuit. Where cinder ballast is used and it is not clear of rails the resistance between the rails, ballast resistance, may run as low as two ohms per thousand feet of track in wet weather; with rock ballast in good condition, dry weather ballast resistance may run as high as 100 ohms per thousand feet of track.

With either storage battery or caustic soda battery, it is necessary to use a fixed resistance in series with the battery to limit the flow of current to rails when the track is short circuited either by a train or unfavorable ballast conditions. This is not necessary with gravity batteries on account of their high internal resistance.

The author has gone somewhat into detail in describing the track circuit for the reason that it is absolutely necessary to understand its operation to get the full benefit of the description of the signal system.

Referring to our description of the track circuit, we see the following possibilities. A broken wire, a broken rail, a broken battery jar, a shunted track, or a misplaced switch (each switch is provided with a circuit controller which shunts the track when switch is open unless otherwise provided) will cause the track relay to become deenergized and its contacts to open. Signals may be controlled through as many track circuits as desired and thus the signal will correctly tell us the condition of the track for a predetermined distance ahead.

Relays which repeat the track relays and which are energized over line wires are used where it is necessary to repeat more than one track relay or where a signal is to be controlled through some distant function.

The new signals which we are using on the Missouri Pacific Line are, as stated before, of the color light type. Each unit is provided with a 10-volt, 18-watt lamp. These lamps are burned at slightly less than nine volts in order to get long life. Where local conditions will permit, we light them automatically on the approach of a train; normally they are dark.

Any signal of this type to give a good indication must be properly lined with respect to an approaching train; it must also be so constructed that all units will give their maximum indication at the same point. Provision must be made to renew lamps without disturbing the focusing of the signal. We are using a rebased lamp in our signals. This is a lamp which has the bayonet collar soldered on in such a way that the pins are always in exactly the same location with respect to the filament; each socket being carefully located with respect to the lens unit, lamps may be replaced without interfering with the focusing of the unit.

A brief description of the lens unit, Fig. 1, of the signal we have used in our latest installations may be of interest. It consists of a doublet lens unit with a fixed light source, the lamp filament. The inner lens of the doublet combination is of high transmission colored optical glass, which determines the color of the signal indication. This inner lens is of very short focal length and therefore intercepts a maximum quantity of the light rays from the filament of the lamp, which is located at its focal point. These rays are bent by refraction so that they are directed upon the outer lens at angles coincident with its focal point and they emerge from the outer lens in practically parallel rays, forming a cylindrical beam of colored light. Where a modification of the beam is necessary to meet condition found on a curve, a roundel or cover glass is used to spread or deflect the light beam. The structure of the entire unit is such that the axial center of the light and the lenses and the focal length of the lenses are accurately positioned and permanently held in their proper fixed relation to one another. Lenses employed have a total spread of three to four degrees, but when necessary this spread can be increased to 20 or 30 degrees by the use of deflecting roundel mentioned above. This is done at the cost of loss in beam intensity; however, long range signals are rarely required on curves so that this is not objectionable.

On our single track we are using a scheme of automatic signaling which has been termed the "absolute permissive block system," Fig. 2. The name refers to the manner of controlling the signals and has nothing whatever to do with the construction of the signals. It may be described as a system of signaling, which provides absolute or positive blocking for opposing train movements between fixed locations, usually passing tracks, but which will permit following train movements between these same two locations. It may best be described by an example.

Assume two passing tracks T and R, five miles apart. A pair of signals will be located at each end of each passing track and the five-mile section between

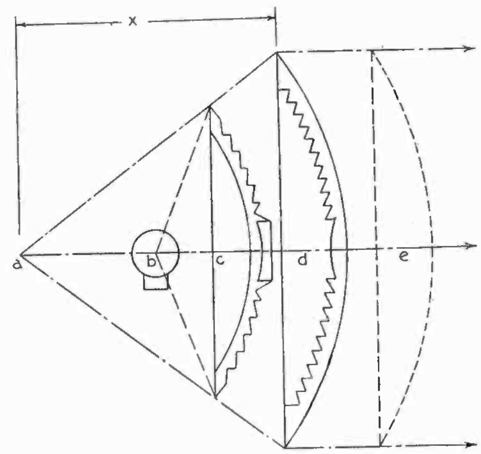


FIG. 1—DOUBLET LENS UNIT

passing tracks may be divided into four blocks, which will require three pairs of intermediate signals. The leaving signal at each passing track will have some special designating mark; we use a large letter A, which is backed with reflecting glass. When this signal is red, trains may not pass it after stopping unless authorized to do so by the dispatcher or when preceded by a flagman. This is the *absolute* signal. All of the others are permissive signals, that is, a train finding one of them red must, unless otherwise provided, stop, after which it may proceed at slow speed expecting to find a train in the block, a broken rail, or some condition affecting the movement of the train. A train leaving T will set all opposing signals between T and R red so that it is protected against any opposing trains. Firstly the absolute signal at R is red and this is a "stop" signal, but further protection is given for the case where both trains happen to pass the *absolute* signals at the same instant, because all other opposing signals will stop the opposing train. This protection results when the train sets all opposing signals between T and R red. As the train proceeds through the territory from T to R, it is protected in the rear by one red and one yellow signal so that following or permissive moves may be made.

There are locations at which, if a heavy train is stopped, it will be unable to proceed without doubling or without a considerable loss of time and fuel and with possible damage to equipment. When necessary to install a permissive signal at one of these places, we provide on the pole below and to the right of the light unit, a special designating marker consisting of a letter *T*, which is constructed similar to the *A* described above. Any train with over 75 per cent of the tonnage rating of the locomotive, may pass a signal equipped with this tonnage marker when the red light is burning, but must

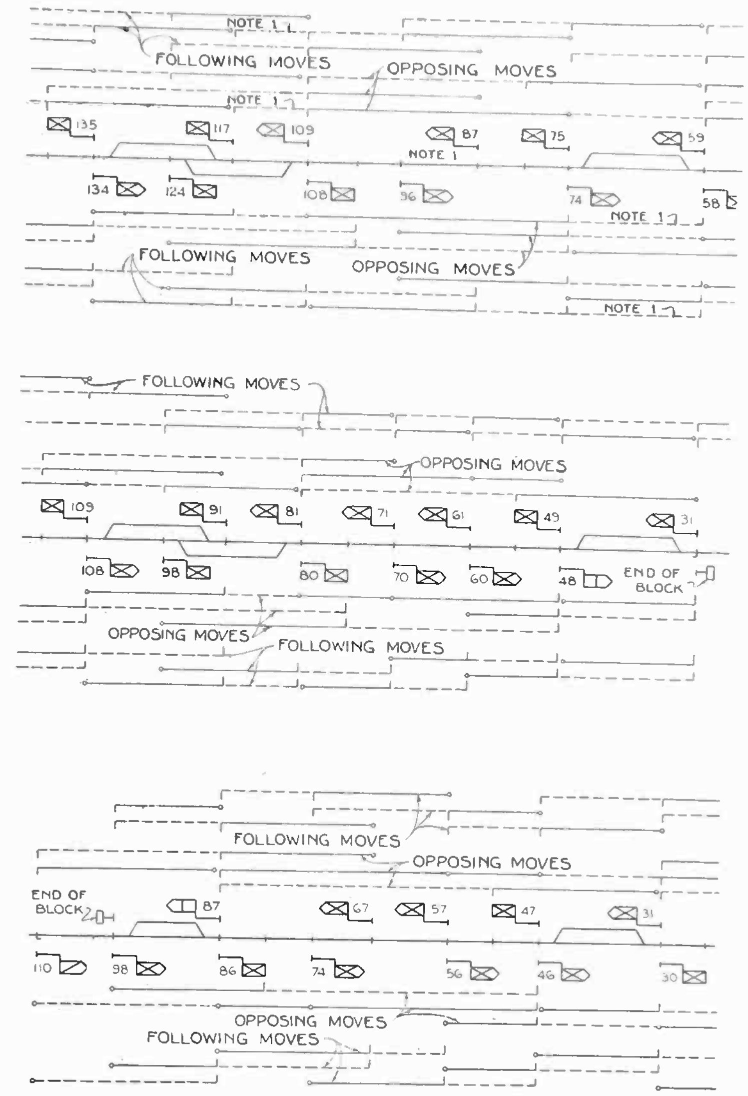


Fig. 2—Typical Overlap Diagram—Absolute Permissive Block System

Note 1. When distance 87 to 96 is less than 2640 ft., distance controls shall extend one track section in rear of opposing absolute signal as shown.

Note 2. Full and dash lines marked "following moves" and "opposing moves" show the control limits of each signal. Full lines indicate the track section which, if occupied by a train, will cause the signal to give a stop indication; as extended by dash lines the same signal will give an approach or caution indication with a train in the section covered by the dash line extension.

Each signal is numbered for identification.

proceed at slow speed prepared to stop short of another train or an obstruction.

There is another type of single-track automatic signaling known as the "overlap system." In this scheme a train moves in a protected zone which extends both ahead and behind a sufficient distance, so that it includes both a red and a yellow signal. This system of signaling is perfectly safe and is used on a large mileage; it is claimed, however, that it will limit track capacity more than the absolute permissive system.

One of the rules of the operating department of a railroad is that a signal imperfectly displayed or the absence of a signal at a place where a signal is usually shown, must be regarded as the most restrictive indication that can be given by that signal.

In so far as practicable, every signal and every signal circuit is designed on this same principle; that is, the failure or removal of any part will result in a more restrictive indication. Every detail must be watched to see that all of the devices will operate under widely varying conditions of service such as temperature and humidity variations, size, weight, and speed of trains, etc.

A very careful record is kept of the failures of the apparatus to function as intended. Inasmuch as every failure may mean a train delay, it is vital that these reports be watched carefully, each failure studied and corrective measures applied as quickly as possible. It is to the credit of the designers of the apparatus and the maintenance forces of the railroads that signal performance records are very high. It is not unusual to have 100,000 operations per failure on a division and averages for an entire system frequently run this high.

As you no doubt realize, it requires a considerable organization to look after the installation and maintenance of the signal system of a large railroad. This work is handled by a sub-department of the engineering department on most railroads. A signal engineer heads the organization and he and his staff are responsible for the design, construction, and maintenance of all signals, interlocking plants, and highway crossing protection. The field work is handled by men reporting to division supervisors of signals. Each maintainer and his assistant are given from 20 to 40 miles of signals to maintain, depending upon the amount of other apparatus, such as interlocking and highway crossing protection, which is located in the territory.

According to the report of the Interstate Commerce Commission, there were as of January 1, 1928, 53,616 miles of automatic block signals in service in the United States. At that time there were 199,154 miles of railroad over which passenger trains were being operated. This excludes lines which operate only one locomotive. During the five year period ending January 1, 1928, automatic block signal mileage increased 12,089 miles.

We now have more than 1700 miles of the Missouri Pacific on which automatic signals are either in service or under construction.

This paper merely touches on some of the more important features of an automatic block system. Interlocking plants, highway crossing protection, and automatic train control devices, all of which are closely related to the automatic signal system, form a large part of the work of the signalman. Each of these subjects would be worthy of a separate description.

Abridgment of

Electrical Wave Analyzers for Power and Telephone Systems

BY R. G. McCURDY[1] and P. W. BLYE[1]

Member, A. I. E. E. Member, A. I. E. E.

Synopsis.—*This paper describes two types of electrical analyzers which have been developed for the direct measurement of harmonic components of voltage and current on power and telephone systems. These devices are assembled mechanically in a form suitable for use in either the laboratory or in the field. Both instruments, which differ chiefly with respect to sensitivity and input circuit arrangement, employ multistage vacuum tube amplifiers and two duplicate interstage selective circuits.*

The power circuit analyzer is designed to measure harmonic voltages in the frequency range from 75 to 3000 cycles, and over a voltage range from 0.5 millivolt to 50 volts. The telephone circuit analyzer operates over the same frequency range and measures harmonic currents as low as 0.05 microampere and voltages as small as 0.005 millivolt. Both analyzers are adapted to measure small harmonic voltages and currents in the presence of the fundamental component and other harmonics relatively large in magnitude.

A number of devices are described which have been adopted for eliminating various sources of error. The paper presents in detail the characteristics of both instruments with respect to selectivity, sensitivity, linearity, balance of input with respect to ground, generation of harmonics and susceptiveness to stray fields.

* * * * *

Introduction

The solution of many problems in electrical engineering, involving currents and voltages of complicated wave-shapes, can be carried out most practicably by a study of the individual sinusoidal components into which these complicated waves may be resolved. This is particularly true in the case of problems dealing with the inductive coordination of power and telephone systems, since the induced noise in telephone circuits occurs largely at frequencies corresponding to the harmonic components in the current and voltage waves of neighboring power systems.

In recent years, many of the development and research problems in inductive coordination, with which the Bell System has been concerned, have required an accurate and comparatively rapid field method of analyzing complex waves. The analyzers which are described in this paper have been developed to meet the particular requirements of these studies. The development of these instruments has proceeded in close association with the progress of the field work and modifications were made in the designs from time to time as necessitated by the requirements of the work. This has resulted in the production of two types of analyzers one of which is particularly adapted for use with suitable instrument transformers and shunts on power circuits, and the other for use on telephone circuits. For convenience, these have been termed the power circuit analyzer and the telephone circuit analyzer.

These analyzers have been in active service in the field for some time and have permitted the obtaining of many valuable data as to coefficients of induction between power and telephone systems, the wave shape of power machinery and systems, and analyses of noise currents on telephone circuits. They are arranged in suitable form for use in either the laboratory or in the field and in some instances have been mounted in specially equipped testing trucks.

Aside from their use in this work on inductive coordination, it is felt that the instruments may have a field in other power and communication problems in which a knowledge of the magnitudes of harmonic voltages and currents is important or where measurements at single frequencies are desired in the presence of extraneous voltages and currents as large or larger than the single frequency it is desired to investigate.

The over-all accuracy of an instrument of this type depends upon the conditions surrounding its use. These include the magnitude of the component being measured as compared to the magnitudes of the fundamental and other harmonics present, the relative magnitudes of the voltage across the terminals of the instrument and the voltage between these terminals and ground, and the severity of stray fields from nearby power circuits. Under average conditions, the analyzers which are described in this paper should give results with an over-all accuracy of within $\pm$ 5 per cent of the quantities measured. By means of these instruments it is possible to make a complete analysis of a complex wave over the frequency range up to 3000 cycles in from 30 to 45 min., depending upon the number of harmonic components present. The working up of the results in terms of volts and amperes consists in multiplying together not more than three quantities. The obtaining of a complete harmonic analysis in terms of volts or amperes should not, therefore, require more than one man-hour. The apparatus is so arranged that practically simultaneous analyses may be made of a number of currents or voltages.

General

As stated above, two general types of analyzers, have been developed, the first being designed for use on

1. Am. Tel. & Tel. Co., New York, N. Y.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

power systems, while the second, a more sensitive instrument, is intended primarily for measuring currents and voltages of the magnitudes commonly experienced on telephone systems.

The requirements of both types of analyzers, with respect to selectivity and at the same time insensibility to commercial frequency variations, are practically the same. Therefore, the same selective equipment, designed to give a response curve which is parabolic in form, has been employed in both instruments. Other

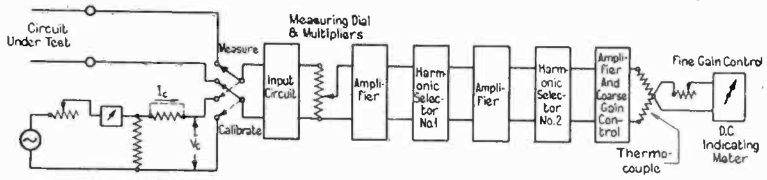


FIG. 1—SCHEMATIC DIAGRAM OF ANALYZER CIRCUIT

requirements which have been particularly considered in the development of the analyzers have to do with sensitivity, impedance of input circuits to be provided, insensibility to stray fields and the limiting of harmonics generated within the instruments due to modulation effects. In both analyzers and in the telephone analyzer in particular, special consideration has been given to the matter of input circuit balance with respect to ground. This is in order that the accuracy of measurement may not be impaired when the voltage across the input circuit is small as compared to the voltage between the input terminals and ground, a condition which frequently obtains on telephone systems. The methods employed in meeting these various requirements and their effectiveness will be discussed in detail below.

Electrical Circuit. Each analyzer consists essentially of a multistage vacuum tube amplifier equipped with suitable controls, a measuring dial and associated multipliers, a calibrating circuit and a sensitive d-c. indicating meter operated by a thermocouple in the output circuit of the amplifier. Selectivity is afforded by means of duplicate tuned circuits inserted between stages of the amplifier. A schematic diagram indicating the general arrangement of the analyzer circuit is shown in Fig. 1.

The particular circuit features of the power and telephone analyzers will be discussed in the following sections of the paper.

Mechanical Arrangement. For convenience in transporting and setting up the apparatus in the field, each type of analyzer has been assembled in two units, known as the "amplifier unit" and the "harmonic selector Unit" respectively. The selector units used with both the telephone and power circuit amplifiers are identical. A completely assembled power analyzer, together with its calibrating oscillator, is shown in Fig. 3, in which the lower unit is the harmonic selector and includes all the equipment making up the selective circuits, the upper is the amplifier unit and includes the measuring circuits, the vacuum tube amplifier and its incidental control apparatus.

Harmonic Selector. These analyzers employ as a selective device two independent tuned circuits operating in tandem. The effect of the two circuits in tandem is to discriminate against extraneous harmonic components close to the tuned frequency in proportion to the square of the differences between their frequencies and that to which the circuits are tuned. The response curve obtained with such an arrangement is therefore approximately parabolic in form, being relatively flat in the immediate neighborhood of the tuned frequency and falling off extremely rapidly at frequencies substantially different from that at which the circuits are in resonance.

On account of the errors which would result from small frequency variations, the maximum selectivity available with two tuned circuits of this type cannot generally be used practicably on commercial systems. The *A* curves in Fig. 4 indicate the over-all degree of selectivity obtained with the analyzer with padding resistances in series with the two resonant circuits to degrade the selectivity somewhat, this being the arrangement commonly used. The *B* curves indicate the selectivity with these resistances short-circuited.

A schematic circuit diagram of a single section of the harmonic selector unit is shown in Fig. 6. As is indicated in this figure each section consists essentially of a series resonant circuit consisting of a fixed inductance and an adjustable capacity. This resonant circuit is coupled to the plate-filament circuit of the preceding amplifying tube by a condenser of relatively low impedance (4.5 μ f.) which is common to both

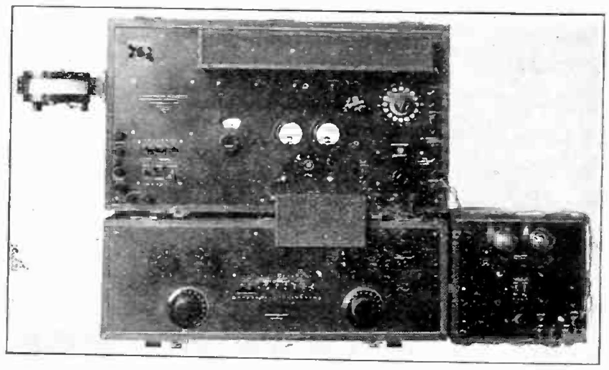


FIG. 3—POWER CIRCUIT ANALYZER AND CALIBRATING OSCILLATOR

circuits. The voltage across the inductance branch is utilized as the output of the tuned circuit and is impressed across the grid-filament circuit of the following amplifying tube. This arrangement together with an equalizing network gives an amplification-tuned frequency characteristic which is relatively flat.

In the amplifier unit designed for use with the harmonic selector on power systems, three input circuits are provided for measuring power circuit voltages, currents, and small voltage across shunts, respectively.

The impedances of these three circuits and the sensitivities available are as follows:

Quantity measured	Input impedance	Minimum measurable current or voltage
Voltage.........	10,000 ohms	0.05 volt
Current.........	0.2 ohm	2.5 milliamperes
Millivolts.......	1,000 ohms (Approx.)	0.5 millivolt

At fundamental frequencies the minimum measurable voltages and currents are ten times those given above.

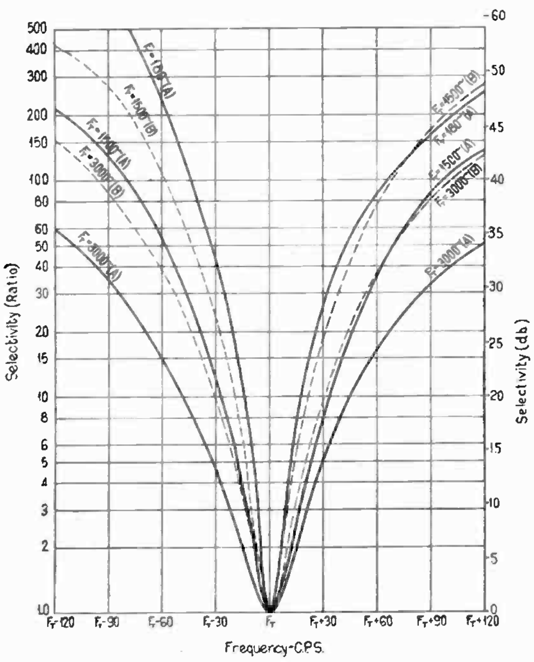


Fig. 4—Selectivity of Two Sections of Harmonic Selector in Tandem

$$\text{Selectivity} = \frac{\text{Response at Tuned Frequency } (F)}{\text{Response at Extraneous Frequency } (T)}$$

A schematic diagram indicating the general arrangement of the input circuits in the power amplifier is given in Fig. 8. These circuits are designed to measure harmonic components over a range of from 1 to 1000

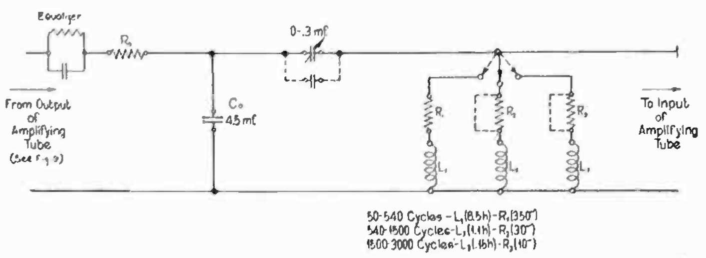


Fig. 6—Single Section of Harmonic Selector—Schematic

times the current and voltage values given in the above table. Errors due to non-linearity in the input circuits over this range do not exceed approximately ± 3 per cent at frequencies from 120 to 3000 cycles.

In order to avoid errors due to the effects of relatively large voltages to ground on the input terminals the input circuits are shielded and accurately balanced with respect to ground. As an example, the degree of balance attained in the input circuits of one particular instrument is indicated in the following table:

Frequency ~per sec.	Apparent voltage across measuring circuit per volt above ground: Current and millivolts circuit	Voltage circuit
180	0.000007	0.0007
540	0.000008	0.0008
1020	0.000013	0.0014
2100	0.000021	0.0022
3000	0.000024	0.0027

In order to avoid the generation of harmonics of appreciable magnitudes within the analyzer itself due to modulation effects, it was found necessary to provide special devices for suppressing the fundamental component of the wave under analysis and for balancing out harmonics generated in the input transformers.

These means for controlling the generation of

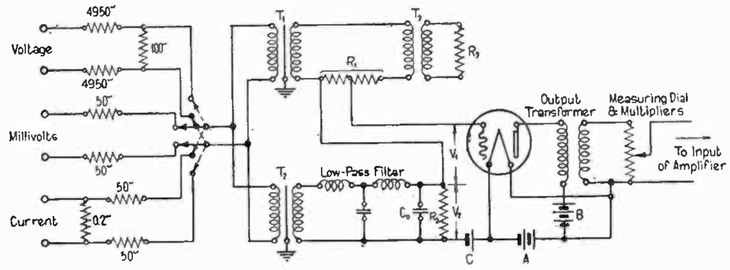


Fig. 8—Power Analyzer—Input Circuit—Schematic

harmonics have proved very effective. In one particular instrument the generated harmonics observed in the case of a 60-cycle fundamental voltage of 102 volts were as follows:

Fundamental voltage	Per cent generated harmonics: 2nd	3rd	4th	5th	6th	7th	9th
102 volts.......	0.07	0.08	0.008	0.02	*	*	*

*Too small to measure—less than 0.01 per cent.

The power amplifier unit is specially shielded against stray electrostatic fields at all susceptible points with copper shielding. Similar shields of annealed iron are provided with all susceptible wound apparatus as a protection against stray electromagnetic fields. A large number of tests carried on in the field indicate that the analyzer is sufficiently well shielded for general use in the vicinity of power apparatus.

A circuit diagram of the amplifier which is used in conjunction with the input circuits described above is shown in Fig. 9. This portion of the circuit is identical in both the power-circuit amplifier and the telephone-circuit amplifier which is to be described below.

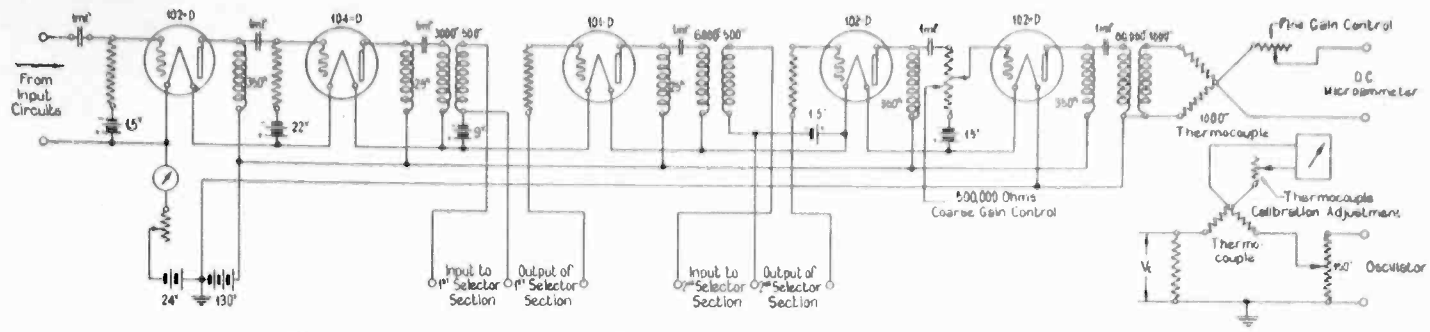


FIG. 9—AMPLIFIER UNIT EXCLUDING INPUT CIRCUITS—CIRCUIT DIAGRAM

TELEPHONE CIRCUIT AMPLIFIER

The amplifier which has been designed for use with the harmonic selector on telephone systems differs from the power-circuit amplifier chiefly in the matter of sensitivity and in the arrangement of its input circuits. A schematic diagram of the input circuit of the telephone circuit amplifier is shown in Fig. 10. As is indicated in this diagram the input circuit is provided with three individual transformers by means of which the following circuit arrangements and sensitivities are obtained:

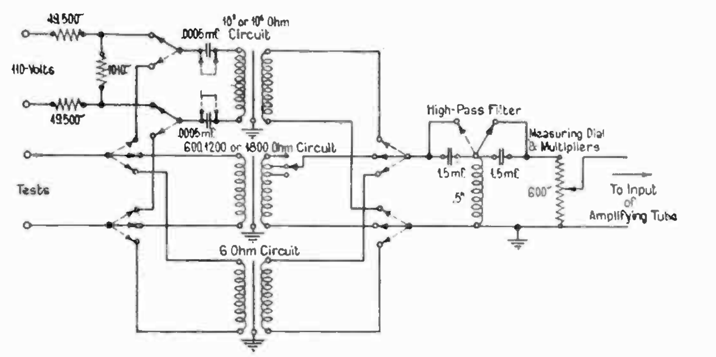


FIG. 10—TELEPHONE ANALYZER—INPUT CIRCUIT—SCHEMATIC

Quantity measured	Input impedance	Minimum measurable current or voltage
Voltages	6 ohms	0.005 millivolt
Voltages	600 ohms	0.05 millivolt
Voltages	120,000 ohms	0.5 millivolt
Voltages	1,000,000 ohms (600 cycles)*	5.
Power Voltages	100,000 ohms	0.05 volt
Currents	600 ohms	0.05 microampere
Currents	1,200 ohms	0.035 microampere
Currents	1,800 ohms	0.03 microampere
Currents	6 ohms	0.5 microampere

*This circuit consists of 0.00025 μ f. in series with the 120,000 ohms of the transformer and measuring dial. Its impedance and sensitivity, therefore, vary with frequency.

The minimum measurable currents and voltages at fundamental frequencies are ten times those tabulated above.

The input circuits of the telephone-circuit amplifier have been found to operate satisfactorily over a range of currents and voltages from 1 to 2000 times those tabulated above.

The balance of the input circuits with respect to ground is an important feature in the case of the telephone-circuit amplifier in view of the large ratios between voltage to ground and metallic-circuit voltage which usually exist on telephone lines.

The degree of balance attained in the input circuits by careful shielding and the use of special transformers is indicated in the following table:

Input circuit	Frequency	Apparent voltage across circuit per volt to ground
Current (6-ohm)	3000	0.0000015
Current (6-ohm)	540	0.00000035
Current (600-ohm)	3000	0.000012
Current (600-ohm)	540	0.000002
Voltage (120,000-ohm)	3000	0.00029
Voltage (120,000-ohm)	540	0.00002
Voltage (0.00025 μ f.)	3000	0.0046
Voltage (0.00025 μ f.)	540	0.0042
Power voltages	3000	0.025
Power voltages	540	0.001

As is indicated in the circuit diagram of Fig. 10 a high-pass filter consisting of a series condenser of 1.5 microfarads and a shunt inductance of 0.5 henry is included in the input circuit. This filter is effective on systems having a fundamental frequency of 60 cycles or less, in suppressing the fundamental component of the complex wave under analysis. The generation of harmonics in the analyzer due to modulation effects is, therefore, practically confined to the input transformers.

The generated harmonics in one particular telephone-circuit amplifier unit, expressed in per cent of the fundamental component are as follows:

Circuit	Fundamental component		Per cent generated harmonic			
			2nd	3rd	5th	7th
Current (600-ohm)	0.001	ampere	0.28	0.27	0.049	0.006
Current (6-ohm)	0.01	ampere	0.25	0.25	0.05	0.009
Voltage (120,000-ohm) volts	10		0.25	0.25	0.05	0.007

While the telephone circuit amplifier is not ordinarily exposed to stray fields of large magnitudes, the instrument has been shielded at susceptible points in much the same manner as the power analyzer. Tests in the laboratory and in the field indicate that except under unusually severe conditions the shielding is sufficient to permit the use of the analyzer in the vicinity of power apparatus.

Abridgment of

Quick-Response Generator Voltage Regulator

Field Tests Made With Oscillograph

BY E. J. BURNHAM[1], Associate, A. I. E. E.
J. R. NORTH[2], Member, A. I. E. E.
and
I. R. DOHR[3], Non-member

Synopsis.—This paper describes elaborate and severe field tests made on high-speed excitation equipment used with a 5385-kv-a. turbo generator. Complete oscillograms and curves showing the performance of this equipment are included, together with a discussion of the results obtained.

* * * * *

DURING 1928, high-speed excitation equipment was provided for a 5385-kv-a. house turbo generator, which is used for supplying power to essential auxiliaries at the Saginaw River Steam Plant of the Consumers Power Company. Elaborate field tests were made on this regulating equipment, constituting the most severe tests made on a machine of such size, and the results are indicative of those which may be obtained on the larger size generators.

Description of Installation

The No. 1 house turbo generator on which these tests were made is a General Electric unit rated 5385 kv-a., 3500 kw., 0.65 power factor, 2500 volts, 3600 rev. per min., 60 cycles and has a direct connected exciter rated 33.5 kw., 250 volts, four-pole, shunt wound.

The house turbo generators supply power to the more essential station auxiliaries consisting of boiler feed pumps, draft fans, circulating pumps, condensate pumps, etc. All motors used with these auxiliaries are started on full voltage and the larger ones of 400-hp. capacity are of the squirrel-cage type. The house generators may be operated in parallel with or isolated from the rest of the system.

A General Electric Type FA-1 high-speed generator voltage regulator is provided to control the excitation of the No. 1 house generator. This regulator is equipped with a three-phase torque motor control and rheostatic follow-up features.

Requirements

This high-speed excitation equipment was installed to accomplish the following:

a. To accurately control the a-c. voltage under all conditions of picking up and dropping load without disturbing the operation of the other station auxiliaries operated from the same machine.

b. To obtain a high speed of excitation response in connection with this generating unit in order that even the largest induction motors (400 hp.) used for station power service could be satisfactorily started at full voltage with minimum disturbance.

c. To obtain first hand information concerning the operation of this type of quick response regulator, particularly regarding its speed of operation, precision, and stability of operation.

Design of Regulating Equipment

In order to meet the above requirements, a quick-response excitation system was provided consisting of an exciter with a high speed of voltage build-up and a high-speed regulator. The exciter is self-excited and has a speed of voltage build-up of approximately 1000 volts per second over the operating range.

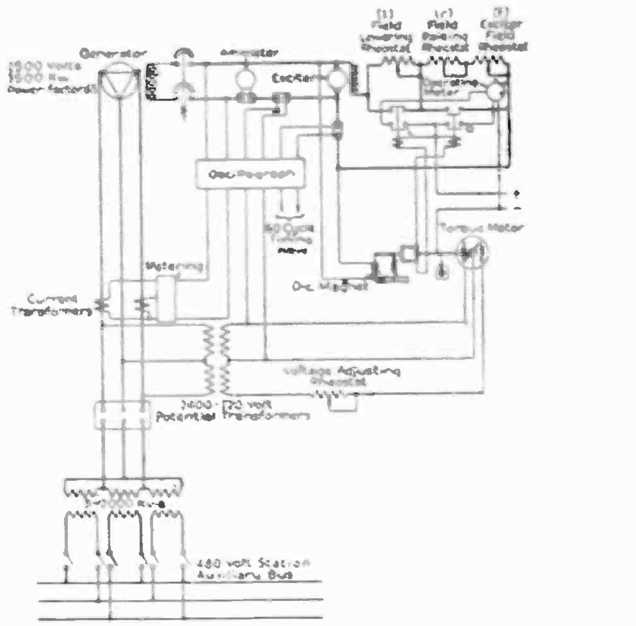


Fig. 1—Diagram of Regulator and Test Connections Saginaw River Steam Plant

Fig. 1 shows a simplified diagram of connections of the house generator excitation system and the FA-1 regulator. Figs. 2 and 3 show illustrations of this regulating equipment. The main control element consists of a d-c. system and an a-c. system and includes two lever arms, one controlled by a three-phase torque motor and the other by a d-c. magnet. A contact on the a-c. lever arm floats between two contacts on the d-c. lever arm. The torque motor is energized from two potential trans-

1. General Electric Co., Schenectady, New York.
2. Stevens and Wood, Incorporated, Jackson, Michigan.
3. Consumers Power Company, Jackson, Michigan.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

29-62

formers which are connected to the three phases of the alternator, thus giving three-phase control. The d-c. magnet is connected across the armature of the exciter and provides the necessary anti-hunting feature and also the vibrating of main contacts.

Quick response in the regulator is obtained by use of a spring dashpot connected to the a-c. lever arm of the main control element. The springs in the dashpot allow either main contact to close without waiting for the movement of the diaphram in the oil dashpot.

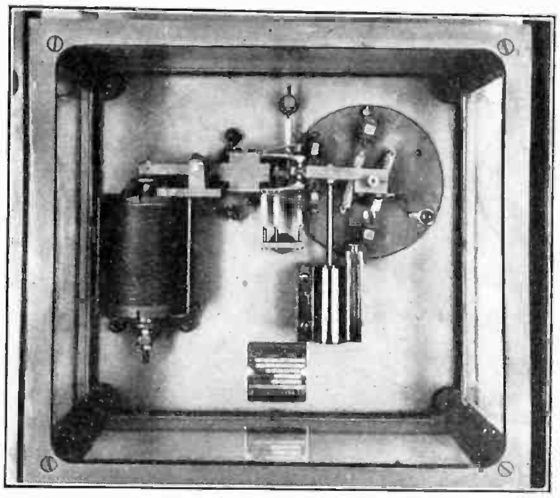


Fig. 2—Front View of Regulator Main Control Element

This dashpot tends to stabilize the operation of the main contacts. This spring dashpot can also be applied to the vibrating type of regulator to obtain quick response.

The anti-hunting feature is provided by means of the d-c. coil on the main control element. This d-c. element opens either the upper or lower main contact, after such contact is once made by the torque motor.

Operation of Regulating Equipment

With the a-c. voltage of the alternator normal, the main control element is in equilibrium, and the regulating equipment remains at rest. A decrease in a-c. voltage causes the torque motor to close the upper main contact, thus energizing contactor *R*, which in turn short-circuits rheostats *r* and *f* causing an increase in excitation. Upon an increase in a-c. voltage, the lower main contact closes, thus energizing contactor *L* which inserts rheostat *l* in the exciter field circuit to decrease the excitation.

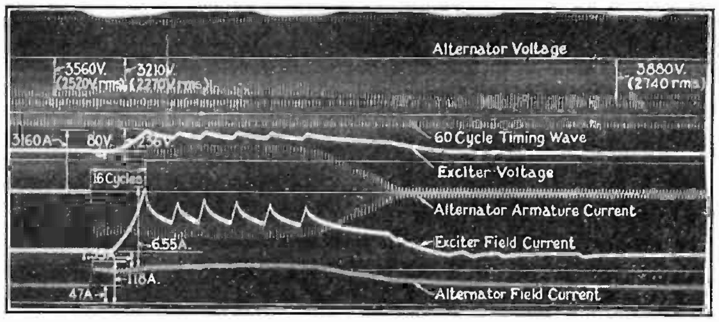
For a decrease in a-c. voltage, the upper main contact and contactor *R* will open and close, thus functioning as a vibrating type regulator until the a-c. voltage returns to normal and the main element is in equilibrium. In the same manner, an increase in a-c. voltage will cause vibration of the lower main contact and contactor *L* until the a-c. voltage returns to normal.

Each time that either high-speed contactor, *L* or *R*, is operated, an auxiliary contact energizes the motor of the motor-operated rheostat in the correct direction to bring the a-c. voltage back to normal, and the equipment back to equilibrium.

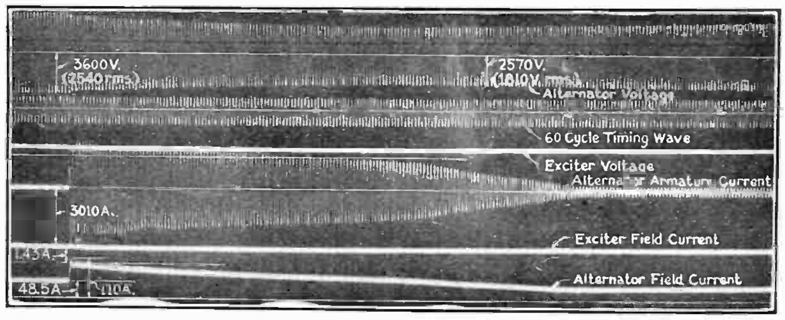
Field Tests on Regulating Equipment

An extensive series of field tests was conducted on this regulating equipment to enable it to be adjusted under actual service conditions and to obtain detail information regarding its operation. These tests consisted of suddenly picking up or dropping large amounts of load with the excitation of the generator under regulator control, and also with fixed excitation. Complete oscillographic records were obtained as well as graphic voltmeter charts and readings on indicating meters. The operation of the regulating equipment when the generator was paralleled with the rest of the system was also recorded.

Load was suddenly applied by starting one or two 400-hp. motors simultaneously at full voltage. Starting two motors simultaneously was equivalent to a momentary load of approximately 7500 kv-a. or approximately 130 per cent generator rating at approximately 35 per cent power factor lagging. The motors came up to speed in a very short time, approximately one second with the regulator in service and two seconds with fixed excitation, and their load demand dropped rapidly to a low value as soon as they came up to speed. Load was suddenly dropped by operating the generator paralleled with the system and carrying load, then suddenly opening the generator oil circuit breaker.



Test No. 7
Generator isolated and carrying no-load
Regulator in service
Started No. 3 and No. 6, 400-hp. motors



Test No. 8
Generator isolated and carrying no-load
Regulator not in service
Started No. 3 and No. 6, 400-hp. motors

Fig. 4—Oscillograms of Tests Nos. 7 and 8

Discussion of Results

From the curves, Figs. 8 to 11 inclusive, the results obtained with and without the regulator can be compared for the different test conditions.

As previously pointed out, the starting of two 400-hp. motors at full voltage constituted a load of approximately 7500 kv-a. at approximately 35 per cent power factor lagging. The inrush current to the motors upon starting is practically all wattless; therefore the duty upon the generator is severe as far as maintaining a-c. voltage is concerned because of the highly demagnetizing action of the armature current. The maximum momentary value of inrush current was the same with fixed excitation as with the regulator in service and was approximately 145 per cent of the generator current rating when starting two motors. It was approximately 100 per cent of the generator current rating when starting only one motor. With fixed excitation this current continually decreased in value after the first instant. However, with the regulator in service it was maintained near its maximum value until the motors approached full speed.

Fig. 8 shows the results with and without the regulator in service under the condition of starting two motors at a time when the generator was carrying no load.

The effect of the generator carrying load when starting two motors can be seen by comparing Figs. 8 and 9.

Fig. 11 shows the effectiveness of the voltage regulator in limiting the rise of generator voltage upon the dropping of load.

Table II gives a summary of the test results and shows the successive operating intervals of the different portions of the excitation system from the instant the generator load changes until the generator voltage is restored to normal, the speed of voltage build-up of the exciter and the generator, and the limits of exciter and generator voltages reached during the tests.

The successive operating time intervals represent the time in cycles required for the individual portions of the excitation equipment to operate. It will be noted that the main contacts of the regulator closed in approximately 2.5 cycles after the load changed. The auxiliary raised contactors closed in approximately

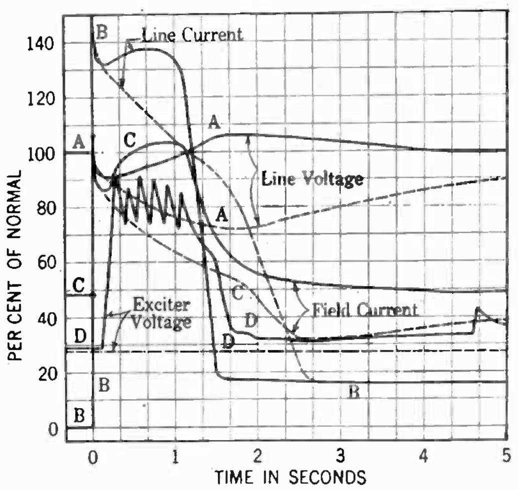


Fig. 8

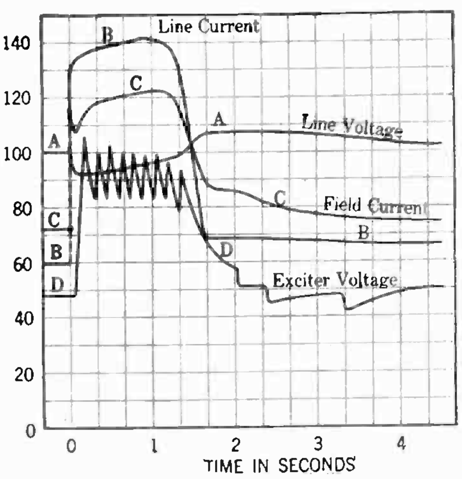


Fig. 9

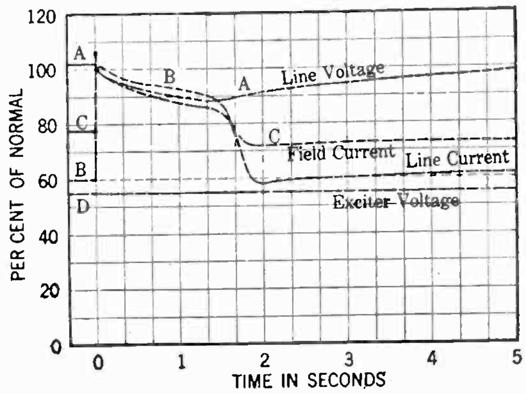


Fig. 10

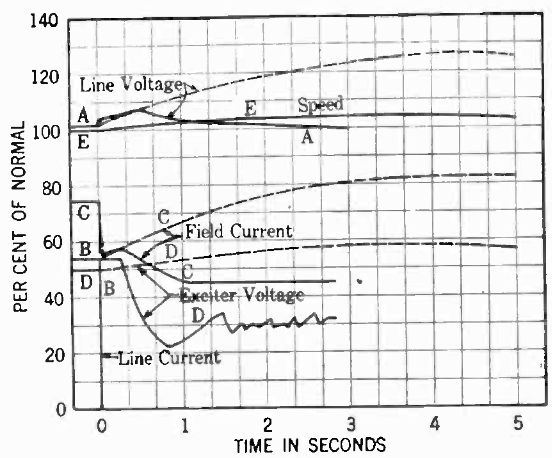


Fig. 11

Figs. 8, 9, 10 and 11.—Curves Showing Results of Tests Nos. 7 and 8, 9, 10, and 11 and 12 Respectively

A. Line voltage 2500 volt = 100 per cent.
B. Line current 1245 amperes = 100 per cent.
C. Field current 110 amperes = 100 per cent.
D. Exciter voltage 250 volts = 100 per cent.

Fig. 8 with generator isolated and carrying no-load started two 400-hp. motors.—Regulator in service; . . . . Fixed excitation. Fig. 9 with generator isolated and carrying load started two 400-hp. motors; regulator in service. Fig. 10 with generator isolated and carrying load started two 400-hp. motors; regulator not in service. Fig. 11 generator paralleled with system and carrying load; dropped load.—Regulator in service: . . . . Fixed excitation.

TABLE II
SUMMARY OF TEST RESULTS

Test conditions			Successive operating time intervals (cycles)					Speed of build-up (Volts per sec.)		Generator voltage		
						Total‡						
Excitation	Generator	Load	Main contacts	Aux. contactors	Exciter voltage	(A)	(B)	Exciter	Gen.†	Normal	Min.	Max.
Regulated	Isolated No load	Picked up	2.0	3.0	9	65	660	930	800	2540	2240	2620
Fixed	Isolated No load	Picked up	....	....	....	1200	1200	....	−200*	2530	1870	2530
Regulated	Isolated No load	Picked up	2.0	3.0	11	70	720	1040	270	2520	2270	2740
Fixed	Isolated No load	Picked up	....	....	....	1200	1200	....	−500*	2540	1800	2540
Regulated	Isolated Carrying load	Picked up	2.0	2.0	7	83	600	1200	225	2540	2250	2660
Fixed	Isolated Carrying load	Picked up	....	....	....	720	720	....	−170*	2630	2210	2630
Fixed	Paralleled Carrying load	Dropped	....	....	....	....	....	....	225	2660	....	3240
Regulated	Paralleled Carrying load	Dropped	3.0	14	37	110	720	−140*	−110*	2540	....	2720
Regulated	Isolated No load	Picked up	2.5	8.0	....	....	....	....	150	2540	2390	2600

Note: *Indicates rate of voltage decay.
†Approximate rate during time motors coming up to speed.
‡A Time interval refers to point when generator voltage first returned to normal.
‡B Time interval refers to point when generator voltage became stable at normal value.

four cycles after the main contacts closed and the exciter voltage built up to its maximum value in an average time of approximately nine cycles after the auxiliary contactors had closed. The corresponding operating time intervals with the regulating equipment decreasing the excitation are somewhat longer. As shown by Test No. 12, the auxiliary lowering contactor closed in 14 cycles, and the exciter voltage decreased to its minimum value in 37 cycles after the auxiliary contactors had closed.

The above time intervals are of interest as regards the operation of the various component parts of the regulating equipment, but from an operating standpoint, the total time interval elapsing from the instant the load changes until the generator voltage is restored to normal is of prime importance. Referring again to Table II, it will be seen that with the regulator in service the generator voltage first returns to the normal value in an average time of approximately 81 cycles or about 1.5 seconds. As previously mentioned, the generator voltage overshot and finally became stable at the normal value after a total average time interval of 570 cycles or 9.5 seconds. With fixed excitation, the voltage returned to normal after an average time interval of approximately 20 seconds. It was rather hard to determine at just what point the generator voltage became stable at the normal value, but the above values are relative.

Conclusions

The following conclusions may be drawn from the results of these tests:

a. The quick response excitation equipment is effective in reducing the magnitude and duration of a-c. voltage surges due to sudden increase or decrease in load.

b. From an operating standpoint, the over-all speed of a-c. generator voltage response is of prime importance rather than exciter speed of build-up. In other words, the total time interval from the instant of load change to the time when the a-c. voltage is restored to normal is most important.

It is estimated that the railroads of America, as the result of systematic safety contests among employes during the past five years, have saved the lives of 1383 employes, and have prevented over 180,000 additional serious accidents to employes.

These estimates are based on official Interstate Commerce Commission statistics, comparing the 1923 accident rates of these railroads with the lessened accident totals which have been achieved as the direct result of systematic and competitive safety contests among employes.

In recognition of this splendid safety work among these railroads for the year 1928, the National Safety Council last month presented a number of awards to the winners of the Railway Employes' National Safety contest. The awards were presented by Major Henry A. Reninger, president of the National Safety Council.

Interconnection in the Southwest

BY GEO. A. MILLS[1]
Member, A. I. E. E.

Synopsis.—Interconnected electric service in the Southwest has kept pace with the country as a whole. Eight states are now connected by a continuous transmission system, operated at a voltage of 60,000 volts or more. This system extends 720 mi. from East to West and 810 mi. from North to South. A description of the system is given in this paper.

A few years ago the supply of electrical energy in the Southwest centered around the larger communities, obtaining such supply from steam plants located within the boundaries of the city. The nearby communities were served by moderate voltage transmission lines radiating from these plants.

In the arid sections of the district where condensing water is scarce, oil engines were used extensively as a basis of power generation and for load development.

In the past few years development has progressed with the expansion of existing power plants and the extension of transmission networks around the larger urban areas. In the northern section of the district this development has practically covered a majority of the territory; however, in the southern portion there still exist many scattered small plants and low voltage transmission systems.

The great industrial development which started a few years ago and is now under way, has brought about a change. The small plants and low voltage networks were not only unable to furnish the capacity needed but were unable to serve economically the large industries demanding a power supply. This brought about a consolidation of the smaller properties into larger operating groups, the constructing of higher voltage transmission lines, and the development of larger base load plants.

Such development, in providing an ample supply of economical energy, has stimulated general expansion in all lines of activity such as agriculture, by providing an energy supply for irrigation pumping, gins, oil mills, creameries, condenseries, cheese factories, and general service to the farm; refrigeration; mining, smelting, and quarrying; saw mills, paper mills, and other wood product industries; the oil industries, in the electrification of drilling and well pumping equipment, refineries, pipe line pumping stations and compressor stations; and last but not least, has improved the standards of city life in industrial, commercial, and domestic activities.

The general territorial growth has been so rapid that at the present time the larger operating groups have covered the intervening territory so the border transmission lines have been interconnected, thus bringing about the present interconnected network. These interconnections have been a natural procedure since the operating executives and transmission engineers have in most cases selected similar distribution voltages from sixty to seventy thousand volts with the idea of interconnection in the future. This selection was made necessary on account of the great distances between load centers and the scarcity of favorable plant locations near the load centers, requiring a high distribution voltage to take care of the situation properly.

The skeleton transmission map, Fig. 1, shows the present interconnected lines operated at 60,000 volts and higher voltage. The map also shows the location

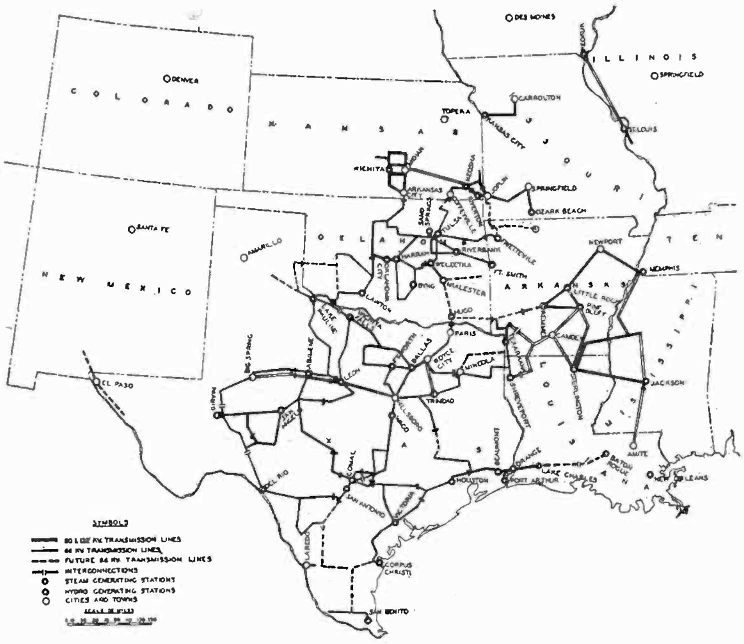


Fig. 1—Interconnected Transmission System of the Southwest

of points of interconnection between various operating groups and the major power stations.

The great distances between power supply points is evident by an inspection of the map. It is to be noted that the distance of continuous interconnected line stretching from Memphis, Tennessee, to the Ozark hydro plant in Missouri, is 1500 miles. The interconnected territory from east to west is 720 miles wide and from north to south is 810 miles in extent.

Interconnection Contracts

The first interconnections made in the Southwest were the result of smaller operating companies purchasing energy from the larger companies having excess prime capacity. The contracts covering these interconnections and the rates used therein were based entirely on the purchase of prime energy. During the

1. Chief Engineer, Central & Southwest Utilities Company, Dallas, Texas.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

past two years several new interconnections have been made under contracts wherein it has been desirable to utilize the excess capacity of a company which has installed a large power unit ahead of its own customers' requirements. These contracts provide for the mutual benefits of interconnection in meeting operating emergencies and provide for emergency operation of standby plants to hold total plant investment to a minimum cost.

Executives and engineers are fast recognizing the desirability of such mutual contracts since they provide a method of keeping the reserve capacity to a minimum and allow the installation of larger, more economical prime movers, resulting in greater economies and better service to the customer than if the developments were made independently.

Power Supply

Table I lists the principal operating plants in the Southwest connected to one interconnected network. It is to be noted that of 1,415,475 kilovolt-ampere capacity, only 22,500 kilovolt-ampere is hydro.

TABLE I
PRINCIPAL OPERATING POWER PLANTS

Name or location	Capacity in kv-a.	Prime movers
Ozark Beach, Mo	11,250	Hydro
Riverton, Kan	72,000	Steam turbine
Neosha, Kan	50,000	Steam turbine
Wichita, Kan	37,500	Steam turbine
Harrah, Okla	81,250	Steam turbine
River Bank, Okla	28,125	Steam turbine
Byng, Okla	21,900	Steam turbine
Oklahoma City, Okla	12,500	Steam turbine
Bell Island, Okla	17,250	Steam turbine
Sand Springs, Okla	14,700	Steam turbine
West Tulsa, Okla	37,500	Steam turbine
Weleetka, Okla	18,750	Steam turbine
McAlester, Okla	10,600	Steam turbine
Lawton, Okla	11,250	Steam turbine
Lake Pauline, Tex	18,750	Steam turbine
Abilene, Tex	6,250	Steam turbine
San Angelo, Tex	12,500	Steam turbine
Girvin, Tex	22,500	Steam turbine
Wichita Falls, Tex	13,500	Steam turbine
Leon, Tex	38,000	Steam turbine
Ft. Worth, Tex	55,000	Steam turbine
Dallas, Tex	103,000	Steam turbine
Trinidad, Tex	50,000	Steam turbine
Waco, Tex	15,000	Steam turbine
Shreveport, La	37,500	Steam turbine
Texarkana, Ark	9,375	Steam turbine
Sterlington, La	101,850	Steam turbine
Little Rock, Ark	16,500	Steam turbine
Pine Bluff, Ark	13,375	Steam turbine
Remmel, Ark	11,250	Hydro
Memphis, Tenn	67,500	Steam turbine
Jackson, Miss	6,875	Steam turbine
Comal, Tex	75,000	Steam turbine
San Antonio, Tex	36,125	Steam turbine
Victoria, Tex	11,250	Steam turbine
San Benito, Tex	26,250	Steam turbine
Deep Water, (Houston) Tex	125,000	Steam turbine
Gable Street, Houston, Tex	35,000	Steam turbine
Neches Plant, Beaumont, Tex	64,750	Steam turbine
Port Arthur, Tex	9,800	Steam turbine
Sahira River, Orange, Tex	9,000	Steam turbine
Total	1,415,475	

The largest and most recently constructed plants in this territory have been laid out with the idea of utilizing the interconnected lines in disposing of the excess energy. In several cases single unit plants were operated, using the interconnected lines to other plants as reserve capacity until the load reached a point justifying a second unit. At the present time four such plants shown in the lists are operating on this basis.

The future power supply will be from the expansion of present base load steam plants located where condensing water is ample and fuel economical, and from future hydro plants in west Texas, northwest Arkansas, southern Missouri, eastern Oklahoma, and south Texas. All of these developments are made possible on account of interconnections since the projects offer capacities in excess of local requirements.

The proposed hydro developments are of unusual interest since the lakes created will be utilized for flood control and in south Texas the water impounded will be of untold value in providing water for irrigation downstream from the dams. The largest sites are in the Texas Big Bend country of the Rio Grande, miles away from any industrial development.

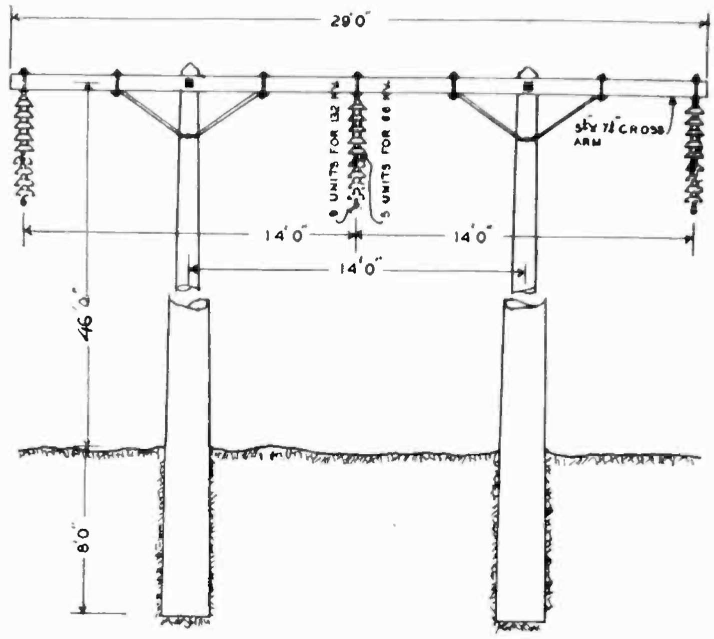


Fig. 2—Typical Structure Used in the Southwest for 66-Kv. and 132-Kv. Transmission Lines

Line Construction

The present tendency in interconnecting line construction is the use of not less than No. 4/0 conductor supported on H-frame creosoted Southern pine pole structures, spaced for 132,000-volt operation, located on private right-of-way following the shortest path between power supply and load centers or interconnecting points. A typical pole structure is shown on Fig. 2.

Steel towers in the Southwest are only used for special crossings, multiple circuits away from plants and substations, through congested urban areas, and in one or two cases, for double circuit lines.

Operation

Successful interconnection operation between several operating companies under different ownership has been accomplished in the Southwest. The total interconnected network is normally operated in four groups, Arkansas, Louisiana, Mississippi, and eastern Texas in one group; the balance of Texas and southwestern Oklahoma in a second group; the balance of Oklahoma and northwestern Arkansas in a third group; and Kansas and Missouri in the fourth group. The largest group is that in Texas where seven large operating companies under five different ownerships normally operate connected.

The rapid industrial growth of Texas has been the result of this interconnected system, especially in the arid regions of west Texas where transmission service is necessary to transmit the energy from distant plants located where circulating water is ample and an economic supply of fuel is obtainable.

Future Problems

On account of the great distances covered by single circuit or loop transmission lines and the remote location of base load plants, greater dependence on transmission line service is a necessity. The future engineering development must take into account the delivery of energy to the customer at the same general costs experienced elsewhere by increasing the reliability of the present and future transmission systems as well as the development of more economic plants to overcome the longer transmission distance between power supply and consumption.

The engineers in the Southwest are actively at work on these problems and through studies now in progress are keeping pace with similar work throughout the country to determine the proper construction to render the maximum service.

Future Interconnection

The future interconnections in the Southwest will require greater capacity lines and voltages in the 132,000-volt class to shift the increasing blocks of energy; lines designed with higher flashover voltage characteristics; use of regulating transformers with tap changers which may be adjusted under load and the use of synchronous condensers to deliver the voltage regulation required on such long lines as well as the design of more economic plants, and most important of all, interconnection contracts which will make the maximum economic use of the combined facilities.

The future holds forth more reliable transmission service, increasing number of interconnection points, higher voltage and higher capacity per single transmission circuit, better voltage regulation methods, more steam plants with larger economic units located where circulating water and cheap fuel is ample, large hydro plant developments and better contractual cooperation in the operation of the combined plants to give the customer the maximum service at lowest possible cost.

Bare Wire Overhead Distribution Practise

BY M. C. MILLER[1]

Non-member

Synopsis.*—An appreciable saving may be made in construction of overhead distribution systems by the use of bare conductors in the place of weatherproof conductors. The reliability of the system will be considerably increased with lower maintenance and operation costs. Bare conductors have practically unlimited life and when removed can be reinstalled as new wire resulting in a reduction of depreciation.*

This paper outlines the advantages of using bare wires and gives also advantages of medium-hard-drawn as compared with annealed conductors.

FOR the purpose of furnishing the electrical industry with data concerning the use of bare wire and to assist in choosing between bare and insulated wires for overhead distribution systems this paper was prepared. It shows relative costs of construction, maintenance, and depreciation with condensed data relative to unit weights and costs, and cost of lines and systems with bare and weatherproof wire.

To give a comparison of cost for conductors of the sizes most frequently used in distribution circuits the following costs per 1000-ft. of bare and weatherproof wires are calculated assuming bare at 20 cents and weatherproof at 22 cents per pound.

No. 6 Solid W. P.	$24.64	No. 6 Solid bare	$16.00	Saving	$8.64	35%
No. 4	36.08	No. 4	25.20		10.88	30%
No. 2 Str. W. P.	59.04	No. 2 Str. bare	41.00		18.40	31%
No 1/0	93.28	No. 1/0	72.40		20.88	22%
No. 4/0	176.00	No. 4/0	130.60		45.40	26%

An average saving on a number of distribution systems would be about 25 per cent in cost of copper conductors if bare wire were used instead of triple braid weatherproof wire.

The installation costs of bare wire as compared to triple braid weatherproof do not vary directly with the weight. On short extensions of one or two or three spans the labor costs would be about equal, with some savings up to 15 per cent or 20 per cent on longer lines where the lesser weight of bare wire saves on transportation, splicing and setting up reels, etc.

Construction men who have been installing and maintaining bare copper conductors for lighting and

1. Distribution Design Engineer, Texas Power & Light Co., Dallas, Texas.

Presented at the Regional Meeting of the South West District of the A.I.E.E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

power secondaries, series street lighting circuits and primaries, 2300 volt to 12,000 volt, express a very definite preference for it over the weatherproof wire.

To operate satisfactorily it must be put up right, sagged correctly, and guyed sufficiently, but once put up right it does not stretch and cause excessive sag which periodically must be pulled up or re-sagged, resulting in a large saving in maintenance costs.

No increase in horizontal spacing is necessary as the smaller sag required for bare conductors reduces the possibility of their swinging together. It has been found desirable, however, to provide additional vertical spacing where bare conductors are installed on vertical secondary racks and 12-inch separation eliminates any possibility of conductors getting together. Eight-inch spacing has been used in many places with no report of trouble from this cause. This increased spacing uses up a foot more of pole height but very seldom requires a five foot higher pole.

The life of weatherproof wire is comparatively short and it is often necessary to replace it with new wire after 10 to 20 years in service. The life of bare copper wire is unlimited. When weatherproof wire is removed from service after 10 to 20 years it usually has to be scrapped as the weatherproofing is deteriorated to such an extent that it is not practicable to reinstall it. Bare copper wire removed is worth practically the same as new wire and may be reinstalled. These two features alone will justify the use of bare copper wire.

In many communities there is an ordinance requiring the use of insulated wires and weatherproof wire is often accepted by inspectors in such communities as meeting these requirements. When such ordinances exist steps should be taken to have them changed. The word insulation might be assumed by the courts to mean insulation sufficient to protect against voltage carried by the conductors. This was practical when the industry was in its infancy and many of the existing electrical ordinances were made at that time. Bare wire has been used in many instances even where insulated wire is required. This has been permitted as it is realized that it is impractical to comply economically with such an ordinance and install wires insulated for voltages from 2300 to 13,000 volts.

Comparative estimates for constructing an 11-kv. distribution system in a small town to serve 60 customers show a saving of 9.5 per cent in total construction cost by using bare in place of weatherproof wire. The saving in cost of conductors is 30 per cent, poles 9.4 per cent and labor 5 per cent. An estimated cost of a mile of No. 4 weatherproof medium hard drawn copper three-phase, 2300-volt line using 35-ft. poles spaced 200 ft. is $1625.00; No. 4 medium hard drawn bare using 35-ft. poles spaced 300 ft. is $1133.00, or a saving of $492.00 or 30 per cent in total cost of bare as compared to No. 4 weatherproof conductors. To summarize the above advantages in using medium hard drawn bare conductors for general distribution construction:

Saving in initial investment cost of conductors may be from 15 per cent to as high as 30 per cent; poles and attachments 5 per cent to 10 per cent; labor 5 per cent to 20 per cent; with a total saving of from 15 per cent to 30 per cent on rural lines and 5 per cent to 10 per cent on complete distribution systems.

Yearly maintenance costs are 15 per cent to 25 per cent less for the reason that conductors do not have to be resagged frequently and there are less outages caused by breaks and conductors swinging together and burning down.

Life of conductors is conservatively three or four times that of weatherproof.

Practically no depreciation occurs in conductors; when salvaged they have practically the same value as new.

Hazard to linemen is not increased as they are necessarily more careful. Hazard to general public is greatly reduced as lines do not break as frequently.

General appearance is greatly improved.

Medium hard drawn has decided advantages over annealed copper wire, having greater strength allowing greater spacing of poles, and considerable savings in construction cost.

The use of bare medium hard drawn copper for overhead distribution systems conductor is worthy of consideration. It has been used on a number of systems in small towns and cities for a sufficient length of time to prove its worth.

Advantages of Medium-Hard-Drawn over Annealed Conductors

In designing or replacing distribution lines another point arises which is worthy of consideration, namely the economy of using medium-hard-drawn instead of annealed wire. Medium hard drawn copper conductors have many advantages over annealed wire, principally on account of the greater strength, being about 25 per cent in No. 1/0, No. 2/0, and No. 4/0 sizes and 35 per cent to 45 per cent in No. 8 to No. 2 sizes. This increase in strength in the smaller sizes allows an increased spacing of poles in urban and rural districts, and in densely built up districts provides an added factor of safety which is very desirable as it affects hazard to the general public as well as reliability of service and maintenance costs.

There is a very slight difference in electrical characteristics, the resistance of medium hard drawn being 1 to 1.5 per cent greater than that of annealed copper wire, which is negligible in distribution system calculation.

Joints in or taps to medium hard drawn copper wire used for overhead lines should not be soldered because annealing of the copper and decreasing its strength would result. There is a number of solderless connectors available. The cost of these installed is usually less than that of a good soldered connection. Various types have been in use for a number of years and no trouble has been experienced from these connectors working loose and causing loose connections. They are more flexible then soldered connections and are of great assistance in replacing conductors, disconnecting taps, services, etc.

The increased working tensions of medium hard drawn copper conductors require more adequate guying to eliminate possibilities of anchors and guys creeping and conductors becoming slack.

Abridgment of

Influence of Temperature on Large Commutator Operation

BY F. T. HAGUE[1]
Associate, A. I. E. E.

and

G. W. PENNEY[1]
Associate, A. I. E. E.

Synopsis.—The paper discusses the operating characteristics of large commutators. It is pointed out that initially many cases of blackened and burned bars are caused by a slight roughness which causes irregular commutation and a slight sparking which when once started gradually becomes worse. The requirements of the surface of a high-speed commutator are discussed, showing that radial variations of the order of one ten-thousandth of an inch between adjacent bars may give serious trouble. Some causes of roughness are discussed, showing that temperature is a major factor, but that redesigning the commutator to reduce the temperature does not necessarily cure the trouble, and may actually give poorer performance. Some methods of commutator testing are described with typical records showing the performance of various types of construction.

The question of safe temperature limits is then discussed. It is maintained that the question of the permissible temperature limits is entirely unlike that of insulated windings, since the materials used are not injured by temperatures considerably above the present limits. The permissible limit of a commutator is determined by its mechanical construction. Low temperature limits may lead to illogical designs, since large heat dissipating surfaces are required which may give higher stresses and larger expansion effects, which may be more harmful than higher temperatures. A temperature limit based on operating characteristics would be more satisfactory.

During the past five years, considerable experimental work on large commutator performance and characteristics has been under way, and many different types of construction have been investigated and compared. Much information of value to designers has been accumulated and this information has led to a clearer understanding of the desirable characteristics of commutators and the influence of operating temperature on performance.

The paper, as indicated in its title, will deal with the subject from the standpoint of large commutators usually found only in power station and substation machinery.

In all types of construction, the heating of the commutator is inevitable because of the mechanical friction of the brushes and the electrical loss at the contact. In most electrical apparatus, the permissible temperature is determined by the temperature at which the insulation is permanently injured, but in large commutators the materials are not injured by temperatures considerably above the limits commonly applied. There are other very important effects of temperature, but this is ordinarily not in the nature of a definite limit fixed by the materials but rather as a limit based on the construction features of the commutator and particularly its ability to withstand the change in dimensions caused by a change in temperature. For this reason the authors believe that a different type of temperature limitation should be used for commutators from that used for apparatus where the temperature is limited by the point at which the material is injured. This paper will be devoted to a general discussion of the nature of the temperature limitation of commutators.

The primary function of the commutator is to make contact with the brush. A certain variation in the contact drop is permissible, but as will be shown later, some commutators reach a condition where the brush cannot transmit direct current to the bars without vicious sparking, even when no commutation is involved. Under such conditions, satisfactory commutation is impossible. With the bars moving at a speed of a mile a minute or more, the commutator surface, if the brushes are to maintain uniform contact with all bars, must be very smooth.

Measurement of Commutator Surface Conditions

Any progress in science or engineering is dependent first on knowledge of the facts. Suitable measuring instruments and methods are fundamental to progress. This study of commutator design and performance made very slow progress until a satisfactory device for measuring commutator surface conditions was developed.

Since the condition of a commutator surface may change with speed and temperature, it must be measured at full speed and operating temperature. The measurement of a variation of the order of one ten-

1. Both of the Power Engineering Department, Westinghouse Electric and Manufacturing Co.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

thousandth of an inch between adjacent bars running at a surface speed of over a mile a minute is beyond the range of ordinary instruments. Because of the difficulty in measuring this mechanically, and since we are primarily interested in the effect of the surface condition on the brush contact drop, the measurement of this contact drop seems to be the most logical means of

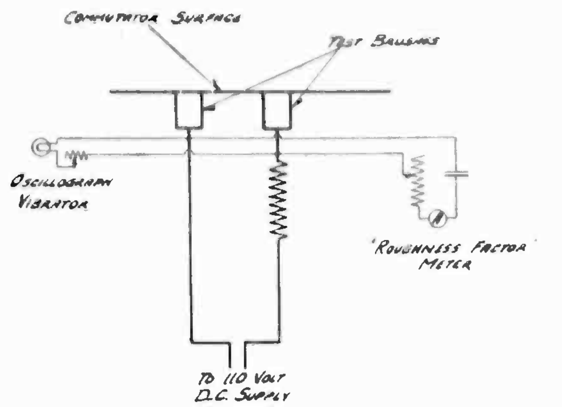


Fig. 2—Wiring Diagram for Brush Drop Test

Power circuits are shown by heavy lines and instrument circuits by light lines. The oscillograph and roughness-factor meter are both shown connected

determining the surface condition. Fig. 2 shows the wiring diagram for a scheme of doing this which will be called the "brush drop test." Fig. 4 shows a small commutator set up for the test. In this test, two or more brushes are mounted in line so as to make contact with the same commutator bar. Current is passed from one brush to the bar and back through one or more brushes in series with sufficient resistance, so that practically constant current is maintained. The double-contact drop is recorded by an oscillograph. In this way, the surface condition of the commutator can be studied during heating and

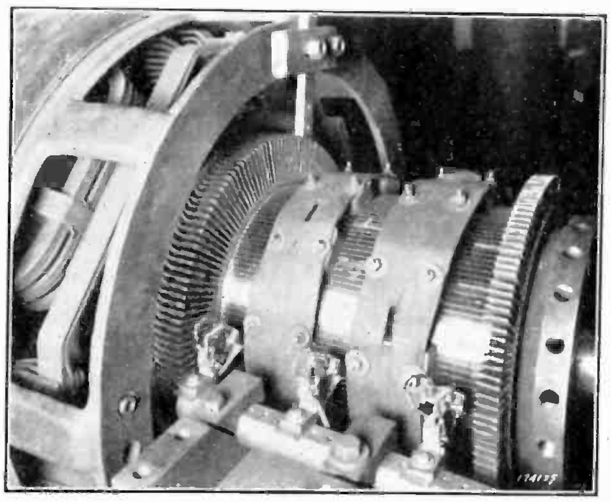


Fig. 4—Commutator Set up for Brush Drop Test

cooling, and for various speeds. If a timing contact is used as a second record on the oscillogram, the position of any roughness of the commutator can be located.

If it is not necessary to locate the bars giving trouble, but only to determine the average operating condition of the surface, then the "roughness factor meter" may be used instead of the oscillograph. Fig. 2 shows the wiring diagram for the brush drop test with both the oscillograph and the "roughness factor" meter connected to measure the brush drop. It consists of a large capacity condenser, variable resistance, and thermal milliammeter all in series. The condenser has sufficient capacity to offer only a negligible impedance to fluctuations in brush drop. For a perfectly uniform contact, the reading is zero, but in case the brush drop fluctuates, the current through the meter is limited by the resistance in series. The product of the resistance in ohms by the current in amperes is called the "roughness factor." It is the r. m. s. value of the fluctuations in brush contact drop in volts and is a measure of the surface condition of the commutator. With a good surface, it should be 0.15 or less, while with a bad surface it may rise to several volts.

This method of measurement does not, of course, give bar movements in inches, and in the case of eccentricity, a movement of several mils may give no indication; but since we are concerned with the uniformity of the contact drop, it does indicate the things in which we are interested. Because of its sensitivity, reliability, and simplicity, this test has been extensively used to

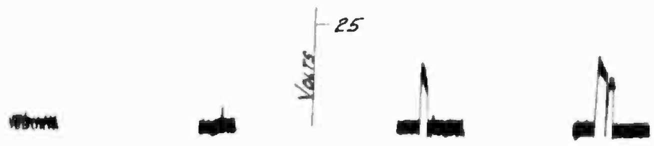


Fig. 6—Contact Drop Obtained with Four Different Brush and Brush Holder Arrangements

The cut was traced from oscillograms showing contact drop passing over the same surface roughness, only the brush and holder being changed

study commutator surface conditions. Usually, the commutator is ground and the test brushes mounted. The commutator is then heated by narrow belts lined with maple blocks. These are so arranged that they do not strike the surface at points where the test brushes will bear. This method gives the surface heating and temperature distribution closely approximating service conditions. It also give additional heat on any bar which tends to become high combined with considerable mechanical vibration, so that it is a very severe test which should disclose any trouble likely to develop in service.

The Causes and Effects of Commutator Roughness

The complete paper discusses briefly the question of the brush rigging, showing that this is another problem of major importance, since a wide variation in contact conditions can be obtained with a given commutator surface, only the brush and holder being changed. Fig. 6 is one example showing the importance of the brush and holder. But even with the best brush and holder, a very smooth commutator surface is still required.

In discussing the effect of roughness, it is pointed out that it is very difficult to determine the effect of roughness from the commutation of the machine, since a slight bar movement may occur which produces only a slight sparking at first, but which gradually produces a smutting or burning of the bar, which still further disturbs the brush action until a serious sparking results. This effect may continue even though the bar movement originally causing the trouble has disappeared.

Because little information has been available concerning the properties of mica, it has frequently been blamed for many troubles due to other causes. The requirements of mica and methods of testing are described in the paper. Upon first thought, centrifugal force will usually be considered to be the most serious cause of commutator roughness. However, tests have shown that it is relatively easy to make a commutator that will remain perfectly smooth at all speeds up to reasonable overspeed, *if tested cold.*

The effect of temperature is usually far more serious in commutator operation than centrifugal force. A number of the effects of temperature which produce roughness are discussed in the complete paper showing that they usually have the nature of a bending or warping of the bar.

It might seem that the solution of the problem is a low temperature rise. However, a low temperature rise requires a large surface for heat dissipation. For any given design, this usually requires a longer bar. The deflections causing roughness usually are of the nature of a bending or bowing of the bar which increases with the second to the fourth power of the bar length, depending on the type of support. Then, since the deflection increases as a power of the length while the temperature decreases only with the inverse of the first power of the length, for any given type of construction, the roughness may be increased, rather than decreased by lowering the temperature rise. A more logical method of attack seems to be to alter the construction so as to reduce the roughness for a given temperature rise.

Types of Commutator Performance Under Influence of Temperature

I. Ideal. The ideal commutator should stay perfectly smooth under all operating conditions. A commutator of 23 in.active face length (26½ in. total bar length) and 5500 ft. per min. peripheral speed was heated to 140 deg. cent. (115-deg.cent. rise) using a belt lined with maple blocks and tested while cooling. Records at 115-deg. cent. rise and when cooled to room temperature show that a temperature rise far above present limits did not produce any measurable roughness in this commutator.

II. Fair. A commutator which becomes rough when heated to the overload temperature, but returns to a smooth condition when cooled, is classed as fair. This might show some sparking at overload, but if this is not of sufficient duration to burn the bars, the performance should be satisfactory when the load is reduced.

III. Bad. A commutator which when heated either to an operating or even a slight overload temperature, becomes rough and fails to return to a smooth condition on cooling is bad, because the surface must be re-ground to put it in a satisfactory condition.

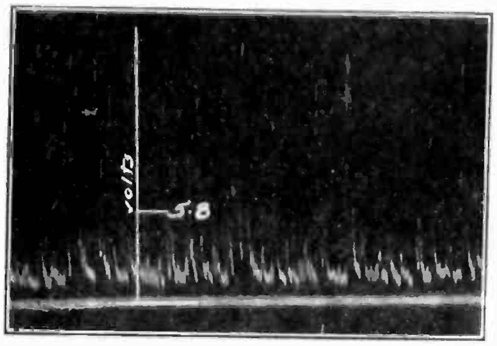
Commutator Seasoning

Practically all large commutators if tested immediately after assembly and before any heating treatment would show the performance just referred to as bad. This is due to the nature of the copper and mica, both of which tend to yield when first subjected to stress and temperature. The gradual yielding of the copper and mica under stress and temperature until finally a stable condition is reached is referred to as seasoning.

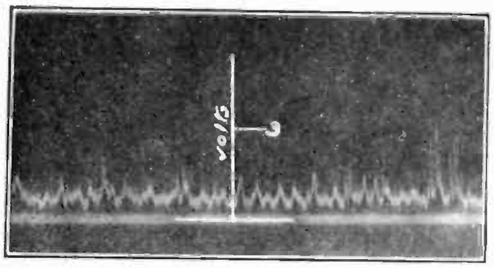
In a low-speed commutator, a sufficiently stable condition may be reached by merely repeated heating and tightening. In a commutator with higher rotational stresses these stresses must act on the commutator for a considerable time during heating and cooling before a stable condition may be reached. Originally, this was done by loading the machine with the brushes set off neutral to give excessive heating. Now, methods have been developed for seasoning the commutator before it is even assembled on the machine. In some cases this may be accomplished by merely rotating in an oven. In other cases, a more severe method known as "block seasoning" may be required. This consists in heating the commutator by the friction of belts lined with maple blocks. This gives the surface heating and temperature distribution approximating operating conditions, combined with mechanical vibrations.

The most obvious effect of seasoning is to eliminate the yielding of the mica, but in the best type of high-speed commutator the copper must be permitted to yield slightly to allow it to conform to any irregular mica surface. Due to the peculiar nature of copper, this yielding will take place only partially during assembly. The rest will take place as a slow creep during the seasoning period. Tests have shown that the mica now used reaches stability in about 30 hours of seasoning at 150 deg. cent., while in some cases the copper may require 150 hours, even when accelerated by overspeed and added building force.

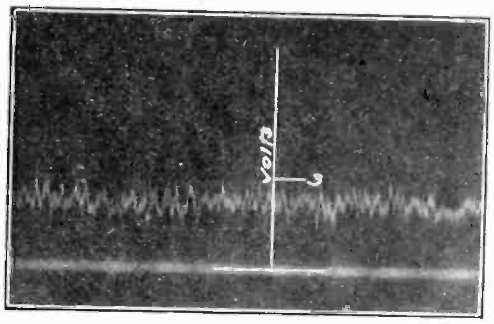
Fig. 14 shows the results obtained by block seasoning. Each record shows the roughness produced by a heating and cooling cycle. In the first test (Fig. 14A), taken after a short period of block seasoning, the surface was very rough, so that only a small current could be used on the test brush. The roughness is shown by the irregularity of the contact drop. The second test (Fig. 14B) shows an intermediate condition. In the test after the final block seasoning the surface remained almost perfectly smooth so that full current was used on the test brush giving the higher normal contact drop evident in Fig. 14c. The roughness is indicated by the irregularity of the contact drop and this irregularity is almost independent of the test current used. The number and value of the "peaks" in the oscillogram are the significant factors, rather than the average value of the voltage drop. Even after all of these precautions, there may be some minute bar shifting during the first few months of operation, so that more maintenance is to be expected during this period than after the commutator has been in service for some time. A large commutator is one of the few mechanical devices which improve with use during early years of service.



A



B



C

FIG. 14—EFFECT OF SEASONING

A—Commutator block seasoned for a short period and then ground smooth while cold, heated for 10 hr., and record taken after cooling to room temperature

B—Given additional period of block seasoning, ground smooth while cold, heated, and record taken when cold

C—Same as "b" except after an additional period of block seasoning

SAFE TEMPERATURE LIMITS

A rational type of commutator design and construction may have a safe limiting temperature of 125 to 150 deg. cent. without developing surface roughness, whereas other types of construction may be unsuited to limits as low as 75 deg. cent. The ability to withstand repeated temperature cycles without developing roughness determines a commutator's safe limiting temperature. The problems involved are entirely mechanical in nature, and the practise of the present rules in setting an arbitrary low-temperature limitation does not meet the requirements of the situation.

The present standard of a temperature rise limit and load test is inconclusive. It is made ordinarily at a low ambient temperature and does not show what trouble might develop from the additional total temperature obtained with the higher ambient temperature permitted by the Standards, and it cannot usually be of sufficient duration to discover effects that may gradually accumulate due to very slight initial mechanical disturbances. The present practise of setting a temperature limit as a criterion for a mechanical problem is objectionable, in that it results in design practise which actually encourages the development of operating trouble which it purports to prevent. Low limiting temperature, such as the present limit of 60 deg. cent. rise on converter commutators, requires large heat-dissipating surfaces on the commutator which frequently necessitate extra long commutators, one or more sets of ventilating vanes, and other characteristics which lead to high stresses, large expansion effects, etc., that may be more detrimental to operation than a higher limiting temperature. A physically large commutator having high mechanical stresses and high surface speed that will operate at a low temperature when newly ground and in good mechanical operating condition, may well be a much less satisfactory commutator to the operating engineer than a physically smaller commutator which, under the same conditions of loading, operates at a considerably higher temperature but stays dead smooth under its maximum operating temperature range. Adherence to the present standards forces the designer to use a highly stressed commutator with high peripheral speed that may be far more detrimental to good operation and low maintenance costs than would be the higher temperature rise resulting from a smaller lower stressed commutator.

A better measure than the load test, although scarcely practical in many cases, would be a repeated cycle test with the maximum ambient temperature. Satisfactory performance would be indicated by no appreciable increase in sparking with successive heat cycle tests. A less expensive and therefore more feasible test for determining the permissible operating temperature would be a "brush drop" or equivalent test, which could be made at the maximum temperature and would have the sensitivity to show any slight roughness which might in time give trouble.

ILLUMINATION ITEMS

Submitted by
The Committee on Pruduction and Application of Light

LIGHT THERAPY

H. P. Gage, Ph. D.*

Light therapy, or more properly speaking, radiation therapy, has for some years been a useful tool in the hands of physicians. It is rapidly coming into popular favor. Countless home treatment devices have been placed on the market and are in use. The effectiveness of radiation therapy, when intelligently used, has been demonstrated by a vast accumulation of evidence.

Some of the beneficial results of light therapy are due entirely to a fairly deep penetration of radiant energy, thereby heating the deeper tissues of the body, causing improved circulation and relief of congestion. Lumbago and numerous "aches and pains" disappear after an application of radiant energy. Radiation capable of tissue penetration must be of a wavelength greater than about 0.6 μ in the red or it will be quickly absorbed by the hemoglobin of the blood, and must be of lesser wavelength than 1.5 μ in the near infra red or it will be absorbed by the water content of the outer layers of the skin. The temperature radiation whose maximum lies in the near infra red at a wavelength of about 1. μ would thus be the most efficient, and as has been pointed out by Luckiesh,[1] some form of high power tungsten filament lamp is the most efficient. For a home treatment lamp, however, the carbon filament lamp has a factor of safety in its favor. Greater energy absorption in the superficial layers of the skin will serve as a check on possible injury due to overheating the deeper tissues before the patient becomes aware that anything is happening.

Two grades of radiation therapy may be distinguished: The high-power, high-speed therapy, having inherent dangers of overdosage should be attempted only by the experienced physician. The short time of treatment required with strong radiation makes it available in the office of the busy practitioner; for example, ultra violet radiation of sufficient intensity to cause an erythema, or sunburn, sometimes of painful intensity, serves as a counter irritant and stirs up healing of wounds and resistance to infection in sluggish tissue. Such violent measures are to be avoided by the inexperienced. Mild, slow-speed radiation therapy may be indulged in by the general public at its pleasure with little fear of danger and considerable promise of benefit. Radiation of the general level of summer sunshine may be considered as the dividing line between high-speed and slow-speed radiation. Summer sunshine at noon has too much heat intensity to be risked by those not used to it for long periods without some protection. The ultra violet intensity of the sun is too great for comfort and has led to painful sunburn, sickness and occasional death by the uncautious overexposure of some people not previously acclimated to it.

*Chief Optical Division, Corning Glass Works Laboratories.

Rickets

The effect of ultra violet in the prevention and cure of rickets has almost the certainty of a chemical reaction. Control of calcium metabolism by vitamin D contained in cod liver oil, specially irradiated foods, etc., or by direct ultra violet irradiation, is essential to growing children, and pregnant and nursing mothers. The region of ultra violet has been experimentally determined as shorter than 0.313 μ.[2,3,4] As sunlight even during the winter months at 42 deg. latitude is useful, and direct summer sunshine is highly effective, the extremely short wavelength region transmitted by the earth's atmosphere, *i. e.*, radiation between the limits 0.31 μ and 0.29 μ[11], is known to be highly efficacious. Skyshine is effective, although less so than direct sunshine.[5] To have any effect, however, practically the entire sky must be visible from the position of exposure. The relatively negligible fraction of the sky hemisphere to be seen through an ordinary window opening is ineffective in curing or preventing rickets according to the experiments of Doctor F. F. Tisdall and the calculations of Doctor Janet H. Clark.[6]

Direct sunshine, even in the winter months, and even when passing through glasses transmitting but 25 per cent (after solarization) of the ultra violet of the 0.302 μ region is capable of preventing rickets in rats[5] and chickens[7] provided a long enough time of exposure is resorted to. With human infants, during the winter at Boston the sun shining through the best available ultra violet transmitting materials, fused quartz and Corex A window panes has cured rickets in the cases of both white and negro children.[8]

A quartz mercury arc consuming about 250 watts at the arc placed 36 in. above the floor of the pen in which the chickens were treated gave approximately the same protection as direct midsummer sunshine when used about eleven minutes.[9]

Other Therapeutic Effects

It would be a mistake to assume that all therapeutic effectiveness of ultra violet is confined to the region needed for the curing rickets.

Pernicious anemia is apparently caused by a specific toxin.[10] The toxin can be destroyed by ultra violet and violet of wavelengths between 0.2536 μ and 0.405 μ, 0.313 μ being the most effective for equal energy. Several times the effectiveness is secured by an addition of chemically pure eosin. In living patients, especially after introducing chemically pure eosin into the blood stream, ultra violet treatments are capable of destroying this toxin so that it can no longer kill the red blood cells as fast as they are formed. The patient recovers, the recovery apparently being permanent, or at least of several years duration.

Colds are reported as less frequent and less severe when ultra violet treatments are given. The desirable dosage and expected advantages have yet to be fully worked out.

Tuberculosis is such a treacherous disease that treatments must be made under the supervision of an experienced physician. Surgical tuberculosis, such as that of the skin (lupus), joints, glands and peritoneum can be aided or cured by ultra violet therapy. Pulminary tuberculosis in the active stages may, on the other hand, be deleteriously affected. In many of the best sanitariums, however, carefully controlled ultra violet treatments are given and doubtless are of definite benefit in many cases. Patients returned to their homes could continue ultra violet treatments, once the method, apparatus, desirable dosage, etc., had been worked out by the skilled physician and learned by the patient.

There are certainly bodily conditions which are aggravated by the use of ultra violet and the practising physician must be familiar with these, especially when employing the high-speed erythema doses. Drawbacks and disadvantages, debunking statements, and exposures of worthless apparatus will from time to time appear to dampen the ardor of the over enthusiastic, but sufficient sound biological and medical evidence is available to justify a firm belief in a very real benefit to be derived from an intelligent use of radiation therapy, both by the physician and in the home.

References

1. M. Luckiesh, "Sources of Visible and Infra-Red Radiation for Deep Therapy," *J. of the Franklin Institute*, Vol. 207, p. 79, Jan. 1929.

2. Alfred F. Hess, A. M. Pappenheimer and M. Weinstock, "A Study of Light Waves in Relation to their Protective Action in Rickets." *Proceedings* of the Soc. for Experimental Biology and Medicine, Vol. XX, pp. 14-16, 1922.

3. Alfred F. Hess, A. M. Pappenheimer and M. Weinstock, "A Study of Light Waves in Relation to their Protective Action in Rickets." *Am. Medical Association*, Vol. 80, pp. 687-690, March 10, 1923.

4. Geo. H. Maughan, "Ultra Violet Wavelength Valuable in the Cure of Rickets in Chickens." *Am. J. of Physiology*, Vol. 87, pp. 381, Dec. 1928.

5. Frederick F. Tisdall and Alan Brown, "Antirachitic Effect of Skyshine," p. 737, and two other related articles, *Am. J. of Diesases of Children*, Vol. 34, pp. 721, 737, 742.

6. Janet H. Clark, "The Probable Amount of Ultra Violet Radiation Obtained Indoors through Ultra Violet Transmitting Glass," *Science*, Vol. LXVIII, p. 165, Aug. 17, 1928.

7. Results of Experiments in Progress. Poultry Dept., Cornell Univ.

8. Dr. Edwin T. Wyman, "The Prevention and Treatment of Rickets, *Boston Medical and Surgical Journal*, Vol. 197, pp. 376-388, Sept. 8, 1927.

9. G. F. Heuser and L. C. Norris, "Rickets in Chicks," *Poultry Science*, Vol. VIII, p. 89, Dec.-Jan. 1928-29.

10. David I. Macht and William T. Anderson, Jr., "Clinical and Experimental Studies on Phototherapy in Pernicious Anemia," *The J. of Pharmacalogy and Experimental Therapeutics*, Vol. XXXIV, p. 365, Dec. 1928.

11. Charles Fabry and H. Buisson, "A Study of the Ultra Violet End of the Solar Spectrum," *Astrophysical J.*, Vol. LIV, p. 297, Dec. 1921.

REPORT ON USE OF INCANDESCENT LAMPS IN MOTION PICTURE PHOTOGRAPHY

By R. E. Farnham*

A census taken about the first of February 1929 shows that of some 60 or more pictures in the process of being photographed, approximately 60 per cent were being made with incandescent lamps, an increase from 25 per cent as of July 1, 1928. The general practise of the studios has been to make their sound pictures entirely with incandescent lamps and to use the former illuminants for the silent pictures.

The Universal Studio has recently completed the filming of the picture "Broadway," taken from the popular New York success of the same name. The largest indoor set ever constructed was used for the cabaret scene. This scene, together with several others immediately adjacent, and really becoming a single large set, was lighted entirely with 4800 incandescent lamps whose wattage totaled 3,900,000. The largest part of this energy was employed in regulation motion picture photographic lighting equipment. There were, however, many thousands of lamps of lower wattage employed for decorative effects. This large set is indicative of a general trend throughout all of the studios to employ many low-wattage lamps for decorative effects in large and miniature signs, in table lamps, wall brackets, and automobile headlamps. Lamps are even being operated under water.

The 2000-watt G-48 bulb lamps in the 18-in. parabolic reflector housing, and the 5000-watt G-64 bulb lamp in the 24-in. housing continue to be the most popular types of lighting units, while the 1000-watt and 1500-watt PS-52 bulb lamps, in high-efficiency glass reflectors, are extensively used for general illumination. And 10-kw. lamps in 36-in. parabolic reflector units are beginning to be used. One of the manufacturers of the 18-in. reflector unit has shortened the housing to about one-half its former length, with the result that 30 per cent more light is emitted when the unit is adjusted for wider beam spreads. Another lighting equipment manufacturer is developing a large glass reflector for general illumination, which has an improved distribution and operates the lamp in a more favorable position than the present types. Also, this unit is being designed so as to use the 2500-watt PS-52 bulb lamp which is now becoming popular where it is desired to increase the quantity of light without an increase in the number of units.

The lamp manufacturers are now incorporating an internal mechanical cleaner in the form of a coarse tungsten powder in the 5- and 10-kw. lamps by which the bulb blackening can be removed from time to time during the life of the lamp. The result is that the light output can be maintained nearly at its initial value throughout the life of the lamp and this permits these lamps to be operated at a higher efficiency.

*National Lamp Works of General Electric Company.

INSTITUTE AND RELATED ACTIVITIES

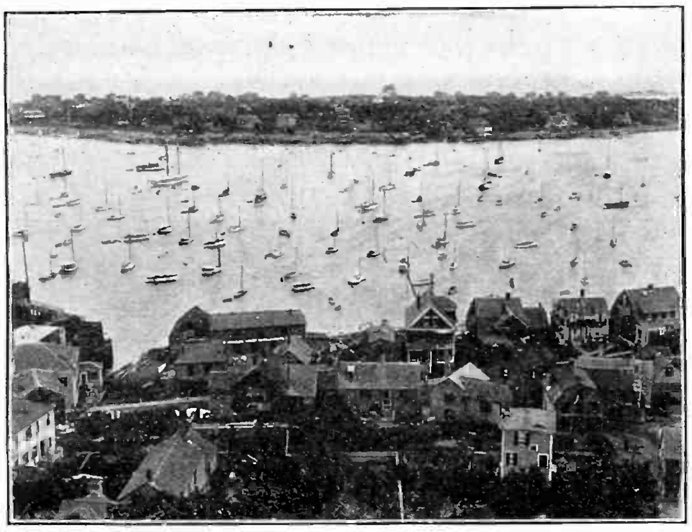
The 1929 Summer Convention

A NOTABLE PROGRAM OF PAPERS, ENTERTAINMENT, AND RECREATION FEATURES

THE 1929 Summer Convention will be one of the finest ever held by the Institute. The Convention will be held June 24 to 28 with headquarters at the New Ocean House, Swampscott, Mass. All features have been considered which might make an enjoyable and worthwhile meeting.

A selection of particularly high-grade technical papers has been made. These will deal with very live topics such as distribution systems synchronized at the load, automatic synchronizing, communication, electrical transportation, electrical machinery, outdoor hydrogen-ventilated synchronous condensers, loading transformers according to temperature, shielding in electrical measurements, electrical heating elements, high-frequency electrical tools, etc. The titles of the individual papers are given elsewhere in this announcement.

Reviews of developments in all electrical fields will be presented in the annual reports of the Technical Committees of the Institute.



PANORAMIC VIEW OF MARBLEHEAD HARBOR

No locality is richer in opportunity for trips of engineering, scenic and historic interest. A large number of trips have been arranged.

For the recreational side of the program, a most enthusiastic local Convention Committee is planning many enjoyable events. Swampscott is an ideal place for a convention, combining seashore and country with excellent hotel facilities. Those who attended the 1923 Summer Convention at Swampscott remember the very enjoyable and successful meeting held at that time and it may be prophesied that the coming meeting will be equally as good.

Golf and tennis, a reception, a banquet, dancing, and card playing will be some of the entertainment features. More information, particularly on the golf tournament, is given in later paragraphs.

For the ladies who attend the meeting a special program has been arranged in addition to the many features on the regular program which they will enjoy.

The business side of the convention will include the Annual Meeting of the Institute, a report of the Committee of Tellers on election of officers for 1929-1930, the address of the President and presentation of prizes for papers.

The first Lamme Medal, which was awarded some months ago, will be presented to the medalist, Mr. A. B. Field of England.

There will be a lecture on the evening of June 25, by Dr. Harlowe Shapley; also several addresses at the banquet on June 26.

As customary at Summer Conventions, the first day will be devoted to conferences of Institute officers and delegates held under the auspices of the Committees on Sections and Branches. All members are invited to these conferences.

OUTLINE OF PROGRAM

(Eastern daylight-saving time is indicated throughout this program)

Monday, June 24

9:00 a. m.	Registration
10:00 a. m.	Conference of Officers and Section Delegates
12:30 a. m.	Section and Branch Delegates Luncheon
2:00 p. m.	Officers and Delegates Conference (continued)
2:00 p. m.	Sports as scheduled
2:00 p. m.	Inspection trips
4:00 p. m.	Branch Delegates Meeting
4:30 p. m.	Afternoon tea
8:00 p. m.	Informal dancing, cards

Tuesday, June 25

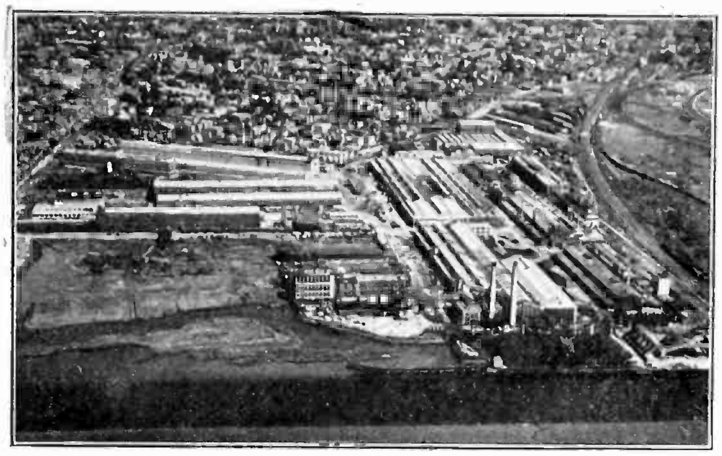
9:00 a. m.	Registration
9:30 a. m.	Annual Business Meeting Address of Welcome, Report of Board of Directors (in abstract); Report of Tellers; Introduction of, and response from, the President-Elect; Presentation of Prizes for Papers; President's Address
10:30 a. m.	Two Technical Sessions, (a) Distribution and Power Plants; (b) Transportation
1:00 p. m.	Past-Presidents and Directors Luncheon.
2:00 p. m.	Trips as scheduled
2:00 p. m.	Sports as scheduled
2:30 p. m.	Board of Directors Meeting
4:30 p. m.	Afternoon tea
8:00 p. m.	Convention Lecture—Prof. Harlowe Shapley of Harvard
9:15 p. m.	Reception—dancing, cards

Wednesday, June 26

9:00 a. m.	Social hour
9:30 a. m.	Technical Committee Reports—2 Parallel Sessions
2:00 p. m.	Technical Session (miscellaneous subjects)
2:00 p. m.	Trips as scheduled
2:00 p. m.	Sports as scheduled
4:30 p. m.	Afternoon tea
7:00 p. m.	Convention Banquet Presentation of Lamme Medals. Speakers, entertainment, dancing, cards

Thursday, June 27

9:00 a. m. All-day Trip to Rye Beach, Maine
9:30 a. m. Sports as scheduled
2:00 p. m. Final round, Mershon Cup play
4:30 p. m. Afternoon tea
8:30 p. m. Presentation of sports prizes, entertainment, dancing, cards



AIRPLANE VIEW—RIVER WORKS, GENERAL ELECTRIC CO.

Friday, June 28

9:00 a. m. Social hour
9:30 a. m. Technical Sessions (a) Electrical Machinery, (b) Shielding in Electrical Measurements
2:00 p. m. Trips as scheduled
2:00 p. m. Sports as scheduled
3:00 p. m. Start of Post-Convention Excursion through White Mountains
4:30 p. m. Afternoon tea
8:00 p. m. Dancing; cards

LADIES' PROGRAM

The ladies are invited to all events, the following being listed as of special interest to them.

Monday, June 24

2:00 p. m. Putting Contest at New Ocean House—or
2:00 p. m. Drive to Boston Art Museum
4:30 p. m. Afternoon Tea
8:00 p. m. Informal Reception
8:30 p. m. Dancing, cards

Tuesday, June 25

10:00 a. m. Drive to points of historical interest in Boston, thence to Wayside Inn, Sudbury
1:00 p. m. Luncheon at Wayside Inn, return trip through Lexington and Concord
4:30 p. m. Afternoon Tea
8:00 p. m. Lecture—Prof. Harlowe Shapley
9:15 p. m. Reception—dancing, cards

Wednesday, June 26

10:00 a. m. Drive to Salem and Marblehead, with visits to Old Witch House and House of Seven Gables
2:30 p. m. Bridge at New Ocean House
7:00 p. m. Banquet, Presentation of Lamme Medal, entertainment, dancing, cards

Thursday, June 27

9:00 a. m. All-day trip to Rye Beach
8:30 p. m. Presentation of sports prizes, entertainment, dancing, cards

Friday, June 28

2:00 p. m. Drive to Plymouth
3:00 p. m. Start of Tour through White Mountains
4:30 p. m. Afternoon tea
8:00 p. m. Dancing, cards

The golf links of the New Ocean House will be open to the ladies and a tournament will be arranged if enough signify their intention to enter.

There will also be opportunity for tennis.

Technical Sessions

JUNE 25

DISTRIBUTION AND POWER GENERATION

10:30 a. m. Symposium on "Synchronized at the Load"

I. *A Fundamental Plan of Power Supply*, A. H. Kehoe, United Electric Light & Power Co.

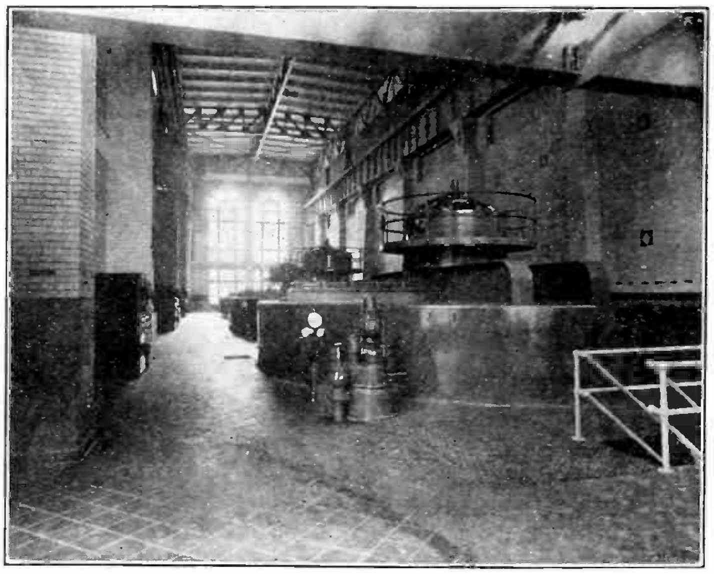
II. *Calculations of System Performance*, S. B. Griscom, Westinghouse Electric & Mfg. Co.

III. *System Tests and Operating Connections*, H. R. Searing and G. R. Milne, United Electric Light & Power Co.

Automatic Transformer Substations of Edison Electric Illuminating Co. of Boston, W. W. Edson, Edison Elec. Ill. Co. of Boston

Rehabilitation and Rebuilding of Steam Power Plants, C. F. Hirshfeld, Detroit Edison Co.

Application of Induction Regulators to Distribution Networks, E. R. Wolfert and T. J. Brosnan, Westinghouse Electric & Mfg. Co.



INTERIOR OF BELLOWS FALLS STATION OF NEW ENGLAND POWER ASSOCIATION SYSTEM

TRANSPORTATION

10:30 a. m. *Electrification of the Mexican Railway*, J. B. Cox, General Electric Co.

Contact-Wire Wear on Electric Railroads, I. T. Landhy, Illinois Central Railroad Co.

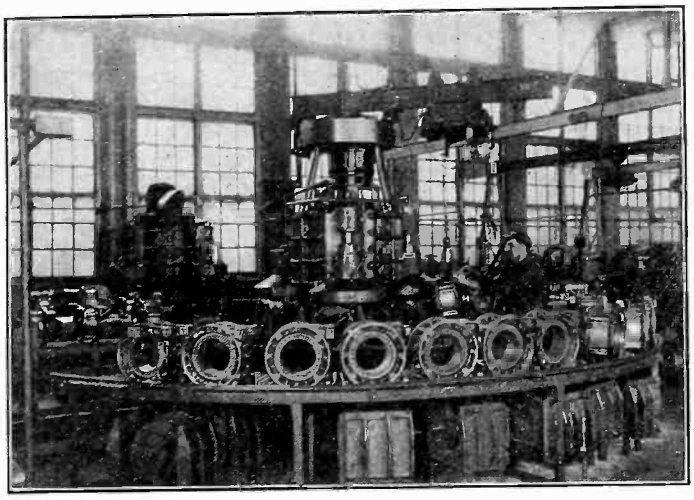
An Electrified Railroad Substation, J. V. B. Duer, Pennsylvania Railroad

D-C. Railroad Substations, A. M. Garrett, Commonwealth Edison Co.

JUNE 26

TECHNICAL COMMITTEE REPORTS

9:30 a. m. About eighteen reports will be presented reviewing the major activities in the fields of the various Technical Committees of the Institute. The reports will be presented in two parallel sessions.



MOTOR ASSEMBLING ROOM AT RIVER WORKS OF GENERAL ELECTRIC COMPANY

MISCELLANEOUS

2:00 p. m. *Master Reference System for Telephone Transmission*, W. H. Martin, American Tel. & Tel. Co., and C. H. G. Gray, Bell Telephone Laboratories, Inc.

Electrical Wave Analyzers for Power and Telephone Systems, R. G. McCurdy and P. W. Blye, American Tel. & Tel. Co.

A New Automatic Synchronizer, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

High-Frequency Portable Electric Tools, C. B. Coates, Chicago Pneumatic Tool Co.

Design of Electric Heating Elements, Edwin Fleischmann, The Niagara Falls Power Co.

JUNE 28

ELECTRICAL MACHINERY

9:30 a. m. *Safe Loading of Oil-Immersed Transformers*, E. T. Norris, Ferranti, Limited

Induction Motor Operation with Non-Sinusoidal Impressed Voltages, L. A. Doggett and E. R. Queer, Pennsylvania State College

Outdoor Hydrogen-Ventilated Synchronous Condensers, R. W. Wieseman, General Electric Co.

Short-Circuit Torque in Synchronous Machines, Without Damper Windings, G. W. Penney, Westinghouse Elec. & Mfg. Co.

Analytical Determination of Magnetic Fields, B. L. Robertson, Pennsylvania State College, and I. A. Terry, General Electric Co.

SYMPOSIUM ON SHIELDING IN ELECTRICAL MEASUREMENTS

9:30 a. m.
1. *Shielding and Guarding Electrical Measuring Apparatus*, H. L. Curtis, Bureau of Standards
2. *Some Problems in Dielectric Loss Measurements*, C. L. Dawes, P. L. Hoover and H. H. Reichard, Harvard University
3. *Shielding in High-Frequency Measurements*, J. G. Ferguson, Bell Telephone Laboratories
4. *Shielding of Cables in Dielectric Loss Measurements*, E. H. Salter, Elec. Testing Laboratories
5. *Precautions Against Stray Magnetic Fields in Measurements with Large Alternating Currents*, F. B. Silsbee, Bureau of Standards
6. *Magnetic Shielding in Electrical Measurements*, S. L. Gokhale, General Electric Co.

Trips

A large number of interesting trips may be taken. Two special trips are being featured, one an all day trip and outing to Rye Beach, Maine, and the other a post-convention tour through the White Mountains.

The all-day outing will be taken on Thursday, June 27, and will prove a most acceptable opportunity for making friends and enjoying the entertainment which will be provided.

The post-convention tour will start on Friday afternoon, June 28, and will end at Greenfield, Mass., or Boston on Monday, July 3. The trip will be through New Hampshire, Maine, and Massachusetts and will take in many beautiful lake and mountain scenes. The complete cost will be $48.50, with return to Greenfield, and $54, with return to Boston. This includes all transportation and hotels (double rooms).

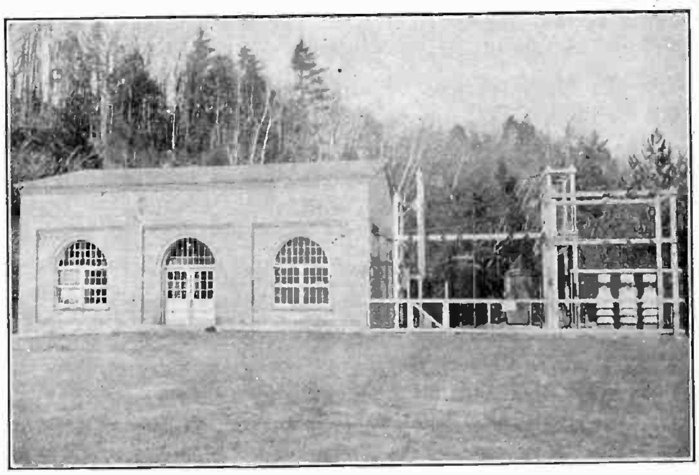
Other trips may be made to colleges, power plants, substations, telephone plants, manufacturing plants and points of historic and scenic interest. Airplane trips will also be available.

Sports

Golf, tennis, swimming, fishing and boating will be available for those who wish to enjoy them.

Both golf and tennis tournaments will be played for the respective Mershon Cups. It is proposed to present the prizes on Thursday evening and in order to accomplish this purpose all competition must be completed before Thursday evening.

On account of the limited time and as the golf competition will be match play, the following information on the golf tournament is given. Special note should be made of the possibility of playing the qualification round on *Monday morning at 8 a. m. or 10 a. m.*



SILVER LAKE HYDROELECTRIC PLANT OF PUBLIC SERVICE CORP. OF VERMONT 675 FT. HEAD. THIS IS BELIEVED TO BE THE HIGHEST HEAD PLANT EAST OF THE MISSISSIPPI RIVER

The golf competition will consist of a qualification round (handicap medal play) of eighteen holes followed by match play (handicap).

The qualification round will be played on *Monday, only*, June 24, 1929. The sixteen low net scores will qualify for the match-play rounds. No green fee will be charged members and registered guests.

A representative of the Committee will be at the Club House at *eight a. m., Monday, June 24*, so that officers, section delegates, etc., who wish may play their qualification round early and still not miss their scheduled meetings. Also those who are not attending the conference may play at 10 a. m. on Monday morning.

In order to avoid conflicts with business meetings and technical sessions, it is the wish of the Committee that play be restricted to the time of scheduled events, namely; Monday a. m. and p. m., Tuesday p. m., Wednesday p. m., and Thursday a. m. and p. m.

Hotels

The following gives information on hotels. Reservations should be made by communicating directly with the hotel selected.

The New Ocean House will be the center of Convention activities. Most of the rooms are double rooms with bath and it is suggested that, as far as possible, members should request reservations in parties of two, since some of the single reservations will have to be sent to the Hotel Preston. Some of the most desriable rooms situated on the ocean side are for three, four or five persons, so that members who make up a congenial party and apply for such a suite, will be assured of desirable rooms. Members who plan to come alone and who signify on their request for reservations that they will share a double room with another member will in general get a more desirable room than if a single room were engaged.

New Ocean House

Swampscott, Mass.

Daily rates per person for room and meals

Room	Number of persons (beds)	With bath	With running water
Single	1	$9–$10	$8–$9
Double	2	$8–$9	$7
Double	3	$7	$6.50
Large	4	$6.50	..
Two*	4	$7.50	..
Two*	5	$7	..
Two*	6	$6.50	..

*Suite of two rooms with bath between.

Rates for Meals only—For non-resident guests, combination tickets for meals taken in one day will be issued as follows:

	In main Dining Room	In Tea Room
Breakfast, Luncheon and Dinner	$5.00	..
Both Luncheon and Dinner	4.00	$2.50
Dinner	3.00	1.50
Luncheon	3.00	1.00

These rates include the Convention Banquet.

Garage space in concrete fireproof garage, $1.00 per day.

Other Nearby Hotels

There will be free bus or auto service between the New Ocean House and the following hotels:

Hotel Prescott, Beach Bluff, Mass., two miles from New Ocean House, rates same as New Ocean House.

Bellevue Hotel, Beach Bluff, Mass., one mile from New Ocean House. Rates per person (including breakfast), single room $5.00; double $3.50.

Deer Cove Inn, Swampscott, $5 per person, with meals.

The Arkhaven, Swampscott, Rates with meals $5–$9 without bath; $6–$11 with bath.

The Priscilla, Swampscott, Rates $2; no meals.

Reduced Railroad Rates

Reduced railroad rates on the certificate plan will be available for those attending the meeting from practically all points. Also summer tourist fares at a lower rate will be in effect from certain Western States.

By the Certificate Plan the round trip will cost only one and a half times the one-way fare, *provided* 150 certificates are deposited at the Convention headquarters. These certificates must be obtained when visitors purchase their one-way tickets to Swampscott. Members of families are also entitled to obtain certificates. After 150 certificates have been deposited and the certificates have been validated, return tickets over the same route may be purchased for half the usual rate. There are certain restrictions regarding purchase dates, travel dates, etc., and local ticket agents should be consulted in every case.

Everyone traveling by train to Swampscott should get a certificate whether he will use it or not. Failure to do so may deprive others of considerable saving.

Register in Advance

By registering in advance by mail, members will help the committees in making plans. Those who plan to attend may notify Institute headquarters, New York.

Committees

The 1929 Summer Convention Committee which is making the arrangements for the meeting consists of the following members who are officers of the committee or chairmen of other committees as indicated or general members: W. F. Dawson, *Chairman*; E. W. Davis, *Vice-Chairman*; H. B. Dwight, *Vice-Chairman*; C. S. Skoglund, *Vice-Chairman;* W. H. Colburn, *Secretary*; V. R. Holmgren, *Asst. Secretary*; F. L. Ball, *Treasurer*; H. P. Charlesworth, *Meetings and Papers*; W. B. Kouwenhoven, *Sections*; C. L. Edgar, *Finance*; C. A. Corney, *Trips*; F. S. Jones, *Transportation*; I. F. Kinnard, *Publicity*; W. E. Porter, *Hotel and Registration*; A. H. Sweetnam, *Sports*; Mrs. W. H. Timbie, *Ladies' Committee*; J. P. Alexander, G. J. Crowdes, W. S. Edsall, S. J. Eynon, J. W. Kidder, R. H. Porter, W. H. Pratt, Ernest Shorrock, D. F. Smalley, H. B. Wood.

Pacific Coast Convention

The 1929 Pacific Coast Convention will be held in Santa Monica, California, September 3-6. Plans are well under way for this meeting and details of the program will be published in the July and August Journals.

Regional Meeting in Chicago in December

A three-day regional meeting will be held under the auspices of the Great Lakes District in Chicago, December 2-4. A local committee has been working on plans for some time. Further information will be published in later issues of the Journal.

Japanese Ambassador Guest of Engineers

Katsuje Debuchi, Japanese Ambassador, was the honor guest at a dinner at the Carlton Hotel, Washington, D. C., Wednesday evening, April 24th, given by engineers, scientists, and industrialists who will represent the United States at the World Engineering Congress in Tokio next November. The occasion marked the last meeting of the American Committee on participation in the Congress, of which President Hoover is honorary chairman, prior to the departure of the delegation for Japan next October.

The Japanese Ambassador, John Hays Hammond and Gano Dunn, noted electrical engineers were the principal speakers, and stressed the importance of welding the forces of engineering and science as an international factor for the promotion of comfort and prosperity in the world and the abolition of warfare.

Ambassador Debuchi said Japan is always ready to cooperate with the rest of the world in the advancement of learning and civilization and expressed the hope that the bond of mutual understanding that has existed between the United States and Japan will be cemented at the congress.

That the engineer will become an ambassador of good will was predicted by Mr. Hammond, who said that in the material development of civilization the engineer has always played an important role and in no period have his activities been more important than during the last few decades.

Mr. Dunn, who reviewed many of the brilliant achievements of Japan in the fields of science, medicine and other arts, pointed to the rapid development of engineering in Japan.

Chairman Elmer A. Sperry of the American Committee presided and the chairmen of various sub-committees made brief reports. About sixty members of the American Committee were present, including the following representatives of the A. I. E. E.: Messrs. A. W. Berresford, Gano Dunn, B. Gherardi, F. L. Hutchinson, Dugald C. Jackson, F. B. Jewett, C. O. Mailloux, O. C. Merrill, Robert A. Millikan, Farley Osgood, E. Wilbur Rice, Jr., Chas. F. Scott, Lewis B. Stillwell, S. W. Stratton and Ambrose Swasey.

The 1929 Lamme Medal

NOMINATIONS FOR THE 1929 AWARD WILL BE RECEIVED UNTIL SEPTEMBER 1

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Company, who died July 8, 1924, to provide for the award by the Institute of a gold medal (together with bronze replica thereof) annually to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery," and for the award of two such medals in some years if the accumulation from the funds warrants.

The first (1928) Lamme Medal has been awarded to Allan Bertram Field, Consulting Engineer, Metropolitan Vickers Electrical Company, Ltd., Manchester, England, "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery," and will be presented during the Summer Convention at Swampscott, Mass., June 24-28.

Special attention is called to the fact that names of members of the Institute, who are considered suitable candidates for the Lamme Medal to be awarded in the Fall of 1929, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal Committee, which is quoted below:

"The Committee shall cause to be published in one or more issues of the A. I. E. E. JOURNAL each year, preferably including the June issue, a statement regarding the 'Lamme Medal' and an invitation for any member to present to the National Secretary of the Institute by September 1 the name of a member as a candidate for the Medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, which will enable the Committee to determine its significance as compared with those of other candidates. If the work of the nominee has been of a somewhat general character, in cooperation with others, specific information should be given regarding the contributions of the individual. Names of endorsers should be given as specified above.

STANDARDS

Test Codes for Electrical Machines

In the April JOURNAL mention was made of the proposed development of "Electrical Test Codes" and that a committee had been appointed to survey the situation. At the meeting of the Standards Committee May 8, the report of the special committee was made by its chairman, F. M. Farmer. The recommendations of the special committee, approved by the Standards Committee were, in brief, as follows:

1. That test codes for the more important classes of electrical apparatus; namely, generators, motors and transformers be prepared. Industry can thus be shown just what is contemplated and some idea of cost can be obtained.

2. That the scope of the tests be the prescription in detail of the procedure followed in making the various tests commonly required.

3. That the work be undertaken as an A. I. E. E. project under the direction of the Standards Committee, but that in view of the close contact of the Electrical Machinery Committee with the subject matter of the first proposed codes, they be prepared by that committee and reported to the Standards Committee.

Definition of Distortion Factor

At the February 27th meeting of the Standards Committee there was presented by the Instruments and Measurements Committee a proposed definition of distortion factor, as follows:

"Distortion factor of a periodic voltage or current wave is the ratio of the effective value of the residue, after the elimination of the fundamental, to the effective value of the original wave."

This definition was referred by the Standards Committee to the Electrical Machinery Committee for consideration.

Methods of Test for Determining Distortion Factor

Following the presentation of the suggested definition of distortion factor given above, the Instruments and Measurements Committee presented at the meeting of the Standards Committee of May 9th a progress report outlining in detail four methods of determining the distortion factor of the voltage wave of alternators. The methods described are as follows: (A) Method of Boucherot using an alternator with a sinusoidal wave and a voltmeter. (B) Method of Belfils using a bridge to suppress the fundamental and a voltmeter to read the residue. (C) From the Oscillogram. (D) By means of a harmonic analyzer. The Instruments and Measurements Committee is gathering further data on this subject, which it is hoped will show which of the various methods is preferable.

Measurement of Core Losses

At the meeting of the Standards Committee of May 9th a report dealing with the determination of the core losses of transformers was presented by the Instruments and Measurements Committee. It recommended that the following be incorporated in the Standards for Transformers, No. 13:

"The core loss of transformers shall be determined preferably with a sine wave of applied voltage; if this is not practicable, the results obtained with a distorted wave of applied voltage shall be corrected to a sine wave basis by a suitable method."

The committee then suggests that the available methods be given in detail and outlines three: The standard core method; the iron-loss voltmeter method; the flux voltmeter method.

The Standards Committee referred this report to the Electrical Machinery Committee for an opinion as to the exact form in which it should appear in the Transformer Standards.

Definitions of Breakdown Voltage and Dielectric Strength

About a year ago the Standards Committee appointed a special committee under the chairmanship of Doctor F. B. Silsbee of the Bureau of Standards to develop definitions for "breakdown voltage" and "dielectric strength." The committee reported at the May 9th meeting of the Standards Committee and the definitions suggested were accepted for reference to the subcommittee of the Standards Committee on Definitions and to a committee on Insulation of the National Research Council. The definitions suggested follow:

Breakdown Voltage

The breakdown voltage of an insulating structure is that minimum voltage, which when applied to a set of conductors separated by the structure causes a sudden disruptive discharge to take place.

In certain cases more specialized terms may be used to designate the breakdown voltage corresponding to particular conditions. Thus

1. The term "flashover voltage" is used in connection with line insulators or bushings to designate the breakdown voltage at which the discharge takes place through an air path around the insulator; while
2. the term "puncture voltage" is used to designate the voltage at which the discharge occurs through the insulating material. Also
3. the term "corona voltage" is used to designate the voltage required to initiate the partial breakdown of gaseous and liquid dielectrics, known as corona or brush discharge; while
4. the term "sparking voltage" is used to designate the equal or higher voltage at which the corona discharge changes to a spark.

The numerical value of the breakdown voltage which is obtained in any particular case will depend upon various factors such as the shape and size of the electrodes, kind, frequency, wave form and rate and time of application of voltage, temperature, atmospheric pressure and humidity, etc.

Values of breakdown voltage are expressed in terms of the crest voltage in the case of direct or of impulse voltage but in terms of effective sine-wave voltage in the case of alternating voltage of low or high-frequency.

Electric Strength

The electric strength of a dielectric is that property by virtue of which the dielectric is able to withstand electric stress.

Electric strength is commonly expressed as the ratio of the breakdown voltage of the dielectric to its thickness; *e. g.*, volts per mil, volts per cm., kilovolts per mm.

Comparable values of electric strength for different materials can be obtained only from tests under identical conditions. Among these conditions are the shape, size and spacing of the electrodes, the frequency, wave form and rate and time of application of the voltage, the temperature, the atmospheric pressure, the humidity, etc., and the surrounding medium, (air or oil, for example).

When the dielectric is of such form that the average electric stress differs from the maximum electric stress within the dielectric, as for example, in electric cables, it is important to specify whether the average or the maximum value is being given.

Electric strength is also called "dielectric strength," "critical gradient," "disruptive gradient," etc.

Proposed Standards for Constant Current Transformers

At the May 9th meeting the Committee on Electrical Machinery presented to the Standards Committee a report in the form of proposed Standard for Constant Current Transformers. This proposed standard will be printed in report form and for purposes of criticism and suggestion will receive wide distribution before coming up for final adoption. Copies will be available within the next two weeks and may be obtained without charge by writing to H. E. Farrer, Secretary, Standards Committee, A. I. E. E. Headquarters.

Code for Protection Against Lightning Becomes American Standard

Under date of April 4, the American Standards Association approved parts I, II and III of the Code for Protection Against Lightning. Part I covers protection of persons and Part II protection of buildings and miscellaneous property. These was approved as American Standard, while Part III, on protection of structures containing inflammable liquids and gases, was approved as a Tentative American Standard. There are two additional parts of the code dealing with electric lines and apparatus still in process of development. While the A. I. E. E. and the Bureau of Standards are joint sponsors of this project, the code will be published and sold by the Government Printing Office, Washington, D. C.

AMERICAN ENGINEERING COUNCIL

ADMINISTRATIVE BOARD SPRING MEETING AT WASHINGTON, D. C.

Upon the call of President A. W. Berresford, the Administrative Board of American Engineering Council met in Washington, Friday and Saturday, May 24-25, preceded by an Executive Committee meeting on May 23 in the same place.

The meeting held in the Mayflower Hotel was the first meeting of the Administrative Board since the annual meeting in January, 1929. The Board is composed of the following members of American Engineering Council: A. W. Berresford, President; H. E. Howe, Treasurer; Vice-Presidents, L. P. Alford, O. H. Koch, I.E. Moultrop, G.S. Williams, Edwin F. Wendt, R. F. Schuchardt, M. M. Fowler, Col. J. H. Finney, H. A. Kidder, Farley Osgood, C. E. Skinner, William Boss, John L. Harrington, William S. Lee, R. C. Marshall Jr., Chas. Penrose, Elmer Sperry, D. R. Yarnall, W. F. Rittman, Edward Robinson, Burritt A. Parks, John S. Dodds, James R. Withrow, A. A. Krieger, H. A. Marshall; also three members of the American Society of Civil Engineers which has recently become a member of Council; *viz.*, A. J. Dyer, Vice-President A. S. C. E.; Frank Williams, Director 1928, and George T. Seabury, Secretary.

The chief matters of business to come before the Board were: Water Resources Legislation now being proposed by the various states and the extent to which, if any, council should participate in this movement; the distribution and use of the Report on Street Traffic Signs, Signals and Markings; the approval of the personnel of important committees; future flood control policy of Council; also a discussion of the program of Council for the next six months.

A. E. C. APPOINTS COMMITTEE ON DAMS

President A. W. Berresford has announced the appointment of the committee on legislation pertaining to the safety of dams, composed as follows: G.S. Williams, Ann Arbor, Mich., Chairman; L. F. Harza, Chicago, Ill.; Chas. G. Hyde, Univ. of Calif., W. P. Kreager, Vice-President and Chief Engr., Northern N. Y. Utilities Co., Trust Power Bldg., Watertown, N. Y.; W. S. Lee, Duke Power Co., Charlotte, N. C.

The integrity and professional qualifications of the members of this committee assure a report of distinct service to the American public and to all professional engineers whose duties bring them in contact with the construction of dams.

One of the first tasks of the committee will be to ascertain the facts connected with this problem. All the various methods of dealing with the question of the safety of dams will be analyzed and the most reasonable and practical solution to the problem will be recommended to A. E. C. In order that those in positions of authority on this subject may avail themselves of its information this report, if approved by Council, will then be circulated widely.

Dallas Holds Outstanding Regional Meeting

An outstanding success among regional meetings of the Institute was the meeting held under the auspices of District No. 7 at the Adolphus Hotel, Dallas, Texas, May 7-9. The registered attendance of 541 is remarkable in a locality where travel distances are great, where the total membership of the District, which includes six states, is only 630 and the membership of the Dallas Section is only about 100. The interest of those attending was maintained throughout the meeting as indicated by the fact that the attendance at the technical sessions was never less than 325. At an address on the evening of May 7, there were 750 present, many of whom were not registered in the regular attendance records. One noteworthy feature was that about 200 members of Branches were present to take part in the Student division of the program.

The senior technical program consisted of fifteen papers presented in four sessions, the first session opening with an address of welcome by J. W. Carpenter, President of the Texas Power and Light Company. A summarized report on the discussion at these sessions will be published in the July JOURNAL and the complete discussion will be published with the respective papers in the TRANSACTIONS.

Two Student sessions were held and these are described more fully in the "Student Activities" section of this JOURNAL.

A most interesting lecture with many striking demonstrations was given on the evening of May 7. This lecture entitled *Science and Research in Telephone Development*, was presented by S. P. Grace of the Bell Telephone Laboratories, Inc. Of special interest were the demonstrations of "inverted" speech, delayed transmission of sound, and the artificial larynx.

Several inspection trips were taken to power stations, telephone plants, factories, and other places of engineering interest. A dinner-dance on the evening of May 8 attended by more than three hundred and a luncheon with the Dallas Electric Club on May 7 were very pleasant features of the meeting.

Highest praise is due the local committees for their organizing ability and enthusiasm in creating exceptional interest in the meeting and for the effective manner in which all events were conducted.

The Regional Meeting Committee which had charge of the meeting was as follows: B. D. Hull, *Chairman, Vice-President South West District*; A. E. Allen, *Secretary, South West District*; L. T. Blaisdell, C. V. Bullen, B. J. George, W. C. Looney, G. A. Mills, C. P. Potter, G. C. Shaad, J. B. Thomas. The general Local Committee consisted of G. A. Mills *chairman*, A. Chetham-Strode, *secretary* and the chairmen of committees as follows: J. B. Thomas, *Meetings and Papers*; L. T. Blaisdell, *Entertainment and Reception*; W. C. Looney, *Transportation and Inspection*; E. L. Glander, *Hotels and Registration*; T. C. Ruhling, *Attendance and Publicity*; C. G. Matthews, *Finance*; G. C. Shaad, *Student Activities.*

National Prizes Awarded for Papers

Four National Prizes for papers presented during 1928 have been awarded by the Committee on Award of Institute Prizes. These prizes consist of suitable certificates and $100 in cash, the cash prize being divided in case of joint authorship. These prizes will be presented to the winners on June 25 at the Summer Convention. The report of the Committee on Award is as follows:

The Committee on Award of Institute Prizes for the year 1928 has had a large number of very excellent papers from which to select the prize winners. In determining which of these should receive final consideration, the Committee has had the valuable assistance of the Chairmen of the various Technical Committees. In all, 107 papers were eligible under the Institute Rules for the First Prize. Nine were eligible for the Prize for Initial Paper and eight for the Prize for Branch paper.

In studying these papers, the procedure outlined in the Rules, adopted by the Board of Directors June 23, 1927, and revised as of December 7, 1928, and the rating plan contained therein, have been followed. As a result of its work, the Committee has awarded four National Prizes. Also five papers have been given honorable mention. The awards are as follows:

National First Prize in the field of Engineering Practise awarded to Philip Sporn for his paper entitled "Rationalization of Transmission-System Insulation Strength," presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12,1928.

National First Prize in the field of Theory and Research awarded to Joseph Slepian for his paper entitled "Extinction of an A-C. Arc" presented at the Summer Convention, Denver, Colorado, June 25-29, 1928.

Honorable Mention in the field of Theory and Research awarded to:

Harry Nyquist for his paper entitled "Certain Topics in Telegraph Transmission Theory" presented at the Winter Convention, New York, February 13-17, 1928.

Robert E. Doherty and Clifford A. Nickle for their paper entitled "Synchronous Machines—IV" presented at the Winter Convention, New York, February 13-17, 1928.

Joseph T. Lusignan, Jr., for his paper entitled "A Study of High-Voltage Flashovers" presented at the District No. 4 Meeting, Atlanta, Georgia, October 29-31, 1928.

National Prize for Initial Paper awarded to Hubert H. Race for his paper entitled "Electric Conduction in Hard Rubber, Pyrex, Fused and Crystalline Quartz" presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12, 1928.

Honorable Mention for Initial Paper awarded to Ludwig Encke for his paper entitled "Interconnection of Power and Railroad Traction Systems by Means of Frequency Changers" presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12, 1928.

National Prize for Branch Paper awarded to Paul Klev, Jr., and D. W. Shirley, Jr. for their paper entitled "The Voltage-Ratio Characteristics of Audio-Frequency Transformers Determined by the Low-Voltage Cathode-Ray Oscillograph," presented at the joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

Honorable Mention for Branch Papers awarded to E. B. Torvik, A. A. Lundstrom and M. D. Pillars for their paper entitled "Electrical Characteristics of Neon Signs" presented at the joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

On account of the excellence of a large number of the papers it was quite difficult to make the final selections. This was particularly true in connection with the papers to be considered for the First Prize in the field of Theory and Research, in which there were many very high-grade papers. As indicated above, it was thought that three papers in this class were deserving of honorable mention. No prize was awarded for a paper in the field of Public Relations and Education.

Respectfully submitted,
(Signed) F. W. PEEK, JR.
(Signed) W. S. GORSUCH
(Signed) H. P. CHARLESWORTH, Chairman
A. I. E. E. Committee on Award of Institute Prizes

Districts Award Paper Prizes

Twelve Regional Prizes for papers presented during 1928 have been awarded by five Districts of the Institute. Each of these prizes consists of an appropriate certificate and $25 cash, the cash award being divided in case of joint authorship. The awards are as shown below.

DISTRICT NO. 1

Regional First Prize. C. F. Estwick for his paper entitled *Shunting of Track Circuits in a Polyphase System of Inductive Train Control*, presented at the New Haven Regional Meeting, May 9-12, 1928.

Regional Prize for Initial Paper. H. H. Race for his paper entitled *Electric Conduction in Hard Rubber, Pyrex, Fused and Crystalline Quartz*, presented at the New Haven Regional Meeting, May 9-12, 1928.

Regional Prize for Branch Paper. J. R. Burnett and S. R. Knapp for their paper entitled *Special Oscillograph Studies of Alternator Short Circuits*, presented at the Student Session of the New Haven Regional Meeting, May 9-12, 1928.

DISTRICT NO. 2

Regional First Prize and Regional Prize for Initial Paper. Lester L. Bosch, for his paper entitled *Development, Theory and Design of the Low-Voltage A-C. Network*, presented before a meeting of the Cincinnati Section on April 12, 1928.

Regional Prize for Branch Paper. D. T. Bell and A. M. Marzulli, for their paper entitled *Acoustic Shock and Hazard in Telephone Communication*, presented before a joint meeting of the University of Cincinnati Branch and the Cincinnati Section on May 10, 1928.

DISTRICT NO. 8

Regional First Prize. J. S. Carroll and Bradley Cozzens for their paper entitled *Sphere-Gap and Point-Gap Arc-Over Voltage as Determined by Direct Measurement*, presented at the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

Regional Prize for Initial Paper. L. J. Turley for his paper entitled *Automatic Mercury Arc Power Rectifier Substation on the Los Angeles Railway*, presented at the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

Regional Prize for Branch Paper. P. E. Warrington for his paper entitled *The Effect of Barriers in Insulating Oil*, presented at the Student Session of the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

DISTRICT NO. 9

Regional Prize for Branch Paper. Paul Kley, Jr., and D. W. Shirley, Jr., for their paper entitled *The Voltage-Ratio Characteristics of Audio-Frequency Transformers Determined by the Low-Voltage Cathode-Ray Oscillograph*, presented at a joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

DISTRICT NO. 10

Regional First Prize. H. M. Lloyd for his paper entitled *Railway Motors*, presented at the Vancouver Section meeting May 1, 1928.

Regional Prize for Initial Paper. H. R. Sills for his paper entitled *Starting Characteristics of Synchronous Motors*, presented at the Toronto Section meeting March 9, 1928.

Plans for Power-Circuit Colloquium Now Complete

Final announcement with regard to the program for the summer colloquium on power-circuit analysis which is scheduled at the Massachusetts Institute of Technology June 10-22, 1929, has now been made by G. Dahl, Director of the Colloquium. The technical sessions will be conducted by means of lectures and round-table discussions by members of the Electrical Engineering staff and engineers invited from the industries, including manufacturing companies, operating companies, consulting engineers and those by whom the problem of power-system stability may be amply represented. Professors D. C. Jackson, V. Bush and Director Dahl will be the speakers at the first technical session, opening the afternoon of Monday, June 10. Information regarding further sessions may be obtained by addressing the Director, G. Dahl, Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Radio Commission Membership Confirmed

In February of this year, former President Coolidge recommended to the Senate for membership on the Federal Radio Commission, Arthur Batchelor of Massachusetts, and Prof. C. M. Jansky of Minnesota. The Senate, however, adjourned March 4 without confirming these appointments.

Upon the advent of President Hoover's administration, Gen. Chas. M. Saltzman and Wm. D. L. Starbuck, of Connecticut, were nominated for membership on the Radio Commission and these appointments have been confirmed by the Senate.

Both men have been identified with the field of radio engineering for a number of years, Gen. Saltzman through the Signal Corps of the U. S. A., and Mr. Starbuck, although receiving his early training as an engineer, is an attorney, and has devoted himself to the legal aspects of radio problems.

Welding Code for Building Construction

Code 1 Park A—Structural Steel, covering fusion welding and gas cutting in building construction has just been formally approved and issued by the American Welding Society. Parts B and C, relating to piping and tankage in buildings are being prepared.

This is the result of the increased use of welding and gas cutting in the construction and equipment of buildings. It has been brought to the attention of the American Welding Society with requests for assistance in the formulation of a revision to the present existing Building Codes, or, if needs be, a set of new codes on the fabrication and erection of structural steel, piping, and tankage of buildings. In response to these requests, the Committee on Building Codes was appointed by F. T. Llewellyn, President of the American Welding Society, and the work of formulation has already progressed as reported in the first paragraph. This being the first edition of the Code, it has been made as simple as possible; the Committee, however, will gladly assist anyone in its interpretation if desired. Address communications to the American Welding Society, 33 West 39th St., New York, N. Y.

Changes in Federal Power Commission

The Federal Power Commission is composed of the Secretary of War, James W. Good; Secretary of Interior, Ray Lyman Wilbur, and Secretary of Agriculture, Arthur M. Hyde. President Hoover has designated Secretary of War Good as Chairman of the commission.

After serving for five years with the Federal Power Commission, Major Glen E. Edgerton has been ordered to the U. S. Military Academy to serve as an instructor of civil and military engineering. He is to be succeeded by Col. Max Tyler.

Prior to becoming chief engineer of the Commission, Major Edgerton occupied the office of Assistant Chief. He had previously served for two years as director of sales for the War Department, five years as Chief Engineer of the Alaskan Railroad Commission, and two years on the Panama Canal. He has served also as a member of the Board of Engineers for Rivers and Harbors. He will not assume new duties at West Point until August 24, 1929.

Grand Rapids Elects Engineer

The citizens of Grand Rapids, Michigan, recently elected Mr. Burritt A. Parks, member of the Assembly of American Engineering Council, and Chairman of the Peninsular Section of the A. S. M. E., a member of the City Commission. The group supporting Mr. Parks ran him under the slogan, "You Put an Engineer in the White House, Why Not One on the Commission."

Patton New Director U. S. Coast and Geodetic Survey

Following the death of Col. E. Lester Jones at his home in Washington on April 9, President Hoover has appointed Raymond F. Patton Director of the U. S. Coast and Geodetic Survey.

Progress on Survey of Land Grant Colleges

The Bureau of Education of the Department of Interior has announced extraordinary progress in the land grant college survey. The first questionnaire in this survey was distributed less than a year ago. Since then, 17 additional questionnaires ranging from 24 to 408 pages have been prepared and sent to 50 colleges attended by white students. Up to the present time, 516 of the questionnaires, or almost three-fourths of the total, have been returned to the Bureau completely filled out by the colleges.

The work of filling out the engineering questionnaire has been completed by almost two-thirds of the colleges. Forty of the Institutions have returned their copies to the bureau. The rapid progress made in the case of this questionnaire, it is stated, was due largely to the personality and energetic activity of Dean A. A. Potter, School of Engineering, Purdue Univ.

The data and items covered by this questionnaire avoid the field covered by the recent study of the Society for the Promotion of Engineering Education. The Bureau is now engaged in compiling and studying the data, and it is expected that within a comparatively short time some very constructive results will be forthcoming. Additional information concerning this survey may be obtained through the Bureau of Education, Department of Interior.

Engineer of Bureau of Public Roads Loaned to Colombia

Edwin W. James, Chief of the Division of Design of the Bureau of Public Roads, U. S. Department of Agriculture, has been appointed by the government of Colombia to serve as a member of a commission to study and prepare plans for the improvement of the entire system of transportation and communication in that country.

Mr. James has secured leave of absence of from three to six months to perform this work. He sailed from New York on March 21.

He has a wide knowledge of all phases of highway engineering problems, and his recent book entitled "Highway Construction, Administration and Finance" translated into Spanish, has enjoyed a wide circulation in Central and South America as well as in this country. He is also the author of numerous papers and technical treatises on highway engineering.

This appointment and method of handling it is considered highly appropriate, and is in conformity with the procedure recommended by American Engineering Council in such cases. In the last session of Congress, a bill, H. R. 7344, provided for the use of Bureau of Public Roads highway engineers in Latin-American countries but made provision for the payment of their salaries during such time by the U. S. Govt. This measure was opposed by American Engineering Council.

Boulder Engineers Named by Wilbur

Secretary Ray Lyman Wilbur of the Department of Interior, has announced the appointment of the following three outstanding engineers as consultants in the field service in the Bureau of Reclamation; Louis C. Hill, Colorado; Andrew J. Wiley, Idaho, and Wm. F. Durand, Cal.

These men will concern themselves particularly with the Boulder Canyon or Colorado River project. Mr. Hill was long in the service of the Bureau of Reclamation. Andrew J. Wiley has had a large experience in constructing irrigation systems, power plants and related works, and has a world reputation in the building of dams. Doctor Durand, for years Professor in the Engineering School at Stanford University, has participated in former studies of the Colorado River made by the Reclamation Service. In 1927 he was appointed a special adviser in the then proposed development of the lower Colorado River. His report was before Congress during the time that the legislation providing for the development of that region was being considered. He served on the President's Aircraft Board in 1925, and as a scientific attache of the American Embassy in London during the war.

Mr. Van Wagenen Appointed Boundary Commissioner

To fill the vacancy caused by the death of E. Lester Jones, James H. Van Wagenen, formerly Chief Engineer of the U. S. Section of the International Boundary Commission, has been appointed Commissioner of the International Boundary Commission for the United States. This Commission is charged with the responsibility of definitely locating the boundary between United States, Alaska, and Canada and the promotion of Mr. Van Wagenen to head the Commission with which he has been connected for so many years is viewed by the engineering profession as not only wise but well-earned. He is a member of the American Society of Civil Engineers and of the Washington Society of Engineers, has been active in American Engineering Council a sa member of the annual meeting committee, and was chairman of a special committee of Council to investigate methods of stabilizing business as part of the work of the Conference on Unemployment, called by Pres. Harding, Sept., 1921.

German Engineer on Lecture Tour

EUROPEAN AUTHORITY ON HYDRAULIC STRUCTURE EXPERIMENTATION VISITS AMERICA

Doctor Theodor Rehbock, an internationally known authority on hydraulics, arrived in America on March 16, and upon the invitation of Doctor S. W. Stratton delivered, at Massachusetts Institute of Technology, a series of lectures which terminated the second week in April. He then made a short trip into Canada, and, returning, lectured at University of Cornell, Detroit, and the University of Michigan. Arriving in Washington, D. C., April 20, he attended the annual meeting of the National Academy of Science, April 22, delivering a lecture on "The Use of Time Corrected Films in Hydraulic Experimentation."

On April 24, he was the honor guest at a dinner at the Cosmos Club given under ths auspices of the Washington Society of Engineers.

Upon the invitation of Col. E. M. Markham, Commandant of the Ft. Humphreys School of Engineering for Army Officers, Doctor Rehbock was scheduled to deliver two illustrated lectures on the afternoons of April 25 and 26, but a slight indisposition caused a postponement of these lectures. He is now on a tour of inspection of the flood control works of the Mississippi River, and will visit Omaha, Kansas City, St. Louis, Memphis, and possibly New Orleans, returning to Washington May 5.

Mississippi Flood Control Opposition Grows

The Flood Control Act of 1928, under which the so-called Jadwin plan is being carried out by the Corps of Engineers, is less than a year old, but as the details of the project have become known, the inhabitants of the region have become more and more incensed and are demanding a reconsideration of the plan by an impartial and competent authority.

It is reported that the Army engineers fearing executive intervention are rushing into immediate construction the two most controversial features of the entire flood control plan, and have advertised the letting of construction contracts in the proposed Missouri floodway for May 22, with served notice that construction contracts on the Bouef floodway will be let on or about June 1. A non-partisan delegation from the Senate and House of Representatives has called upon President Hoover to discuss with him the Mississippi flood control situation and has been requested to prepare a written memorandum for his consideration setting forth its recommendations as to the executive action which he could and should take, and, the remedial legislation necessary to carry out the flood control act of 1928 as Congress had intended it to be carried out.

The report of the A. E. C. Flood Control Committee composed of Baxter L. Brown, John R. Freeman, Arthur E. Morgan, and Gardner S. Williams, was presented in January 1928, and there is nothing to indicate that the situation is any different today than a year ago.

Government Reorganization

Hon. Frederick W. Dallinger of Massachusetts introduced into the special session of Congress, April 18, a bill H. R. 1214, to authorize the President of the United States to reorganize the executive departments of the Government. The power given in the bill expires two years from date of passage.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Wednesday, May 22, 1929.

There were present: President R. F. Schuchardt, Chicago, Ill.; Past-President B. Gherardi, New York City; Vice-Presidents J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; H. A. Kidder, New York City; Directors M. M. Fowler, Chicago, Ill.; C. E. Stephens, New York City; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Niagara Falls, N. Y.; National Secretary Hutchinson, New York City. Present by invitation, Professor Harold B. Smith, Worcester, Mass., presidential nominee.

The minutes of the Directors' meeting of March 21, 1929, were approved as previously circulated.

The Board ratified the action of the Executive Committee, under date of April 8, 1929, on pending applications as follows: 143 Students enrolled; 189 Associates elected; 11 Members elected; two applicants transferred to the grade of Member; six applicants transferred to the grade of Fellow.

Appointment by the Executive Committee of Mr. Bancroft Gherardi as a Director of the American Standards Association was confirmed.

Reports of meetings of the Board of Examiners held April 3 and May 15, 1929 were presented. Upon the recommendation of the Board of Examiners, the following actions were taken: 183 Students were enrolled; 138 Associates were elected; 21 applicants were elected to the grade of Member; one applicant was elected to the grade of Fellow; 25 applicants were transferred to the grade of Member; six applicants were transferred to the grade of Fellow.

The Secretary reported 1462 members in arrears for dues for the year ending April 30, 1929, and was directed to transfer these members from the mailing list to a "suspended" list, and to employ the usual methods of collecting the dues and restoring the members to the active membership list.

Approval by the Finance Committee, for payment, of monthly bills amounting to $27,963.46, was ratified.

The annual report of the Board of Directors to the membership, for the fiscal year ending April 30, 1929, as prepared under the direction of the National Secretary, was considered and approved for presentation at the Annual Meeting of the Institute, on June 25.

The annual report of the National Treasurer for the fiscal year ending April 30, 1929, was received.

The annual reports of the general standing committees of the Institute (exclusive of the reports of the technical committees, which are presented at the Annual Summer Convention, in June), were presented, abstracts of which were incorporated in the Board of Directors' annual report.

The following were made "Members for Life" by exemption from future payment of dues, in accordance with Sec. 22 of the Constitution: Alton D. Adams, W. L. Bliss, L. S. Boggs, W. C. Burton, F. Elliot Cabot, H. B. Coho, Edward A. Colby, L. K. Comstock, F. J. Dommerque, W. L. R. Emmet, J. B. Entz, C. S. Hammatt, William R. Hewitt, H. M. Hobart, Thomas R. Rosenburgh, Frank J. Sprague, Henry C. Townsend, E. W. Trafford, P. V. R. Van Wyck, Charles H. Wilson.

A petition for the formation of a Section at Birmingham, Ala., was presented, and in accordance with the recommendation of the Sections Committee, the petition was granted.

Upon the recommendation of the Committee on Student Branches, authorization was given for the establishment of Student Branches at North Dakota Agricultural College, Southern Methodist University, and University of New Mexico.

In accordance with Sec. 37 of the Constitution, the appointment of a National Secretary for the administrative year beginning August 1, 1929, was considered, and National Secretary F. L. Hutchinson was reappointed.

Upon the recommendation of the Standards Committee, approval was given to the discharge of the Sectional Committee on Rating of Electrical Machinery; a revision of the Standards for Hydraulic Symbols was approved, and approval given to the preparation of electrical tests codes for the important classes of electrical apparatus; namely, generators, motors, and transformers.

The President was authorized to appoint delegates of the Institute to the International Conference on Large Electric High-Voltage Systems to be held in Paris, June 6-15.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Book Reviews

HANDBOOK OF REFRIGERATING ENGINEERING. By W. R. Woolrich, M. E. D. Van Nostrand Company, Inc., New York, N. Y., 332 pp., 5 x 7 in., flexible cloth, illustrated, 1929. Price $4.00.

This book comprises a very complete compilation of data on refrigeration which has recently come into such common use that a study of its general principles and the apparatus employed becomes of importance. The work has been designed for the instruction of constructing and operating engineers and for students in engineering colleges, and has been developed as a series of lectures. It contains 19 sections on various phases of refrigeration and a supplementary section of miscellaneous tables. Each section concludes with a series of practical problems and questions by means of which the student can test his knowledge of the subjects covered. The treatment is brief and concise, and the book contains sufficient information to solve almost any practical problem in refrigeration.

HOW TO WIND DIRECT-CURRENT ARMATURES. By W. E. Hennig. The Bruce Publishing Company, Milwaukee, Wisconsin. Second edition, revised, 206 pp., 7 x 10¼ in. cloth, illustrated, 1928. Price $3.00.

The author presents in a very clear and practical manner the numerous types of d-c. armature windings with diagrams and explanations which a student who has had no engineering training can understand. The book is addressed to the practical armature winder and home student rather than the technically educated engineer, as it contains but little mathematics and theory, and is not a treatise on the principles and design of d-c. machines. It, however, explains and illustrates practically all of the d-c. winding diagrams in general use and in addition contains useful information on armature testing, adapting machines to changed conditions, and numerous examples of rewinding for voltage changes. The author's experience both as a teacher and a commercial engineer has enabled him to produce a work in accord with the latest commercial and manufacturing practises.

The Electrical Conductivity of the Atmosphere and Its Causes. By Victor F. Hess. Translated from the German by L. W. Codd. D. Van Nostrand Company, Inc., New York, N. Y., 5¾ by 8⅞ inches, 204 pp., cloth, illustrated, 1928. Price $4.00.

The rapid advances in the knowledge of the conduction of electricity in the atmosphere which has taken place in recent years has been available only in articles scattered through technical periodicals. The book by Dr. Hess offers a very complete treatise on atmospheric ionization under a single cover, which has been revised during the course of translation to include the progress in this field down to January, 1928. The general explanation of electrical conductivity in the atmosphere is followed by a study of gas ions and the sources of ionization. The concluding chapters treat of the processes which operate to destroy ions, and the ionization balance of the atmosphere. The work of the numerous investigators in this field is reviewed and a bibliography on atmospheric electricity and collateral researches is included. The book is addressed primarily to scientists but it includes fundamental theory and results which will appeal to the general reader.

The Radio Manual. By George E. Sterling. Edited by Robert S. Kruse. D. Van Nostrand Company, Inc., New York, N. Y., 5¾ by 8 inches, 666 pp., cloth, illustrated, 1929. Price $6.00.

This is a comprehensive handbook on the general theory and practise of radio, and covers the subject so fully that it will be found useful to anyone interested in the subject, whether expert or amateur. There are several chapters devoted to the elements of electricity and magnetism leading up to the theory of radio, followed by detailed descriptions of numerous transmitting and receiving sets with their circuit diagrams. There are also descriptions and circuit diagrams of commercial and broadcast apparatus as used on board ships and in land stations, with instructions for maintenance, operation, finding defective parts, and making necessary repairs and replacements. Radio laws of the United States and the International Telegraphic Conference are given and a chapter is devoted to handling and abstracting traffic. Sufficient information is given to enable the student to secure a commercial or broadcast license or to pass the U. S. Civil Service examinations for radio inspectors and engineers in Federal service.

Elements of Practical Mechanics. By Charles R. MacInnes. D. Van Nostrand Company, Inc., New York, N. Y., 6¼ x 9¼ inches, 130 pp., cloth, illustrated, 1929. Price $2.25.

The book is the outcome of the author's classroom experience and it is intended for use especially with classes of engineering students. Its use presupposed a knowledge of calculus and physics. The treatment takes up in turn coplanar and non-coplanar forces, center of gravity, rectilinear and curvilinear motion, work, energy, power, moment of inertia, motion, impact, momentum, and cases involving friction. Graphical methods are developed in parallel with the analytical methods, and illustrative examples are freely used. Numerous problems are included with each chapter, to which answers are given.

Speech and Hearing. By Harvey Fletcher. D. Van Nostrand Company, Inc., New York, N. Y., 6¼ by 9¼ inches, 330 pp., cloth, illustrated, 1929. Price $5.50.

The results of work in the Bell Research Laboratory are embodied in this volume. Some fifteen years ago an investigation of the constitution of speech and hearing was planned with the object of analyzing every part of the system from the voice through the telephone instruments to and including the ear. During the progress of this research a number of new instruments and devices has resulted which have found other important uses, such as providing means of speech for some whose vocal chords are gone, and means of accurately measuring the sense of hearing. The primary object of this research, which is yet far from finished, was to determine the requirements and limitations of transmission of speech in the telephone system, and with the facts of this investigation established, the effect of contemplated changes or developments can be more readily evaluated.

The book is divided into four parts: (1) Speech, (2) Music and Noise, (3) Hearing, (4) Perception of Speech and Hearing. Part I describes the mechanism of speaking, characteristics of speech waves, speech power, and frequency of occurrence of different sounds. Part II gives similar information in regard to music and noise. Part III deals with the mechanism of hearing, limits of audition, minimum perceptible differences in sound, masking effect of different pitched sounds, binaural effects, and a description of apparatus used in determining these values. Part IV treats of loudness of sound, recognition of pitch and those features which involve personal judgment. Methods of measurements and experimental results are given of types of sound distortion and the ability of persons to recognize them. The book well illustrates the value of systematic research which, though much remains to be completed, has yielded valuable results in its special field as well as in entirely unforeseen directions.

PERSONAL MENTION

H. Calvert, of Calvert and Barnes, Designing and Consulting Engineers, Philadelphia, announces a change of address to the twelfth floor of the Crozer Building, 1420 Chestnut Street.

C. H. Mayer has resigned from his position in the Works Department of the Westinghouse Lamp Company, Bloomfield, N. J., to become Electrical Engineer of the Ce Co Manufacturing Company of Providence, R. I.

E. H. Bollenbacher, who was connected with the firm of McClellan & Junkersfeld, Inc., New York, for the past six years, has opened an office in Atlanta, Ga., as Manufacturers' Representative on Sales Power Plant Equipment.

H. P. Davis, Vice-President, formerly in charge of Westinghouse manufacturing operations, will now devote his entire time to the company's radio activities. He will report to Mr. A. W. Robertson, Chairman of the Board of Directors.

Herbert C. Moyer, who for the past five years has served as Meter Engineer of the Standardizing Laboratory of the Pennsylvania Power & Light Company, has resigned and accepted a position as Assistant Chief Engineer of the U. S. Gauge Company, Sellersville, Pa.

H. W. Young, President of the Delta-Star Electric Company, Chicago, Illinois, sailed June 1 on the Majestic and will visit the Delta-Star European connections. He will also present a paper on Outdoor Substations at the International High-Tension Conference to be held in Paris, June 6 to 15.

Thomas C. Clark, formerly District Manager of the St. Louis territory for W. N. Matthews Corporation, St. Louis, has been made sales manager of the company. Mr. Clark was Superintendent of the Central Division of the Union Light & Power Company previous to his affiliation with the W. N. Matthews Corporation.

W. J. S. Dormer, previously on the staff of the District Engineer of the Bell Telephone Company of Canada, at Quebec City, as Assistant Field Engineer, has accepted a position as Toll Line Engineer, Eastern District of the Bell Telephone Company of Canada, with headquarters at Montreal, in charge of toll line reconstruction and the building of new toll lines.

Colin B. Kennedy, one of America's oldest radio manufacturers, has organized a new company to be known as the Colin B. Kennedy Corporation, South Bend, Ind. It is expected that a thousand people will be employed by this new organization which anticipates production of over 1000 sets per day. Mr. Kennedy will be its President.

F. J. Bullivant, who for the past several years has had extensive electrical and radio experience and has done much in the development and application of rectifiers, will have full charge of the Sales Department of the B-L Electric Manufacturing Co., St. Louis, Mo., a new company formed from The Benwood-Linze Co.

Doctor Charles C. Lauritsen, formerly Chief Engineer of the Kennedy Company, will continue in like capacity with the newly formed company in charge of the Engineering Department. For the past two years he has been engaged in research at the California Institute of Technology, where his work in connection with X-ray experimentation has been of great interest to the scientific world.

David B. Rushmore, a retired engineer of New York City and Fellow of the Institute since 1913, has been appointed by President Hoover to represent the United States at the meeting of the World Power Conference in Barcelona, Spain, this month. Mr. Rushmore has represented this country at previous meetings of the conference. The subject of complete utilization of water power will be taken up at the meeting.

John B. Klumpp, after 35 years of continuous service with the United Gas Improvement Company, has resigned from the vice-presidency of that company to become a utility consultant, with offices in Philadelphia. From 1904 to 1919 Mr. Klumpp made examinations and reported on all utility properties, both gas and electric, for the United Gas Improvement Company. He was later made Assistant General Manager, and for the past five years has been a Vice-President.

John C. Clendenin formerly associated with the Automotive Engineering Department of the General Electric Co., has accepted a position as Sales Engineer with the Ward Motor Vehicel Company, Mount Vernon, N. Y. Mr. Clendenin has spent many years in the design, manufacture and application of electrical equipment for use on battery-driven and gasoline-electric vehicles, and in his new position he will continue to serve the industry in a capacity to which he has been fitted by long experience.

Obituary

Ferdinand Voelker, Jr., a member of the Technical Staff of the Bell Telephone Laboratories, died May 12, following an operation in the Rahway General Hospital, Rahway, N. J.

Mr. Voelker was born in New York City July 11, 1902 and after four years in general High School work and three years in technical training courses in engineering arranged by the Western Electric Company, he remained with that company from February 1920 to December 1924 doing drafting and test work. Upon January 1, 1925 he joined the Bell Telephone Laboratories, Inc., where his work was that of Telephone Equipment Engineer, working on current telephone equipment development.

Mr. Voelker joined the Institute in 1927 as an Associate.

Edmund Perkins Edwards, manager of the Radio Department of the General Electric Company since its organization in 1921, died at his home in Schenectady on April 27, following an illness of nearly a year. Graduated from Rose Polytechnic Institute in 1899 with the degree of Bachelor of Science in electrical engineering, he entered the employ of the General Electric Company in the same year.

In 1906 he went with the Lighting Department, becoming Assistant Manager of the department after a time. He was active in the early commercial activities regarding radio apparatus and in 1921, when the Radio Department was organized, he became Manager of the department, in charge of commercial, engineering and manufacturing activities.

Mr. Edwards was commissioned in May, 1922, as a lieutenant-colonel in the Signal Officers' Reserve Corps, and was assigned to the war-time procurement office of the chief signal officer. He was a member of numerous engineering and technical associations, and became a member of the Institute in 1925.

Clarence G. Hadley, Superintendent of the Franklin Heating Station, Rochester, Minn., and an Associate of the Institute (1910), died the early part of May last. He was born at Mumford, New York, January 25, 1884; in 1902 he was graduated from the Friends Boarding School at Westtown, Pa., and in 1907, from Cornell University with an M. E. degree. During 1900 he worked as a telegrapher, and other summer vacations were spent in the employ of the Baltimore, Reading, and Pennsylvania Railroad and the Baltimore and Ohio Railroad Company. After finishing at Cornell, the next two and a half years were given to departmental test work for the General Electric Company. He was Assistant Foreman of the Turbine Test Department at the time of his leaving that company in 1910 to become Electrical Engineer of the Fessenden Wireless System for the National Electric Signaling Company at Brant Rock, Mass. In 1925 he removed to Rochester, Minn., where he was chosen first superintendent of the Municipal Electric Properties, later to become Manager of the Central Heating and Power Plant, designed by Ellerbe & Company, St. Paul. This plant supplied water, light, heat, and power to the Mayo Clinic in that City. In 1927 he was made Manager of the Franklin Heating Station, the position he last occupied.

William Eugene Keily, Associate 1904, died April 23, 1929, at his home in the Webster Hotel, Chicago, after an illness of only three days with angina pectoris.

For years Mr. Keily was western editor of the *Electrical World*, but had more recently been engaged in special work for Mr. Samuel Insull. He was born at Utica, New York, June 4, 1865, and after an academic education, public schools and high school at Syracuse, he became interested in journalistic work, taking his first position as Associate Editor of the *Western Electrician* March 1, 1891 and promoted to the managing editorship July 15, 1899. Throughout his entire career he was devoted to literary and consulting work connected with public utility problems and relationships. In 1908 the *Western Electrician* was sold and Mr. Keily resigned. For a short period he did free lance work, but early in 1909 he became Western Editor for the *Electrical World*, the position which he retained until 1915. Conspicuous among his editing accomplishments is his work on Mr. Insull's books, "Central Station Electric Service" and "Public Utilities in Modern Life." He held membership in the Western Society of Engineers, the American Association for the Advancement of Science, the Illuminating Engineering Society and other similar professional bodies.

Henry W. Blake, who joined the Institute as an Associate in in 1888 and was made a Member in 1913, died May 20 at his home in Englewood, N. J. A pioneer in the field of business journalism devoted to street railways, Mr. Blake, at the time of his death, was senior editor of the *Electric Railway Journal*, the editorial staff of which he joined in 1891 when it was the *Street Railway Journal*, a publication devoted to horse-car transportation; in 1894 he became its Editor-in-Chief, and when in 1908 it changed its name to the *Electric Railway Journal*, Mr. Blake assumed his new editorial duties, continuing without interruption until his death.

Born in New Haven, Connecticut, December 7, 1865, the son of Henry Taylor Blake, a noted member of the Connecticut bar, he graduated a civil engineer from Yale University in 1886, after which he studied electrical engineering at Massachusetts Institute of Technology. Following this course, he did advertising work for the Sprague Electric Railway and Motor Company, an organization engaged in the construction of electric railways in various cities throughout the United States. This is the organization which he left to joint the staff of the *Street Railway Journal*. In 1927, Mr. Blake took an extended editorial tour abroad, for the purpose of specific study of the street railway transportation systems in Europe, visiting Naples, Rome, Florence, Milan, Nice, Paris, Brussels, Berlin, Hamburg and London.

He was always active in the affairs of the American Electric Railway Association and was a regular attendant at its annual meetings. Mr. James H. McGraw, with whom Mr. Blake was continually associated during his 35 years of service on the *Electric Railway Journal*, said of him "He was a great editor. His name will go down in the history of industrial journalism with those of Col. Henry G. Prout of the Railway Gazette, W. D. Weaver of the *Electrical World*, Arthur M. Wellington of the *Engineering News*, Charles Kirkchoff of *Iron Age*, John M. Godell of *Engineering Record* and Frank Wright of *Engineering News-Record*." In addition to his membership in the American Electrical Railway Association, he was a member of the Engineers Club of New York, the Englewood Club and the Knickbocker Country Club of Tenefly. He was also an Associate member of the Union Internationale de Tramways et de Chemins de Fer d'Interet local of Brussels.

Fred C. Hamer, Electrical Engineer, Sargent & Lundy, Inc. and since 1919 an Associate of the Institute, died early in May in Chicago, his native city, where, since 1909, he has pursued his professional activities. After a two years' correspondence course in mechanical drafting, one year in the Chicago Technical College, and three years at Armour Institute of Technology, completing his course in electrical engineering, Mr. Hamer spent ten years in drafting, designing and inspection work. During 1909 he was employed by Franklin J. Cary, M. E. in machine design work, then he joined the Commonwealth Edison Company remaining two years in its Transmission and Distribution Departments, on record and drafting work. From 1912 to 1917, Mr. Hamer was with the Electrical Department of the Sanitary District of Chicago, doing work on inspection and design of line construction and substation construction, street lighting and power work. In 1918 he entered the employ of Sargent & Lundy, Inc., where his first year's work was on power plant design. As an applicant for membership in the Institute, Mr. Hamer received the hearty endorsement of all asked to give the customary personal references, both with regard to his professional ability and his own characteristics.

A. I. E. E. Section Activities

FUTURE SECTION MEETINGS

St. Louis

June 19.

Sharon

Communism, by Capt. J. Robert O'Brien. Banquet meeting. June 4.

NEW YORK SECTION ELECTS OFFICERS FOR 1929-30

At the meeting of the New York Section of April 26th the announcement of the election of officers of the New York Section for 1929-30 was made. The Executive Committee of five men will take office August 1st as follows:

Chairman:	H. P. Charlesworth, Vice-President, Bell Telephone Laboratories,
Secretary-Treasurer:	T. F. Barton, District Engineer, General Electric Co.
Executive Committee:	E. E. Dorting, Lighting Engineer, I. R,
	T. Henry Flood, Consulting Engineer. Murray & Flood,
Junior Past Chairman:	R. H. Tapscott, Electrical Engineer, New York Edison.

COMMUNICATION GROUP OF NEW YORK SECTION ORGANIZED

On Friday evening May 17, the newly formed Communication Group of the New York Section held its first meeting. Through the courtesy of the New York Telephone Company the meeting was held in the auditorium of the New York Telephone Building, 140 West St., New York at 7:30 p. m. Following a brief talk by Chairman R.H. Tapscott of the Section on the "Group Idea" and an election of temporary officers of the Communication Group to hold office until August 1, 1930, there were two papers presented as follows: "Some Telegraph Traffic Engineering Problems," by C. M. Brentlinger and I. S. Coggeshall, General Traffic Supervisors, Western Union Telegraph Company; "Handling Telephone Traffic In and Around New York City," by J. P. Andrews, General Traffic Engineer, Long Island Area, New York Telephone Company. After the presentation of the second paper the meeting was opened to general discussion.

Preceding the meeting a very excellent cafeteria supper was served for a nominal figure in the cafeteria on Floor B of the telephone Building. The large lounge room adjoining the restaurant was opened to accommodate those attending the meeting. About 200 members and guests of the Section took advantage of the supper accommodations and later on over 300 attended the meeting.

NORTH CAROLINA SECTION ORGANIZED

The formation of a North Carolina Section of the Institute was authorized by the Board of Directors on March 21, 1929. The organization meeting held in Charlotte on May 2 was attended by twenty-one petitioners. An address of welcome to the visiting members was delivered by Mr. C. O. Kuester, Secretary and Business Manager of the Charlotte Chamber of Commerce.

The following officers of the Section were elected: Chairman, E. P. Coles; Secretary and Treasurer, M. E. Lake; Executive Committee, P. H. Daggett, J. H. Paget and J. H. Roddey. Mr. Coles took charge of the meeting immediately after the election and invited the members to discuss methods by which the Section might most effectively proceed, in order to contribute a definite service to both its members and the Institute. An interesting and helpful discussion followed.

JOINT SECTION AND BRANCH MEETING AT UNIVERSITY OF IDAHO

A joint meeting of the Spokane Section and the Student Branches of the State College of Washington and the University of Idaho was held at the latter University on April 26, with an attendance of 47. Following a dinner, entertainment was supplied by the University of Idaho quartet. Brief addresses were given by Bernhard Olsen, Chairman, Spokane Section, Dean H. V. Carpenter of State College of Washington, and Professor J. H. Johnson, Counselor, University of Idaho Branch. Orland Mayer, Chairman of University of Idaho Branch, presided. The principal paper of the evening was entitled "Power Limit of Synchronous Machines and Its Influence on System Design" by Richard McKay, Assistant Electrical Engineer, Washington

Water Power Company, and N. P. Bailey, Assistant Professor of Mechanical Engineering, University of Idaho.

INSTITUTE AFFAIRS DISCUSSED BY WASHINGTON SECTION

A dinner meeting of the Washington Section held on April 24 was devoted to a discussion of various phases of the subject "Institute Affairs and Their Relation to Our Section and Community." Brief addresses were given by the following: Hon. Proctor L. Dougherty, Commissioner of the District of Columbia; Maj. W. A. Danielson, Quartermaster Corps, U. S. Army; Dr. M. G. Lloyd, Senior Electrical Engineer, Bureau of Standards; Capt. A. F. E. Horn, Local Manager, General Electric Co.; E. C. Crittenden, Chief, Electrical Division, Bureau of Standards; J. A. Ferry, Electrical Engineer, Potomac Electric Power Co.; C. A. Robinson, Chief Engineer, Chesapeake and Potomac Telephone Co.; H. H. Henline, Assistant National Secretary; Prof. J. L. Beaver, Vice-President, Middle Eastern District, A. I. E. E., and President R. F. Schuchardt.

Some of the topics particularly emphasized by various speakers were the duties of engineers as citizens, the importance of interpreting engineering to the public, benefits received by individuals from participation in Institute activities, methods by which the interest of members may be increased, and the need for cooperation in the advancement of the profession. President Schuchardt spoke briefly upon these topics and others, and mentioned his efforts during the present year to encourage the Sections to study themselves in order to determine whether they are living up to their magnificent opportunities.

CONTACTS BETWEEN ENGINEERS AND PUBLIC DISCUSSED BY LOUISVILLE SECTION

The meeting of the Louisville Section held on April 11 was devoted to a discussion of the subject "The Desirability of Developing Closer Contacts Between Engineers and the General Public." The principal papers presented were: Mr. Public and Mr. Engineer Must Meet," by Robert E. Tafel, Nachod and United States Signal Co., and "The Relation of the Electrical Engineer to the Public," by Professor D. C. Jackson, Jr., University of Louisville. A discussion of these papers was presented by George W. Hubley, Consulting and Advisory Engineer.

SECTION ACTIVITIES DISCUSSED IN SCHENECTADY

At the dinner meeting of the Schenectady Section held on April 9, 1929, the following addresses were given on the general subject "Service Through the Institute Section:"

As Viewed by a Past-President, C. C. Chesney, Vice-President, General Electric Co.

As Viewed by a Member, L. T. Robinson, General Engineering Laboratory, General Electric Co.

As Viewed by the President, R. F. Schuchardt.

E. S. Lee, Chairman, reviewed the activities of the Section during the past year.

As a direct result of the meeting, the Executive Committee of the Section is considering means by which it can take an active interest in civic affairs. The attendance was 175, and the informal nature of the meeting promoted general discussion and acquaintanceship.

JOINT SECTION AND BRANCH MEETING IN COLUMBUS

The annual joint meeting of the Columbus Section and Ohio State University Branch was held at the University on May 3. After a dinner at the Ohio Union, the present officers, a number of past officers, and other members of the Columbus Section were called upon for brief remarks. Professor F. C. Caldwell, first Chairman of the Section, and all other Past Chairmen, except one, were present.

The evening session was opened by a two-reel motion picture on electric welding. This was followed by a talk on the subject "Progress after Graduation" by R. E. Knox, a senior in electrical engineering. A. G. Gibbony of the Ohio Power Company gave a brief address. A talk, entitled "Branch Activities," was given by H. H. Henline, Assistant National Secretary. The attendance was about 45.

JOINT SECTION AND BRANCH MEETING IN SEATTLE

The annual joint meeting of the Seattle Section and the University of Washington Branch for the presentation of a student program was held on April 16. After a brief business session of the Section, over which C. R. Wallis, Chairman, presided, the meeting was turned over to C. W. Huffine, Chairman, University of Washington Branch, and the following papers were presented by students:

Energy Losses by Radiation from Domestic Hot Water Tanks, R. P. Wailes.

Voltage Amplification of the Screen Grid Tube as an Intermediate Frequency Amplifier, by Frank Giovanini, presented by Kenneth M. Durkee.

Students of the University of Washington supplied music before and after the technical program. The attendance was 150.

JOINT SECTION AND STUDENT MEETING IN URBANA

The Urbana Section, the Electrical Engineering Society of the University of Illinois, and the Student Branches of Purdue University and Rose Polytechnic Institute held a joint meeting at the University of Illinois on April 20, for a discussion of the subject "Electrical Society Activities of Undergraduate Students." The total attendance of 140 included 30 from Purdue and 18 from Rose Polytechnic Institute.

Addresses were given by representatives of the three student organizations as follows: B. D. Landes, Purdue University, H. A. Moench, Rose Polytechnic Institute, and Herbert Levy, University of Illinois. Each reported upon the principal activities of his organization. President R. F. Schuchardt emphasized the need of engineers for appreciation of other fields of activity and offered suggestions for student participation in programs. A luncheon was served after the program.

JOINT SECTION AND BRANCH MEETING IN NEBRASKA

The Nebraska Sections of the Institute and the A. S. M. E. gave a complimentary dinner to the enrolled Students of the two societies in the University of Nebraska and the University of South Dakota, in Omaha, on April 17. C. D. Robison, Chairman of the Nebraska Section, A. I. E. E., presided over the business meeting, and L. E. Shoemaker, Electrical Engineering '29, of the University of Nebraska, served as toastmaster during the program.

Professor B. B. Brackett, Counselor, University of South Dakota Branch, Dean O. J. Ferguson, University of Nebraska, Vice-President, North Central District, A. I. E. E., and E. Johnson, Chairman, University of South Dakota Branch gave brief addresses. The following papers were given by students:

Diesel Engines for Aeroplanes, C. W. Sharp, Mechanical Engineering '30, University of Nebraska.

Telephone Rates, P. F. Fink, Electrical Engineering '29, University of Nebraska.

Music was furnished at various times during the program by students of the two Universities. The attendance was 98.

JOINT SECTION AND BRANCH MEETING IN AKRON

The Akron Section and University of Akron Branch held a joint meeting on April 25. John C. Schacht, Chairman of the Papers and Meetings Committee of the Branch, presided during the presentation of the following papers by students:

Interesting Facts on Radio, H. Shively.

Our "Co-op" System, P. Bierman and L. Rang.

Development of Photoradiogram Service, T. Starr.

Westinghouse Portable Oscillograph, W. Wilson.

After the completion of the technical program, the following laboratory demonstrations were given by students: Westinghouse portable oscillograph, W. Wilson and W. Woodward; cathode ray oscillograph, E. Hartman; high-frequency apparatus in operation, P. Bierman; paralleling of alternators, G. Hite and W. Hoffman; phase advancer test, L. Rang and T. Starr.

The meeting was considered very successful. The attendance was 50, of whom about one-half were members of the Section.

PAST SECTION MEETINGS

Akron

Joint meeting with University of Akron Branch. See report in Student Activities dept. April 25.

Boston

Some Aspects of Railway Electrification, by B. S. Cooper, Westinghouse Electric & Mfg. Co. Slides. April 2. Attendance 120.

Chicago

Iron and Steel Melting in the Electric Furnace, by D. T. Waby. The following officers were elected: Chairman, T. G. LeClair; Vice-Chairman, F. H. Lane; Secretary-Treasurer, L. S. Leavitt; Executive Committee, P. B. Juhnke, W. O. Kurtz and E. H. Freeman. Joint meeting with Western Society of Engineers, Electrical Section, preceded by a dinner for the speaker and the Executive Committee. April 22. Attendance 130.

Cleveland

The Electric Eye, by P. B. Findley, Managing Editor, Bell Laboratories Record. A number of other engineering societies in Cleveland were invited to attend this meeting. April 18. Attendance 1250.

Columbus

Outdoor Lighting, by S. E. Strunk, Engg. Dept., National Lamp Works, General Electric Co. Illustrated. October 26. Attendance 22.

Electric Welding of Steel Building and Bridges, by F. P. McKibben, Consulting Engr., General Electric Co. (Illustrated). November 23. Attendance 75.

Television, by Dirk Schregardus, Transmission Engr., The Ohio Bell Telephone Co. Illustrated. January 4. Attendance 130.

Discussion of the following subjects: Continued membership in the Affiliated Technical Society of Columbus; Programs for the remainder of the year; Means for increasing membership; The Section's attitude toward membership in a general engineering society. Film, "Driving the Longest Railroad Tunnel in the Western Hemisphere." March 1. Attendance 15.

Tour of Oil Fields of Europe, by A. E. Dralle, Westinghouse Electric & Mfg. Co. Illustrated. Joint with Columbus Engineers' Club. March 29. Attendance 60.

Connecticut

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. Joint with Yale University Branch, in New Haven. April 23. Attendance 2500.

Dallas

Static and Transient Stability of Interconnected Power Systems, by P. H. Robinson. Transmission Engr., Houston Lighting & Power Co. Nominating Committee appointed. Reports received from Regional Meeting Committees. April 15. Attendance 65.

Denver

Luncheon meeting of Colorado Engineering Council handled by Denver Section. W. G. Baldry and Miss Eleanor Fish gave a demonstration of the operation of the dial telephone. April 2. Attendance 45.

Recent Developments of Electrical Research, by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Demonstrations. W. H. Bullock, Chairman, Program Committee, reported on future meetings. The meeting was preceded by a dinner. April 12. Attendance 60.

Annual College Branch Night. See report in Student Activities dept. April 26.

Detroit-Ann Arbor

Protective Relays and Their Application, by T. R. Hallman, Detroit Edison Co., and J. R. North, Stevens and Wood, Inc. Business session. A dinner preceded the meeting. April 16. Attendance 175.

Erie

Making Sound Visible and Light Audible, by J. B. Taylor, Consulting Engr., General Electric Co. April 19. Attendance 250.

Fort Wayne

Recent Developments in Aviation, by Major W. A. Bevan, Air Corps Reserve, Associate Professor of Aeronatuical Engg., Purdue University. Motion pictures before meeting and refreshments after. April 18. Attendance 100.

Houston

Power Factor—Its Improvement and Relation to Rates, by J. O. Coates, Houston Lighting & Power Co. A dinner preceded the meeting. April 24. Attendance 36.

Indianapolis-Lafayette

Operating Experiences with the A. C. Network Method of Power Distribution, by F. E. Pinckard, Union Gas & Electric Co., Cincinnati. Program followed by smoker and social time. May 3. Attendance 67.

Ithaca

The Future of This Mechanistic Age, by Ralph Flanders, General Mgr., Jones & Lamson Co., Vice-President, A. S. M. E., who spoke for E. A. Sperry. R. F. Schuchardt, President A.I.E.E., gave a talk which took the form of an inspiration to young engineers. Banquet and joint meeting with Cornell University Branch, A. S. M. E. March 15. Attendance 220.

The Present Status of Railway Electrification, by N. W. Storer, Consulting Railway Engr., Westinghouse Electric & Mfg. Co. Illustrated. April 19. Attendance 32.

Kansas City

Broader Aspects of Engineering, by E. B. Black, Consulting Engr. A very interesting discussion followed, the trend of which was that it is the duty of the engineers themselves to get a better appreciation of their profession by the public.

The High-Pressure Installation Northeast Station, by J. A. Keeth, Assistant to the Vice-President in Charge of Production, Kansas City Power & Light Co. Slides. Coffee and sandwiches served. Jount with Kansas City Section, A. S. M. E. April 29. Attendance 200.

Lehigh Valley

Electrical Applications in Automotive Plants, by W. P. Mitchell, International Motor Co. Slides.

The National Electrical Code, by A. R. Small, Vice-President, Underwriters' Laboratories. J. L. Beaver, Vice-President, Middle Eastern District, gave a brief address. The meeting, held at Allentown, was preceded by a dinner, April 19. Attendance 179.

Los Angeles

Recent Developments in Electrical Research, by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Joint meeting with local Section, A. S. M. E., preceded by a dinner. April 2. Attendance 120.

Lynn

Gaseous Discharges, by Clifton Found, Research Laboratory. General Electric Co. Demonstration of new 110-volt Neon Lamp. April 10. Attendance 125.

The Story of Steel, by G. A. Richardson, Mgr., Technical Publicity Dept., Bethlehem Steel Co. Illustrated by seven reels of moving pictures. Beverly, Mass. April 24. Attendance 175.

Madison

Some Recent Research Developments of the Westinghouse Electric & Mfg. Co., by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Demonstrations of photoelectric devices and grid-glow tube. April 16. Attendance 61.

Mexico

Dinner meeting for promoting friendly relations with the local engineering societies, representatives of four of which were present. February 12. Attendance 38.

Farewell dinner to Chairman P. M. McCullough. March 26. Attendance 18.

Nebraska

Joint meeting with A. S. M. E. Section and students. See report in Student Activities dept. April 17.

New York

Student Convention and evening meeting of Section. Complete report in Student Activities dept. April 26. Attendance 700.

Niagara Frontier

Thyratron Control, by F. E. Vogdes, Research Laboratory, General Electric Co. Slides. Demonstration apparatus. Dinner for the speaker held prior to the meeting. Joint with Engineering Society of Buffalo. February 15. Attendance 65.

What a Serious Accident Means to the Injured Man and Also to the Company, by J. C. VanVleet, Safety Engineer, Buffalo General Electric., and

200,000 K. W. Hydroelectric Development, by W. S. Murray, Murray and Flood. Illustrated with motion pictures and slides. Mr. Murray was entertained at a dinner. March 22. Attendance 110.

Pittsburgh

Inspection trip to Lake Lynn Hydroelectric Generating Station, West Penn Power Co. on the Cheat River, West Virginia. Guests of West Penn Power Co. at dinner in Uniontown, Pa. April 13. Attendance 225.

Pittsfield

High-Power Transmission and Transformers, by F. F. Brand, General Transformer Engg. Dept., General Electric Co. Speaker was entertained at dinner. March 19. Attendance 75.

Annual Dinner. Captain Irving O'Hay, U. S. Army, Retired, Humorist, Traveler and Lecturer. April 2. Attendance 222.

Researches with Natural and Artificial Lightning, by F. W. Peek, Jr., Consulting Engr., General Electric Co. Slides and moving pictures. Joint meeting with Springfield Section and Engineering Society of Western Massachusetts. Speaker was entertained at dinner. April 16. Attendance 250.

Providence

The New England Power Association's System, by C. R. Oliver, Vice-President, New England Power Association. Joint with Providence Engineering Society and Providence Section, A. S. C. E. April 23. Attendance 140.

Rochester

Hum Elimination in All-Electric Radio Receivers, by B. F. Miessner, Elec. and Acoustical Engr., Joint meeting with Rochester Engg. Society and Rochester Section, I. R. E. Dinner in honor of speaker. April 19. Attendance 71.

Annual business meeting. The following officers were elected: Chairman, V. M. Graham; Vice-Chairman, H. J. Klumb; Secretary, C. F. Estwick; Executive Committee, D. C. Jones, H. C. Ward, A. E. Soderholm and E. C. Karker. After the business meeting a joint meeting was held with the Rochester Engineering Society. Motion picture, "Hoover, Master of Engineers." May 3. Attendance 32.

St. Louis

Structural Development of the Deion Circuit Breaker up to 15,000 Volts, by R. C. Dickinson, Westinghouse Electric & Mfg. Co. Illustrated. Attendance prizes awarded to S. V. Hornbeck and H. O. Deutscher. Amendments to Section By-laws adopted. The following officers were elected: Chairman, G. H. Quermann; Vice-Chairman, C. B. Fall; Secretary-Treasurer, O. J. Rotty. April 17. Attendance 83.

San Francisco

Recent Research Development of the Westinghouse Electric & Mfg. Company, by C. E. Skinner, Asst. Director of Engg. of that company. Display of various materials and demonstration of super-sensitive vacuum tubes. Dinner preceded the meeting. March 29. Attendance 130.

Annual joint meeting with neighboring Branches. See report in Student Activities dept. April 10.

Schenectady

Aviation, by W. P. McCracken, Jr., Asst. Secretary of Commerce for Aeronautics. March 22. Attendance 200.

Seattle

Joint meeting with University of Washington Branch. See report in Student Activities dept. April 16.

Sharon

Long Distance Toll Cable Transmission, by J. A. Cadwallader, Engineer of Transmission and Outside Plant, Bell Telephone Co. of Pa. Moving pictures. Demonstration of effect of speech and music of the suppression of various frequency bands. April 2. Attendance 76.

Syracuse

Assessment Records in Rochester, by H. C. Bratt, Rochester Bureau of Municipal Research. March 11. Attendance 63.

Toledo

Circuit Breakers, by Mr. Edsel, Condit Mfg. Co. Slides. Two reels of motion pictures on the construction of transformers, turbines, blast furnace blowers, etc. One reel on the assembly and testing of electric locomotives for the St. Gothard Railway Co., Switzerland. April 12. Attendance 35.

Toronto

Building of the Leaside Transformer Station, by G. E. Kewin. Slides. C. F. Publow spoke on the theoretical considerations involved in the design of this station. April 12. Attendance 116.

Joint meeting with Hamilton Section, Engineering Institute of Canada. J. V. Breisky, Westinghouse Electric & Mfg. Co., demonstrated photo-electric glow discharge devices and their applications to industry. Slides. Persons coming into the hall were counted automatically as they interrupted a beam of light across the entrance. April 26. Attendance 560.

Urbana

Joint meeting with student groups. See report in Student Activities dept. April 20.

Utah

Electrical Transmission of Speech and Music, by H. W. Oddie, Utah Transmission and Protection Engr., The Mountain States Telephone and Telegraph Co. Slides. April 15. Attendance 75.

Annual student program. See report in Student Activities dept. May 13.

Vancouver

Aeroplane Design, by Prof. Vernon, University of British Columbia. Members of Engineering Institute of Canada and Aeronautical organizations in the city invited. April 10. Attendance 78.

Contract Law, by R. W. Ginn, Barrister & Solicitor, Vancouver. Engineering Institute of Canada members invited. May 7. Attendance 16.

Washington

Some New Industrial Economics, by Dean D. S. Kimball, College of Engineering, Cornell University. Talk followed by social hour and light refreshments. Preceding the meeting a dinner was served in honor of the speaker. Apirl 9. Attendance 79.

Worcester

Physical Principles Involved in Television, by Dr. J. O. Perrine, American Tel. & Tel. Co. February 13. Attendance 350.

Research in Engineering, by T. W. Spooner, Asst. Mgr., Research Dept., Westinghouse Electric & Mfg. Co. March 8. Attendance 100.

Edison and His Inventions, by W. J. Hammer, Consulting Electrical Engineer. April 15. Attendance 100.

A. I. E. E. Student Activities

FOURTH STUDENT BRANCH CONVENTION, NORTH EASTERN DISTRICT, A. I. E. E.

The fourth annual Student Branch Convention of the North Eastern District of the A. I. E. E. was held at Rensselaer Polytechnic Institute, Troy, N. Y., on Friday and Saturday, May 10-11, 1929.

The total registration of 262 included 86 students and 11 professors from Rensselaer, 146 students and 13 professors from other institutions in the district, as well as representatives of the different Sections of District No. 1.

The schools represented were Clarkson College of Technology, Cornell University, Harvard Engineering School, University of Maine, Massachusetts Institute of Technology, University of New Hampshire, Northeastern University, Rensselaer Polytechnic Institute, Rhode Island State University, University of Vermont, Worcester Polytechnic Institute, Syracuse University and Yale University.

The Friday morning session, presided over by S. E. Benson of Rensselaer, was opened with an address of welcome by President Palmer C. Ricketts of Rensselaer. The session was given over to a discussion of Branch activities during the past year. About 200 attended this session.

At 11:30 a. m. the District Executive Committee met, and, among other subjects, discussed plans for the 1930 Regional Meeting at Springfield, Mass.

At 12:30 p. m. the Luncheon Conference of incoming Branch Chairmen and Branch Counselors was held at the Hendrick Hudson Hotel. The Counselors and Chairmen were joined at luncheon by the members of the District Executive Committee.

The Friday afternoon session, presided over by R. M. Durrett of M. I. T., was devoted to the presentation and discussion of eight technical papers. The authors of these papers were J. L. Daley and A. F. Metzger of Yale, M. M. Hubbard of M. I. T., L. B. Hochgraf of Rensselaer, T. A. Rich of Harvard, H. E. Furman and T. S. Bills of Cornell, E. W. Jones of Maine, E. R. Gardner and A. A. Jones of M. I. T., and A. H. Coon of Rhode Island State. The papers were ably presented and discussed. About 300 attended this session.

The Convention Banquet given by Rensselaer Polytechnic Institute without charge to guests was held on Friday evening. Music was furnished by the Student Quartette and by the Campus Serenaders. Doctor W. L. Robb, Head of the Electrical Engineering Department, made a few opening remarks and introduced Mr. A. C. Stevens, the District Secretary, who presented the Branch Paper Prize to Mr. S. R. Knapp and Mr. J. R. Burnett of Cornell, and announced as winners of the First Paper and Best Paper Prizes, Professor H. H. Race of Cornell and Mr. C. F. Estwick of the Rochester Section. Doctor Robb also introduced Doctor W. R. Whitney, Director of the Research Laboratory of the General Electric Company, who gave a very interesting talk on the value of having a hobby.

On Saturday, inspection trips arranged by the Schenectady Section were made. The Schenectady Works of the General Electric Company were visited in the morning, after which a complimentary luncheon given through the courtesy of the General Electric Company, was enjoyed at the Schenectady Y. M. C. A. After luncheon the party inspected the Erie Barge Canal lock at Cranesville and the Amsterdam Steam Plant of the New York Power & Light Corporation.

NEW YORK SECTION STUDENT BRANCH CONVENTION AND SECTION MEETING

On Friday April 26th the New York Section held its fourth Annual Student Branch Convention and also the monthly Section meeting. All details of the Student activities were arranged by committees appointed by the students themselves, and were all under the direction of a general student convention committee. For the morning April 26, five inspection trips were scheduled by and for the students only as follows: Bell Telephone Laboratories; American Telephone and Telegraph Company; Brooklyn Navy Yard; Lackawanna Railroad Company; and Brooklyn Edison Company.

The afternoon session, starting at 2 p. m. in the Engineering Auditorium, was devoted to the competition for the New York Section Student Prize of $25.00 in gold. George A. Taylor was presiding officer and chairman of the Student Convention Committee. Each of the seven students representing seven colleges was limited to exactly 15 minutes for presentation. The following list gives speakers and their subjects:

Interconnection of Power Systems, by C. M. Stuehler of Newark College of Engineering;

Frequency Stabilization, by L. O. Foernsler of Cooper Union;

Trends in Systems of Railroad Electrification, by H. M. Hobson of Rutgers;

The Condenser Motor, by I. Galante, College of City of New York;

Sound Recording, by A. W. Schneider, New York University;

An Ultra-Violet Photometer, by J. G. Trump, Polytechnic Institute of Brooklyn;

Some Aspects of Machine Switching, by E. J. Moore, Stevens Institute.

All presentations, given largely without reference to the written text, were extremely well done so that the judges Messrs. A. H. Kehoe, L. W. Morrow and R. R. Kime found it difficult to select a winner, but J. G. Trump of the Polytechnic Institute was ultimately chosen. This award is the fourth made successively to a student of the Polytechnic.

In addition to the student presentations, Chairman Tapscott of the New York Section made an address of welcome in opening the session and after the presentation of the fourth paper there was an intermission during which a movie comedy was presented. A student dinner was held at the Fraternity Club at 6 p. m., Farley Osgood, Past-President of the Institute giving a short after-dinner talk to the students on the problems faced upon graduation. Some 350 students attended the afternoon session and the dinner.

The regular New York Section monthly meeting was held at 8:15 p. m. in the Engineering Auditorium, the speaker of the evening being Colonel Hugh L. Cooper, consulting engineer of New York, who gave an address on "Russia." Colonel Cooper has been engaged in extensive hydroelectric developments in Russia and has traveled widely within its borders. He has made a practise of studying the situation in Russia thoroughly from all angles and has interviewed Russians of every type and class. His address very graphically presented, was of great interest and was followed by a long period of discussion with Colonel Cooper answering many queries.

Preceding the talk on Russia the announcement of the election of officers of the Section for 1929-30 was made. Amendments to the Section By-laws providing for the Group Activities were passed. Presentation of the prize to the winner of the Student Branch competition was also made. Attendance totalled about 350.

STUDENT ACTIVITIES AT DALLAS REGIONAL MEETING

In making plans for the Regional Meeting of the South West District held in Dallas, Texas, May 7-9, 1929, the committees in charge gave special attention to the student activities. A program of special interest to Section and Branch representatives was arranged for the second session of the meeting Tuesday afternoon and a student session was held on Wednesday morning.

All of the 177 students attending the regional meeting, most of whom were from outside of Dallas, showed great interest in various sessions in addition to those at which student programs were presented as indicated below.

TUESDAY AFTERNOON

Remarks, R. F. Schuchardt, President, A. I. E. E.

Substation Design, T. E. Peter, Chairman, University of Arkansas Branch.

Piezo-Electric Crystal-Controlled Oscillators, LeRoy Moffett, Jr., Secretary, University of Oklahoma Branch.

Frequency Stability of Split-Anode Magnetron Oscillators, Norvel Douglas, Chairman, University of Kansas Branch.

Solution of Electrical Networks by the Use of a General Network Theorem, L. E. Brown, University of Texas.

The Effect of Terminating Impedances on the Characteristics of Filters, Harold J. Miller, Chairman, Washington University Branch.

WEDNESDAY MORNING

Opening Remarks, B. D. Hull, Vice-President, South West District, A. I. E. E.

Student Activities, H. H. Henline, Assistant National Secretary, A. I. E. E.

General Discussion of Student Activities.

A Method of Investigating Surface Iron Losses, R. A. Foltz and H. E. Gove, University of Missouri.

Positive Directions as Applied to Electric and Electro-Magnetic Circuits, G. W. Beams and E. L. Andrews, Texas A. & M. College.

Performance of Standard Transformers Connected as Auto-Transformers, J. J. Loving and C. R. Redden, Texas A. & M. College.

Supervision of Gas, Electric and Water Meters in Texas, W. T. Henrichson, University of Texas.

A Universal Deficiency-Compensating Amplifier, J. E. Peek, Oklahoma A. & M. College.

A Graphical Solution of Networks, E. G. Downie, Kansas State Agricultural College.

A handsome cup had been provided for award to the Branch represented by the student who presented the best technical paper. At the close of the Wednesday morning session, the decision of the judges was announced by President Schuchardt, who presented the cup to the University of Oklahoma Branch, for the paper delivered by its Secretary, LeRoy Moffett, Jr., entitled "Piezo-Electric Crystal-Controlled Oscillators."

THURSDAY LUNCHEON

At a luncheon Conference of Counselors and officers of the Institute, held on Thursday, Dean George C. Shaad of the University of Kansas was re-elected Chairman of the District Committee on Student Activities.

Various problems encountered in the conduct of Branch work were discussed and each of the nine Counselors present gave brief statements regarding the principal activities of his Branch. Ways and means of increasing interest in Branch meetings were mentioned, and considerable emphasis was placed upon the desirability of having nearly all of the papers presented by students. The value of occasional moving picture films, debates, smokers and dinners was recognized.

ANNUAL COLLEGE BRANCH NIGHT OF DENVER SECTION

The annual meeting of the Denver Section with students of the neighboring schools was held on April 26 with a total attendance of 90. The meeting was preceded by a dinner, at which 36 students from the University of Colorado, University of Denver, and Colorado School of Mines were guests of the Section. The following papers were presented by students:

Some Factors Affecting the Power Limits of Transmission Systems, W. A. Merriam, University of Colorado.

Uses of Electricity in Metallurgy with Special Reference to the Production of Electrolytic Iron, James Ogilvie, Colorado School of Mines.

Variation of the Pole Strength of a Permanent Magnet as Dependent upon Its Weight, F. A. St. John, University of Denver.

Dean O. J. Ferguson, Vice-President of the North Central District, gave a brief address on the obligation of individuals to the electrical industry.

ANNUAL STUDENT MEETING OF SAN FRANCISCO SECTION

The annual joint meeting of the San Francisco Section and the Student Branches at the University of California, University of Santa Clara, and Stanford University was held at the Engineers Club in San Francisco on April 10, with an attendance of 165, and was preceded by an informal dinner attended by about 90 members and visitors.

The following program was presented by students:

Design Equations for Vacuum Tube Voltmeters, Harry R. Lubcke, University of California.

Voltage Surges in Audio Frequency Apparatus, Elmer H. Fisher, Stanford University.

Characteristics of Electrostatic Loud Speakers, F. J. Somers, University of Santa Clara.

Entertainment was supplied by University of Santa Clara students.

The papers showed a great deal of thought and study and were presented in an interesting manner. On account of the nature of the subjects discussed, members of the San Francisco Section of the Institute of Radio Engineers were invited, and about 20 were present.

These joint meetings have proven very popular and have served to bring the students into contact with the older men of the profession.

ANNUAL STUDENT MEETING OF UTAH SECTION

The annual joint meeting of the Utah Section and the University of Utah Branch for the presentation of student papers was held at the Newhouse Hotel in Salt Lake City on May 13, with an attendance of 45.

The following papers based upon thesis work done by the students were presented:

Voltage Distribution on High-Tension Insulators, Floyd Gowan and Ned Chapman.

Impedance Curves of Some Loud Speaker Units, D. W. Hatfield and C. M. Bisbee.

The Location of Inductive Interference and Its Elimination by a Network, Jay R. Wrathall and Andrew Watt.

The papers were well presented and interesting discussions followed.

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

Business Meeting. Election of Officers. April 18. Attendance 28.

T. C. I. Plant in Birmingham, by N. W. Geist, '29, and *The Empire Coal Mine*, by C. D. Bradley, '29. Impromtu talks by J. R. Alexander, W. T. Edwards, and W. R. Coleman, students. April 25. Attendance 32.

Following talks by students: *Automatic Telephone Equipment*, by W. T. Edwards; *What Price Television*, by Paul Brake; *Squeezing Gas Out of Iron and Steel*, by R. A. Mann; *What the A. I. E. E. Means to Me*, by J. R. Alexander; *Boyhood Experiments*, by P. C. Avant; *Microphone Adjustments*, by A. C. Cohen; and *Methods of Cooling Transformers*, by W. F. Nabers. May 2. Attendance 23.

University of Arkansas

Wave Traps and Band Pass Filters in Radio Circuits, by James Boswell, student. March 21. Attendance 15.

Brooklyn Polytechnic Institute

Four papers presented in competition, the winning paper to be presented at New York Section Student Convention: *Regenerative Crystals*, by A. W. Nagy; *Traffic Signals*, by

Thomas Detwiler; *Accelerometers*, by George Logan, and *Talking Pictures*, by John Trump. J. Trump declared winner of contest. Refreshments served. March 8. Attendance 48.

Oscillographs, by C. A. Mead, Westinghouse Electric & Mfg. Co., Newark. Refreshments served. April 19. Attendance 41.

California Institute of Technology

New and Interesting Phases of Electrical Engineering, by Dean P. S. Biegler, University of Southern California. May 2. Attendance 20.

University of California

The General Electric Test Course, by Prof. T. C. McFarland, Counselor. Slides. C. W. Mors, student, gave an explanation and demonstration of his newly devised radio circuit. John A. Reynolds, A. S. U. C. President-elect, gave a brief review of his plans. Election of officers. April 17. Attendance 22.

Carnegie Institute of Technology

The Recording and Reproduction of Sound in Connection with Motion Pictures, by Harry Greenman, student. J. R. Britton, Chairman-elect, presented a report upon the Regional Meeting in Cincinnati. Short social meeting. April 10. Attendance 32.

Case School of Applied Science

Senior Farewell Dinner, followed by theater party. Branch business turned over to the newly elected officers. May 1. Attendance 38.

University of Cincinnati

Atomic Hydrogen Welding, with demonstration, by J. E. Middleton, '29. Election of officers. April 4. Attendance 53.

Clarkson College of Technology

Inspection trip to Massena Works of the Aluminum Company of America. April 17. Attendance 32.

Papers presented by students as follows: *The Art of Arc Welding*, by C. F. Vaughn; *The Economics of Arc Welding*, by W. F. Cooney; *Aeronautical Instruments*, by K. T. Henry; and *Development of Aviation*, by H. J. Sullivan. April 20. Attendance 26.

Annual election of officers. April 25. Attendance 57.

Following papers presented by students: *The Progress of Railway Electrification*, by G. W. Aucock; *The Theoretical and Field Study of Lightning Discharges*, by F. A. Grant; and *The Manufacturing of Ice Cream*, and *Other Ammonia Freezing Installations*, by J. M. Kimball. April 27. Attendance 22.

Colorado Agricultural College

The Photoelectric Effect, by Dr. F. L. Poole, Associate Professor of Electrical Engineering. January 14. Attendance 13.

Three-reel motion picture showing construction and manufacture of insulated wire. April 15. Attendance 12.

University of Colorado

Manufacture and Calibration of Electrical Measuring Instruments, by A. S. Corby, Jr., Weston Electrical Instrument Corp. Slides. Refreshments. April 24. Attendance 30.

Cooper Union

Frequency Stabilization, with demonstrations, by Louis Fernsla. April 10. Attendance 10.

University of Denver

Demonstration given by representatives of the General Electric Company of some experiments on the relation between life and cost of an electric lamp, and magnetic braking and motor control. March 29. Attendance 105.

Motion pictures, entitled "Street Lighting" and "Driving the Longest Railroad Tunnel in the Western Hemisphere." April 12. Attendance 76.

Business Meeting. April 24. Attendance 15.

Business Meeting. Following officers were elected for next year: President, L. J. Wright; Vice-President, H. H. Ward; Secretary, R. B. Convery; Corresponding Secretary, G. W. Bindschadler. May 1. Attendance 11.

University of Detroit

Uses of Psychology in Factory Maintenance, by E. E. Walerych, Elec. Engr. and Supt. of Maintenance, Plymouth Plant, Chrysler Corporation. Film: "Description and Operation of the Radio Beacon in Aviation." April 18. Attendance 35.

Duke University

Mathematical Short-Cuts, by S. G. Lindsay, Jr., '30, and

Radio Application to Railroad Signal Systems, by C. W. Berglund, Jr., '29. April 19. Attendance 19.

University of Florida

Business Meeting. Following officers were elected: Chairman, J. W. McKay; Vice-chairman, L. R. Bassett; Secretary-Treasurer, A. L. Webb. April 29. Attendance 15.

Georgia School of Technology

Inspection trip to the Atlantic Steel Mills, Atlanta. April 10. Attendance 45.

University of Idaho

Talks on their work during past summer by the following students: H. Hattrup, Bell Telephone Co.; Fred Dicus, Clearwater Timber Co.; Orland Mayer, Washington Water Power Co.; and Bob Olin, Clearwater Timber Co. March 13. Attendance 30.

Forests, by L. D. Schmitz, '29, and

Steinmetz, by J. L. Thomason, '29. F. E. Dicus, Jr., elected Secretary-Treasurer. Dinner meeting. March 20. Attendance 32.

Iowa State College

Business Meeting. The following officers were elected: President, H. H. Stahl; Vice-President, Phil Pryor; Secretary-Treasurer, H. Kirk. April 24. Attendance 24.

Kansas State College

Current Events in Engineering World, by A. R. Wecke, Jr., student, and

Design of Long Distance Telephone Circuits to Provide Satisfactory Transmission, by A. B. Covey, Transmission and Protection Engr., Southwestern Bell Tel. Co., and Secretary, Kansas City Section. Election of officers. April 4. Attendance 138.

University of Kansas

Westinghouse Student Course, by Mr. Randel;

Dates of Important Discoveries and Developments in the Electrical Field, by Mr. Leonard, and

The Modern Radio Receiver, by Mr. Baxter. Entertainment. April 11. Attendance 58.

Business Meeting. The following officers were elected for next year: Chairman, M. W. Hammond; Vice-Chairman, O. N. Magers; Secretary, H. W. Yenzer; Treasurer, Wayne Powell; Senior Representative, Leslie Flory; Junior Representative, G. E. Berg. April 25. Attendance 80.

Lehigh University

Recent Developments in the Electric Utility Systems, by Raymond Bailey, Asst. Elec. Engr., Philadelphia Electric Co. and Secretary, Middle Eastern District, A. I. E. E. Illustrated.

Summer Experiences, by R. S. Taylor, '29. A prize of $10.00 was awarded to L. K. Sowers for the best student paper of the year. The following newly-elected officers were in charge of the meeting: President, B. O. Steinert; Vice-President, R. A. Baker; Secretary, J. E. Zeaser; Treasurer, P. A. Bahr. May 2. Attendance 58.

Lewis Institute

Four motion pictures: "Building New York's Newest Subway," "Driving the Longest Railroad Tunnel in the Western Hemisphere," "Dynamite, the Modern Ditch Digger," and "Letting Dynamite Do It." May 8. Attendance 100.

Louisiana State University

Motion picture—"The Story of Dynamite." March 21. Attendance 22.

Motion pictures—"Driving the Longest Railroad Tunnel in the Western Hemisphere" and "Building New York's Newest Subway." April 1. Attendance 26.

Massachusetts Institute of Technology

An Outline of the Development of Electric Illumination, by C. A. Turner, '29, and

Lighting in Industry, by M. M. Hubbard, '29. March 22. Attendance 15.

Inspection trip to Edgar Station of the Edison Electric Illuminating Company of Boston. March 28. Attendance 50.

An Introductory Discussion of the Gasoline-Electric Drive, by A. A. Jones, student, and

Application of the Gasoline-Electric Drive to Pleasure Vehicles, by E. R. Gardner, student. Luncheon meeting. May 1. Attendance 76.

University of Maine

Lightning Disturbances on Transmision Lines, by E. W. Jones, '28. Following officers elected: President, A. E. Crockett; Vice-President, E. P. Bailey; Secretary-Treasurer, H. R. Mayers. April 18. Attendance 38.

Montana State College

Direct Scanning in Television, by Frank Gray, from Bell Laboratories Record, March, 1929. Presented by Frithiof Johnson, student.

Some Developments in the Electrical Industry During 1928, by John Liston, from *General Electric Review*, January 1929. Presented by Vincent Morgan, student.

Talking Movies by the Density Method, by Donald MacKenzie, from the *Bell System Technical Journal*, January 1929. Presented by Joseph Hurst, student. April 11. Attendance 50.

High-Voltage Mercury Arc Rectifiers, by L. Smede, from *Electric Journal*, August 1928. Presented by Homer Morton, student.

Advances in Industrial Lighting Practise, by A. D. Bell, from A. I. E. E. JOURNAL, April 1929. Presented by Earle Rudberg, student. Three-reel film—"Electric Arc Welding." April 25. Attendance 61.

Smoke Precipitator, by E. T. Braden, student;

Rural Power Electrification in Gallatin Country, by Foster Buck, student, and

Electric Thermometers for the Stars, by H. N. Russell, from the Scientific American, May 1929. Presented by Harrell Renn, student. May 2. Attendance 68.

University of Nebraska

Experiences in Summer Employment, by H. E. Cook and Otto Saar, students. Plans for "Engineers Week" were discussed. Film—"Largest Single Unit Electric Locomotive," April 24. Attendance 35.

Newark College of Engineering

Evolution of the Elevator, by S. C. Lawson, Sales Engr., Otis Elevator Co., and G. K. Stackpole, of the same company. April 15. Attendance 24.

Electrolysis, by L. Hompesch, New Jersey Bell Telephone Co. May 6. Attendance 25.

University of New Hampshire

Transient Disturbances on Transmission Lines, by T. Elliott, student, and

District Representative Plan in the Black Valley, by G. Sumner, student. October 13. Attendance 26.

Two motion pictures—"Telephone Current" and "Artificial Respiration." Following officers elected: Chairman, Philip Nudd; Secretary, Danforth Coogins. April 6. Attendance 32.

Following talks by students: "Turbine-Electric Drive for Ship Propulsion," by R. G. Ballard; "Aircraft Compass Problems," by W. S. Bartlett; and "Construction of the Vacuum Tube," by A. W. Boyles. April 13. Attendance 30.

Following talks by students: "Electrical Progress in Japan," by J. K. Clark; "The Deion Circuit Breaker," by J. J. Donnelly; and "Measurement of Reactance with the Wheatstone Bridge," by N. J. Pierce. April 20. Attendance 30.

Raising the Load Factor, by H. Duquette, student, and

Tests on Glazed Insulators, by B. C. Files, student. As a means of increasing the interest in the meetings of the Branch, two or three students are called upon each week to speak extemporaneously on topics assigned by the Chairman. This feature is in addition to the regular program. April 27. Attendance 28.

College of the City of New York

Motion picture—"Modern Manufacturing with a 'Stable-Arc' Welder." May 9. Attendance 37.

North Carolina State College

The following officers were elected: Chairman, H. W. Horney; Vice-Chairman, D. E. Jones; Secretary-Treasurer, E. R. Price; Member of Engineering Council, W. W. Weltmer; Reporter, T. S. Ellington. April 16. Attendance 18.

Business meeting. May 7. Attendance 8.

University of North Carolina

The following program was given by students: *The History of the Telephone*, by H. J. Hines, Jr.; *Professional Relations of the Electrical Engineer*, by W. B. Massenburg; and *The Development of the Electric Railway*, by J. W. Holt, Jr. April 18. Attendance 32.

Lightning Effects on Transmission, by Wayne Burch, Carolina Power & Light Co., and

Effects of Transmission Lines on Long Distance Telephone Lines, by Mr. Jenkins, of the same company. Following the regular meeting, a smoker was held. May 2. Attendance 32.

University of North Dakota

Still film—"Mercury Arc Rectifier." The following officers were elected: Chairman, R. W. Olson; Vice-Chairman, J. S. McKechnie; Secretary-Treasurer, G. E. Glass. May 2. Attendance 21.

Northeastern University

The Development of Television, by J. W. Horton, Chief Engr., General Radio Co. Slides. April 23. Attendance 50.

University of Notre Dame

Indiana-Michigan Electric Company Lines, by H. J. Kiely and E. P. Kreimer, Indiana-Michigan Electric Co. Election of officers. Refreshments served. April 29. Attendance 60.

Ohio Northern University

Business Meeting. February 28. Attendance 21.

Modern Electric Equipment in R. R. Systems, by Robert Davis, student. March 21. Attendance 22.

Prof. I. S. Campbell, Counselor, emphasized several of the many advantages in membership in the A. I. E. E. President McGahan reported upon the Regional Meeting in Cincinnati. April 18. Attendance 16.

Electrical Equipment Used in Salt Mining, by A. Schifino, student, and

Oil Circuit Breakers, by H. R. Garn, student. May 2. Attendance 21.

Ohio University

Business meeting. October 31.

Inspection trip to the electrically operated coal mine of the Boston Coal Company, Millfield, Ohio. February 13. Attendance 12.

Three-reel film—"Arc-Welding." April 18. Attendance 28.

Motion picture—"Driving the Longest Railroad Tunnel in the Western Hemisphere." April 25. Attendance 25.

Oklahoma A. & M. College

Business session. Four-reel picture "Fifty Years of Telephone Progress." April 25. Attendance 30.

Oregon State College

Electrical Measuring Instruments, by A. S. Corby, Jr., Educational Department, Weston Electrical Instrument Corp. April 5. Attendance 52.

Chairman Mize gave a report on the Conference on summer employment which he attended in Portland. Prof. F. O. McMillan, Counselor, gave a resume of the accomplishments of the conference. April 22. Attendance 21.

Prof. F. O. McMillan, Counselor, announced that the prize for the best student paper in the North West District had been won by Paul Kley and Audrey Shirley for their paper entitled "The Determination of Voltage Ratio of Audio Frequency Transformers by Means of the Cathode Ray Oscillograph." May 1. Attendance 22. The following officers were elected on May 6: Chairman, B. G. Griffith; Vice-Chairman, R. B. Haight; Secretary-Treasurer, D. C. Gillanders.

University of Pennsylvania

Following officers elected: Chairman, R. R. Creighton; Vice-Chairman, F. C. Iglehart; Secretary, Newbern Smith; Treasurer, J. S. Moore, Jr. March 18. Attendance 27.

University of Pittsburgh

One-reel picture—"Water Power." March 22. Attendance 42.

Japanese Power Development, by S. Q. Hayes, General Engr., Westinghouse Electric & Mfg. Co. April 5. Attendance 56.

Work with the Wagner Electric Corporation, by J. O. Pattillo, '26. Chairman J. B. Luck gave a report on the Student Activites Session at the Cincinnati Regional Meeting. April 12. Attendance 63.

Processes and Equipment Used in Obtaining Copper Electrolytically from the Low Grade Ore of a Mine in Chile, by G. W. Goebel, Superintendent, Inspection & Testing Depts., Westinghouse Elec. & Mfg. Co. April 19. Attendance 66.

Business session. Motion picture "The History of Transportation." May 3. Attendance 67.

Princeton University

Deion Circuit Breaker, by W. K. Murray, student. April 10. Attendance 8.

Purdue University

Relativity, by C. S. Roys, Instructor in Elec. Engg. Business session. March 2. Attendance 20.

The Dynamic Speaker, by W. H. C. Higgins, III, student. Election of officers. April 16. Attendance 45.

Rensselaer Polytechnic Institute

The Use of Series Capacitors in Transmission Lines, by T. A. E. Belt, General Electric Co. Complete demonstration given. March 12. Attendance 150.

Television, by R. A. Deller, Bell Telephone Laboratories, Inc. Motion pictures and apparatus. Election of officers. April 9. Attendance 402.

Rhode Island State College

Development of Power in New England, by T. H. Lloyd, student, and

Early Power Plants, by Edward Kenyon, student. December 19. Attendance 13.

Developments of 1928, by F. E. Caulfield, student. April 12. Attendance 14.

Inspection trip to Narragansett Electric Power Station at Providence, Dyer Street Substation, and the Industrial Trust Building. April 19. Attendance 14.

Hydrogen-Filled Synchronous Condenser, by F. E. Caulfield, student;

Condenser Motor, by A. H. Coon and Arnold Judkins, students, and

Radio Spectrum, by A. Z. Smith, student. April 26. Attendance 16.

Prof. William Anderson, Counselor, announced plans for the Student Convention at Troy. Election of officers. May 3. Attendance 18.

Rutgers University

The Rocky River Hydro Development, by President J. Cost, and

The Development of the Mercury Arc, by Prof. P. S. Creager, Counselor. March 26. Attendance 24.

Sound Recording with Light Valve, by E. Wilson, '29, and

Transmission Troubles in California Power Lines, by T. Stauber, '30. April 19. Attendance 18.

The Graphical Solution of A-C. Transmission Problems, by Mr. Wolf, '29, and

The Electrolytic Zinc Plant of the Sullivan Mining Company, by L. Gorka, '30. April 16. Attendance 20.

University of Santa Clara

Inspection trip to the Hetch-Hetchy Power and Water Project. Joint function of the Branch and the University of Santa Clara Engineering Society. April 13-15. Attendance 29.

Inspection trip to the General Electric Company's Radio Broadcasting Station KGO and to the General Electric Company's lamp factory, Oakland, California. April 17. Attendance 23.

Inspection trip to Station "C", Pacific Gas & Electric Co., Oakland. May 1. Attendance 24.

Business Meeting. Following officers elected: Chairman, T. L. Selna; Vice-Chairman, G. W. Vukota; Secretary, J. D. Gillis. May 5. Attendance 27.

South Dakota State School of Mines

Electrical Measuring Devices, by A. S. Corby, Weston Electrical Instrument Corp. April 29. Attendance 41.

Film—"The Single Ridge." April 11. Attendance 20.

University of South Dakota

Business Meeting. April 29. Attendance 14.

University of Southern California

Development of the Electric Power Industry in Los Angeles, by E. R. Northmore, Supt. of Electric Distribution, Los Angeles Gas & Electric Corp., and Vice-President, Pacific District, A. I. E. E. April 11. Attendance 60.

The Reconstruction of Power Plant No. 2 on the Los Angeles Aqueduct. C. M. Allen, Construction Engr., Dept. of Water and Power, City of Los Angeles. April 25. Attendance 110.

Stanford University

A Harmonic Generator, by E. H. Fisher, graduate student, and

Methods of Training an Engineer in England, by R. H. Angus (Yorks. England), graduate student. April 3. Attendance 23.

C. H. Delaney, Pacific Gas and Electric Co., spoke on Station C, the new steam plant of that company in Oakland. April 22. Attendance 23.

Inspection trip to Station C. April 27. Attendance 17.

Stevens Institute of Technology

The Economics of Locomotive Assignment, by W. Titus, student. Two-reel film to illustrate. Smoker of Stevens Engineering Society. Refreshments were served. April 24. Attendance 40.

Syracuse University

Calculation of Forces on Automatic Circuit Breakers, by Mr. Allen, student, and

Electrification of a Steel Mill, by Mr. Casavant. W. B. McCann, Chairman of the Syracuse Section, discussed the papers. The relationship between the Section and the Branch was discussed. Following the meeting, a luncheon was given in honor of Mr. McCann. February 28. Attendance 22.

Following talks by students: "Spacing of Poles on a Transmission Line," by Mr. Noxon;

Trolley Pole Design, by Mr. Martin. April 11. Attendance 21.

Selection of a Transformer, by Mr. Zogby, student, and

Electrification of a Rolling Mill, by Mr. Warntz, student. April 25. Attendance 21.

University of Tennessee

Film—"The Single Ridge." February 15. Attendance 21.

Texas A. & M. College

Calculation of Inductance of Overhead Wires, by O. M. Somers, student, and

General Transmission Line Equations for Steady State Conditions, by M. E. Horn, student. Pictures—"Power Transmission" and "The Induction Voltage Regulator." March 1. Attendance 27.

Neon Gas-Tube Lamp, by I. W. Corhart, student, and

Speed of Vision, by W. D. Neff, student. Pictures—"Making Mazda Lamps," "Light of a Race," "Liquid Air" and "Nature's Frozen Credits." March 15. Attendance 48.

Television, by E. F. Shawver and W. C. Rowland, students;

Ray-Photo, by A. D. Martin, student, and

The A. T. & T. System of Picture Transmission, by C. S. Robertson, student. Film—"Wizardy of Wireless." April 5. Attendance 41.

Radio-Activity, by C. C. Neighbors, student;

Electrical Units, by S. L. Moseley, student, and

Crystals and Piezo-Oscillators, by C. W. Jackson, student. Film "The Single Ridge." Election of officers. April 12. Attendance 50.

University of Texas

Television, by J. O. Perrine, American American Tel. & Tel. Co. March 21. Attendance 220.

Power Line Maintenance, by J. B. Robuck, student, and

Electric Refrigeration, by Chairman L. R. Bagwell. Plans for the coming Power Show discussed. April 11. Attendance 23.

University of Vermont

Lecture on and demonstration of a new oscillograph by Prof. L. P. Dickinson, Counselor. April 10. Attendance 21.

Radio Control of Trains, by L. M. Donahue, '30. Discussion of plans for the Student Convention in Troy. April 24. Attendance 13.

Virginia Polytechnic Institute

Modern Distributing Equipment, by F. C. Graves, Line Material Co. April 17. Attendance 17.

University of Virginia

Effect of Glazing on Insulators, by P. S. Beach, student, and *Airplane Compasses*, by H. R. Holt, student. Four reels on the construction and operation of electrical instruments. Refreshments. April 8. Attendance 35.

Washington University

Business meeting. April 13. Attendance 17.

Transformers, by F. H. Barrington, Chief Electrical Engr., Moloney Elec. Co. April 9. Attendance 19.

University of Washington

The Engineer in Business, by H. M. Gustafson, Sales Agent, General Electric Co. Business session. April 19. Attendance 21.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, APRIL 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AIRCRAFT FLOAT DESIGN.

By Holden C. Richardson. N. Y., Ronald Press Co., 1928. (Ronald Aeronautic Series) 111 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

A discussion of the fundamentals of float shapes and arrangements, intended to assist the designer in selecting a satisfactory arrangement and correct proportions, and in determining performance. The book presents material that has not been available heretofore in connected form.

DYNAMICS.

By A. S. Ramsey. Cambridge, Eng., University Press, 1929. N. Y., Macmillan Co., 259 pp., diagrs., tables, 9 x 6 in., cloth. 10s 6d.

Intended primarily for those preparing for a first honors examination in an English university and based upon lectures at Cambridge. Some knowledge of the calculus and elementary dynamics is assumed. Many worked and unworked examples are included.

E. T. Z. GESAMTINHALTSVERZEICHENIS; 1903 bis 1927 der Elektrotechnischen Zeitschrift, der bände 1 bis 18 des Archivs für Elektrotechnik, und der V. D. E.-Fachberichthefte 1926 und 1927. Edited by Franz Mooller. Berlin, Julius Springer, 1928. 653 pp., 12 x 9 in., paper. 24.-r. m.

The Electrotechnische Verein and the Verband Deutsche Elektrotechniker have joined in issuing this index, which covers the various publications of the societies from 1903 to 1927. With the index covering the first twenty-four years of the Elektrotechnische Zeitschrift which appeared in 1904, it is now possible to review quickly the important German literature on electrical engineering.

The index is both by author and subject. The subject portion is classified according to a simple, sensible plan. The type is of good size and the print clear.

ELECTRICAL TRANSMISSION AND DISTRIBUTION.

Edited by R. O. Kapp. v. 3 and v. 4, Switchgear. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., tables, 8 x 5 in., cloth. $1.75 each.

These two volumes on switchgear form part of a treatise on electrical transmission and distribution by a number of English specialists. The work is descriptive, rather than theoretical, combining practical data with descriptions of commonly used switchboards and apparatus.

Part one discusses layouts and apparatus for high, average, and low tension a-c. switchgear and for d-c. switchgear. Part two discusses the care and operation of switchgear, ironclad switches for industrial and mining use, and protective systems for a-c. mains.

ELECTRICITY APPLIED TO MINING.

By H. Cotton. N. Y., Isaac Pitman & Sons, 1929. 625 pp., illus., plates, diagrs., 9 x 6 in., cloth. $10.00.

First discusses briefly the generation, transmission and distribution of electricity with particular reference to the problems of mining. The uses of electricity for driving fans, air compressors, pumps, coal cutters and conveyors, and for hauling, hoisting and lighting are then treated systematically in more detail. The author is in charge of the electrical department at University College, Nottingham.

ELEKTRIZITAT IM HAUSE.

By F. Niethammer. Ber. u. Lpz., Walter de Gruyter & Co., 1929. 140 pp., illus., tables, 6 x 4 in., cloth. 1,50 r. m.

Describes briefly and in simple language the ways in which electricity is used in the home. Methods and apparatus for heating, lighting and cooking are described. Various forms of motors, cleaners, ironing and washing machines, telephones, radio receivers, etc., are illustrated and explained.

ENGINEERING ELECTRICITY.

By Ralph G. Hudson. 2d edition. N. Y., John Wiley & Sons, 1928. 214 pp., illus., diagrs., tables, 8 x 5 in., fabrikoid. $2.50.

A brief, yet rigorous course covering the general principles of electricity and magnetism most frequently applied in engineering practise. The book is primarily intended for students who are not specializing in electrical engineering and represents the instruction given junior and senior students of other branches of engineering at the Massachusetts Institute of Technology.

HISTORY OF MANUFACTURERS IN THE UNITED STATES, v. 1; 1607-1860.

By Victor S. Clark. N. Y., McGraw-Hill Book Co., 1929. Published for the Carnegie Institution of Washington. 607 pp., maps, 10 x 7 in., cloth. $15.00.

This is a revision of the volume published by the Carnegie Institution of Washington in 1916, which has been out of print for several years. It is now republished and will be extended later in the year by two volumes bringing the story down to the present time.

Dr. Clark has provided a basic work for students of manufacturing. It is strictly an economic history, not an account of technology and mechanics, but students of the latter will nevertheless find it valuable and be helped further by the bibliographic footnotes. The book is a pioneer work, based on original material, which interprets the development, organization, and economic interactions of our manufacturing industry from its beginnings to the time when the nation changed from an agricultural to an industrial state.

HISTORY OF MATHEMATICAL NOTATIONS; v. 2, Notations mainly in higher mathematics.

By Florian Cajori. Chic., Open Court publishing Co., 1929. 367 pp., 9 x 6 in., cloth. $6.00.

The concluding volume of Dr. Cajori's history discusses the symbols of advanced arithmetic, algebra, and geometry, and of modern analysis. The two volumes contain almost all the symbols used down to the beginning of the nineteenth century and a representative selection of those occurring in recent writings. The amount of research that the work represents is extraordinary, and the history will be of great usefulness to mathematicians.

INDUSTRIAL DEVELOPMENT OF SEARLES LAKE BRINES.

By John E. Teeple. N. Y., Chemical Catalog Co., 1929. (Amer. Chemical Soc. Monograph series). 182 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

The author calls this a "short story of the application of research, technology and common sense to the development of a potash and borax business." Such histories of the infantile diseases of new industries are seldom written, and this graphic account of the early trials of one that finally succeeded will not only be welcome to those who are interested in potash, but may also be read with profit by young chemical engineers generally.

The equilibrium diagrams and data which fill about half the book cover 86 systems of from two to six components. They were prepared in connection with the development of the brines at Searles Lake.

JAHRBUCH DER HAFENBAUTECHNISCHEN GESELLSCHAFT. v. 10, 1927. Hamburg, Verlag der Hafenbautechnischen Gesellschaft, 1928. For sale by V. D. I. Verlag, Berlin. 222 pp., illus., diagrs. maps, 12 x 9 in., cloth. 30.-r. m.

Engineers interested in learning how German and Dutch harbors are equipped will find much information in this yearbook, which contains good descriptions of several important docks on the Rhine and in Holland. Particular attention is paid to machinery for handling coal and other bulk freight.

There are also extensive articles on the construction of the Rotterdam quay walls and the lighting and buoyage of the Elbe. A short account of the oil loading plants at the Chilean oil field is given. All the articles are profusely illustrated with drawings and photographs.

MANUFACTURE OF PULP AND PAPER, v. 5, 2d edition.

By Joint Executive Committee on Vocational Education representing the ...... Industry of the U. S. and Canada. N. Y., McGraw-Hill Book Co., 1929. Various paging, illus., diagrs., tables, 9 x 6 in., cloth. $6.00.

This volume is the concluding part of a work prepared under the direction of the Canadian Pulp and Paper Association and the Pulp and Paper Industry, which aims to provide a text-book covering the fundamentals of mathematics and science and the principles and practise of pulp and paper manufacture. The course of study is arranged definitely for home study.

About one-half of this volume is devoted to paper-making machines. The other topics are hand-made papers, tub sizing, paper finishing and testing, coated papers and paper-making details. The new edition has been thoroughly revised, several sections have been rewritten and some new topics have been added.

PHYSICAL PRINCIPLES OF WIRELESS.

By J. A. Ratcliffe. Lond., Mathuen & Co., 1929. 104 pp., diagrs., tables, 7 x 5 in., cloth. 2/6.

This small book, written by a physicist for physicists, is concerned with the physical principles on which radio is based, and omits engineering details. It discusses the electrical and acoustical phenomena concisely, yet clearly, and is especially intended for physicists who are not specialists in this subject.

RADIO OPERATING; Questions and Answers.

By Arthur R. Nilson and J. L. Hornung. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 267 pp., illus., diagrs., tables, 8 x 6 in., cloth. $2.00.

Presents the essentials of radio operation in catechism form. Intended for use with "Practical Radio Telegraphy," by the same authors, and designed for students preparing for operator's licenses. This edition is revised in accordance with the U. S. Radio Act of 1927.

SIX-PLACE TABLES. with Explanatory Notes by Edward S. Allen.

3rd edition. N. Y., McGraw-Hill Book Co., 1929. 167 pp., 7 x 4 in., fabrikoid. $1.50.

These tables are clearly printed and the size is actually convenient for the pocket. The book contains the mathematical tables used regularly and continuously by engineers and engineering students, accurate to six places.

In the new edition the values of natural secants and cosecants have been added, and new tables for conversion between radians and degrees are included.

STATISTICAL MECHANICS. based on an Essay awarded the Adams Prize in the University of Cambridge, 1923-24.

By R. H. Fowler. Cambridge, Eng., University Press, 1929. N. Y., Macmillan Co., 570 pp., tables, 11 x 8 in., cloth. $10.50.

At the time (1924) when this work was begun, there was no recent exposition of the equilibrium theory of statistical mechanics, and the book is still the only one in English. The work aims to give a connected account of the theory, by the method developed by the author and Professor Darwin, with an exposition of its applications to physical and chemical problems. The book incorporates the results of the new mechanics, as well as those of classical mechanics.

STRENGTH OF MATERIALS.

By Arthur Morley. 7th edition. N. Y. Longmans, Green & Co., 1928. 569 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.20.

Covers the ground of the usual college courses in the subject, paying attention to several subjects, such as the strength of rotating disks and cylinders, and unstayed flat plates, the bending of curved bars and vibratory stresses, which are sometimes given scanty treatment. The changes from the sixth edition consist of added articles on the circular stress diagram and a rewritten statement about fatigue of metals.

THEORETICAL MECHANICS.

By Joseph S. Ames and Francis D. Murnaghan. Bost. & N. Y., Ginn & Co., 1929. (Engineering Series). 462 pp., 9 x 6 in., cloth. $5.00.

The purpose of this work is to privide students of physics, mathematics, and chemistry with a text and reference book which will correspond with the new view of theoretical mechanics which has resulted from recent advances in mathematical physics. It includes a systematic treatment of vector analysis, gyroscopic theory, wave motion, etc. The volume furnishes a foundation for advanced study of statistical mechanics, quantum dynamics, atomic theory, etc., and is adapted for class or private study.

THEORY OF HEAT.

By Thomas Preston. 4th edition. Lond. & N. Y., Macmillan Co., 1929. 836 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.50.

This comprehensive survey, from a historical point of view, of the development of the theory of heat, has been a favorite work since its appearance in 1894. The clear, connected account, illustrated by critical discussions of typical experiments, gives the reader a clear view of the subject, not limited by adherence to any arbitrary standards of curriculum or mathematical attainments.

This revision is chiefly in the experimental determinations of thermal data. The book has been brought up to date by careful additions and omissions.

WAVE MECHANICS; being one aspect of the New Quantum Theory.

By H. T. Flint. Lond., Methuen & Co., 1929. 117 pp., diagrs., 7 x 5 in., cloth. 3/6.

This little book aims to present in a reasonably simple manner an account of wave theory of mechanics as developed by de Broglie and Schroedinger. It is intended for those not in close contact with recent work in physics who wish to become familiar with this new method and its relation to existing theory. References to more advanced works are included.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

COMMERCIAL ENGINEER, with sufficient experience to plan and make complete proposals in the field for outdoor switching equipment and complete outdoor substations. Opportunity for engineer with proper experience. Apply by letter. Location, Pennsylvania. X-8203-C.

ENGINEER, 25-35, familiar with design of medium a-c. or d-c. motors. Apply by letter, stating age, training, experience and approximate salary expected. Location, Pennsylvania. X-8204-C.

ELECTRICAL ENGINEER, graduate, for motor and generator design work. Prefer man with test experience. Apply by letter. Location, Middle west. X-8291-C.

RECENT ELECTRICAL ENGINEERING GRADUATES, for work on communication apparatus testing equipment. Direct responsibility is assumed for the maintenance of this equipment. Opportunity is afforded for the practical application of a-c. and d-c. theory on complex circuits of most recent and highly developed electrical testing apparatus. Apply by letter. Location, Middle west. X-8237-R-398-C-S.

AGENTS REPRESENTATIVES

ELECTRICAL ENGINEER, sales and construction, 38, technical graduate. Seventeen years' experience, desirous of representing manufacturers who have no representative in Texas. Can give attention from sales through installation and maintenance. Specializes on complicated automatic apparatus, all or part time; has office and well acquainted with the trade. C-5887.

AGENCIES WANTED by manufacturer's representative maintaining office in New York City. Complete coverage of industrial plants in Metropolitan New York and adjacent territory assured. Electrical and mechanical lines preferred. B-6603.

MEN AVAILABLE

GRADUATE ELECTRICAL ENGINEER, desires position in office of consulting or contracting electrical engineer. Desirous of learning business with an opportunity of becoming a permanent part of firm. Has had four years' experience with public utilities, contracting electrical engineers and an oil corporation. Location, preferred, New York City or New Jersey. C-444.

TECHNICAL GRADUATE in electrical engineering, 30, single, desires position where there is a future for an ambitious man. Six years' test floor and service engineering experience with Westinghouse. Best of references. B-8985.

YOUNG MAN, 32, married, wishes to become associated with growing steel company or consulting firm. Practical experience in by-product coke works, blast-furnace and open hearth departments. Thoroughly familiar with foundry, machine shop, drafting practise. Educated in general engineering at leading technical school. Three years' general factory training, one year as plant engineer. Available upon one month's notice. C-5878.

ELECTRICAL ENGINEER, 24, single, six months' general testing; two and a half years' design of rural and city distribution. Desires connection in a distribution department with a future. Available on reasonable notice. Location, preferred, East. C-5454.

DISTRIBUTION ENGINEER, 31, married, graduate E. E. Eight years' experience in distribution construction and engineering. Now employed as division distribution engineer of large utility. Desires permanent position with large responsibilities and future. B-8214.

ELECTRICAL ENGINEER, single, 41. Experienced in public utility work, buying, selling, investigating and managing. Has had charge of important construction and engineering projects in this country and abroad, including hydroelectric power plants, transmission lines, substations, railway electrification, etc. Has made reports on projects. Speaks Spanish. C-5846.

DOCTOR IN ELECTRICAL ENGINEERING. Graduate of foreign university, American born but speaking little English, although under standing it, seeks connection with engineering firm or consulting engineer as draftsman computor. C-5830.

ELECTRICAL ENGINEER, 31, ten years' experience; two years complete wiring plans, specifications, engineering correspondence, for light, power, signals on theaters, hotels, office buildings, loft buildings, clubs, etc.; one year with electrical contractor on large buildings; desires permanent connection anywhere as designing engineer with architect or estimating engineer with contractor. B-4217.

GRADUATE, 22, single, who has obtained a B. S. in Electrical Engineering, desires a position with a company doing engineering work, preferably electrical. Ready to do anything to get ahead. Location, New England or New York. C-5872.

ELECTRICAL ENGINEER, 30, married, 1922 graduate E. E., Cornell University. Seven years' experience in electrical layout, construction, maintenance and supervision in nationally known industrial concern. Desires position with industrial concern, consulting engineer or construction company. C-5929.

PROFESSOR OF ELECTRICAL ENGINEERING. Head of Department in a state institution would like a change in schools if opportunity and larger income are available. Excellent technical training as well as practical experience. Especially successful in department organization and development. Writer of technical articles and member of honorary and professional societies and state engineering board and committees. B-3253.

ELECTRICAL ENGINEER AND DESIGNER, 38. Ten years' experience in development of a-c. motors, generators and transformers with leading manufacturers. Capable of handling both the electrical and mechanical design of new lines of a-c. machinery and having also valuable selling experience. Available immediately. B-8592.

ELECTRICAL ENGINEER, B. S., 28, desires connection with concern doing business in Spain or South America. Three years' practical experience in power plants, testing, transmission and distribution with two large public utility companies. Speaks Spanish and French fluently; knowledge of Portuguese. Available to travel on short notice. C-5935.

ELECTRICAL ENGINEER, 32, married. Eight years' experience with public utilities covering construction, design, estimating and general engineering work on power houses and substations. East or Middlewest preferred. C-5925.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING, 39, married. B. S. and E. E. degrees, General Electric Test and nine years' experience in state universities, desires position as head of department or professor of electrical engineering in a first-class university or engineering school. West preferred. C-4403.

ELECTRICAL ENGINEER, 36, single, B. S. in E. E.; seven years' public utility experience in laboratory and field testing of power and industrial equipment, protective relays and meters. Considerable oscillographic experience. Desires position with engineering or industrial firm. No preference as to location. C-5713.

ELECTRICAL ENGINEER, technically trained, mature judgment, pleasing personality. Eleven years' experience with large industrial plants such as steel and paper mills, construction, maintenance, repairs, including redesigning, rewinding of armatures, stators, transformers; design, construction of special automatic controls for specific duty. Four years' experience, large custom repair shop. Excellent references. Desires position with industrial concern or custom repair shop. C-5916.

ELECTRICAL ENGINEER, university graduate, 36. Wide knowledge of electrification including generation, substations, distribution, motor application, control, lighting, etc., as applied to mining, cement mills and other industries. Experience covers estimates, design and layout, construction and maintenance. Desires to correspond with large industrial concern requiring the services of a man of above qualifications. B-9113.

ELECTRICAL ENGINEER, 25, B. S. in E. E. Experience in special investigations, tests, calculations, designing of special equipment, devising methods of test, report writing, etc., with public utility. Desires engineering or teaching position with opportunity for advancement. Available on reasonable notice. C-5957.

GRADUATE ELECTRICAL ENGINEER, with degree of E. E., with wide experience in testing, construction, operating, investigation, sales and managing. Has been in charge of hydroelectric systems aggregating 250,000 kv-a., operating on heads of 1700 ft. and transmitting at 110,000 volts. Capable of managing a property or group of properties and putting them on a paying basis. Now employed. Location, immaterial. C-4222.

CONNECTION LEADING TO MANAGERIAL OR EXECUTIVE POSITION, desired by employed electrical engineer with successful record in organizing and developing nationally known engineering service. Other experience includes direction maintenance for large public utility and eight years erection and service shop direction for one of larger electrical manufacturers. Married. Salary $8000 a year. B-122.

ELECTRICAL ENGINEER. One year engineering course, four years' apprenticeship with large manufacturer of electrical equipment, one year test, erection of switchgear, three years' course for E. E. degree. Since graduation, two years construction, then electrical designer for utility company. Five years supervision of electrical design, tests, construction for coal company. Familiar with automatic controls. West preferred. C-5958.

SALES ENGINEER, 42, technical education, twelve years' experience in sales engineering, sales management. Lines handled have been electrical apparatus and electric power equipment. Married, good health and habits, intensive worker. Desires position, preferably in East, as sales manager of electrical manufacturing house. Would consider attractive proposition to represent in sales capacity. C-5966.

ELECTRICAL ENGINEER, 34, single, 1917 graduate. General Electric Test and Central Station Engineering Department experience. At present in charge of a group handling system relaying and apparatus specifications for large public utility company. Prefer East or Southeast. Available on one month's notice. C-2591.

INSTRUCTOR IN ELECTRICAL ENGINEERING, 36, married, college graduate; also graduate of U. S. Navy Electrical School and U. S. Navy Radio School. Ten years' experience teaching electrical engineering and radio. Successful teacher and organizer. Member of honorary and professional societies. Desires position as assistant professor in electrical engineering or would consider research work in engineering experiment station. C-5885.

ELECTRICAL ENGINEERING GRADUATE, single, 23. Desires position connected with the design, construction or maintenance of transmission systems. Future prospects considered more important than initial salary. Best references. Available on one month's notice. Location preferred, South or Middle west. C-5967.

ELECTRICAL ENGINEER, 38, married. A. B. degree, DePauw University, M. E. and E. E. degrees, Cornell University. Eight years' public utility experience; also power and meter experience. General Manager of telephone company for four years. Salary, $300 a month. Middle west preferred. C-5979.

ELECTRICAL ENGINEER, M. S. and E. E., married. Twelve years' experience, including teaching, university and industrial research, operating department of large utility. Desires position as research and development engineer with an industrial or engineer on interconnection problems with a utility. Location, immaterial. Available, two weeks. B-7223.

ELECTRICAL ENGINEER, 29, married. Graduate B. S. in E. E., now employed by one of the largest manufacturing companies. Seven years' experience including student course and Central Station Sales at factory and district office. Desires sales or purchasing electrical equipment with progressive organization. Location preferred, New York City or vicinity. C-3802.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting of May 15, 1929, recommended the following members for transfer to the grades of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BYNG, EDWARD S., Managing Director, Standard Telephones and Cables, Ltd., London, England.
CURRIE, HARRY A., Electrical Engineer, New York Central Railroad Co., New York, N. Y.
NESBIT, WILLIAM, Northeastern Engg. Mgr., Westinghouse Elec. & Mfg. Co., New York.
VANDERSLUIS, WARREN M., Electrical Engineer, Illinois Central Railroad, Chicago, Ill.

To Grade of Member

BOECK, CHRISTIAN F., Communication Engineer, Bell Telephone Labs., New York.
BULLER, FRANCIS H., Electrical Engineer, General Electric Co., Schenectady, N. Y.
CHARLTON, JOHN R., Division Plant Engr., American Tel. & Tel. Co., St. Louis, Mo.
CREASEY, JOHN W., District Plant Supt., American Tel. & Tel. Co., Dallas, Texas.
CURDTS, EDWARD B., Supt., Light and Power, Carolina Division, Va. Elec. & Pr. Co., Roanoke Rapids, N. C.
DUFFIN, CHARLES G., Foreign Wire Relations Engr., Pacific Tel. & Tel. Co., Seattle, Wash.
EDDY, WILTON N., Director of Elec. Research Lab., Simplex Wire & Cable Co., Boston, Mass.
FISHER, WILLIAM B., Electrical Supt., Stone & Webster Engg. Corp., Boston, Mass.
FLATH, EARL H., Dean of Engg., Southern Methodist University, Dallas, Texas.
GIBBONS, EDWARD J., Operating Engineer, Halcomb Steel Co., Syracuse, N. Y.
GRZYBOWSKI, JOHN M., Research Elec. Engr., Westinghouse Elec. & Mfg., E. Pittsburgh, Pa.
GUSTAFSON, CLIFFORD W., Chief Engr., Mutual Fire Prevention Bureau, Chicago, Ill.
HARZA, CARL W., Asst. Supt., Meter Installation and Inspection, The Detroit Edison Co., Detroit, Michigan.
HENDERSON, EBERT W., Design Engr., Reliance Elec. & Engg. Corp., Cleveland, Ohio.
HUTCHINS, CHARLES C., Elec. Engr., Elliott Co., Ridgway, Pa.
JONES, WARREN C., Telephone Engr., Bell Tel. Labs., New York.
KUTNER, SIDNEY D., Asst. Engr., N. Y. Central R. R. Co., New York.
LYMAN, OLIVER B., Vice-President, Utilities Equipment Corp., San Francisco, Calif.
MARVIN, RICHARD H., Research Fellow in Elec. Engg., Johns Hopkins University, Baltimore, Md.
MAXSON, R. H., Electrical Engr., Burdick Corp., Milton, Wis.
MELVILLE, SAMUEL P., Designing Elec. Engr., Stone & Webster Engg. Corp., Boston, Mass.
MENDENHALL, IVAN S., Engineer, Detroit Edison Co., Detroit, Michigan.
MOWRY, HARRY W., Installation Development Engr., Western Electric Co., Inc., New York, N. Y.
REED, LINWOOD E., Junior Elec. Engr., Potomac Electric Power Co., Washington, D. C.
RICHARDS, LEE M., Elec. Engr., Emerson Elec. Co., St. Louis, Mo.
RICHTER, HENRY, General Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
SAWYER, LEON G., Electrical Engineer, 50 Church St., New York.
SCHOFIELD, ALBERT, Sales Engineer, Ferranti Elec. Ltd., Toronto, Ont., Canada.
SEABURG, HAROLD, Chief Elec. Engr., United Fruit Co., Banes, Oriente, Cuba.
SHIPEK, ADOLPH, Design Engr., Puget Sound Pr. & Lt. Co., Seattle, Wash.
SMITH, PAUL C., Instructor of Elec. Engg., University of Akron, Akron, Ohio.
SMITH, REGINALD S., General Foreman, N. Y. Edison Co., New York.
SNYDER, CHARLES C., Engr., Dept. of Water & Power, Los Angeles, Calif.
VAN HOUTEN, LESLIE P., Technical Employee, American Tel. & Tel. Co., New York.
WUNSCH, FELIX, Technical Advisor, Leeds & Northrup Co., Philadelphia, Pa.
YOUTZ, J. P., Lighting Service Bureau, Rio de Janiero, Brazil, S. A.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1929.

Andriessen, A., Union Gas & Electric Co., Cincinnati, Ohio
Banes, C. R., (Member), E. L. Phillips & Co., New York, N. Y.
Barkey, I. H., General Talking Pictures, New York, N. Y.
Beaman, W. M., Texas Creosoting Co., Dallas, Tex.
Bishop, G. E., Southern California Edison Co., Los Angeles, Calif.
Bonelli, J., F. A. D. Andrea Co., Long Island City, N. Y.
Brower, R., Jr., Emerson Electric Co., St. Louis, Mo.
Brosnan, T. J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Burris, C. A., Yonkers Electric Light & Power Co., Yonkers, N. Y.
Caldwell, S. E., Portland Electric Power Co., Portland, Ore.

Chassinat, M., 142 West 78th St., New York, N. Y.
Chen, T. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Clifford, W. R., Layne & Bowler, Los Angeles, Calif.
Cooper, V. E., Union Gas & Electric Co., Cincinnati, Ohio
Crabtree, K. G., University of Maine, Orono, Me.
Darcy, H. B., (Member), Electrical Equipment & Construction Co., Houston, Tex.
Davidson, D. H., Pacific Tel. & Tel. Co., Sacramento, Calif.
DeKeyser, J. F., (Member), Acme-International X-Ray Co., Chicago, Ill.
Dickinson, J., Philadelphia Coke Co., Philadelphia, Pa.
Dillard, G. B., Commonwealth Edison Co., Chicago, Ill.
Dougherty, P. B., Indiana General Service Co., Marion, Ind.
Dunkle, A. V., Sullivan Mining Co., Kellogg, Idaho
Edwards, J. B., New York Telephone Co., Brooklyn, N. Y.
Elerick, A. G., Stone & Webster, Inc., Seattle, Wash.
Elliott, J. O., Union Gas & Electric Co., Cincinnati, Ohio
Ellis, C. A., Warren Telechron Co., Ashland, Mass.
Elmer, W. B., Edison Electric Illuminating Co. of Boston, Roxbury, Mass.
Felcher, E. H., Underwriters Association, Reading, Pa.
Garner, R. C., R. C. A. Photophone Inc., New York, N. Y.
Goodnow, A. C., (Member), General Electric Co., Lynn, Mass.
Gray, C. H. G., Bell Telephone Laboratories, Inc., New York, N. Y.
Gring, M. H., Pennsylvania Power & Light Co., Pottsville, Pa.
Hauschild, J. W., United Engineers & Constructors, Inc., Philadelphia, Pa.
Hoffmann, E. A., Johnson Electric Supply Co., Cincinnati, Ohio
Hoover, I. M., Montpelier Municipal Plant, Montpelier, Ohio
Houchens, J. M., Ahrens Trade School, Louisville, Ky.
Hulan, A. G., R. C. A. Photophone Inc., New York, N. Y.
Jones, L., University of Pittsburgh, Pittsburgh, Pa.
Jopp, J. M., Manitoba Paper Co., Pine Falls, Manitoba, Can.
Kantenberger, W. J., Electrical Engineers Equipment Co., Melrose Park, Ill.
Kidder, A. H., Philadelphia Electric Co., Philadelphia, Pa.
Kilbourne, C. E., General Electric Co., Schenectady, N. Y.
Kirkwood, R. H., Pacific Tel. & Tel. Co., San Francisco, Calif.
Klintworth, G., Commonwealth Edison Co., Chicago, Ill.
Kronmiller, C. W., General Electric Co., Fort Wayne, Ind.
Lakas, J. M., Cornell University, Ithaca, N. Y.
Leamy, J. M., (Member), Spooner & Merrill, Inc., Chicago, Ill.
Legare, T. C. R., General Electric Co., Schenectady, N. Y.
Leicht, J. H., New York Telephone Co., Mt. Vernon, N. Y.
Leonnig, L. J., General Railway Signal Co., Rochester, N. Y.
Lewis, H. R., Commonwealth Edison Co., Chicago, Ill.
Loeffler, B. T., Indiana Bell Telephone Co., South Bend, Ind.
Lusk, R. R., Kansas City Power & Light Co., Kansas City, Mo.
Martin, H. G., Jr., (Member), 545 Atlantic Ave., Brooklyn, N. Y.
Matson, I. M., Electrical Prod. Corp. of Utah, Salt Lake City, Utah
McCarter, H. A., Standard Oil Co. of California, Whittier, Calif.
McClure, J. B., General Electric Co., Schenectady, N. Y.
Milburn, W. H., Bailey Meter Co., Cleveland, Ohio
Millard, T. O., General Electric Co., Chicago, Ill.
Mortimer, H. E., Stone & Webster, Inc., Boston, Mass.
Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio
Neubauer, E. O., Illinois Bell Telephone Co., Chicago, Ill.
Nichols, E. B., (Member), Victor Talking Machine Co., Camden, N. J.
Noll, G. B., Electric League of Erie, Erie, Pa.
Northrop, M. G., Cornell University, Ithaca, N. Y.
Nuber, F. J., American Electric Co., Inc., Chicago, Ill.
Oram, J., (Member), Dallas Power & Light Co., Dallas, Tex.
Parker, O. B., Pacent Electric Co., New York, N. Y.
Phillips, L. A., Pennsylvania Power & Light Co., Hazleton, Pa.
Pierson, M. F., Pierson Electric Shop, Knoxville, Ill.
Quinn, J. L., University of Santa Clara, Santa Clara, Calif.
Radler, R. W., Union Gas & Electric Co., Cincinnati, Ohio
Rall, A. A., Kansas City Power & Light Co., Kansas City, Mo.
Rasmussen, P. J., Cushman Lumber Co., Cushman, Ore.
Redding, J. A., General Electric Co., Schenectady, N. Y.
Richardson, W. J. (Member), Palace Theatre, South Bend, Ind.
Roof, B. J., Union Gas & Electric Co., Cincinnati, Ohio
Rose, M. M., Furest-Friedman Co., Cleveland, Ohio
Ross, R. D., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Ruehlin, W. H., Electric Auto-Lite Co., Toledo, Ohio
Ruzicka, C. J., Standard Oil Co. of California, Whittier, Calif.
Seltzer, S., Emerson Electric Mfg. Co., St. Louis, Mo.
Seyler, H. F. L. J., Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Shedlock, E. T., Coast Artillery Corps, U. S. Army, Fort H. G. Wright, New York
Sparks, W. S., Western Union Tel. Co., New York, N. Y.
Starr, E. C., (Member), Oregon State College, Corvallis, Ore.
Stupak, J. L., Weston Electrical Instrument Corp., Newark, N. J.
Sveen, E. A., French Battery Co., Madison, Wis.
Teckoe, J. E., (Member), Hydro-Electric Commission of Niagara Falls, Niagara Falls, Ont., Can.
Taff, J.C., State Trade School, Middletown, Conn.
Thomson, H. W., Southern California Edison Co., Los Angeles, Calif.
Thomson, J. F. P., Southern Sierras Power Co., El Centro, Calif.
Tilson, H. M., Department of Public Works, Sacramento, Calif.
Vogele, A. J., (Member), Commonwealth Edison Co., Chicago, Ill.
Wallace, A. M., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Walter, F. W., Postal Telegraph & Cable Co., New York, N. Y.
Warner, E. S., Hudson Coal Co., Scranton, Pa.
Wild, A. A., Jr., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Winder, I. T., Wickwire Spencer Steel Corp., Palmer, Mass.
Woodworth, C. O., Public Service Co. of Colo., Denver, Colo.
Zangler, R. M., Hastings Wire & Cable Co., Hastings, N. Y.
Total 101.

Foreign

Gulati, P. C., Hydro Electric Branch, Kangra, Punjab, India
Kitagawa, K., Sumitomo Electric Wire & Cable Works, Ltd., Osaka, Japan
Lu, T. Y., Ho-Zan Bank, Main St., Changchow, Kiangsu, China
Page, A., (Fellow), Central Electricity Board, London, Eng.
Williams, C. S., (Member), Cerro de Pasco Copper Corp., Oroya, Peru, So. America
Total 5.

STUDENTS ENROLLED IN MAY

Abeles, I. Meyer, University of Pennsylvania
Adams, Bennett R., Jr., Georgia School of Tech.
Adamson, Ralph T., University of Nevada
Aeberli, William A., University of Pittsburgh
Alusic, Joseph, University of Wisconsin
Andres, Robert R., University of Notre Dame
Angst, Derrill C., University of Nevada
Arehart, Oscar M., University of Louisville
Atwood, Byron E., Kansas State Agricultural College
Augustus, Lee M., University of Michigan
Beling, Geert D., Marquette University
Belvin, Charles H., Jr., North Carolina State College
Berg, George E., Jr., University of Kansas
Billhartz, W. H., University of Pittsburgh
Bliss, Warren H., Michigan State College
Bodnar, Arthur A., University of Pittsburgh
Bohne, Ray K., University of Utah
Boley, Harold C., Kansas State Agricultural College
Bolze, Joseph N., Brooklyn Polytechnic Institute
Bornemann, Fred E., Rensselaer Polytechnic Inst.
Bottonari, Samuel A., Carnegie Institute of Tech.
Bratton, Edward W., University of Michigan
Bredehoft, Elmer H., Kansas State Agricultural College
Brunk, Ralph E., Kansas State Agricultural College
Brusa, Armand L., Rensselaer Polytechnic Inst.
Bruse, Carl B., Purdue University
Bruun, Lorentz A., Oregon Institute of Tech.
Burke, Bryon R., University of Colorado
Buttram, Henry J., Georgia School of Technology
Castiglia, Frank H., New York University
Chapman, James F., University of Nebraska
Clark, George G., The Municipal University of Akron
Clark, Paul L., Montana State College
Clarkson, William G., University of Toronto
Clayton, John T., Ohio Northern University
Conley, J. Joseph, University of Notre Dame
Conroy, Edward G., University of Notre Dame
Conway, Ralph W., University of Cincinnati
Cook, Harry E., University of Nebraska
Cook, Lewis, C., Michigan State College
Corn, Lawrence H., University of Pennsylvania
Creighton, Robert R., University of Pennsylvania
Crews, Ray F., Oregon Institute of Technology
Darling, Horace, Brown University
De Journett, Homer V., West Virginia University
Denman, Walter R., Kansas State Agricultural College
Deschner, Fabian S., South Dakota State College
Detwiler, Frank T., Brooklyn Polytechnic Inst.
Diffenderfer, Samuel F., Rensselaer Polytechnic Institute
Dodson, Whitney E., Ohio Northern University
Dolan, John M., University of Notre Dame
Drury, Cecil MacB., University of Southern California
Dysart, Ronald R., University of Nebraska
Edwards, William H., University of Toronto
Elfman, Bernard L., Pennsylvania State College
Emurian, Albert D., University of Pennsylvania
Fay, Joseph, University of Notre Dame
Fife, William H., University of Cincinnati
Fisher, Lawrence T., Oregon State College
Fitzsimmons, Albert W., University of Cincinnati
Flory, Leslie E., University of Kansas

Fraser, William S., University of British Columbia
Freeman, Robert L., Stanford University
Garrett, William A., University of Denver
Gaskell, Joe, Engineering School of Milwaukee
Gerstein, Leo H., University of Nebraska
Gilchrist, Fred W., Ohio State University
Gilroy, John W., University of Southern Calif.
Googins, Danforth M., Univ. of New Hampshire
Graham, Henry U., University of Pennsylvania
Griffin, Lowell L., Engg. School of Milwaukee
Gueffroy, Russell S., Oregon Institute of Tech.
Gurley, Glenwood H., University of Kansas
Gustanoff, Abe L., University of Washington
Hammond, Merle W., University of Kansas
Harmony, Harold A., University of Washington
Hartshorn, Rolfe, I., Ohio Northern University
Hasley, Andrew D., University of Michigan
Hauser, Herman T., University of California
Helgesson, Leonard, Oregon State College
Henderson, Valtin L., University of Toronto
Hensley, Marvin S., University of Kansas
Holmes, John R., McGill University
Hoyt, Philip F., University of Nebraska
Hughes, Cyril A., University of Notre Dame
Hunt, Spencer, University of Southern California
Iglehart, Ferdinand C., University of Pennsylvania
Jacobson, Leo, Brown University
Jautz, Gilbert J., University of Wisconsin
Jensen, Walter H., University of Nevada
Jochem, Theodore B., Marquette University
Johansen, Harold C., Purdue University
Jones, Bernard A., University of Pittsburgh
Jones, Daniel E., North Carolina State College
Jones, Harold W., Clarkson College of Technology
Karr, J. Harold, Kansas State Agricultural College
Kawaguchi, Tadashi, Stanford University
Kelly, Richard E., Carnegie Institute of Tech.
Kirkwood, Loren R., Kansas State Agricultural College
Kling, John J., Michigan State College
Kohler, Ernest Jr., Massachusetts Inst. of Tech.
Lampson, Curtis W., South Dakota State College
Lantry, Tom, University of Notre Dame
Lewis, Rodney C., University of Southern Calif.
Lockner, Sidney P., University of Pittsburgh
Lunn, Edward O., University of British Columbia
Lydick, Lawrence N., Kansas State Agricultural College
Magers, Oliver N., Kansas University
Markle, Bruce H., Kansas State Agricultural College
Martinoff, Vcévolod M., University of Toronto
Martz, Merrill J., University of Colorado
Millen, William I., Jr., Marquette University
Miller, Henry D., University of Nebraska
Mitcham, John D., Texas A. & M. College
Nartker, Leo J., University of Cincinnati
Nelson, Albert H., University of Southern Calif.
Nelson, Charles H., University of Pennsylvania
Nickerson, Allan F., Brown University
Nonken, Gordon C., Kansas State Agricultural College
Orth, Richard T., Purdue University
Pankow, Edmund G., Ohio Northern University
Parker, Nelson H., Jr., Goergia School of Tech.
Parker, William H., Jr., Mass. Inst. of Tech.
Paulson, William D., University of Colorado
Perry, Herbert J., University of Notre Dame
Peters, Leo R., Ohio State University
Peterson, Reuben, Iowa State College
Phillips, Albert F., Carnegie Institute of Tech.
Pickett, George E., North Carolina State College
Pinkerton, Frank, Georgia School of Technology
Podlaski, Charles G., University of Notre Dame
Powell, Wayne M., University of Kansas
Powers, William F., Brooklyn Polytechnic Inst.
Pryor, Philip L., Iowa State College
Reed, Fred J., University of Pittsburgh
Roland, Stanley W., Michigan State College
Roth, William F., University of Pennsylvania
Rowe, Edward L., Jr., University of Vermont
Russell, Stephen S., University of Cincinnati
Sallemi, John B., University of Illinois
Schmid, J. Leonhard, University of Pennsylvania
Schmidt, Elmer C., University of Illinois
Schumacher, Lawrence R., South Dakota State College
Sento, Tadashi, Tokyo Imperial University
Sewell, Seymour W., Lewis Institute
Sheehy, Joseph J., Marquette University
Shen, Pao-Guay, Harvard University
Shoemaker, Malcolm G., University of Nebraska
Simon, Andrew, Jr., Purdue University
Smith, Harold A., Brown University
Smith, Harold W., University of New Hampshire
Smith, Newbern, University of Pennsylvania
Smith, W. Morden, Michigan State College
Spies, John F., Washington University
Sproul, Robert R., Brown University
Steele, Arlo L., Kansas State Agricultural College
Stiles, Merrill R., South Dakota State College
Strasbourger, Julius C., University of Cincinnati
Stuttle, Alfred F., University of Illinois
Swyter, Carl, South Dakota State College
Tanner, Raymond E., Brown University
Taylor, Clyde O., University of Cincinnati
Tebo, Gordon B., University of Toronto
Tobe, Samuel S., Brown University
Townsend, Paul H., Northeastern University
Tsao, Tsen-Cha, Harvard University
Tynan, Andrew G., University of Pennsylvania
Vanderlippe, Richard A., University of Nebraska
Varga, George E., University of Pittsburgh
Viola, Albert G., University of Illinois
Verd, Paul H., University of Washington
Walsh, J. A., University of Nevada
Weber, Joe, University of Cincinnati
Weddington, William W., Georgia School of Tech.
Werner, Lawrence H., Jr., University of Detroit
Westendarp, Franz G., University of Pennsylvania
Wherry, W. J., University of Pittsburgh
Whitney, Herbert W., Texas A. & M. College
Wiegreffe, John L., University of Illinois
Wilson, Lee H., Bucknell University
Wood, Wallace J., Pennsylvania State College
Woodland, Harold E., University of British Columbia
Ziochovski, Edward F., Rhode Island State College

Total 183.

Officers of the A. I. E. E., 1928-1929

PRESIDENT
(Term expires July 31, 1929)
R. F. SCHUCHARDT

JUNIOR PAST PRESIDENTS
(Term expires July 31, 1929) C. C. CHESNEY
(Term expires July 31, 1930) BANCROFT GHERARDI

VICE-PRESIDENTS

(Terms expire July 31, 1929)	(Terms expire July 31, 1930)
O. J. FERGUSON (District No. 6)	E. B. MERRIAM (District No. 1)
E. R. NORTHMORE (District No. 8)	H. A. KIDDER (District No. 3)
J. L. BEAVER (District No. 2)	W. T. RYAN (District No. 5)
A. B. COOPER (District No. 10)	B. D. HULL (District No. 7)
C. O. BICKELHAUPT (District No. 4)	G. E. QUINAN (District No. 9)

DIRECTORS

(Terms expire July 31, 1929)	(Terms expire July 31, 1931)
M. M. FOWLER	F. C. HANKER
E. C. STONE	E. B. MEYER
CHARLES E. STEPHENS	H. P. LIVERSIDGE
(Terms expire July 31, 1930)	(Terms expire July 31, 1932)
I. E. MOULTROP	J. ALLEN JOHNSON
H. C. DON CARLOS	A. M. MacCUTCHEON
F. J. CHESTERMAN	A. E. BETTIS

NATIONAL TREASURER — GEORGE A. HAMILTON
NATIONAL SECRETARY — F. L. HUTCHINSON
(Terms expire July 31, 1929)

HONORARY SECRETARY — RALPH W. POPE
GENERAL COUNSEL — PARKER & AARON, 30 Broad Street, New York

PAST PRESIDENTS—1884-1928

*Norvin Green, 1884-5-6.
*Franklin L. Pope, 1886-7.
*T. Commerford Martin, 1887-8.
Edward Weston, 1888-9.
Elihu Thomson, 1889-90.
*William A. Anthony, 1890-91.
*Alexander Graham Bell, 1891-2.
Frank Julian Sprague, 1892-3.
*Edwin J. Houston, 1893-4-5.
*Louis Duncan, 1895-6-7.
*Francis Bacon Crocker, 1897-8.
A. E. Kennelly, 1898-1900.
*Carl Hering, 1900-1.
*Charles P. Steinmetz, 1901-2.
Louis A. Ferguson, 1908-9.
Lewis B. Stillwell, 1909-10.
Dugald C. Jackson, 1910-11.
Gano Dunn, 1911-12.
Ralph D. Mershon, 1912-13.
C. O. Mailloux, 1913-14.
Paul M. Lincoln, 1914-15.
John J. Carty, 1915-16.
H. W. Buck, 1916-17.
E. W. Rice, Jr., 1917-18.
Comfort A. Adams, 1918-19.
Calvert Townley, 1919-20.
A. W. Berresford, 1920-21.
William McClellan, 1921-22.
Charles F. Scott, 1902-3.
Bion J. Arnold, 1903-4.
John W. Lieb, 1904-5.
*Schuyler Skaats Wheeler, 1905-6.
*Samuel Sheldon, 1906-7.
*Henry G. Stott, 1907-8.
Frank B. Jewett, 1922-23.
Harris J. Ryan, 1923-4.
Farley Osgood, 1924-25.
M. I. Pupin, 1925-26.
C. C. Chesney, 1926-27.
Bancroft Gherardi, 1927-28.

*Deceased.

LOCAL HONORARY SECRETARIES

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.
H. W. Flashman, Aus. Westinghouse Elec. Co. Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.
Frederick M. Servos, Rio de Janeiro Tramways Lt. & Pr. Co., Rio de Janeiro, Brazil, S. A.
Charles le Maistre, 28 Victoria St., London, S. W. 1, England.
A. S. Garfield, 45 Bd. Beausejour, Paris 16 E., France.
F. W. Willis, Tata Power Companies, Bombay House, Bombay, India.
Guido Semenza, 39 Via Monte Napoleone, Milan, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
Axel F. Enstrom, 24a Grefturegatan, Stockholm, Sweden.
W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa.

A. I. E. E. Committees

GENERAL STANDING COMMITTEES

EXECUTIVE COMMITTEE

R. F. Schuchardt, Chairman, 72 West Adams St., Chicago, Ill.
C. C. Chesney, G. A. Hamilton, E. B. Meyer, Bancroft Gherardi, H. A. Kidder, I. E. Moultrop.

FINANCE COMMITTEE

E. B. Meyer, Chairman, 80 Park Place, Newark, N. J.
H. A. Kidder, C. E. Stephens.

MEETINGS AND PAPERS COMMITTEE

H. P. Charlesworth, Chairman, 463 West St., New York, N. Y.
E. H. Hubert, Secretary, 33 W. 39th St., New York.
A. E. Knowlton, E. B. Meyer, H. S. Osborne, A. M. MacCutcheon, L. W. W. Morrow, C. E. Skinner, J. E. Macdonald, T. A. Worcester.
Chairman of Committee on Coordination of Institute Activities, *ex-officio*.
Chairmen of Technical Committees, *ex-officio*.

PUBLICATION COMMITTEE

W. S. Gorsuch, Chairman, 600 West 59th Street, New York, N. Y.
H. P. Charlesworth, F. L. Hutchinson, E. B. Meyer, Donald McNicol.

COMMITTEE ON COORDINATION OF INSTITUTE ACTIVITIES

H. A. Kidder, Chairman, 600 West 59th St., New York, N. Y.
C. O. Bickelhaupt, W. S. Gorsuch, W. B. Kouwenhoven, H. P. Charlesworth, F. L. Hutchinson, E. B. Meyer.

BOARD OF EXAMINERS

E. H. Everit, Chairman, Southern New England Tel. Co., New Haven, Conn.
F. J. Chesterman, Erich Hausmann, L. W. W. Morrow,
H. W. Drake, A. H. Kehoe, S. D. Sprong,
Harold Goodwin, G. L. Knight, George Sutherland,
S. P. Grace, John B. Taylor.

SECTIONS COMMITTEE

W. B. Kouwenhoven, Chairman, Johns Hopkins University, Baltimore, Md.
J. D. Ball, J. L. Beaver, W. S. Rodman.
G. E. Quinan,
Chairmen of Sections, *ex-officio*.

COMMITTEE ON STUDENT BRANCHES

J. L. Beaver, Chairman, Lehigh University, Bethlehem, Pa.
Edward Bennett, A. B. Gates, W. E. Wickenden.
Charles F. Scott,
Student Branch Counselors, *ex-officio*.

MEMBERSHIP COMMITTEE

J. E. Kearns, Chairman, General Electric Co., 230 South Clark St., Chicago, Ill.

Vice-Chairmen

G. O. Brown, John B. Fisken, S. H. Mortensen,
F. E. Dellinger, J. J. Frank, Joseph Showalter,
Herbert B. Dwight, C. R. Jones, G. J. Yundt.
G. M. Keenan,

Ex-officio

Chairmen of Section Membership Committees.

HEADQUARTERS COMMITTEE

R. H. Tapscott, Chairman, 124 East 15th Street, New York, N. Y.
F. L. Hutchinson, E. B. Meyer.

LAW COMMITTEE

C. O. Bickelhaupt, Chairman, Southern Bell Tel. & Tel. Co., Atlanta, Ga.
M. M. Fowler, Paul M. Lincoln, E. C. Stone.
A. G. Pierce,

PUBLIC POLICY COMMITTEE

D. C. Jackson, Chairman, 31 St. James Ave., Boston, Mass.
H. W. Buck, Gano Dunn, John W. Lieb,
C. C. Chesney, F. B. Jewett, Harris J. Ryan.

STANDARDS COMMITTEE

F. D. Newbury, Chairman, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
H. E. Farrer, Secretary, 33 W. 39th St., New York.
C. M. Gilt, A. M. MacCutcheon, V. M. Montsinger,
C. R. Harte, J. F. Meyer, C. E. Skinner,
H. A. Kidder, W. I. Slichter.

Ex-Officio

President, U. S. National Committee of I. E. C.
Chairmen of Working Committees.
Chairmen of delegations on other standardizing bodies.

EDISON MEDAL COMMITTEE

Appointed by the President for term of five years.

(Terms expire July 31, 1929)
N. A. Carle, Charles L. Edgar, John W. Lieb.
(Terms expire July 31, 1930)
George Gibbs, Samuel Insull, Chairman, Ralph D. Mershon.
(Terms expire July 31, 1931)
John W. Howell, L. F. Morehouse, David B. Rushmore.
(Terms expire July 31, 1932)
E. B. Craft, Paul M. Lincoln, C. E. Skinner.
(Terms expire July 31, 1933)
Charles F. Brush, D. C. Jackson, Elmer A. Sperry.

Elected by the Board of Directors from its own membership for term of two years.

(Terms expire July 31, 1929)
H. P. Liversidge, E. B. Meyer, I. E. Moultrop.
(Terms expire July 31, 1930)
B. Gherardi, H. A. Kidder, E. B. Merriam.

Ex-Officio

R. F. Schuchardt, President, George A. Hamilton, National Treasurer,
F. L. Hutchinson, National Secretary.

LAMME MEDAL COMMITTEE

(Terms expire July 31, 1929)
W. L. R. Emmet, C. F. Kettering, Elmer A. Sperry.
(Terms expire July 31, 1930)
P. M. Lincoln, E. B. Meyer, L. W. W. Morrow.
(Terms expire July 31, 1931)
H. H. Barnes, Jr., Charles F. Scott, Chairman N. W. Storer.

COMMITTEE ON CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT

H. B. Smith, Chairman, Worcester Polytechnic Institute, Worcester, Mass.
A. H. Babcock, F. B. Jewett, H. P. Liversidge,
G. Faccioli, John W. Lieb, J. B. Whitehead.

COMMITTEE ON COLUMBIA UNIVERSITY SCHOLARSHIPS

W. I. Slichter, Chairman, Columbia University, New York, N. Y.
Francis Blossom, H. C. Carpenter.

COMMITTEE ON AWARD OF INSTITUTE PRIZES

H. P. Charlesworth, Chairman, 463 West St., New York, N. Y.
W. S. Gorsuch, F. W. Peek, Jr.

COMMITTEE ON SAFETY CODES

F. V. Magalhaes, Chairman, Hall Elec. Heating Co.,
1429 Walnut St., Philadelphia, Pa.
A. E. Bettis, H. B. Gear, R. W. E. Moore,
Philander Betts, J. P. Jackson, R. H. Nexsen,
J. E. Brobst, H. W. Leitch, H. R. Sargent,
L. L. Elden, M. G. Lloyd, W. H. Sawyer,
J. C. Forsyth, Wills MacLachlan, H. S. Warren.

SPECIAL COMMITTEES

LICENSING OF ENGINEERS

Francis Blossom, Chairman, 52 William Street, New York, N. Y.
H. W. Buck, Gano Dunn, E. W. Rice, Jr.
L. E. Imlay,

ADVISORY COMMITTEE TO THE MUSEUMS OF THE PEACEFUL ARTS

J. P. Jackson, Chairman, 130 East 15th Street, New York, N. Y.
R. H. Nexsen, George K. Thompson.

TECHNICAL COMMITTEES

AUTOMATIC STATIONS

W. H. Millan, Chairman, 2615 Clifton Ave., St. Louis, Mo.
P. H. Adams, H. C. Don Carlos, O. Naef,
Caesar Antoniono, P. E. Hart, E. W. Seeger,
L. D. Bale, Joseph Hellenthal, Roy M. Stanley,
C. A. Butcher, Chester Lichtenberg, L. J. Turley,
M. S. Coover, S. J. Lisberger, F. Zogbaum.
G. H. Middlemiss,

COMMUNICATION

H. W. Drake, Chairman, Western Union Telegraph Co.,
195 Broadway, New York, N. Y.
G. R. Benjamin, E. H. Everit, R. D. Parker,
H. P. Charlesworth, D. H. Gage, S. R. Parker,
F. J. Chesterman, S. P. Grace, F. A. Raymond,
L. W. Chubb, Erich Hausmann, C. A. Robinson,
J. L. Clarke, P. J. Howe, J. K. Roosevelt,
R. N. Conwell, H. L. Huber, H. A. Shepard,
B. R. Cummings, B. D. Hull, John F. Skirrow,
Charles E. Davies, G. A. Kositzky, H. M. Turner,
R. D. Evans, F. H. Kroger, F. A. Wolff.
Ray H. Manson,

EDUCATION

Edward Bennett, Chairman, University of Wisconsin, Madison, Wis.
H. H. Henline, Secretary, 33 West 39th St., New York, N. Y.
E. W. Allen, A. B. Gates, H. S. Osborne,
J. L. Beaver, W. B. Hartshorne, A. G. Pierce,
H. W. Buck, Paul M. Lincoln, C. S. Ruffner,
V. Bush, C. E. Magnusson, W. S. Rugg,
O. J. Ferguson, W. E. Mitchell, W. E. Wickenden.

ELECTRICAL MACHINERY

W. J. Foster, Chairman, General Electric Co., Schenectady, N. Y.
E. B. Paxton, Secretary, General Electric Co., Schenectady, N. Y.
P. L. Alger, B. G. Jamieson, O. K. Marti
B. L. Barns, J. Allen Johnson, V. M. Montsinger,
A. B. Cooper, A. H. Kehoe, F. D. Newbury,
W. M. Dann, C. W. Kincaid, J. M. Oliver,
C. M. Gilt, H. C. Louis, A. M. Rossman,
W. S. Gorsuch, A. M. MacCutcheon, R. B. Williamson.
S. L. Henderson, H. L. Zabriskie

ELECTRIC WELDING

A. M. Candy, Chairman, Westinghouse E. & M. Co., East Pittsburgh, Pa.
C. A. Adams, O. H. Eschholz, J. C. Lincoln,
P. P. Alexander, H. M. Hobart, Ernest Lunn,
C. W. Bates, C. J. Holslag, A. M. MacCutcheon,
Ernest Bauer, C. L. Ipsen, J. W. Owens,
Alexander Churchward, Wm. Spraragen.

ELECTROCHEMISTRY AND ELECTROMETALLURGY

G. W. Vinal, Chairman, Bureau of Standards, Washington, D. C.
Lawrence Addicks, E. B. Dawson, C. G. Schluederberg,
Arthur N. Anderson, F. A. J. Fitzgerald, J. A. Seede,
T. C. Atchison, F. C. Hanker, Magnus Unger,
P. H. Brace, W. E. Holland, J. B. Whitehead,
Farley G. Clark, F. A. Lidbury, E. A. Williford,
Safford K. Colb J. L. Woodbridge.

ELECTROPHYSICS

V. Karapetoff, Chairman, Cornell University, Ithaca, N. Y.
Carl Kinsley, Secretary, 22 Lynwood Road, Scarsdale, N. Y.
O. E. Buckley, W. F. Davidson, R. A. Millikan,
V. Bush, K. B. McEachron, R. H. Park,
John R. Carson, O. J. Ferguson, L. J. Peters,
F. M. Clark, C. L. Fortescue, J. Slepian,
W. D. Coolidge, A. Hund, F. E. Terman.
W. B. Kouwenhoven,

Liaison Representatives of American Physical Society

Dr. W. F. G. Swann, Prof. A. P. Wills

GENERAL POWER APPLICATIONS

J. Frank Gaskill, Chairman, 1000 Chestnut Street, Philadelphia, Pa.
D. H. Braymer, A. C. Lanier, H. W. Price,
C. W. Drake, A. M. Lloyd, H. L. Smith,
Harry L. Grant, A. M. MacCutcheon, A. H. Stebbins,
Clyde D. Gray, W. S. Maddocks, E. C. Stone,
C. Francis Harding, N. L. Mortensen, W. H. Timbie,
E. W. Henderson, E. B. Newill, F. M. Weller,
Geo. H. Jones, K. A. Pauly, M. R. Woodward,
P. C. Jones, D. M. Petty, W. C. Yates.

INSTRUMENTS AND MEASUREMENTS

Everett S. Lee, Chairman, General Electric Co., Schenectady, N. Y.
E. J. Rutan, Vice-Chairman,
H. C. Koenig, Secretary, Elec. Testing Laboratories,
80th St. & East End Ave., New York, N. Y.
O. J. Bliss, W. N. Goodwin, Jr., W. J. Mowbray,
Perry A. Borden, F. C. Holtz, T. E. Penard,
W. M. Bradshaw, I. F. Kinnard, R. T. Pierce,
H. B. Brooks, A. E. Knowlton, G. A. Sawin,
A. L. Cook, W. B. Kouwenhoven, R. W. Sorensen,
Melville Eastham, E. B. Merriam, H. M. Turner.

APPLICATIONS TO IRON AND STEEL PRODUCTION

M. M. Fowler, Chairman, General Electric Co., 230 So. Clark St., Chicago, Ill.
A. C. Bunker, A. M. MacCutcheon, G. E. Stoltz,
F. B. Crosby, O. Needham, Wilfred Sykes,
A. C. Cummins, A. G. Pierce, T. S. Towle,
S. L. Henderson, F. O. Schnure, J. D. Wright.

PRODUCTION AND APPLICATION OF LIGHT

B. E. Shackelford, Chairman, Westinghouse Lamp Co., Bloomfield, N. J.
W. T. Blackwell, H. H. Higbie, F. H. Murphy,
J. R. Cravath, C. L. Kinsloe, F. A. Rogers,
W. T. Dempsey, A. S. McAllister, W. T. Ryan,
Lewis Fussell, G. S. Merrill, W. M. Skiff,
G. C. Hall, P. S. Millar, C. J. Stahl,
L. A. Hawkins, G. H. Stickney.

APPLICATIONS TO MARINE WORK

W. E. Thau, Chairman, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.

Edgar C. Alger, R. A. Beekman, H. C. Coleman, E. M. Glasgow, H. F. Harvey, Jr., C. J. Henschel, Wm. Hetherington, Jr., H. L. Hibbard, A. Kennedy, Jr., J. B. Lunsford, E. B. Merriam, I. H. Osborne, G. A. Pierce, Wm. H. Reed, Edgar P. Slack, H. M. Southgate, Oscar A. Wilde, J. L. Wilson, R. L. Witham.

APPLICATIONS TO MINING WORK

Carl Lee, Chairman, 1652 McCormick Bldg., Chicago, Ill.

A. R. Anderson, F. N. Bosson, Graham Bright, M. M. Fowler, E. J. Gealy, L. C. Ilsley, G. M. Kennedy, R. L. Kingsland, A. B. Kiser, W. H. Lesser, John A. Malady, C. H. Matthews, F. C. Nicholson, W. F. Schwedes, F. L. Stone, E. B. Wagner, J. F. Wiggert, C. D. Woodward.

POWER GENERATION

F. A. Allner, Chairman, Pennsylvania Water & Power Co., Lexington Building, Baltimore, Md.

J. R. Baker, Secretary, Pennsylvania Water & Power Co., 1611 Lexington Building, Baltimore, Md.

A. E. Bettis, J. B. Crane, P. M. Downing, James H. Ferry, N. E. Funk, W. S. Gorsuch, F. C. Hanker, C. F. Hirshfeld, A. H. Hull, A. H. Kehoe, H. A. Kidder, G. L. Knight, W. H. Lawrence, W. S. Lee, F. T. Leilich, James Lyman, E. B. Meyer, W. E. Mitchell, I. E. Moultrop, F. A. Scheffler, W. F. Sims, A. R. Smith, E. C. Stone, R. W. Stovel, William M. White.

POWER TRANSMISSION AND DISTRIBUTION

H. R. Woodrow, Chairman, Brooklyn Edison Co., Inc., Pearl and Willoughby Sts., Brooklyn, N. Y.

R. E. Argersinger, Geo. M. Armbrust, R. W. Atkinson, E. T. J. Brandon, V. Bush, P. H. Chase, C. V. Christie, D. D. Clarke, W. H. Cole, R. N. Conwell, M. T. Crawford, W. A. Del Mar, Herbert H. Dewey, E. W. Dillard, R. E. Doherty, L. L. Elden, R. D. Evans, F. M. Farmer, Harland C. Forbes, C. L. Fortescue, K. A. Hawley, V. L. Hollister, J. P. Jollyman, A. H. Kehoe, A. H. Lawton, W. E. Mitchell, E. R. Northmore, L. L. Perry, T. F. Peterson, D. W. Roper, A. E. Silver, L. G. Smith, H. C. Sutton, Percy H. Thomas, Philip Torchio, Theodore Varney, H. L. Wallau, H. S. Warren, R. J. C. Wood.

PROTECTIVE DEVICES

E. A. Hester, Chairman, 435 Sixth Avenue, Pittsburgh, Pa.

Raymond Bailey, Vice-Chairman

V. J. Brain, Secretary, N. Y. Edison Co., 13th St. & Irving Place, New York, N.Y.

A. C. Cummins, E. W. Dillard, H. W. Drake, W. S. Edsall, L. E. Frost, E. E. George, James S. Hagan, H. Halperin, F. C. Hanker, F. L. Hunt, B. G. Jamieson, J. Allen Johnson, S. M. Jones, R. L. Kingsland, M. G. Lloyd, J. B. MacNeill, R. C. Muir, N. L. Pollard, A. M. Rossman, A. H. Schirmer, H. P. Sleeper, R. M. Spurck, E. R. Stauffacher, H. R. Summerhayes.

RESEARCH

F. W. Peek, Jr., Chairman, General Electric Company, Pittsfield, Mass.

H. D. Arnold, Edward Bennett, V. Bush, E. H. Colpitts, W. F. Davidson, W. P. Dobson, J. A. Johnson, V. Karapetoff, A. E. Kennelly, S. M. Kintner, M. G. Lloyd, Chester W. Rice, D. W. Roper, Clayton H. Sharp, C. E. Skinner, R. W. Sorensen, T. S. Taylor, J. B. Whitehead.

TRANSPORTATION

W. M. Vandersluis, Chairman, 1201 S. Michigan Avenue, Chicago, Ill.

Reinier Beeuwkes, A. E. Bettis, J. V. B. Duer, H. H. Field, E. R. Hill, W. K. Howe, D. C. Jackson, John Murphy, W. S. Murray, W. B. Potter, Ralph H. Rice, N. W. Storer, Richard H. Wheeler, Sidney Withington.

A. I. E. E. Representatives

ALFRED NOBLE PRIZE COMMITTEE

H. P. Charlesworth

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE COUNCIL

Edward Bennett, O. J. Ferguson.

AMERICAN BUREAU OF WELDING

H. M. Hobart.

AMERICAN COMMITTEE ON ELECTROLYSIS

B. J. Arnold, N. A. Carle, F. N. Waterman.

AMERICAN ENGINEERING COUNCIL ASSEMBLY

H. H. Barnes, Jr., A. W. Berresford, C. O. Bickelhaupt, C. C. Chesney, F. J. Chesterman, *John H. Finney, *M. M. Fowler, F. L. Hutchinson, *H. A. Kidder, William McClellan, L. F. Morehouse, I. E. Moultrop, *Farley Osgood, E. W. Rice, Jr., *R. F. Schuchardt, Charles F. Scott, *C. E. Skinner, Calvert Townley.

*Representatives on Administrative Board

AMERICAN MARINE STANDARDS COMMITTEE

R. A. Beekman

AMERICAN STANDARDS ASSOCIATION

J. F. Meyer, F. D. Newbury, John C. Parker.

H. M. Hobart, H. S. Osborne, L. T. Robinson, Alternates.

AMERICAN YEAR BOOK, ADVISORY BOARD

Henry H. Henline

BOARD OF TRUSTEES, UNITED ENGINEERING SOCIETY

H. P. Charlesworth, H. A. Kidder, G. L. Knight.

CHARLES A. COFFIN FELLOWSHIP AND RESEARCH FUND COMMITTEE

R. F. Schuchardt

COMMITTEE OF APPARATUS MAKERS AND USERS, NATIONAL RESEARCH COUNCIL

C. E. Skinner

COMMITTEE ON ELIMINATION OF FATIGUE, SOCIETY OF INDUSTRIAL ENGINEERS

C. Francis Harding

COMMITTEE ON HEAT TRANSMISSION, NATIONAL RESEARCH COUNCIL

T. S. Taylor

ENGINEERING FOUNDATION BOARD

Gano Dunn, L. B. Stillwell.

JOHN FRITZ MEDAL BOARD OF AWARD

C. C. Chesney, Bancroft Gherardi, M. I. Pupin, R. F. Schuchardt.

JOINT COMMITTEE ON WELDED RAIL JOINTS

D. D. Ewing, A. P. Way.

JOINT CONFERENCE COMMITTEE OF FOUNDER SOCIETIES

The Presidents and Secretaries, *ex-officio*.

LIBRARY BOARD OF UNITED ENGINEERING SOCIETY

Edward D. Adams, E. B. Craft, F. L. Hutchinson, W. B. Jackson, W. I. Slichter.

NATIONAL FIRE PROTECTION ASSOCIATION, ELECTRICAL COMMITTEE

F. V. Magalhaes.

NATIONAL FIRE WASTE COUNCIL

John H. Finney, F. V. Magalhaes.

NATIONAL RESEARCH COUNCIL, ENGINEERING DIVISION

Cary T. Hutchinson, F. B. Jewett, F. L. Hutchinson, *ex-officio*, S. M. Kintner.

NATIONAL SAFETY COUNCIL, ELECTRICAL COMMITTEE OF A. S. S. E.—ENGINEERING SECTION

F. V. Magalhaes

THE NEWCOMEN SOCIETY

E. B. Craft

RADIO ADVISORY COMMITTEE, BUREAU OF STANDARDS

A. E. Kennelly

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION BOARD OF INVESTIGATION AND COORDINATION

Gano Dunn, Frank B. Jewett.

U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON ILLUMINATION

A. E. Kennelly, C. O. Mailloux, Clayton H. Sharp.

U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

E. W. Allen, W. A. Del Mar, Gano Dunn, F. V. Magalhaes, C. O. Mailloux, William McClellan, L. T. Robinson, D. W. Roper, R. F. Schuchardt, (*ex-officio*)

F. C. Hanker, H. M. Hobart, D. C. Jackson, F. B. Jewett, A. E. Kennelly, H. A. Kidder, John W. Lieb, E. B. Meyer, (*ex-officio*) J. F. Meyer, F. D. Newbury, (*ex-officio*) H. S. Osborne, Farley Osgood, F. W. Peek, Jr., E. W. Rice, Jr., C. H. Sharp, C. E. Skinner, W. I. Slichter, A. R. Stevenson, Jr. N. W. Storer, Elihu Thomson, John W. Upp.

WASHINGTON AWARD, COMMISSION OF

L. A. Ferguson, Charles F. Scott.

LIST OF SECTIONS

Name	Chairman	Secretary
Akron	John Grotzinger	H. C. Paiste, No. Ohio Pr. & Lt. Co., Akron, Ohio
Atlanta	H. L. Wills	W. F. Bellinger, Elec. & Gas Bldg., Atlanta, Ga.
Baltimore	W.B.Kouwenhoven	R. T. Greer, Cons. Gas Elec. Lt. & Pr. Co., Lexington Bldg., Baltimore, Md
Boston	H. B. Dwight	G J. Crowdes, Simplex Wire & Cable Co., Sidney Street, Cambridge, Mass.
Chicago	P. B. Juhnke	T. G. Le Clair, Commonwealth Edison Co., Rm. 822, 72 W. Adams St., Chicago, Ill.
Cincinnati	R. C. Fryer	L. O. Dorfman, Westinghouse E. & M. Co., 3rd & Elm Sts., Cincinnati, Ohio
Cleveland	E. W. Henderson	P. D. Manbeck, National Carbon Co., Madison Ave. & West 117th St., Cleveland, Ohio

LIST OF SECTIONS—*Continued*

Name	Chairman	Secretary
Columbus	W. E. Metzger	R. A. Brown, 87 E. Dunedin Road, Columbus, Ohio
Connecticut	E. J. Amberg	R. G. Warner, Yale Univ. 10 Hillhouse Ave., New Haven, Conn.
Dallas	G. A. Mills	A Chetham Strode, Dallas Pr. & Lt. Co., Interurban Bldg., Dallas, Texas
Denver	L. N. McClellan	R. B. Bonney, Telephone Bldg., P. O. Box 960, Denver, Colo.
Detroit-Ann Arbor	A. H. Lovell	L. F. Hickernell, Stevens & Wood, Inc., Consumers Power Bldg., Jackson, Mich.
Erie	M. L. Elder	A. W. Wennerstrom, General Electric Co Erie Pa
Fort Wayne	C. F. Beyer	J. F. Eitman, 1841 Broadway, Ft. Wayne, Ind.
Houston	C. A. Williamson	L. K. Del Homme, Houston Lighting & Power Co., Houston, Texas
Indianapolis-Laf.	Herbert Kessel	G. R. Anderson, 2060 Northwestern Ave., Fairbanks, Morse & Co., Indianapolis, Ind.
Ithaca	R. F. Chamberlain	H. H. Race, School of Elec. Engg., Cornell University, Ithaca, N. Y.
Kansas City	B. J. George	A. B. Covey, Southwestern Bell Tel. Co., Kansas City, Mo.
Lehigh Valley	H. D. Baldwin	E. F. Weaver, Pa. Pr. & Lt. Co., 901 Hamilton St., Allentown, Pa.
Los Angeles	H. L. Caldwell	N. B. Hinson, Southern Cal. Edison Co., 3rd and Broadway, Los Angeles, Calif.
Louisville	E. D. Wood	H. W. Wischmeyer, Louisville Railway Co., Louisville, Ky.
Lynn	Charles Skoglund	V. R. Holmgren, Turbine Engg. Dept., G. E. Co., Bldg. 64 G, Lynn, Mass.
Madison	L. J. Peters	L. C. Larson, Dept. of Elec. Engg., University of Wisconsin, Madison, Wisconsin
Mexico	P. M. McCullough	F. Aubert, 2 A de Queretaro 22, Mexico City, Mexico
Milwaukee	E. R. Stoekle	R. R. Knoerr, Engr., Knoerr & Fischer, 553 Milwaukee St., Milwaukee, Wis.
Minnesota	M. E. Todd	V. E. Engquist, Northern States Pr. Co., Rice & Atwater Streets, St. Paul, Minn.
Nebraska	C. D. Robison	L. F. Wood, Room 1319, Telephone Bldg., Omaha, Neb.
New York	R. H. Tapscott	H. S. Sheppard, Dept. of Dev. & Research, Amer. Tel. & Tel. Co., 195 Broadway, New York, N. Y.
Niagara Frontier	G. H. Calkins	E. P. Harder, Buffalo General Electric Co., 205 Electric Bldg., Buffalo, N. Y.
North Carolina	E. P. Coles	M. E. Lake, Duke Power Co., Power Bldg., Charlotte, N. C.
Oklahoma	C. V. Bullen	C. T. Almquist, Dept. of Elec. Engg., Univ. of Oklahoma, Norman, Okla.
Panama		
Philadelphia	L. F. Deming	R. H. Silbert, Philadelphia Electric Co., 2301 Market St., Philadelphia, Pa.
Pittsburgh	H. E. Dyche	J. A. Cadwallader, The Bell Telephone Co. of Pa., 416 7th Ave., Pittsburgh, Pa.
Pittsfield	J. R. Rue	V. M. Montsinger, General Electric Co., Pittsfield, Mass.
Portland, Ore.	L. M. Moyer	H. H. Cake, Pacific State Elec. Co., 5th and Davis Streets, Portland, Ore.
Providence	A. E. Watson	F. W. Smith, Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Rochester	H. E. Gordon	C. F. Estwick, c/o General Railway Signal Co., Rochester, N. Y.
St. Louis	C. P. Potter	E. G. McLagan, 2188 Railway Exchange Bldg., St. Louis, Mo.
San Francisco	B. D. Dexter	A. G. Jones, General Electric Co., 804 Russ Bldg., San Francisco, Calif.
Saskatchewan	E. W. Bull	S. R. Parker, 2400 Montague St., Regina, Sask., Canada
Schenectady	E. S. Lee	E. E. Johnson, Room 435, Bldg. No. 2, General Electric Co., Schenectady, N. Y.
Seattle	C. R. Wallis	Ray Rader, Puget Sound Pr. & Lt. Co., Seattle, Wash.
Sharon	H. B. West	J. B. Gibbs, Westinghouse Electric & Mfg. Co., Sharon, Pa.
Southern Virginia	H. C. Leonard	Cecil Gray, Westinghouse Electric & Mfg. Co., Richmond, Va.
Spokane	Bernhard Olsen	H. L. Vincent, General Electric Co., 402 Paulsen Bldg., Spokane, Wash.
Springfield, Mass.	J. F. Murray	B. V. K. French, Am. Bosch Magneto Corp., Springfield, Mass.
Syracuse	W. R. McCann	F. E. Verdin, 1206 Hills Bldg., Syracuse, N. Y.
Toledo	W. T. Lowery	Max Neuber, 1257 Fernwood Ave., Toledo, Ohio
Toronto	E. M. Wood	W. F. Sutherland, Toronto Hydro Elec. System, 225 Yonge St., Toronto, Ont., Canada
Urbana	J. K. Tuthill	M. A. Faucett, University of Illinois, 301-A Elec. Engg. Laboratory, Urbana, Ill.
Utah	C. B. Shipp	A. C. Kelm, 133 So. West Temple, St., Salt Lake City, Utah
Vancouver	C. W. Colvin	J. Teasdale, British Columbia Elec. Railway Co., Vancouver, B. C., Canada
Washington	L. D. Bliss	R.W.Cushing, Federal Pr. Comm., Interior Bldg., 18th & F Sts., N. W., Washington, D. C.
Worcester	A. F. Snow	F. B. Crosby, Morgan Const. Co., 15 Belmont St., Worcester, Mass.

Total 55.

LIST OF BRANCHES

Name and Location	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Municipal University of, Akron, Ohio	C. D. Tinley	G. E. Burkholder	J. T. Walther
Alabama Polytechnic Institute, Auburn, Ala		O. T. Allen	W. W. Hill
Alabama, University of, University, Ala			
Arizona, University of, Tucson, Ariz	J. H. Hopper	Wm. Tremaine	J. C. Clark
Arkansas, University of, Fayetteville, Ark	T. E. Peter	B. H. Dorman	W. B. Stelzner
Armour Institute of Technology, 3300 Federal St., Chicago, Ill	C. J. McDonald	J. E. Wack	D. P. Moreton
Brooklyn Polytechnic Institute, 99 Livingston St., Brooklyn, N. Y.	H. F. Steen	F. J. Mullen	Robin Beach
Bucknell University, Lewisburg, Pa	R. E. Snauffer	J. E. Bridegum	W. K. Rhodes
California Institute of Technology, Pasadena, Calif	G. R. Crane	A. W. Dunn	R. W. Sorensen
California, University of, Berkeley, Calif	C. E. Cherry	L. G. Levoy, Jr.	T. C. McFarland
Carnegie Institute of Technology, Pittsburgh, Pa	G. M. Cooper	J. H. Ferrick	B. C. Dennison
Case School of Applied Science, Cleveland, Ohio	W. A. Thomas	J. O. Herbster	H. B. Dates
Catholic University of America, Washington, D. C.			T. J. MacKavanaugh
Cincinnati, University of, Cincinnati, Ohio	C. E. Young	W. C. Osterbrock	W. C. Osterbrock
Clarkson College of Technology, Potsdam, N. Y.	D. R. Carpenter	C. H. Joy	A. R. Powers
Clemson Agricultural College, Clemson College, S. C.	Laird Anderson	J. F. Callahan	S. R. Rhodes
Colorado State Agricultural College, Fort Collins, Colo	G. W. Mitchel	P. H. Lindon	H. G. Jordan
Colorado, University of, Boulder, Colo	H. R. Arnold	E. E. Stoeckly	W. C. DuVall
Cooper Union, New York, N. Y.	Wilfred Henschel	H. H. Reuter	N. L. Towle
Cornell University, Ithaca, N. Y.	R. S. Milans	J. D. Russell	H. H. Race
Denver, University of, Denver, Colo	J. N. Petrie	D. S. Cooper	R. E. Nyswander
Detroit, University of, Detroit, Mich	E. T. Faur	Wm. F. Haldeman	H. O. Warner
Drexel Institute, Philadelphia, Pa	D. M. Way	C. W. Kenyon	E. O. Lange
Duke University, Durham, N. C.	W. E. Cranford	C. W. Berglund, Jr.	W. J. Seeley
Florida, University of, Gainesville, Fla	J. W. McKay	A. L. Webb	J. M. Weil
Georgia School of Technology, Atlanta, Ga	E. M. Burn	K. W. Mowry	T. W. Fitzgerald
Idaho, University of, Moscow, Idaho	O. C. Mayer	F. E. Dicus, Jr.	J. H. Johnson
Iowa State College, Ames, Iowa	R. R. Law	C. E. Rohrig	F. A. Fish
Iowa, State University of, Iowa City, Iowa	Drew MacDougal		
Kansas State College, Manhattan, Kansas	B. L. Remick	A. W. Broady	R. G. Kloeffler
Kansas, University of, Lawrence, Kans	Norvel Douglas		G. C. Shaad
Kentucky, University of, Lexington, Ky	C. W. Daniel	L. L. Massie	W. E. Freeman
Lafayette College, Easton, Pa	H. W. Lovett	C. W. Zook	Morland King
Lehigh University, Bethlehem, Pa	B. O. Steinert	J. E. Zeaser	J. L. Beaver
Lewis Institute, Chicago, Ill	A. Gaimari	Leo Weinshank	F. A. Rogers
Louisiana State University, Baton Rouge, La	J. C. Bice	J. J. Bridges, Jr.	M. B. Voorhies
Louisville, University of, Louisville, Ky	Samuel Evans	J. S. Overstreet	D. C. Jackson, Jr.
Maine, University of, Orono, Maine	A. V. Smith	G. A. Whittier	W. E. Barrows, Jr.
Marquette University, 1200 Sycamore St., Milwaukee, Wis	P. C. Neumann	W. E. Schmitz	J. F. H. Douglas
Massachusetts Institute of Technology, Cambridge, Mass	R. M. Durrett	F. O. Urban	W. H. Timbie
Michigan State College, East Lansing, Mich	M. H. Blivin	W. G. Keck	M. M. Cory

LIST OF BRANCHES—*Continued.*

Name and Location	Chairman	Secretary	Counselor (Member of Faculty)
Michigan, University of, Ann Arbor, Mich	W. R. Hough	H. L. Scofield	B. F. Bailey
Milwaukee, School of Engineering of, 163 East Wells St., Milwaukee, Wis	G. E. Henkel	T. J. Coleman, Jr.	J. D. Ball
Minnesota, University of, Minneapolis, Minn	C. L. Elliott	C. J. Johnston	J. H. Kuhlmann
Mississippi Agricultural & Mechanical College, A. & M. College, Miss	R. S. Kersh	L. L. Stokes	L. L. Patterson
Missouri School of Mines & Metallurgy, Rolla, Mo	F. B. Beatty	E. J. Gregory	I. H. Lovett
Missouri, University of, Columbia, Mo	G. L. Crow	C. B. Holt	M. P. Weinbach
Montana State College, Bozeman, Mont	J. M. Fjeld	G. E. West	J. A. Thaler
Nebraska, University of, Lincoln, Neb	D. E. Schneider	H. G. Wiltse	F. W. Norris
Nevada, University of, Reno, Nevada	Alden McCullom	A. B. Chace	S. G. Palmer
Newark College of Engineering, 367 High St., Newark, New Jersey	C. P. Hurd	W. R. Ackor	J. C. Peet
New Hampshire, University of, Durham, N. H	Philip Nudd	Danforth Googins	L. W. Hitchcock
New York, College of the City of, 139th St., & Convent Ave., New York, N. Y	Daniel Klatzko	Walter Broleen	Harry Baum
New York University, University Heights, New York, N. Y	G. A. Taylor	A. W. Schneider	J. L. Arnold
North Carolina State College, Raleigh, N. C	O. M. Carpenter	W. E. Moseley	R. S. Fouraker
North Carolina, University of, Chapel Hill, N. C	W. B. Sharp	E. T. Gross, Jr.	P. H. Daggett
North Dakota, University of, University Station, Grand Forks, N. D	R. W. Olson	G. E. Glass	D. R. Jenkins
Northeastern University, 316 Huntington Ave., Boston 17, Mass	R. W. Cleveland	H. F. Wilder	W. L. Smith
Notre Dame, University of, Notre Dame, Ind	J. J. Donahue	F. J. Weiss	J. A. Caparo
Ohio Northern University, Ada, Ohio	J. D. McGahan	R. I. Hartshorn	I. S. Campbell
Ohio State University, Columbus, O	W. M. Webster		F. C. Caldwell
Ohio University, Athens, O	Clarke Kenney	H. W. Giesecke	A. A. Atkinson
Oklahoma A. & M. College, Stillwater, Okla	E. L. Weathers	H. E. Bradford	Edwin Kurtz
Oklahoma, University of, Norman, Okla	C. K. Ittner	Le Roy Moffet, Jr.	F. G. Tappan
Oregon State College, Corvallis, Ore	Harry Loggan	A. W. Swingle	F. O. McMillan
Pennsylvania State College, State College, Pa	H. W. Bair	J. F. Houldin	L. A. Doggett
Pennsylvania, University of, Philadelphia, Pa	T. E. Manning	H. W. Brown, Jr.	C. D. Fawcett
Pittsburgh, University of, Pittsburgh, Pa	J. B. Luck	J. G. Hoop	H. E. Dyche
Princeton University, Princeton, N. J	W. V. G. Eakins	C. F. Nesslage	Malcolm MacLaren
Purdue University, Lafayette, Indiana	J. F. Nuner	P. C. Sandretto	A. N. Topping
Rensselaer Polytechnic Institute, Troy, N. Y	S. E. Benson	David Younger	F. M. Sebast
Rhode Island State College, Kingston, R. I	F. E. Caulfield	A. Z. Smith	Wm. Anderson
Rose Polytechnic Institute, Terre Haute, Ind	R. H. Dowen	G. P. Brosman	C. C. Knipmeyer
Rutgers University, New Brunswick, N. J	John Cost	H. M. Hobson	P. S. Creager
Santa Clara, University of, Santa Clara, Calif	T. L. Selna	J. D. Gillis	L. J. Neuman
South Carolina, University of, Columbia, S. C	W. E. Eargle	L. A. Griffith	T. F. Ball
South Dakota State School of Mines, Rapid City, S. D	H. E. Sattler	Vern Hagmann	J. O. Kammerman
South Dakota, University of, Vermillion, S. D	Enar Johnson	E. E. Lovejoy	B. B. Brackett
Southern California, University of, Los Angeles, Calif		W. E. Woodruff	P. S. Biegler
Stanford University, Stanford University, Calif	N. R. Morgan	W. G. Snyder	T. H. Morgan
Stevens Institute of Technology, Hoboken, N. J	F. C. Gilman	George Habach	F. C. Stockwell
Swarthmore College, Swarthmore, Pa	D. B Spangler	B. C. Algeo	Lewis Fussell
Syracuse University, Syracuse, N. Y	F. C. Casavant	J. H. Behm	C. W. Henderson
Tennessee, University of, Knoxville, Tenn	O. D. Fleming	E. E. Moyers	C. A. Perkins
Texas, A. & M. College of, College Station, Texas		H. L. Willke	H. C. Dillingham
Texas, University of, Austin, Texas	L. R. Bagwell	C. L. Jeffers	J. A. Correll
Utah, University of, Salt Lake City, Utah	N. M. Chapman	Garnett Littlefield	J. H. Hamilton
Vermont, University of, Burlington, Vt	F. L. Sulloway	L. G. Cowles	L. P. Dickinson
Virginia Military Institute, Lexington, Va	Lomax Gwathmey	R. A. Wright	S. W. Anderson
Virginia Polytechnic Institute, Blacksburg, Va	J. L. Rothgeb	Labon Backer	Claudius Lee
Virginia, University of, University, Va	C. E. McMurdo	L. R. Quarles	W. S. Rodman
Washington, State College of, Pullman, Wash	W. L. Webb	V. E. Enz	R. D. Sloan
Washington University, St. Louis, Mo	H. J. Miller	W. L. Knaus	H. G. Hake
Washington, University of, Seattle, Wash	C. W. Huffine	R. C. Leithead	G. L. Hoard
Washington and Lee University, Lexington, Va			R. W. Dickey
West Virginia University, Morgantown, W. Va	C. C. Coulter	C. B. Seibert	A. H. Forman
Wisconsin, University of, Madison, Wis	Eugene Odbert	A. L. Sweet	C. M. Jansky
Worcester Polytechnic Institute, Worcester, Mass	E. C. Wilde		E. W. Starr
Wyoming, University of, Laramie, Wyoming	E. C. Moudy		G. H. Sechrist
Yale University, New Haven, Conn	R. W. Miner	J. R. Sutherland	C. F. Scott
Total 100			

AFFILIATED STUDENT SOCIETY

Brown Engineering Society, Brown University, Providence, R. I	B. A. Church, Jr.	H. S. Sizer

ORDER FORM FOR REPRINTS OF PAPERS ABRIDGED IN THE JOURNAL*

(June 1929) Number	Author	Title
☐ 29-18	F. T. Hague and G. W. Penney	Influence of Temperature on Large Commutator Operation
☐ 29-62	E. J. Burnham, J. R. North and I. R. Dohr	Quick-Response Generator Voltage Regulator
☐ 29-76	W. W. Edson	Automatic Transformer Substations
☐ 29-77	R. C. McCurdy and P. W. Blye	Electrical Wave Analyzers for Power and Telephone Systems
☐ 29-78	E. H. Salter	Guarding and Shielding for Dielectric Loss
☐ 29-83	F. B. Silsbee	Precautions Against Stray-Field Errors in Measurements
☐ 29-84	C. L. Dawes, F. L. Hoover and H. H. Reichard	Some Problems in Dielectric Loss Measurments
☐ 29-85	H. L. Curtis	Shielding and Guarding Electrical Apparatus

*Members, Enrolled Students, and JOURNAL subscribers are entitled to one complete copy of each paper free of charge; additional copies, at 25 cents each.

Name...

Address...

Please order reprints by number. *Address* **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Choke Coils and Fuse Mountings.—Bulletin 'F" describes a new line of outdoor reinforced choke coils, fuse mountings and combined choke coils and fuse mountings. The Champion Switch Company, Kenova, West Va.

Motor Starter.—Bulletin 482, 4 pp. Describes Condit Type A-30 air motor starter, made in capacities of 20 horsepower or less. Condit Electrical Manufacturing Corporation, Boston, Mass.

Automatic Stations.—Bulletin GEA-90D, 32 pp. Describes G-E automatic installations to January 1, 1929. General Electric Company, Schenectady, N. Y.

Low-Voltage A-C. Networks.—GED—265, 44 pp. This publication is a reprint of articles on the subject of low-voltage a-c. networks by D. K. Blake appearing in 1928 and 1929 issues of *General Electric Review*. General Electric Company, Schenectady, N. Y.

Pyrometers.—Supplement 400-1, 4 pp. Describes type FD pyrometer outfits consisting of a 4 in. instrument, a thermocouple and leads. The device is used on typecasting machines to determine the temperature of the metal. The Roller-Smith Company, 12 Park Place, New York.

Arc Welding.—The Lincoln Electric Company, Cleveland, Ohio, has issued twice each month supplement sheets on various phases of the application of welding as applied to the manufacturing of machinery and equipment. A new monthly issue is devoted to "Studies in Structural Welding" showing the latest application of welding to structural work.

Deion Circuit Breakers.—S. P. 1836, 50 pp., entitled The New Deion Circuit Breakers. This publication consists of a series of A. I. E. E. papers, together with *Electrical World* and *Electric Journal* articles which have been published recently covering the theory and development of the deion circuit breaker and field tests which have been applied to it. An A. I. E. E. paper presented at the summer convention in June 1928 on Extinction of an A. C. Arc by Dr. J. Slepian, inventor of the deion breaker, is also included. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electric Controls.—Catalog 29. A publication of several hundred pages devoted to "Bull Dog" electric controls, including safety switches, knife switches, light and power panelboards and cabinets, metering panelboards and cabinets, and safety switchboards. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit, Mich.

Transformer Performance.—Bulletin 164, 12 pp. Discusses the losses which occur in distribution and power transformers, the method of making tests on transformers to determine their acceptability and the calculations of operating characteristics from the test data. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis, Mo.

NOTES OF THE INDUSTRY

The Champion Switch Company, Kenova, West Va., has appointed George L. Carlisle vice-president and general manager. Mr. Carlisle has had wide experience in the public utility field, having spent nine years with the West Penn Power Company. Prior to that connection he was engaged in consulting engineering work, principally in connection with mining developments.

First Double-Deck Compound Turbine-Generators.—Several unusual or new features will be incorporated in two steam turbine generators which are to be added to the generating facilities of the Pacific Gas and Electric Company, San Francisco. The two machines, of General Electric manufacture, each rated at 50,000 kilowatts, will be the first of the new "double-deck compound" type, will be the first high-pressure turbines on the Pacific Coast, and will be fueled with natural gas piped from a source 240 miles away.

Illinois Electric Porcelain Appoints J. W. Ward.—The Illinois Electric Porcelain Company, Macomb, Illinois, announces that J. W. Ward, for the past six years general superintendent of the Porcelain Insulator Corporation, Lima, N. Y., and previously in the same capacity with the Westinghouse plant at Derry, Pa., is now associated with its organization and will give the Illinois Company the benefit of his long experience in the manufacture of high-tension insulators.

Solderless Connector.—The Penn-Union Electric Corporation, Erie, Penn., is manufacturing a solderless connector with a locking action, which holds tight permanently, for use on high-tension lines. In the use of the connector a lock-nut is turned onto the yoke, a split wedge-shaped sleeve forces the body of the connector tightly against the main conductor. At the same time the sleeve clamps tighter to the branch, equalizing the pressure on the main and branch conductors. The conductors are made in a complete line and a variety of types are carried in stock for prompt delivery in combinations and sizes for every electrical requirement.

New Oil Circuit Breakers by Delta-Star.—The Delta-Star Electric Company, Chicago, has announced a new line of outdoor oil circuit-breakers in voltages from 37 kv. to 73 kv. inclusive. Reliability and ruggedness to withstand repeated punishment has been the key-note throughout the entire design. They are of the double gas isolated type with special oil retractors to prevent oil throw. Among the noteworthy points are high flashover, bushings of the oil or compound type, multiple ratio current transformers, hot dipped galvanized support frames, gas and oil proof terminal blocks, and a closing mechanism of the trip free any position type.

A thorough oscillographic study given to the relief of dynamic stresses of the moving parts, resulted in a breaker having a maximum contact velocity with minimum dynamic stresses, and with safety factors for these moving mechanical parts far in excess of that generally considered satisfactory. Special steel alloys having shock resisting and fatigue qualities are used throughout.

Allis-Chalmers Receives Large Orders.—Contracts have been placed with the Allis-Chalmers Manufacturing Company covering equipment for the extension of the Waukegan Generating Station of the Public Service Company of Northern Illinois, Sargent & Lundy, Incorporated, Engineers, including a 65,000 kw. tandem steam turbine unit with condenser, circulating water and condensate pumps. This is the fourth unit for this station. The first was rated 25,000 kw. and was installed in 1923. A 35,000 kw. unit was installed in 1925 and a 50,000 kw. in 1927, all of the Allis-Chalmers make. Unit No. 4 will be rated 65,000 kw. tandem compound with one generator and will be similar to the 50,000 kw. unit No. 3 except it will be arranged for boiler reheat. The operating conditions are 600 lbs. steam pressure, 725° F. total steam temperature and 29 in. vacuum referred. The electrical end is 60 cycle, 3 phase, 12,000 volts, and includes a 250 volt direct connected exciter.

An order has also been received from the Milwaukee Electric Railway & Light Company for a steam turbine unit to be installed in the Lakeside Power Station. This unit is rated 60,000 kw. and will be of the straight reaction, single-cylinder, single-generator type with direct connected exciter. The turbine is designed for a normal operating steam pressure of 290 lb. gauge and a temperature of 700° F. The electrical characteristics of the unit are 13,800 volts, 60 cycles, 3 phase, and exciter has a capacity of 200 kw. The unit will operate at 1800 rev. per min.


KERITE
In 1752 Franklin invented the Lightning Conductor and identified lightning and electricity. A century later, Day invented
KERITE
Over half a century of experience has identified it as the most reliable and permanent insulation for Electrical Conductors
DAYS KERITE
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO SAN FRANCISCO

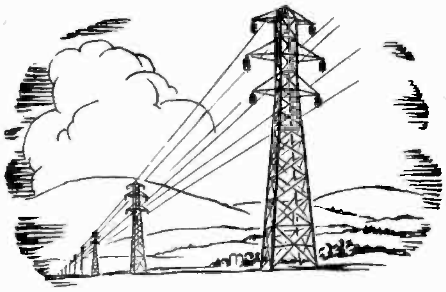
THE MINERALLAC STATISCOPE

Why take a chance?

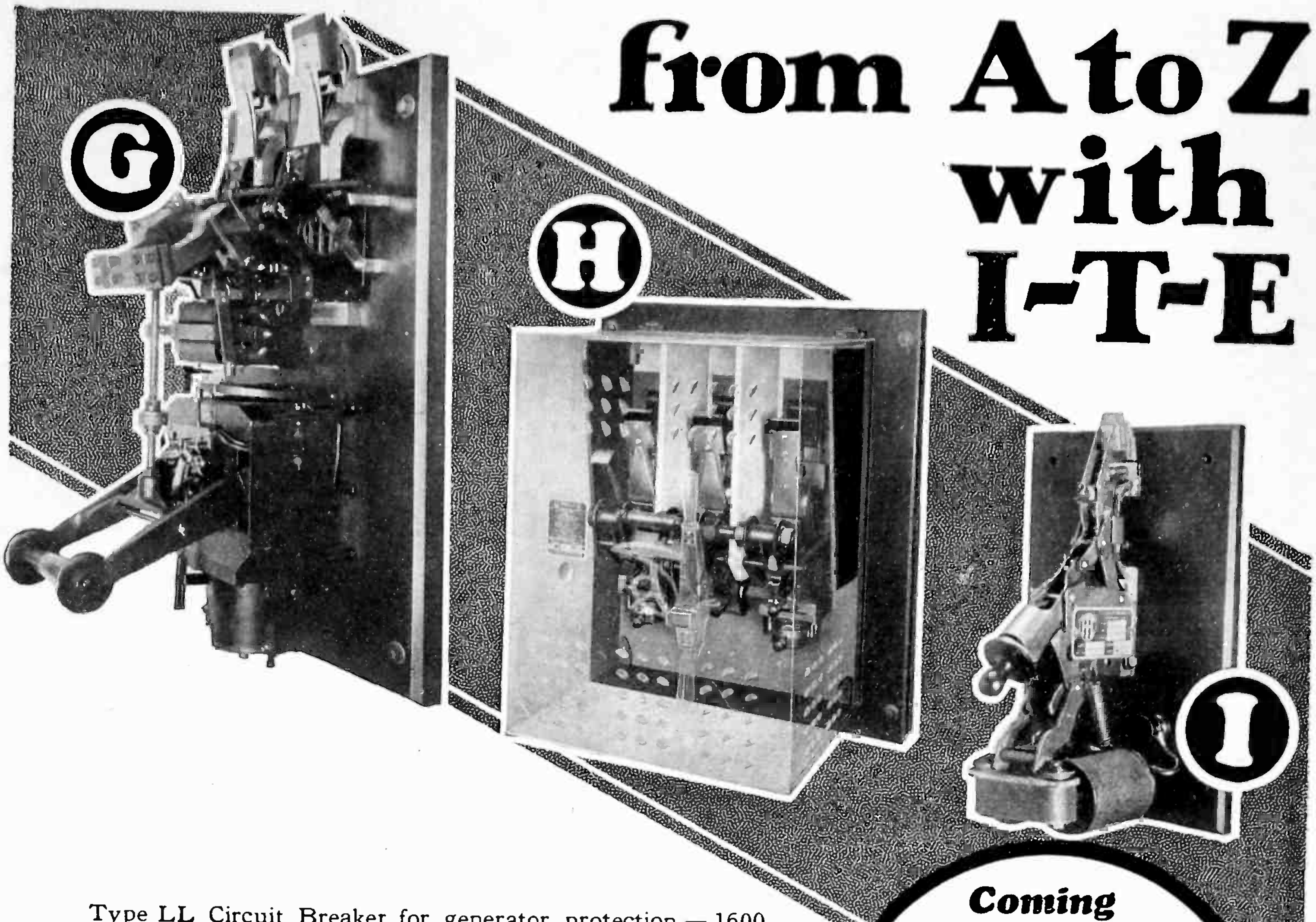
Use the Statiscope
and be safe

Detects
A. C. Voltage

MINERALLAC ELECTRIC COMPANY
25 North Peoria Street
CHICAGO, ILL.



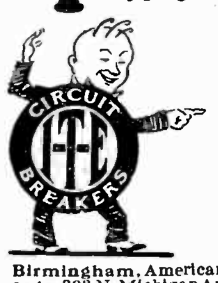
from A to Z with I-T-E



G Type LL Circuit Breaker for generator protection — 1600 amperes at 250 volts D.C.—field discharge clips mechanically operated by breaker, clips close just before breaker opens and open as breaker closes — direct acting reverse current protection—solenoid or hand operation.

H Auto U-Re-Lite LL — 1600 amperes at 550 volts A. C. — 3 pole — two direct acting overload coils with time limit (Dalite) — non-closable against overload or short circuit (Autoite)—closed or opened manually with full safety to operators—rupturing capacity 40,000 amperes at 440 volts A. C.

I Type J Circuit Breaker—10 amperes at 110 volts A.C.—single pole—direct acting under-voltage or no-voltage protection.



"Folks, you ain't seen nothin' yet! (Apologies to Mr. Jolson.) There's just the breaker you need in the I-T-E line—or we'll make it for you. What'll it be?"

★ ★ ★

I-T-E CIRCUIT BREAKER COMPANY
19th and HAMILTON STS., PHILADELPHIA

Birmingham, American-Traders Bank Building; **Boston**, 201 Devonshire; **Buffalo**, Ellicott Sq. Bldg.; **Chicago**, 333 N. Michigan Ave.; **Cincinnati**, Union Trust Bldg.; **Cleveland**, 439 Terminal Tower Bldg.; **Dallas**, 1810 Allen Bldg.; **Denver**, Tramway Bldg.; **Detroit**, Penobscot Bldg.; **Duluth**, 611 Providence Bldg.; **Kansas City**, Midland Bldg.; **Los Angeles**, 106 W. 3rd; **Minneapolis**, Plymouth Bldg; **Montreal**, P. Q., 35 Notre Dame St. West; **New Orleans**, Hibernia Bank Bldg.; **New York**, 12 E. 41st St.; **Omaha**, Electric Bldg.; **Philadelphia**, 1505 Race St.; **Pittsburgh**, Park Bldg.; **St. Louis**, Bank of Commerce Bldg.; **San Francisco**, Russ Bldg.; **Seattle**, 802 33rd Ave.; **Toronto**, 149 Adelaide Street East; **Tulsa**, **Oklahoma**, 1165 N. Elwood Street; **Vancouver**, 500 Beatty Street.

Coming Attractions

J *I-T-E transfer switch* — 7500 amperes at 250 volts D. C. — full automatic switching from normal to emergency power source.

K *Auto U-Re-Lite Senior*—motor operated for remote starting of motors across-the-line — overload protection with time limit (Dalite) — 200 amperes at 550 volts D. C.

L *Type S circuit breaker* — 5 amperes at 110 volts D. C. — single pole—time limit (Dalite) overload protection.

M *Truck type* air circuit breaker switchboard — Cel-I-T-E construction — protecting circuits from 200 to 2500 amperes at 550 volts A. C.

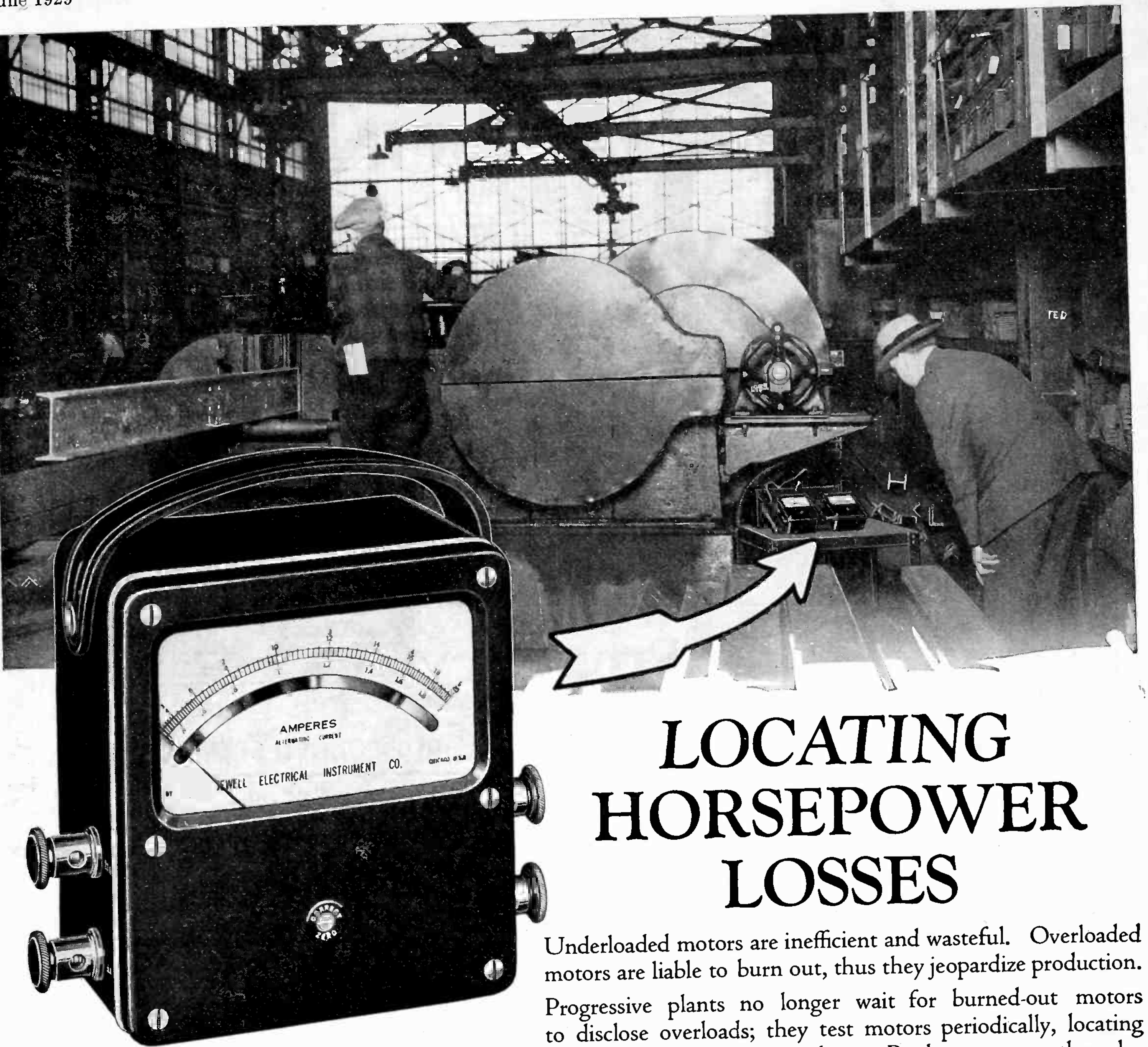
N *I-T-E pneumatic type* electric railway circuit breaker — 4000 amperes at 600 volts D. C. — single pole—operated by compressed air.

O *Type LX circuit breaker* — 600 amperes at 250 volts D. C. — single pole — direct acting overload protection with time limit (Dalite).

For complete information on dependable protection for any circuit up to 750 volts D.C. or 550 volts A.C. write or call our nearest office.

I-T-E PROTECTION

URELITES — I-T-E CIRCUIT BREAKERS



LOCATING HORSEPOWER LOSSES

Underloaded motors are inefficient and wasteful. Overloaded motors are liable to burn out, thus they jeopardize production.

Progressive plants no longer wait for burned-out motors to disclose overloads; they test motors periodically, locating overloads before damage is done. By the same tests they also discover underloaded motors and eliminate their inefficiencies.

Jewell Master Instruments are designed especially for industrial testing. Their convenient size, reliability and low cost make accurate checking of motor loads possible for even the smallest manufacturer.

Jewell Master Instruments comprise a complete line of intermediate size, portable instruments of uniform dimensions for every industrial testing requirement.

Bakelite cases, unusually long scales, large scale openings protected by non-shatterable glass, shielded A. C. movements, are features that reflect the painstaking care used throughout to make Jewell Master Instruments accurate, reliable and durable.

Although remarkably compact in size, for added portability they possess all the refinements necessary to dependable, accurate testing.

Jewell Electrical Instrument Company

1650 Walnut Street -::- Chicago, Illinois

Manufacturers of a complete line of high grade portable and switchboard instruments.

Mail Coupon for Bulletin

Jewell Electrical Instrument Company
1650 Walnut St., Chicago, Illinois

Please send Bulletin No. 2012 describing Jewell Master Instruments.

Name-----------------------------------

Address-----------------------------------

29 YEARS MAKING GOOD INSTRUMENTS

JEWELL

Master Instruments

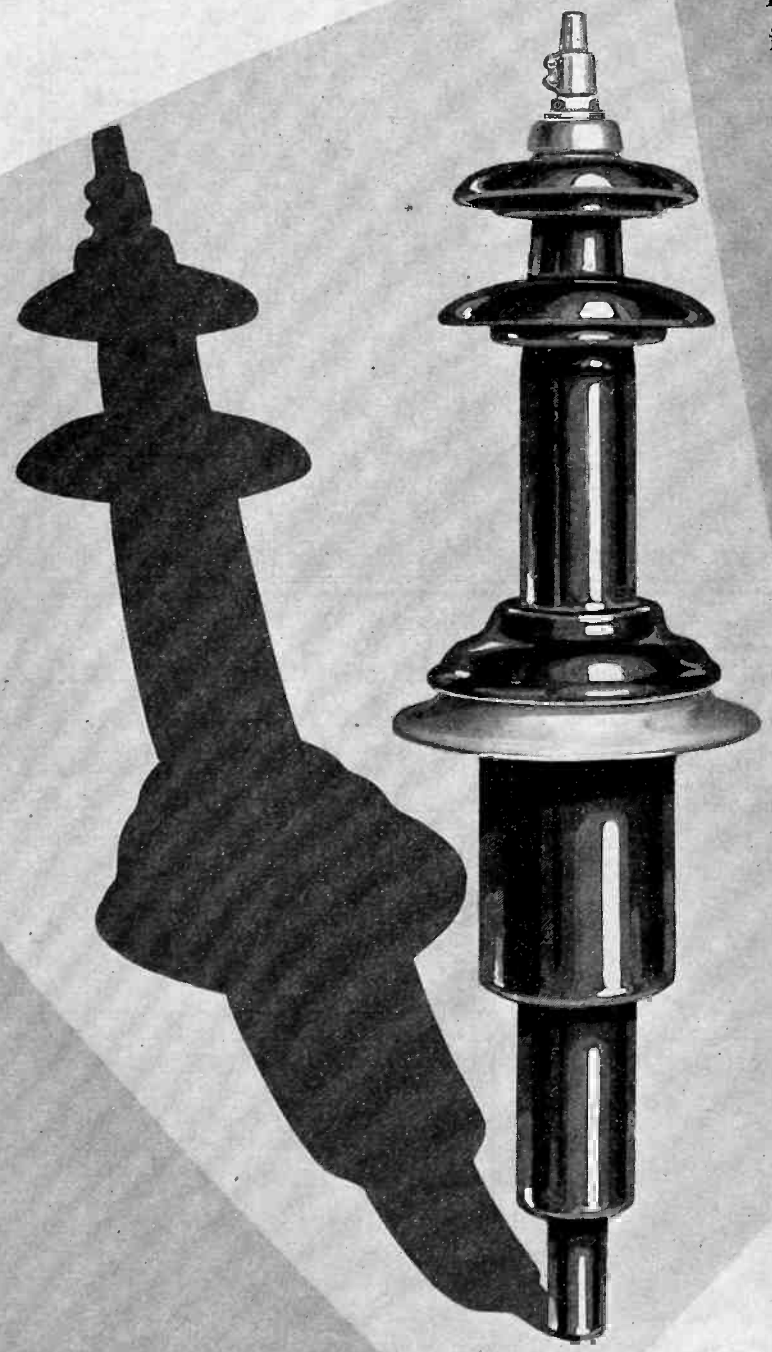
The J. G. White Engineering Corporation

ENGINEERS AND CONSTRUCTORS

43 EXCHANGE PLACE

NEW YORK

BUSHINGS BY O-B



The importance of a *balanced design* in bushings has been most forcefully demonstrated by the outstanding records of O-B Bushings, which, in the face of the most severe type of service to which porcelain is subjected, have delivered maximum efficiency electrically, and at the same time have maintained a high degree of mechanical reliability. That the principle of *balanced design* is fully evaluated and appreciated by the industry is attested to by ever-increasing specification "Bushings by O-B".

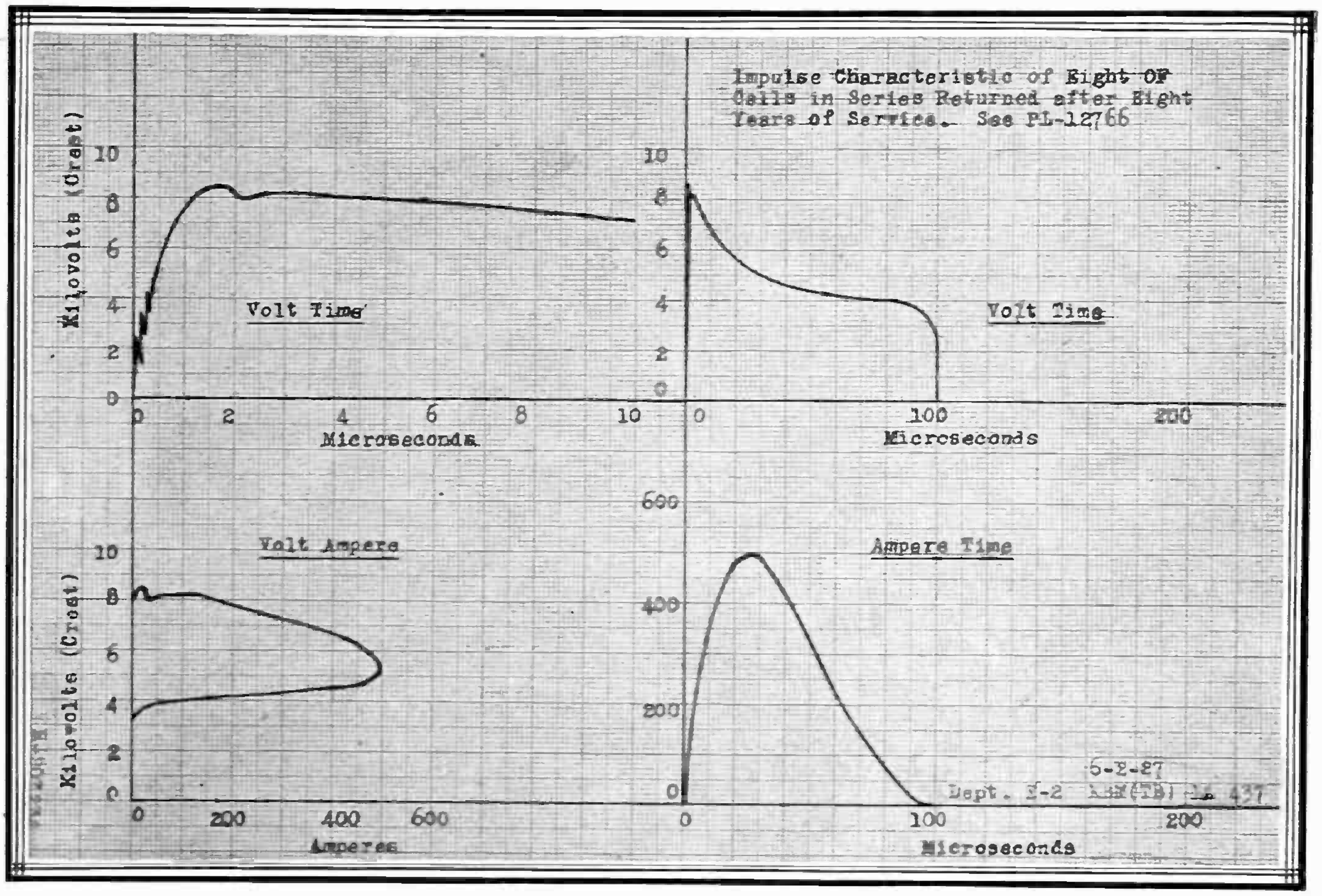
Ohio Brass Company, Mansfield, Ohio
Canadian Ohio Brass Co., Limited
Niagara Falls, Canada
1037H

Ohio Brass Co.

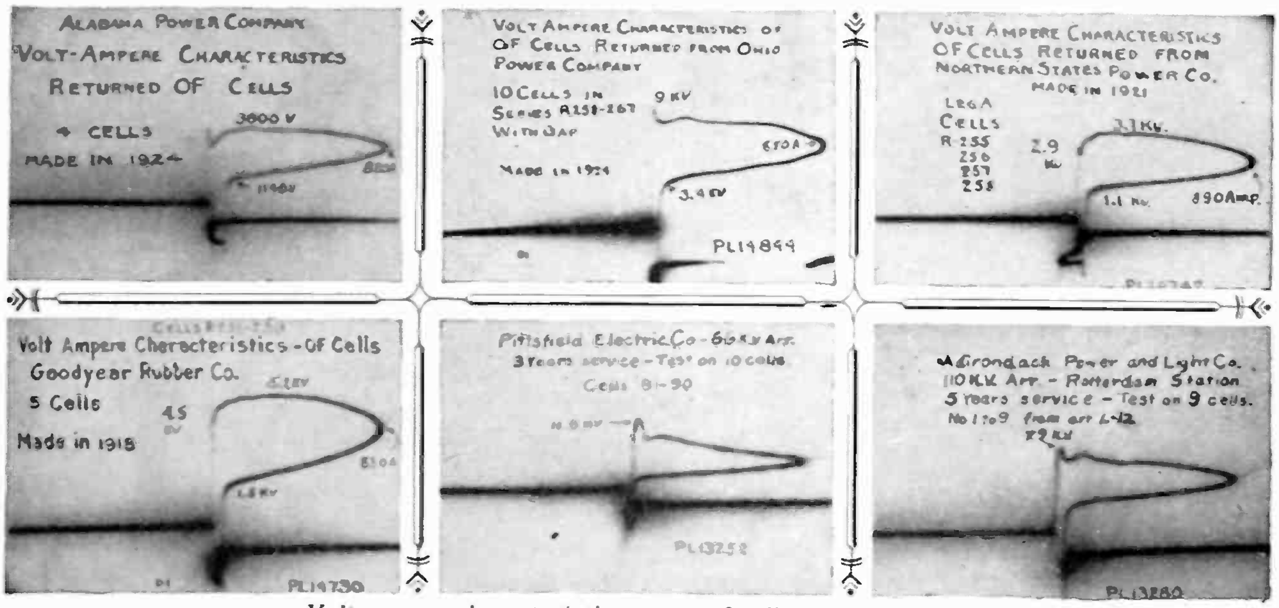
NEW YORK CHICAGO PHILADELPHIA PITTSBURGH BOSTON ATLANTA SAN FRANCISCO CLEVELAND LOS ANGELES

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

Arrester performance is



Typical impulse characteristic curves of oxide-film cells that have been in service eight years



Volt-ampere characteristic curves of cells from oxide-film arresters that have been in service three to ten years

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

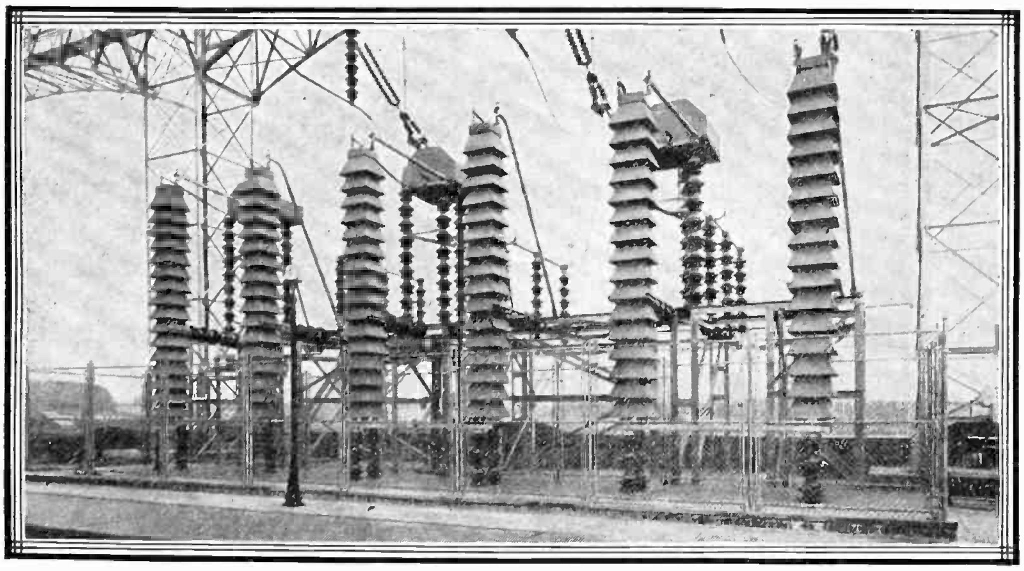
proved by oscillograms

The characteristics of the oxide-film arrester are shown by these cathode-ray oscillograms. Many similar curves prove that oxide-film arresters in service for ten years continue to possess the same high protective qualities.

Thus, the cathode-ray oscillograph has been invaluable in proving the performance of G-E arresters, especially since field data have been obtained by extending its use to the recording of an actual lightning discharge and, more recently, to the study of the effects of known surges on an actual transmission line.

The technique of this oscillograph in arrester research required much original work by engineers of the G-E lightning-arrester laboratory, who, with the same equipment, were also the first to measure artificial surges placed on a commercial high-voltage line.

A complete analysis of cathode-ray oscillograms of oxide-film arresters was given in the *General Electric Review* for May, 1928.



Oxide-film arresters at the hydro-electric station of The Philadelphia Electric Company System, Conowingo, Md. These were the first arresters to operate at 220,000 volts

440-14

GENERAL ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

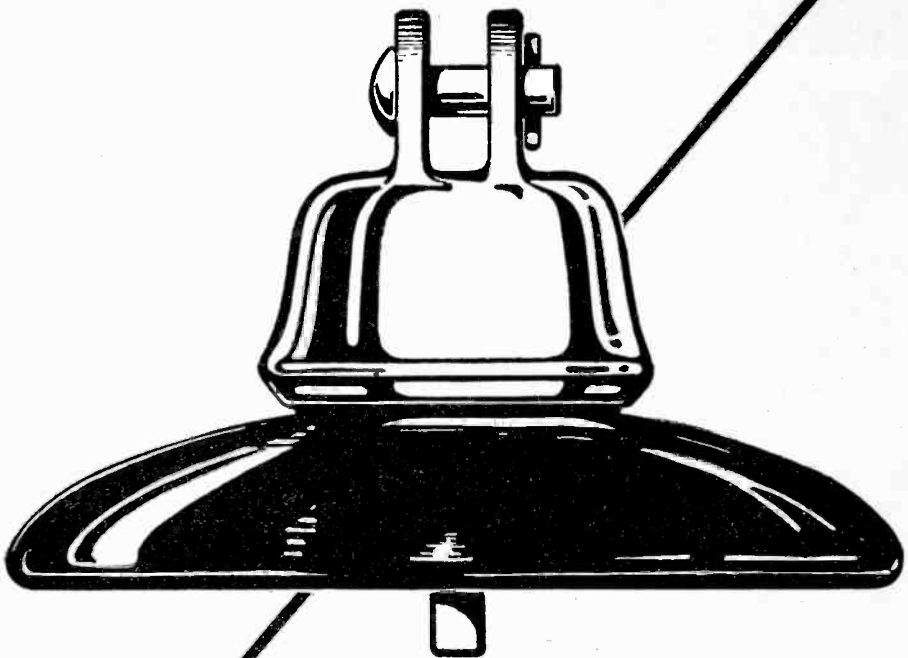
EQUALS ALL NEW ENGLAND'S PLANTS

POWER installations by Stone & Webster Engineering Corporation now exceed four million horse power. They equal the installed capacity of all the power plants in New England—a territory where seven per cent of the country's population is producing ten per cent of the country's manufactured goods.

These plants are located in all parts of the country. They range from small industrial plants to some of the largest steam and hydro central power stations in the country. Many of them are making records for economy in operation.

STONE & WEBSTER ENGINEERING CORPORATION

LOCKE



One operating company alone has almost a million of these insulators—Locke 5800—in active, satisfactory service. Electrically and mechanically they compare favorably with any insulators of the same type. In addition, they are made particularly rugged to stand harder use than the average insulator. This ruggedness means a decided saving of time and money in construction.

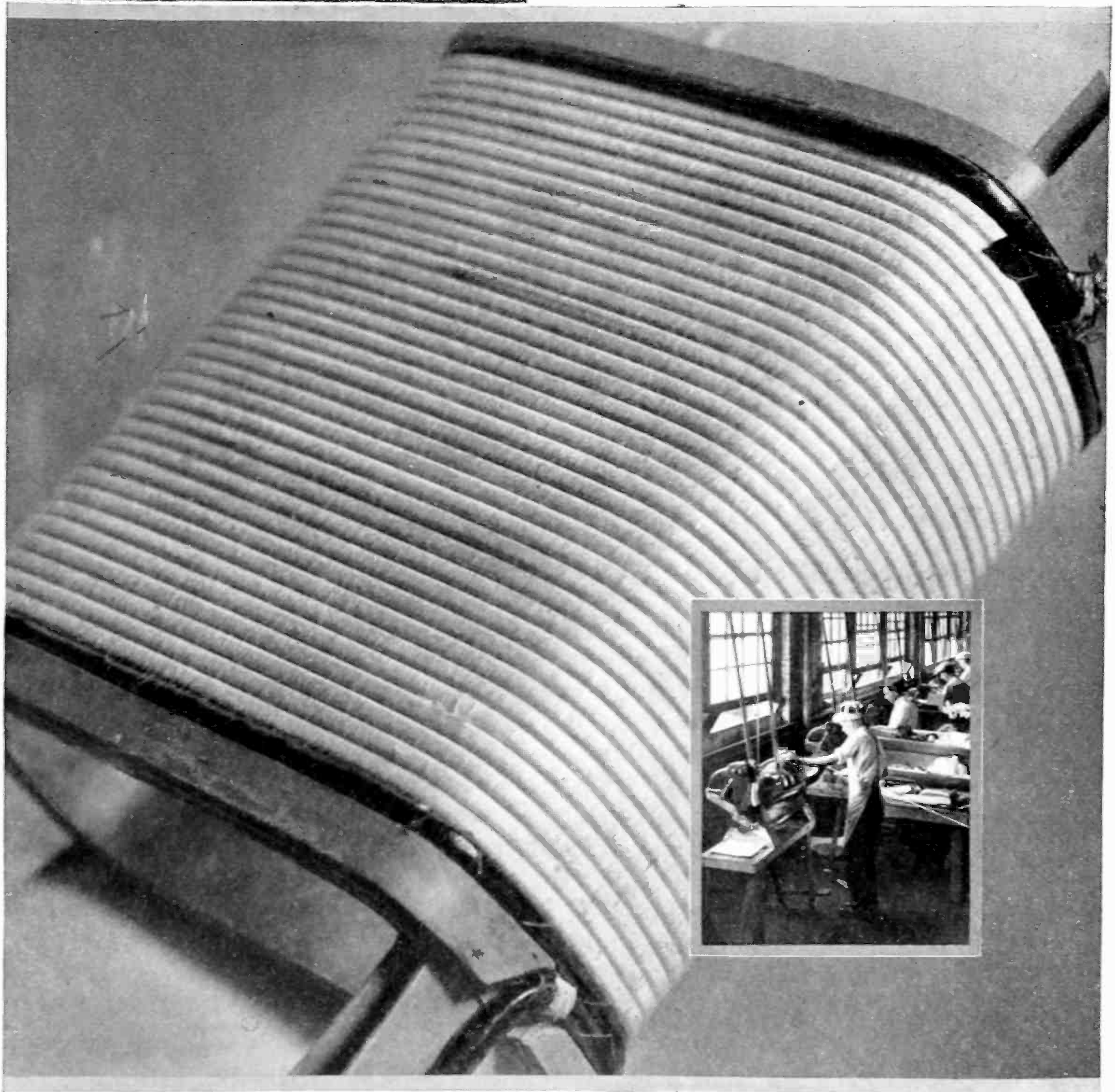
Whenever you need maximum insulator reliability under even the most exacting operating conditions, Locke insulators will more than meet every demand put upon them. Both laboratory tests and operating experience have thoroly endorsed the correctness of design and manufacture.

LOCKE INSULATOR CORPORATION
BALTIMORE MARYLAND

PORCELAIN INSULATORS

Wagner Transformers

Wagner transformer coils are all form wound. Insulating material, equal in thickness to the depth of the layer, is assembled at the ends of each layer, positively locating the winding. All end turns are tied and insulated . . . In no detail is honesty of manufacture so important . . . only craftsmanship and integrity of the workers, plus supervision, will insure proper quality. Wagner details make Wagner . . . Quality.



Write for complete details of Wagner Distribution, Power and Subway Type Transformers.

Literature on Request

WAGNER ELECTRIC CORPORATION
6400 Plymouth Avenue, St. Louis, U. S. A.

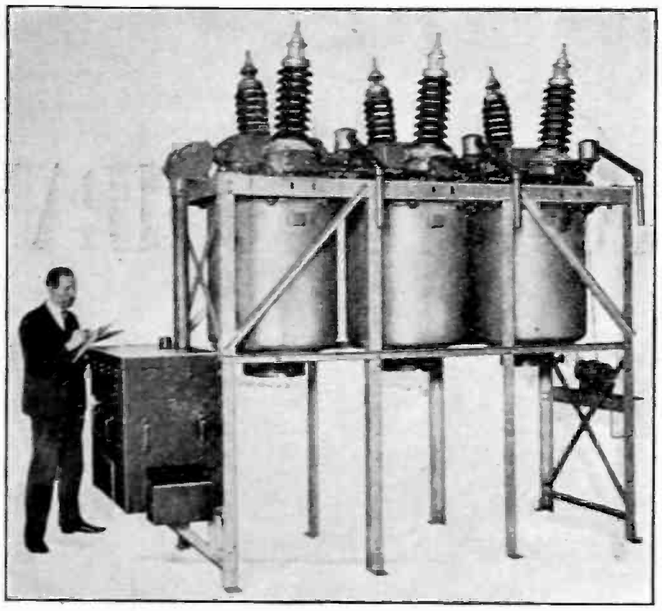
Wagner Sales Offices & Service Stations in 25 Principal Cities

Products: FANS . . . . Desk, Wall and Ceiling
TRANSFORMERS . . . Power, Distribution and Instrument
MOTORS . . . Single-phase, Polyphase and Direct Current

Wagner . . . quality

61-6731-12

OPPORTUNITY IS KNOCKING AT YOUR DOOR



50 K.V. OIL CIRCUIT BREAKER

SPECIALIZATION

The specializing company with its complete freedom to seek the most competent men and the counsel of experienced operating men, will always expand in this essentially plastic and kinetic system of business.

Forms, modes of arrangement and financial set-ups are important, but in this business of constant technical change, no scheme has been devised to dispense with the specialist. We are ready to serve you.

A most striking example of success is the public utility business and one reason for it is the willingness to work with the specialized manufacturer who will do his part in real development.

Far seeing executives realize success is not merely getting ahead in their own field but includes making it possible for the whole industry to be prosperous. Today another opportunity is at your door.

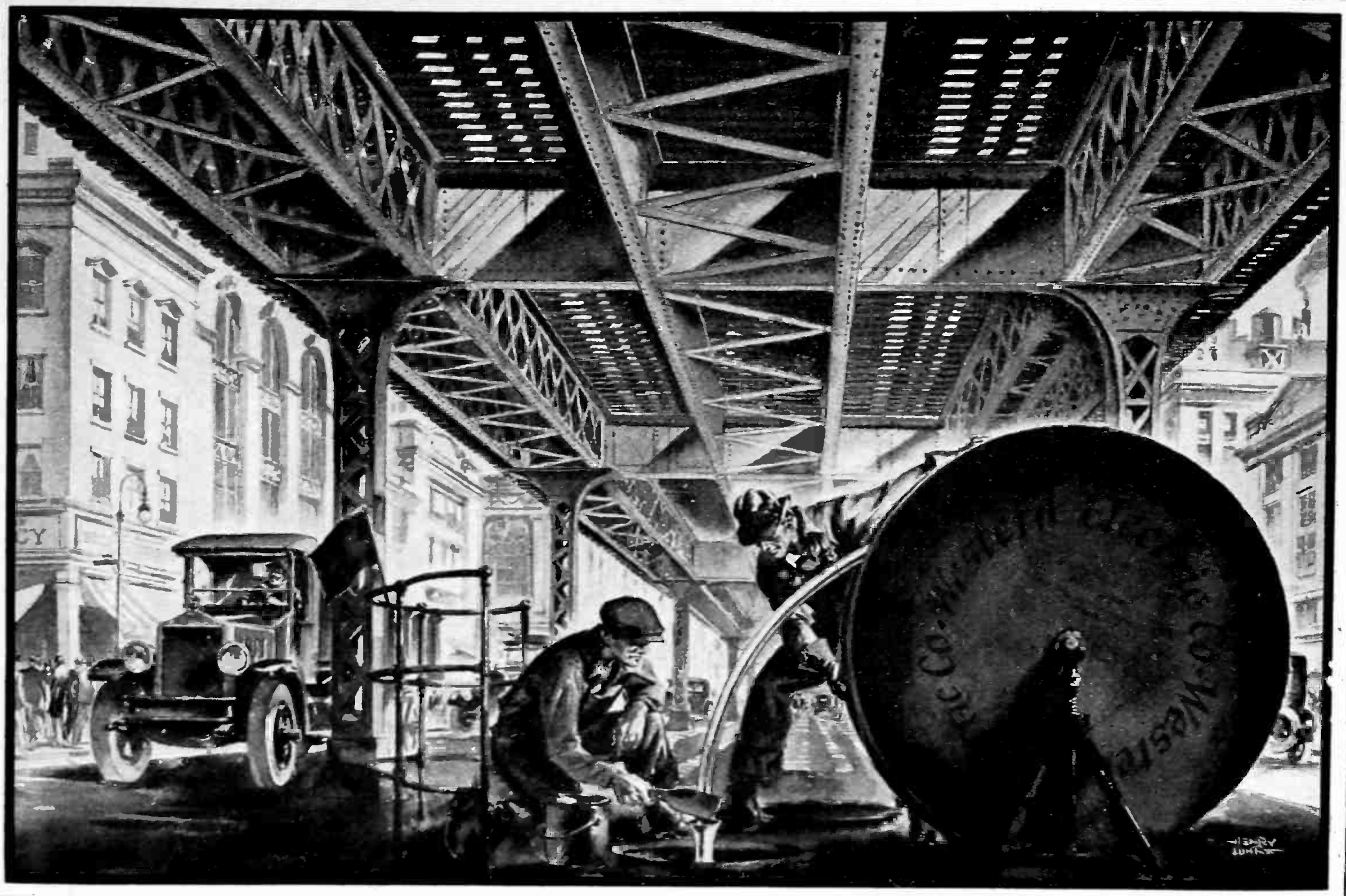
This opportunity is for you to analyze the oil circuit breaker situation just as you have analyzed your own territory in the hope of bringing more power into it and you will need breakers to do it

A most experienced and resourceful organization has entered the oil circuit breaker field. From your own and an industry standpoint, you cannot afford to overlook this new opportunity and new source of supply.

Why not send an engineer to see for himself what we can offer you in quality, price and delivery? Our engineers are ready to welcome yours. Let's make an appointment today.

Way down in your heart is a desire to help the manufacturer help you. Purchasing a few breakers will be in line with the spirit of the successful public utility industry.

H W Young
President



1800 conversations at once through a cable less than 3 inches thick

An Advertisement of the
American Telephone and Telegraph Company

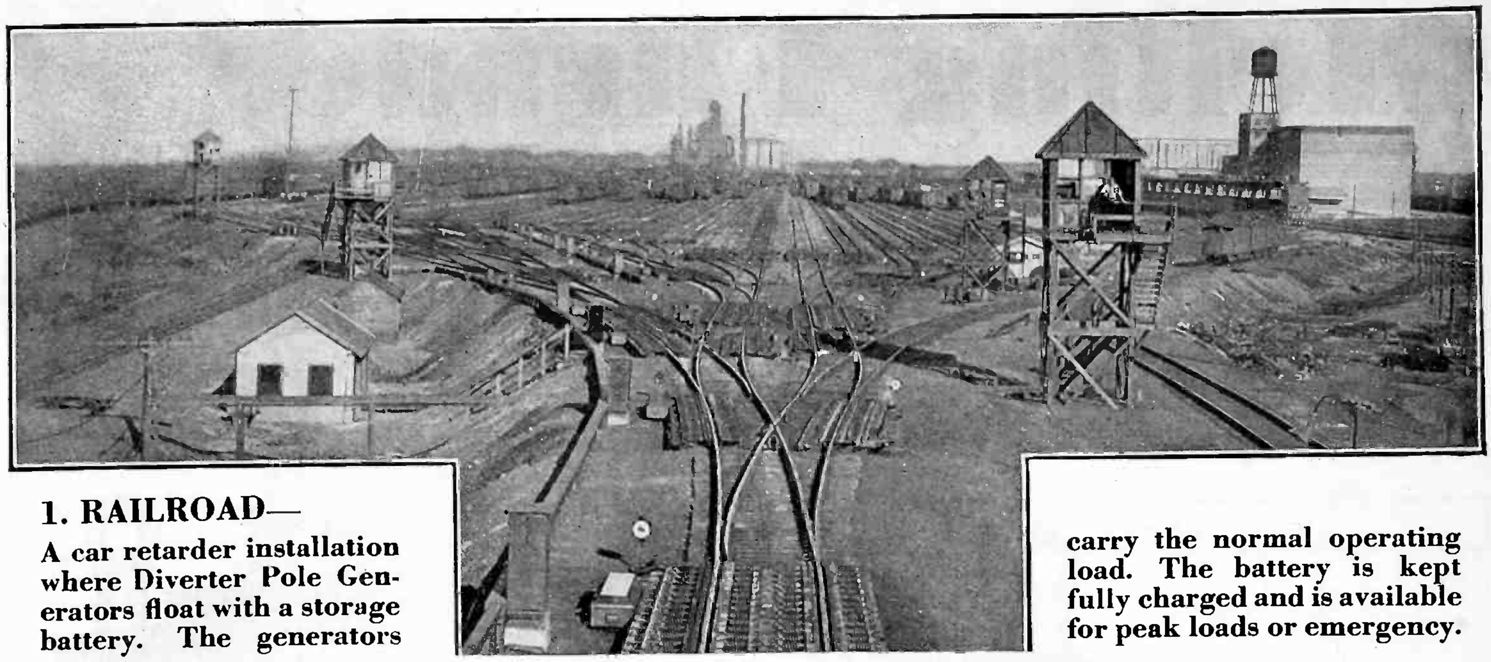
THE earth beneath our great cities is crowded. Steam, gas, sewer and water-mains, compressed air pipes, pneumatic tube systems, telephone and telegraph cables, light, power and rapid transit conduits lie so close together that any further additions create serious engineering problems. Yet the number of telephone calls that must flash through the underground arteries of great cities is steadily increasing.

The challenge to the scientific minds of the Bell System was to find a way for more conversations in existing conduits. Fifteen years ago, the pride of the System was a cable containing nine hundred pairs of wires. Then by many improvements a cable of twelve hundred pairs was perfected. It was rightly considered a scientific triumph.

Today, cables containing eighteen hundred pairs of wires are in service and these cables with every wire insulated are only two and five-eighths inches in diameter, one-half as large as the first nine hundred-pair cable. Eighteen hundred conversations at once—six hundred more than before—can now pulse through this two and five-eighths inches of cable.

There is no standing still in the Bell System. Better and better telephone service at the lowest cost is the goal. Present improvements constantly going into effect are but the foundation for the greater service of the future.

"THE TELEPHONE BOOKS ARE THE DIRECTORY OF THE NATION"



1. RAILROAD—
A car retarder installation where Diverter Pole Generators float with a storage battery. The generators carry the normal operating load. The battery is kept fully charged and is available for peak loads or emergency.

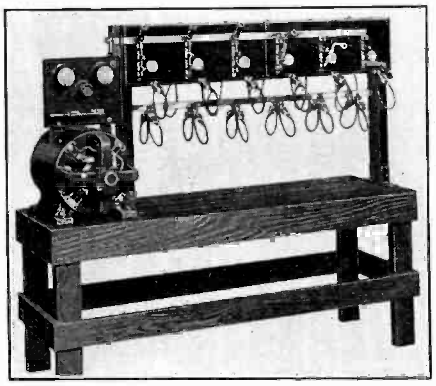
Proven Most Economical—In All Fields—For All Kinds of Battery Charging

SHUNT WOUND — BATTERY CHARGER

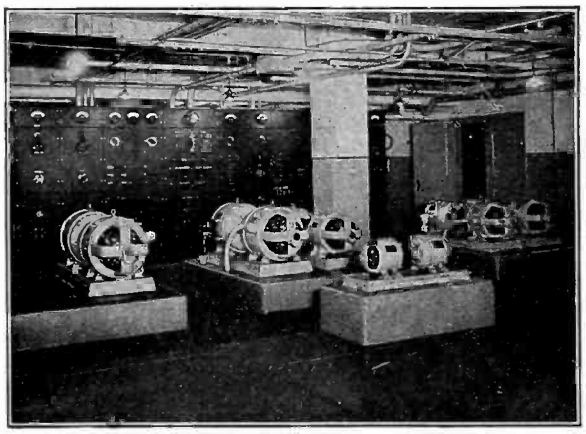
ROCHESTER ELECTRIC PRODUCTS CORP. — PATENTED — JAN. 1926 — ROCHESTER, N. Y. U. S. A.

THE DIVERTER POLE GENERATOR

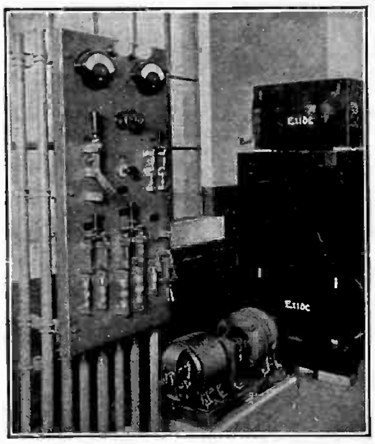
CONSTANT VOLTAGE INHERENT — RUNS AS MOTOR SAFELY



2. AUTOMOTIVE—
A Diverter Pole Generator charging outfit that assures every battery of getting the right charge.



3. TELEPHONE—
Diverter Pole Generators floating with storage batteries in a repeater station.



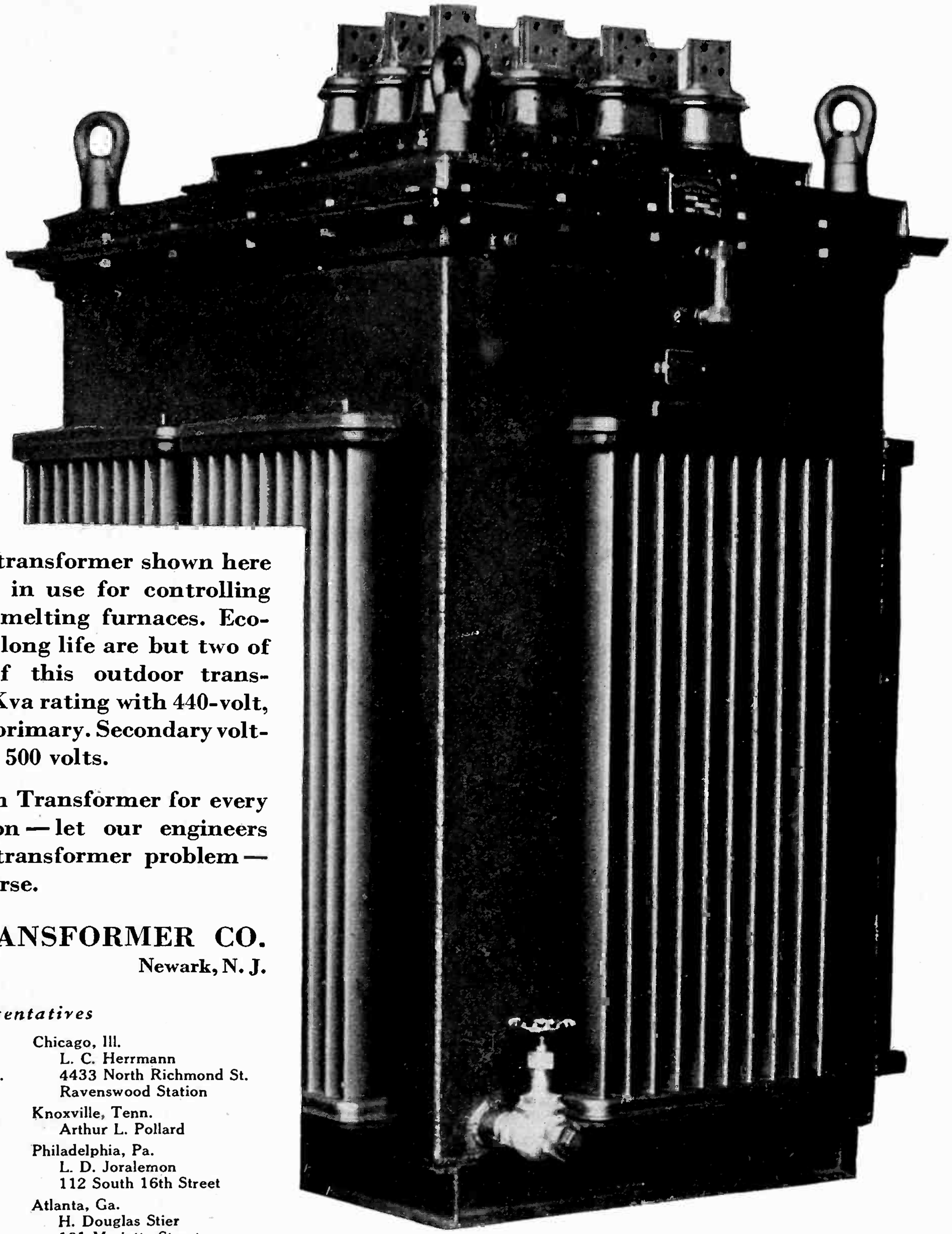
4. CENTRAL STATION—
A Diverter Pole Generator floating with a bus control battery in an automatic substation.

A New Bulletin, with interesting illustrations, is yours for the asking.

Rochester Electric Products Corp.
87 Allen Street **Rochester, N. Y.**

BUILDERS OF D. C. MOTORS AND GENERATORS FOR 30 YEARS

Melting Furnace Transformers



The **outdoor type transformer shown here is one of three now in use for controlling the energy input to melting furnaces. Economical service and long life are but two of the qualifications of this outdoor transformer. It has a 500 Kva rating with 440-volt, 60 cycle single phase primary. Secondary voltage range from 50 to 500 volts.**

There is an American Transformer for every industrial application — let our engineers advise you on your transformer problem — no obligation, of course.

AMERICAN TRANSFORMER CO.
176 Emmet Street **Newark, N. J.**

Representatives

Montreal, Canada
W. O. Taylor & Co., Ltd.
415 Canada Cement B'ldg.

Minneapolis, Minn.
Elliott Equipment Co.
708-6th Avenue, South

San Francisco, Calif.
James H. Southard
682 Mission Street

St. Louis, Mo.
J. W. Jones
432 Pennant B'ldg.

Chicago, Ill.
L. C. Herrmann
4433 North Richmond St.
Ravenswood Station

Knoxville, Tenn.
Arthur L. Pollard

Philadelphia, Pa.
L. D. Joralemon
112 South 16th Street

Atlanta, Ga.
H. Douglas Stier
101 Marietta Street

AMERICAN TRANSFORMER

PACIFIC ELECTRIC FLOOR MOUNTED OIL CIRCUIT BREAKERS

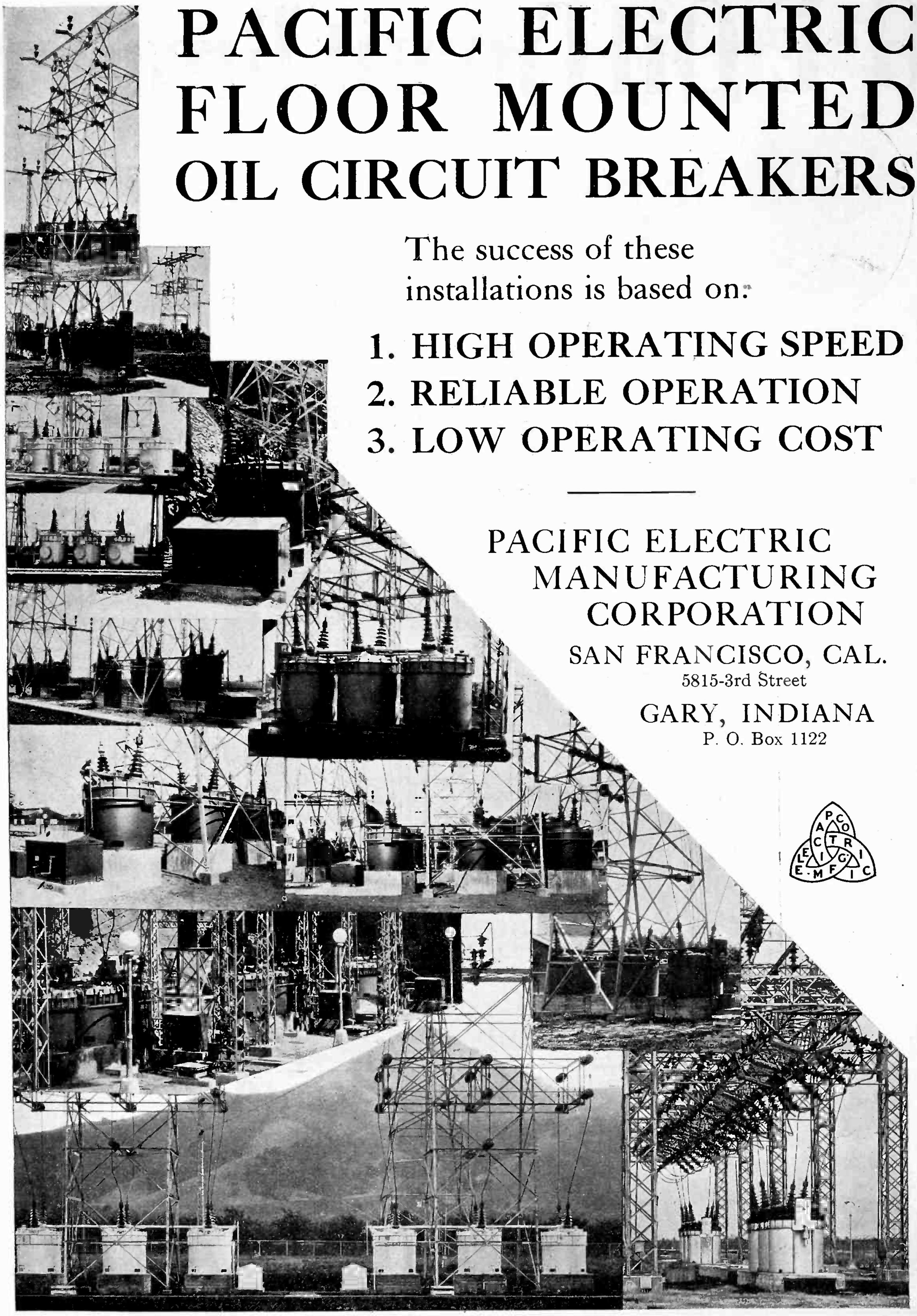
The success of these installations is based on:

1. HIGH OPERATING SPEED
2. RELIABLE OPERATION
3. LOW OPERATING COST

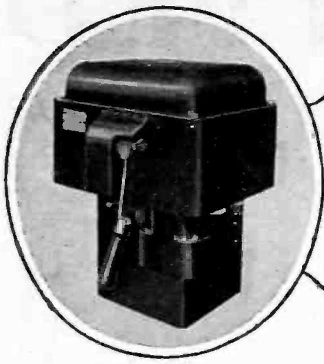
PACIFIC ELECTRIC
MANUFACTURING
CORPORATION

SAN FRANCISCO, CAL.
5815-3rd Street

GARY, INDIANA
P. O. Box 1122

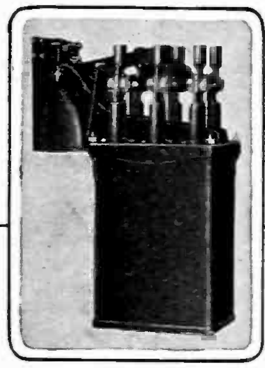


G-E Oil Circuit Breakers



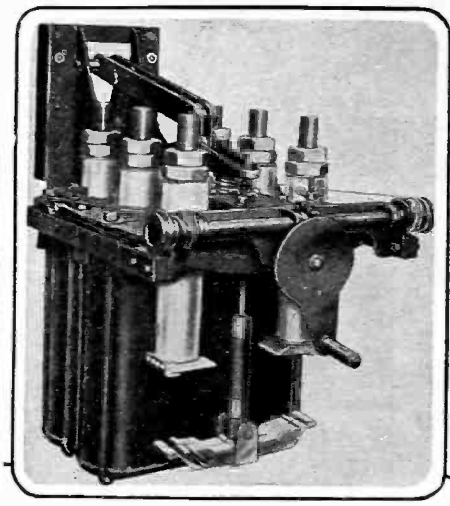
Type FK-20

Industrial Type



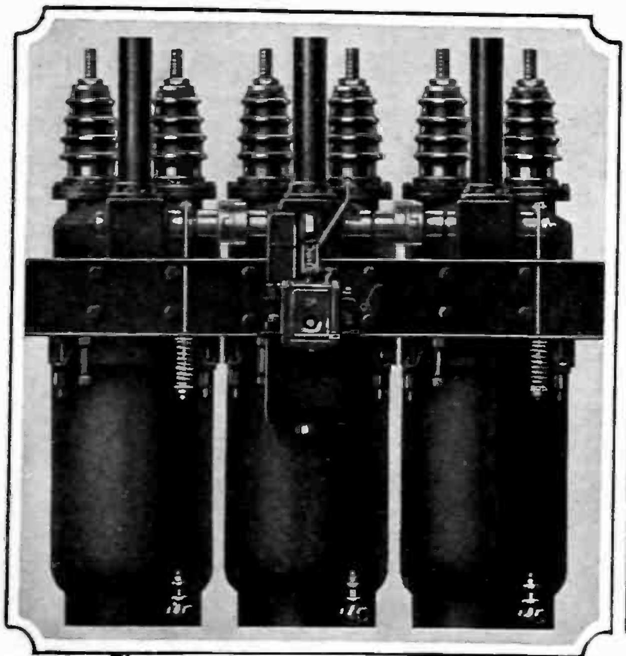
Type FK-33

Type FK-35

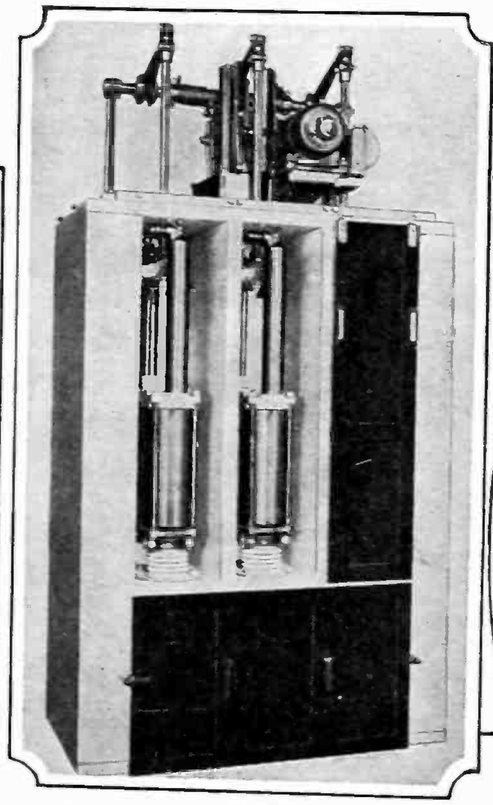


Type FK-132A

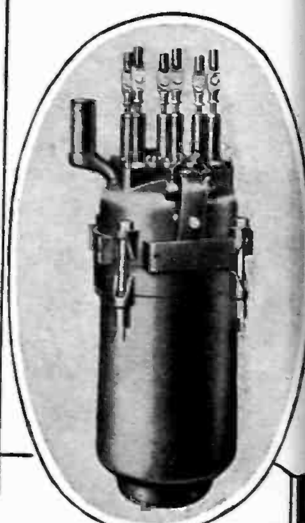
Switchboard Type



Type FK-330



Type FH-203



Type FKR-55

Station Type

JOIN US IN THE GENERAL ELECTRIC HOUR, BROADCAST EVERY

GENERAL

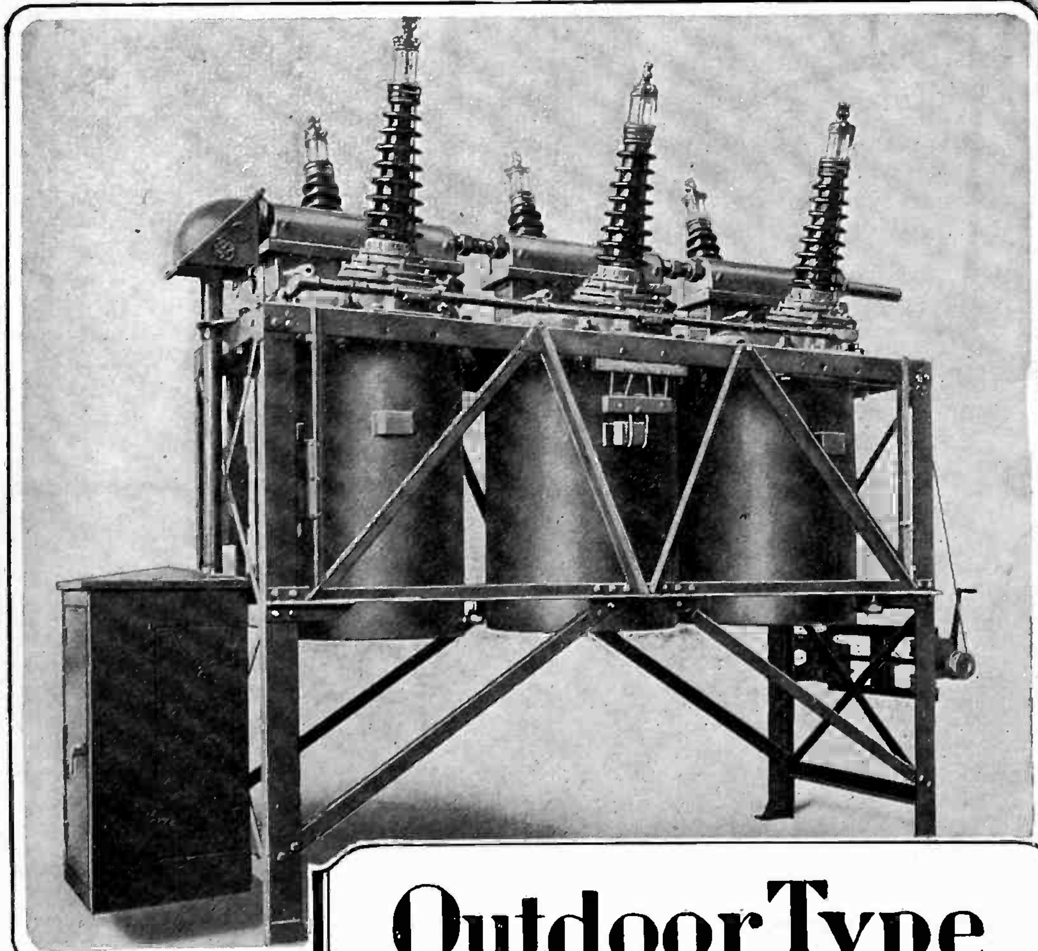
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

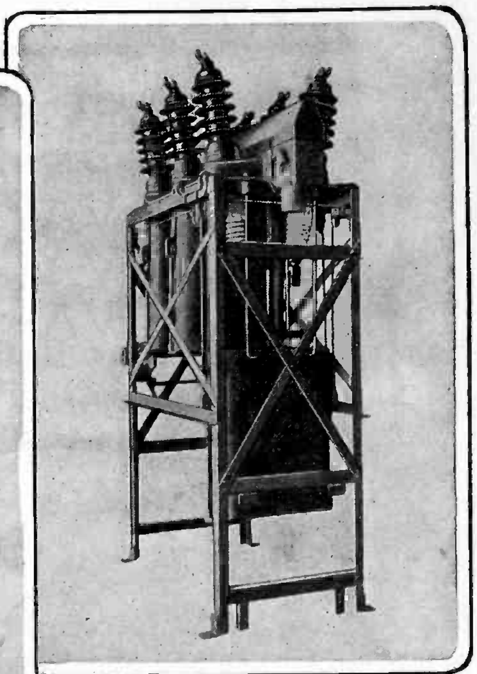
for Every Service-

GENERAL ELECTRIC manufactures a complete line of oil circuit breakers for industrial, pole or manhole, switchboard, station, and outdoor applications. They range, in voltage, from 600 to 220,000; in interrupting capacity, from 250 to 2,500,000 kv-a.

A complete research laboratory, a corps of skilled designers, a specially equipped high-voltage test, a large interrupting-capacity test, modern factory equipment, and uniformly high-grade materials all help to maintain the standard of excellence for which G-E oil circuit breakers are everywhere known.

Improvements are constantly being introduced—such as the explosion chamber for increasing interrupting capacity, the separating chamber for preventing oil throw, and, recently, emergency vents for protecting the breaker against pressures which are abnormal even for short-circuit conditions.





Type FKO-37

Type FK-139

Outdoor Type

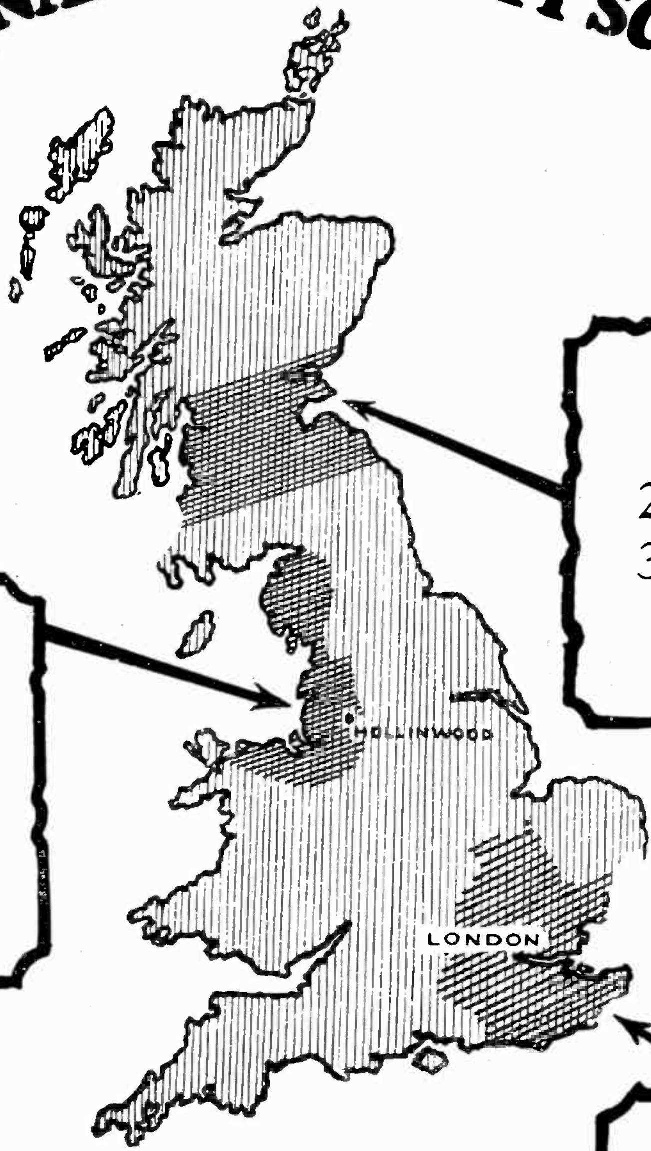
470-11

SATURDAY AT 8 P.M., E.S.T. ON A NATION-WIDE N.B.C. CHAIN

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

The LARGEST TRANSFORMERS for the NATIONAL ELECTRICITY SCHEME



CENTRAL SCOTLAND

20,000 kVA
30,000 kVA

132 Kilovolt
3-Phase Units

NORTH-WEST ENGLAND and NORTH WALES

45,000 kVA
60,000 kVA
75,000 kVA

132 Kilovolt
3-Phase Units

SOUTH-EAST ENGLAND

20,000 kVA
30,000 kVA
60,000 kVA

132 Kilovolt
3-Phase Units

H. T. Tappings Changed on Load

ARE BEING MADE ENTIRELY BY

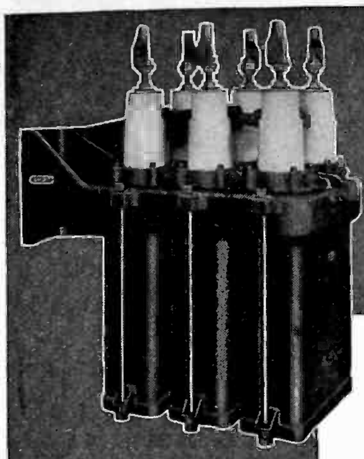
FERRANTI

Ferranti, Inc.
130 West 42nd Street
New York, U. S. A.

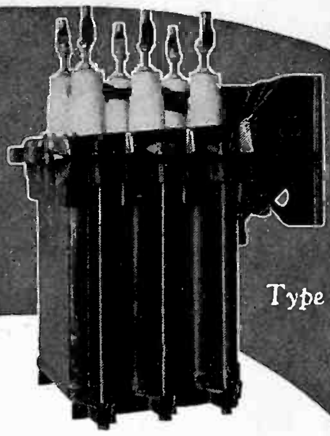
Ferranti, Ltd.
Hollinwood
Lancashire, England

Ferranti Electric Limited
26 Noble Street
Toronto, Canada

The Condit D-Line



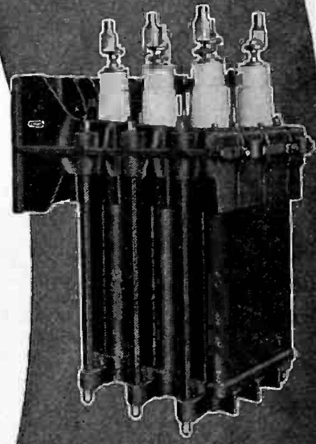
Type D-123



Type D-118

"D" for Dependability

Inverted laminated brushes; exceptionally heavy arcing contacts designed to minimize arcing; massive, rigid frames; deeper tank per pole construction; oversize one-piece wet-process porcelain bushings—the Condit Type D Oil Circuit Breakers have *everything* for safe, dependable, efficient service.

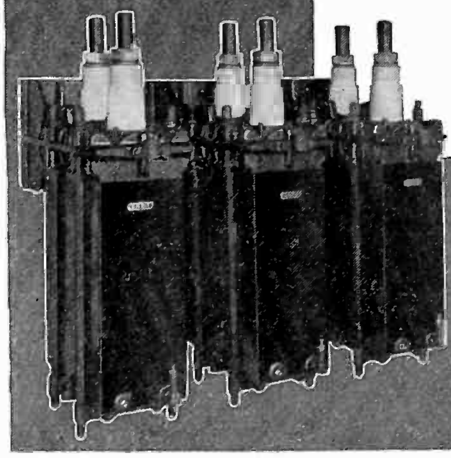


Type D-128

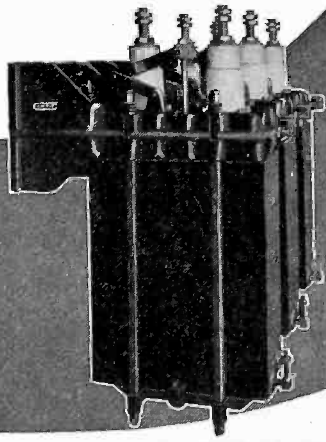
"*Get in touch with Condit*"

CONDIT ELECTRICAL MFG. CORPORATION
Manufacturers of Electrical Protective Devices
BOSTON, MASS.

Northern Electric Company
LIMITED
Distributor for the Dominion of Canada



Type D-127

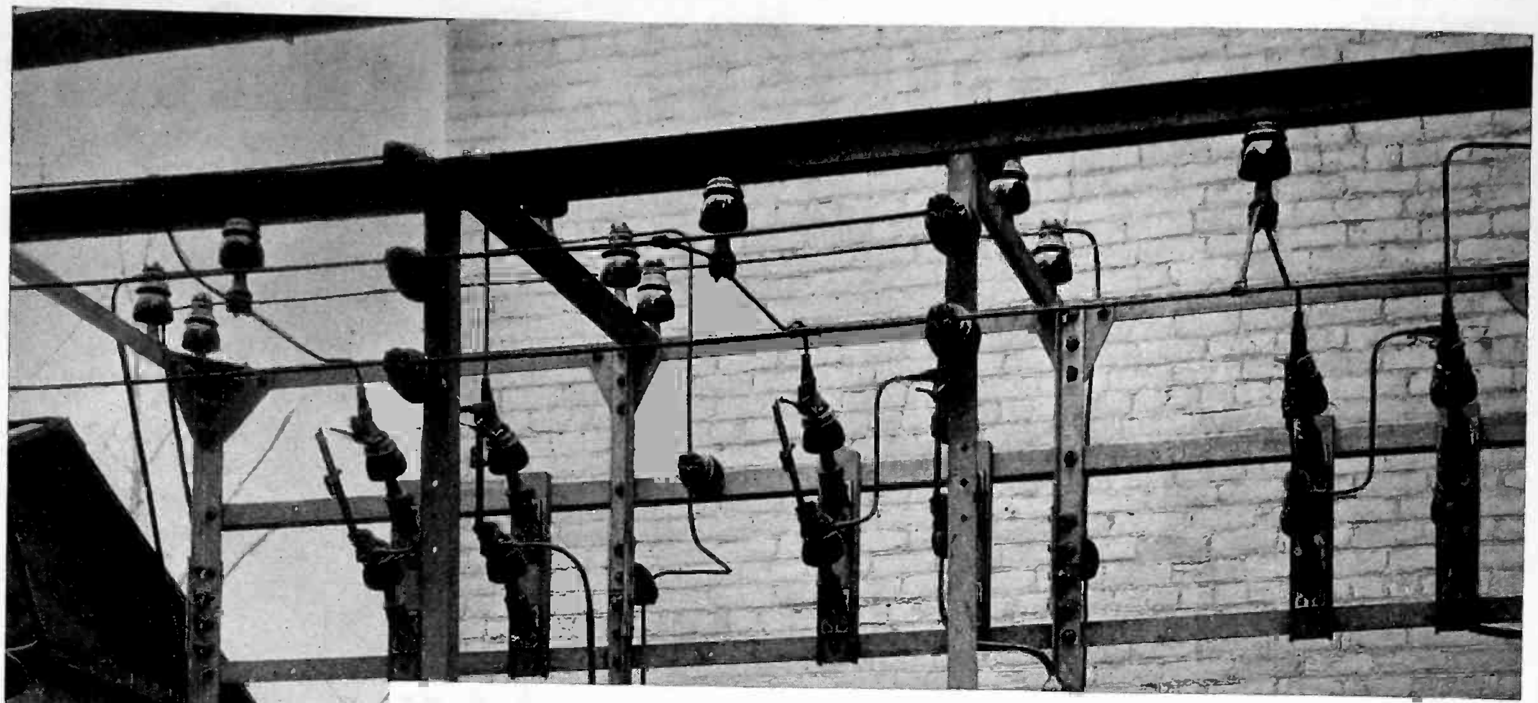


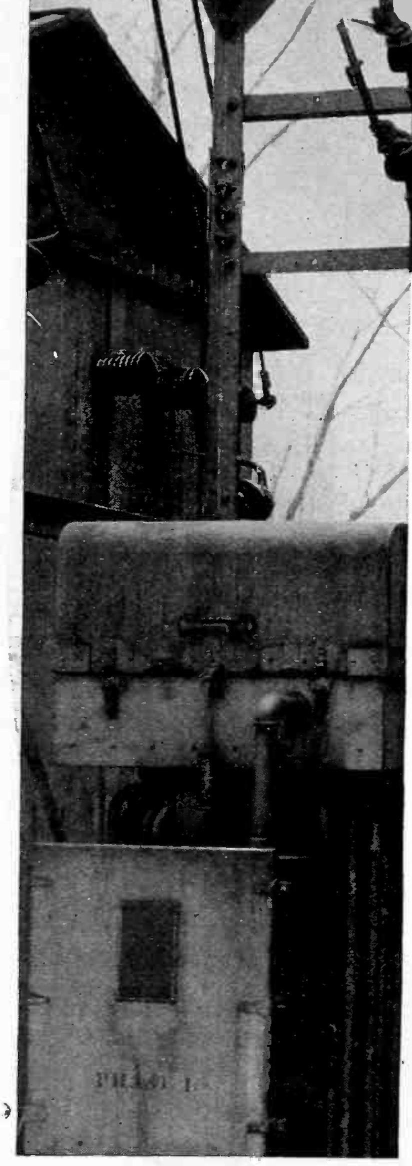
Type D-117

SPECIFICATIONS: ***1200 amperes or less, 15,000 volts; 1600 amperes, 7500 volts; estimated interrupting capacity at 15,000 volts. Type D-123, 2500 amperes. Type D-118, 3500 amperes. Type D-128, 5000 amperes. Type D-117, 5000 amperes. Type D-127, 7000 amperes.***

CONDIT

2593





DOSSERTS
on Automatic Station

The Chase Avenue substation of the Union Gas & Electric Company at Cincinnati, Ohio, uses 4500 volts and 13200 volts—DOSSERTS being used for connections.

DOSSERTS are also used by this company on 4000 volt feeders.

The reason for DOSSERT preference is the DOSSERT *tapered sleeve* principle of connection insuring a good connection electrically and mechanically — a connection easily made — the time saved frequently paying for the joint.

A book showing the variety of connections and terminals made by DOSSERTS—containing also valuable wiring data—sent on request.

DOSSERT & COMPANY
H. B. LOGAN, *President*
242 West 41st St., New York, N. Y.

Where your Wires or Cables Come Together

CONNECT 'EM WITH

DOSSERTS

THE TAPERED SLEEVE SOLDERLESS CONNECTORS

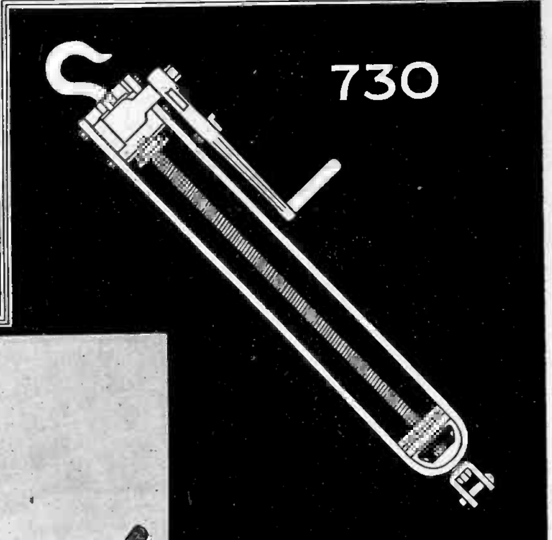

Another New
PEIRCE
Specialty
The
ADJUSTABLE
POLE BAND
"PEIRCE"
HUBBARD &CO
PAT
APPLIED
FOR
for attachments
to tubular steel
or
concrete poles
Stocked and Sold through the leading Electrical Jobbers—There is one near you
The new Peirce Adjustable Pole Band has been designed to attach all types of Pole Line Hardware to tubular steel or concrete poles without drilling or cutting the pole.
Mast Arms, Secondary Racks, Pole Steps, Guy Hooks, Lamp Lead Brackets, Pole Top Pins and Fixtures are the more important items which may be readily attached by merely drawing tight two to four carriage bolts.
Attachments may be made to any diameter pole at any height. For complete information on this new Peirce Specialty write to Hubbard & Company, 6301 Butler Street, attention Advertising Department.
HUBBARD
Hubbard and COMPANY
PITTSBURGH • OAKLAND, CAL. • CHICAGO

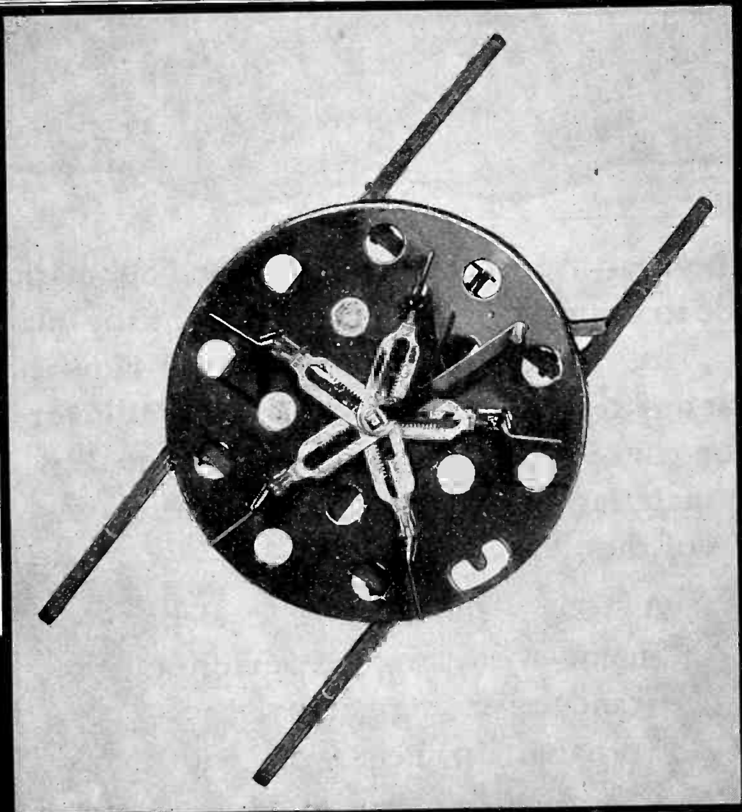
MATTHEWS

MONEY SAVING TOOLS FOR CONSTRUCTION WORK

Adjustable Reels *for Pay-Out and Take-Up*

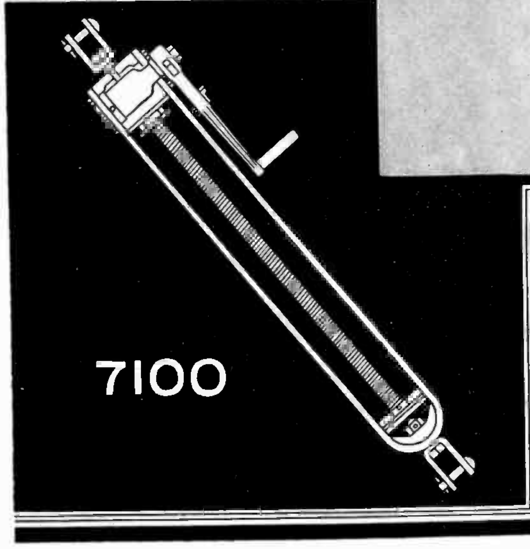
Slack Pullers *Quick Release*





Quick Release Matthews Slack Pullers are much faster and more economical to use than block and tackle. One man does the work of four. No slack is lost in dead-ending.

The Quick Release feature on Matthews Slack Pullers speeds work. When the entire take-up has been used, the wire is temporarily dead-ended and the lock released. This permits the Slack Puller to be immediately extended to its full or any intervening length.



Matthews Adjustable Reel eliminates cost of wooden reels and their freight charge when buying wire. Makes wire stringing and pulling out much safer and faster. It is not necessary to pull the wire down on the road as the pulling out and coiling on the reel can be done at the same time. Send for bulletins.

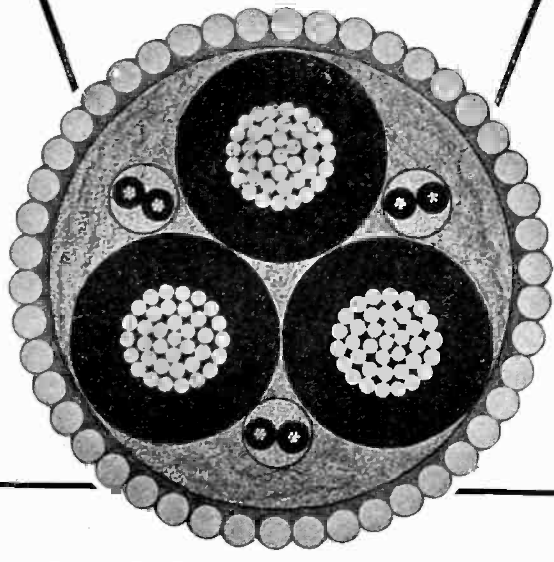
W. N. MATTHEWS CORPORATION
Engineers and Manufacturers
3706 Forest Park Blvd., St. Louis, Mo.
Offices in all principal cities

W.N. MATTHEWS CORPORATION ST. LOUIS, U.S.A.

MATTHEWS ELECTRICAL SPECIALTIES

in all types—Aerial, Underground and Submarine. Made to the most rigid specifications, in any quantity, size or length for any voltage. Finished for any service, single or multiple conductor or concentric laid. Only highest quality materials enter into the construction of these cables.

A fully equipped cable department with long experienced and able engineers is prepared to help you with cable problems.



Section of a 500,000 C. M. Stranded 3-conductor rubber insulated Steel Wire Armored Submarine Power Cable for 11,000 volts W. P. with three sets of telephone conductors.

If you have not a copy of our present "Electrical Wires and Cables" handbook, we will gladly send you copy upon request.

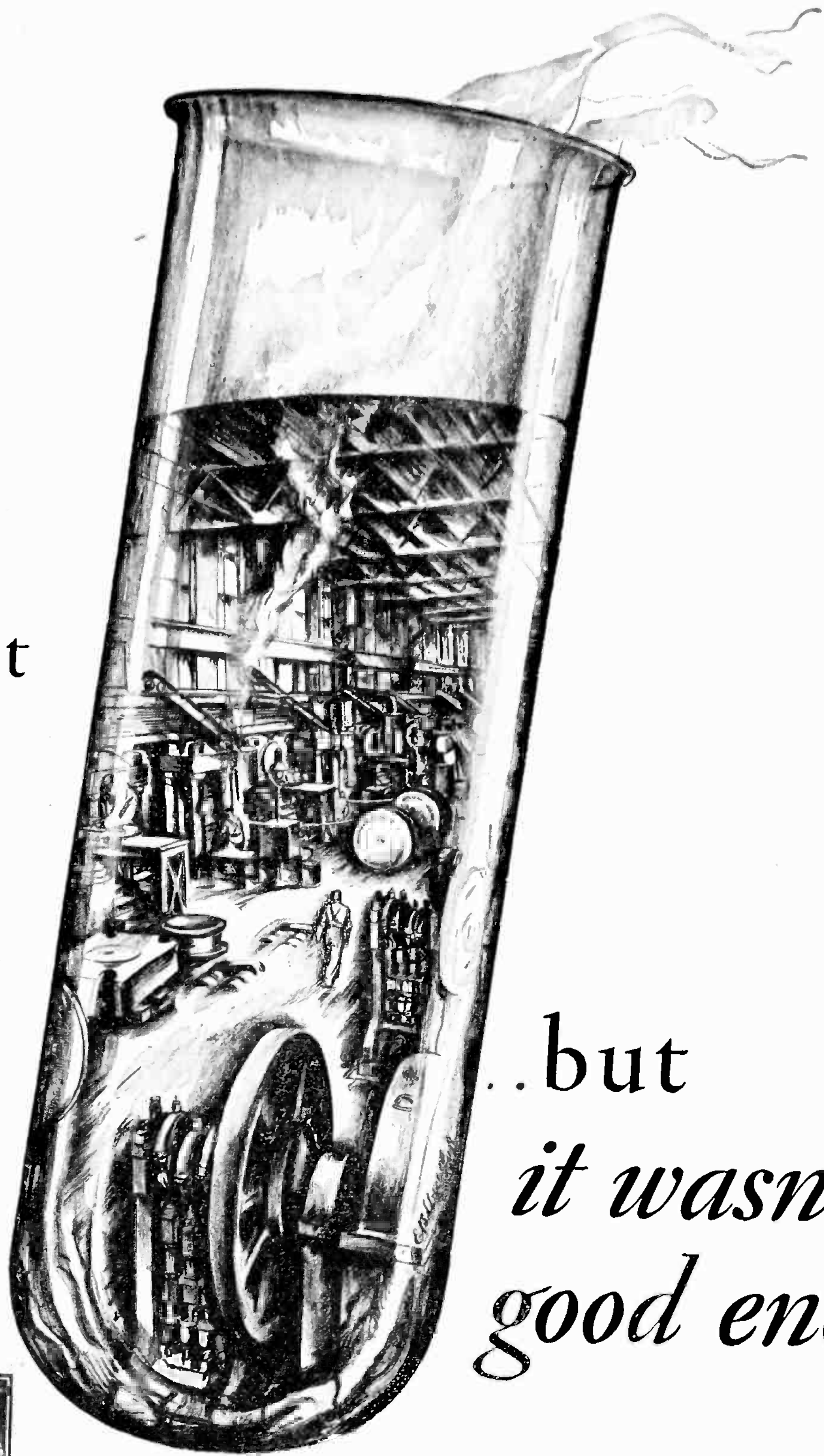
AMERICAN STEEL & WIRE COMPANY

Subsidiary of United States Steel Corporation

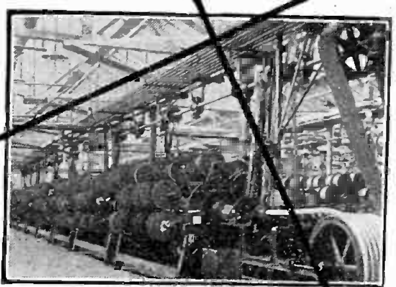
208 S. La Salle Street, Chicago 30 Church Street, New York

Other Sales Offices: Boston Cleveland Worcester Philadelphia Pittsburgh Buffalo Detroit Cincinnati Baltimore Wilkes-Barre St. Louis Kansas City Minneapolis-St. Paul Oklahoma City Birmingham Atlanta Memphis Dallas Denver Salt Lake City

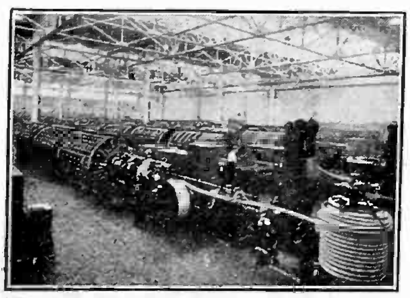
U. S Steel Products Company: San Francisco, Los Angeles, Portland, Seattle *Export Representatives:* United States Steel Products Co., 30 Church St., New York, N. Y.



The best cable shop in the country . . . . . but *it wasn't good enough*



The old way. This machine for stranding cable was the best in the country, but—



Western Electric engineers worked out a new way, stranding cable more quickly, more safely, more economically.

In equipment and methods the Western Electric telephone cable plant of 1927 set the pace. But that didn't satisfy the company's manufacturing engineers. They put the plant in the test tube of critical judgment—and they came out with something even better.

It meant revising processes, redesigning machines, rebuilding a factory which occupied sixteen huge structures. But it was worth it!

Whether making cable or any of the 10,000 items of telephone apparatus, Western Electric seeks till it finds the better and more efficient and more economical way. As manufacturer for the Bell System this is its share in good telephone service.

Western Electric

MAKERS OF YOUR TELEPHONE

Aluminum Busbars give lower costs

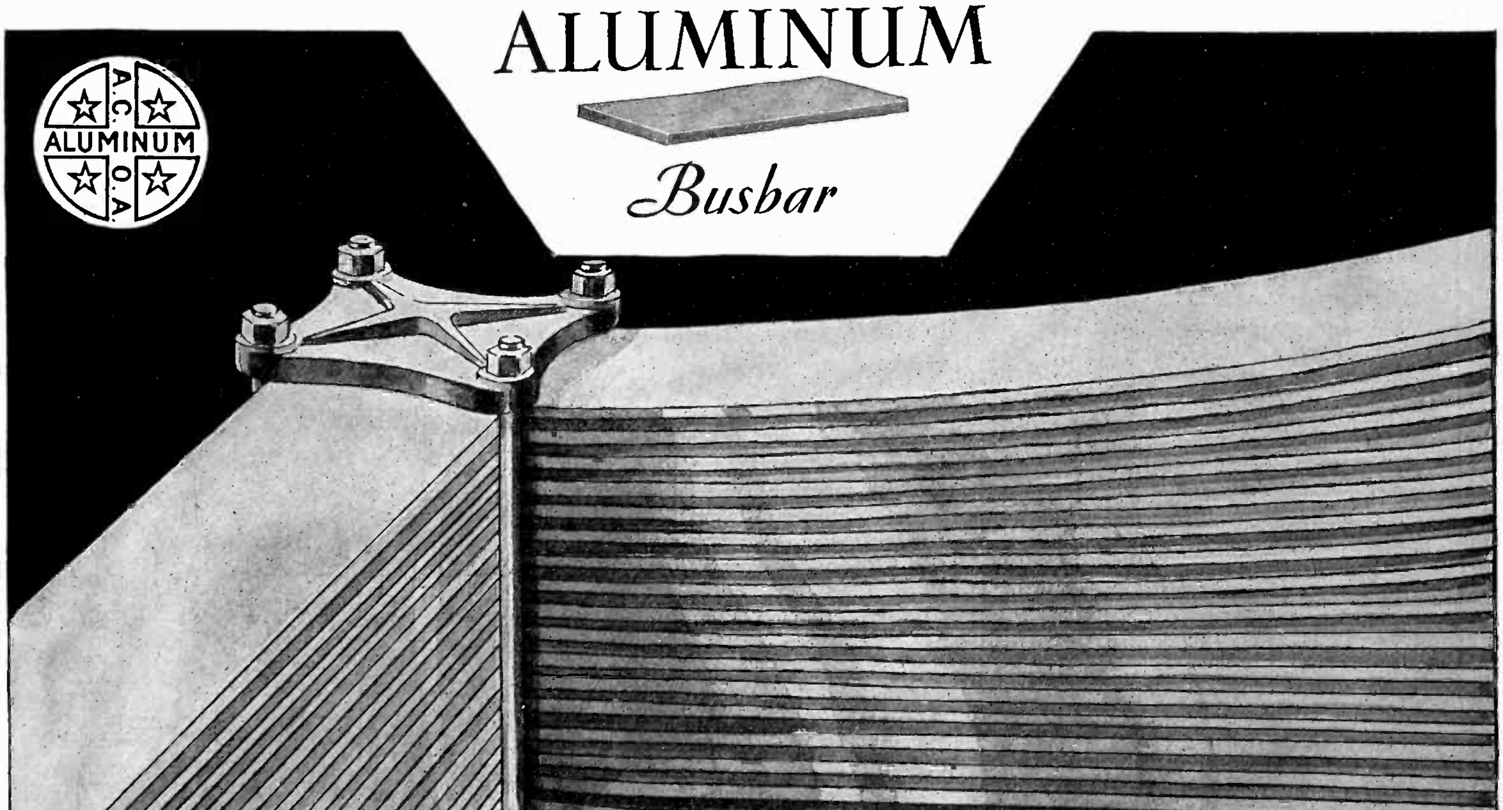
THE lower first cost of Aluminum Busbars is a matter that may well receive the consideration of designing engineers.

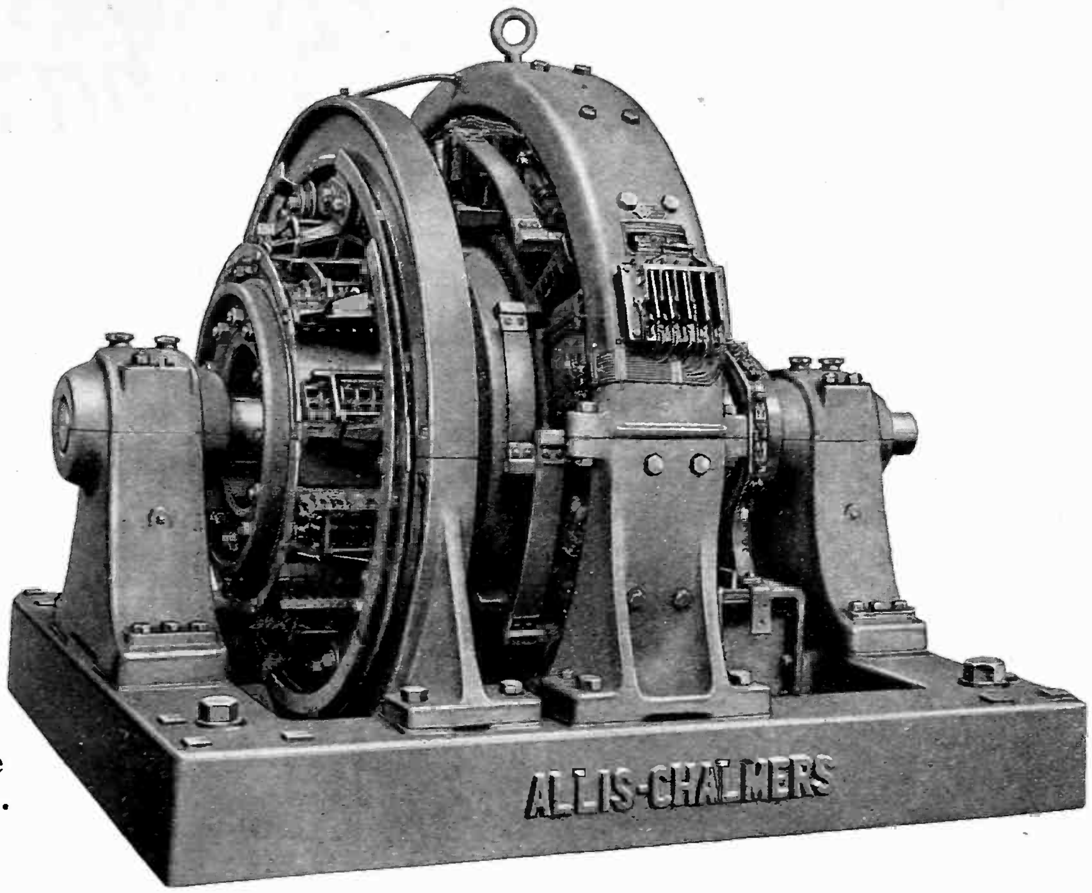
For the handling of power at a large station the adoption of Aluminum Busbars develops an initial saving that appreciably affects the relation of operating profit to equipment investment.

To this important economic factor may be added lighter weight, with structural economy and complete dependability.

A booklet setting forth Carrying Capacities, Joints, Deflections and Stresses, Specifications and Tables will be forwarded upon request.

ALUMINUM COMPANY OF AMERICA
2448 Oliver Bldg., Pittsburgh, Pa.
Offices in 19 Principal American Cities.





1,000 Kw., 600 Volt, D.C., 6 Phase 60 Cycle, 720 R.P.M. Rotary Converter

Rotary Converters

Electrical energy may be transformed from alternating to direct current and from direct to alternating current economically and conveniently through a rotary or synchronous converter.

Allis-Chalmers builds converters in capacities from 100 kw. up to the largest in commercial operation. They are used for railway and municipal service, in mines, steel mills, and in industries of all types.

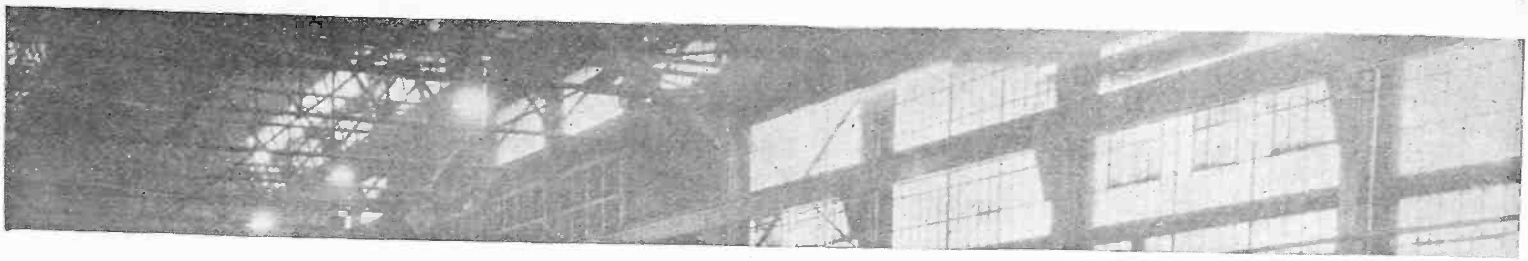
Frog-Leg winding insures perfect commutation under all conditions of load. Separately mounted direct current brush rigging allows easier access to the windings. The brush arm yoke completely encircles the commutator and forms a rigid support for the brush rigging. These features together with Allis-Chalmers standards of design and workmanship insure years of constant and trouble-proof service.

PRODUCTS

Allis-Chalmers Electrical Machinery includes—Motors for all purposes; A.C. and D.C. Generators; Motor-Generator Sets; Transformers; Frequency Changers; Balancers; Boosters; Equalizing Sets; Synchronous Motors and Condensers; Armor-clad Switchgear; and Motor Starters. Power Equipment includes Prime Movers of all types, Condensers, Centrifugal Pumps, and Texrope Drives. Industrial Machinery is built for many basic industries.

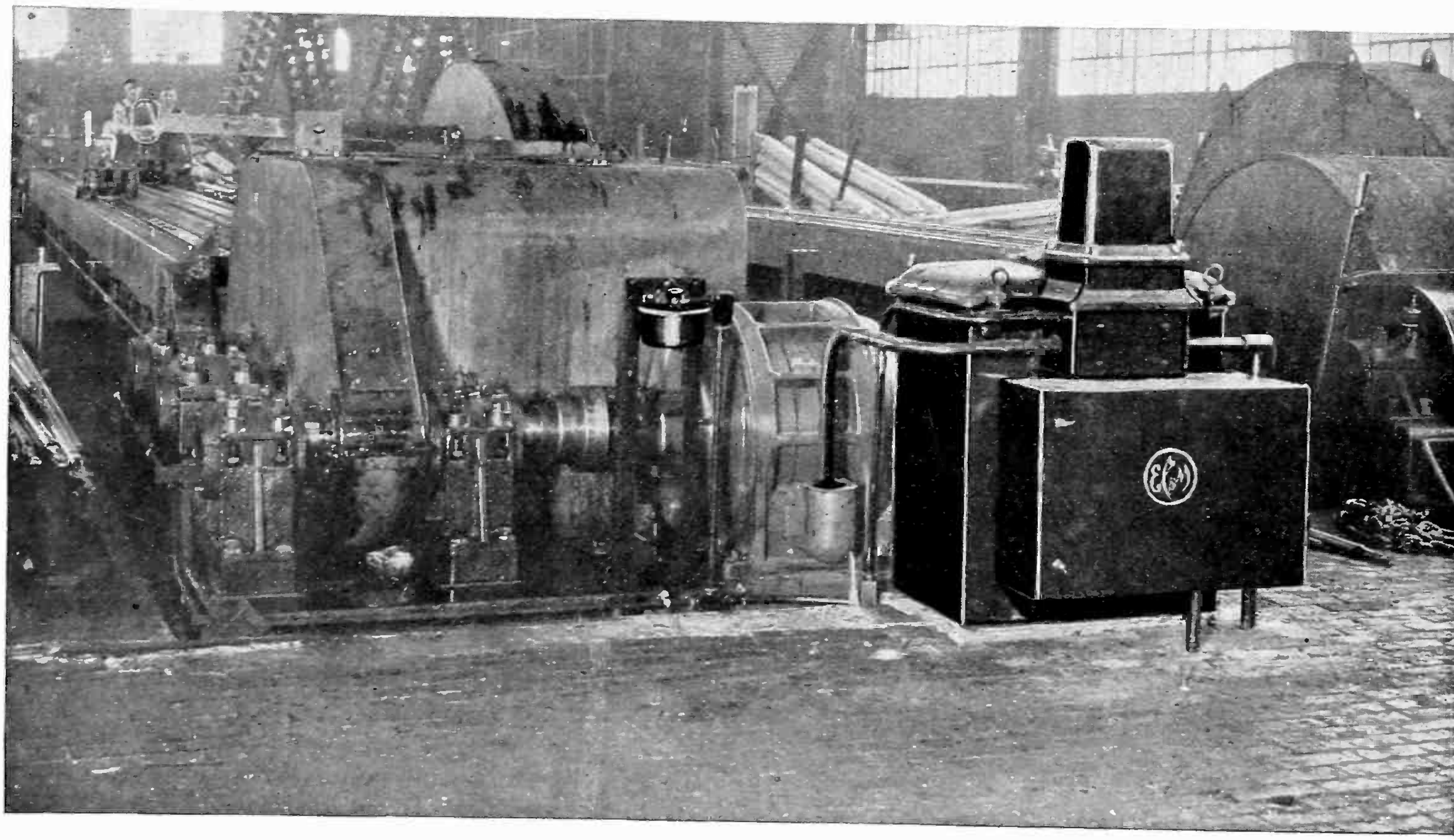
ALLIS-CHALMERS

MILWAUKEE, WIS. U. S. A.



Before Building an Expensive Control Room

—Investigate EC&M Synchronous Motor Starters



COSTLY control rooms can be eliminated by employing EC&M oil-immersed fully automatic Synchronous Motor Starters, because they can be placed right out in the mill. They are dust-proof and can be made shock-proof by simply grounding the enclosing case.

Additional saving is also obtained in installation cost of this EC&M Automatic Starter illustrated above and controlling a 100 H.P., 2300 volt Synchronous Motor driving a Tube Draw Bench, because it is completely wired and self-contained as one unit. Placing the controller right by the motor permits further economy by reducing the cost of wiring. You may have complete information on EC&M Synchronous Motor Starters by writing our nearest branch office for Bulletins 1047 and 1042-F.

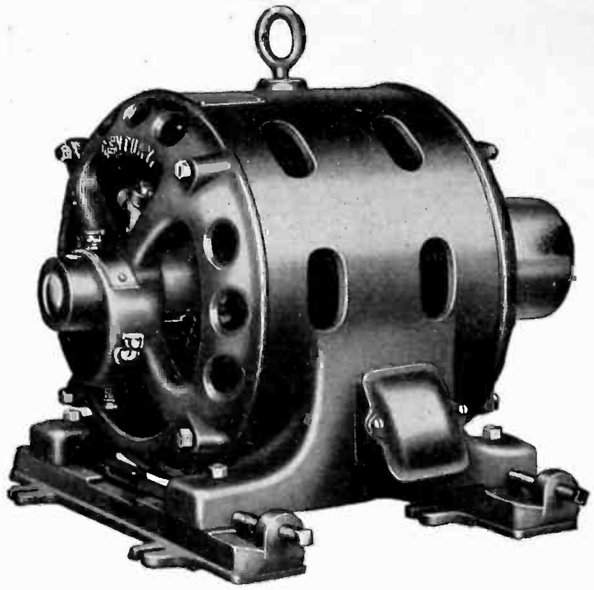
THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
DENVER-KITTREDGE BLDG.

LOS ANGELES-912 E. THIRD ST.
HOUSTON-1006 WASHINGTON AVE.
TORONTO-REFORD BLDG.

PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
TULSA-217 E. ARCHER ST.
SEATTLE-ALASKA BLDG.



5 Horse Power Century Type RS
Repulsion Start Induction Single Phase Motor

High Starting Torque Low Starting Current

Built in standard sizes from 1/8 to 40 horse power. Temperature rating, 40° C.

Century Type RS Repulsion Start Induction Single Phase Motors are particularly suited for installations where the load is hard to start . . . where unexpected static loads are frequently encountered . . . or where heavy flywheels or similar inertia loads are present.

Starting torque of all sizes is not less than 250% of full-load torque . . . starting current is not more than 260% of full-load current.

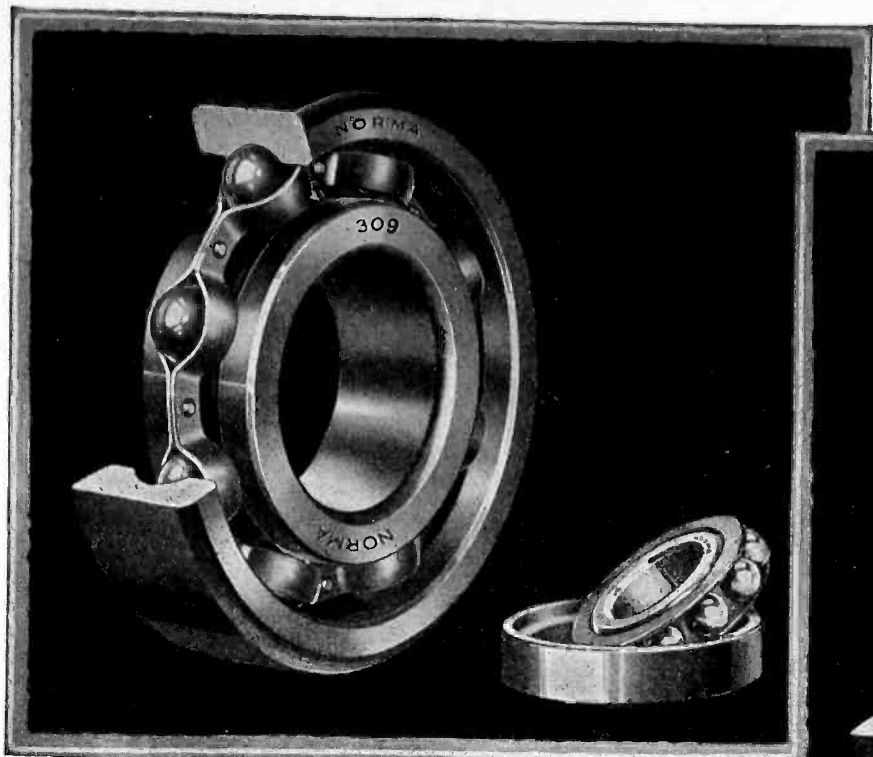
Fuses which will protect the motor while running and carrying its load are usually large enough to effect a start. Any approved single-throw switch may be used for starting, making these motors well adapted to automatic or remote control service.

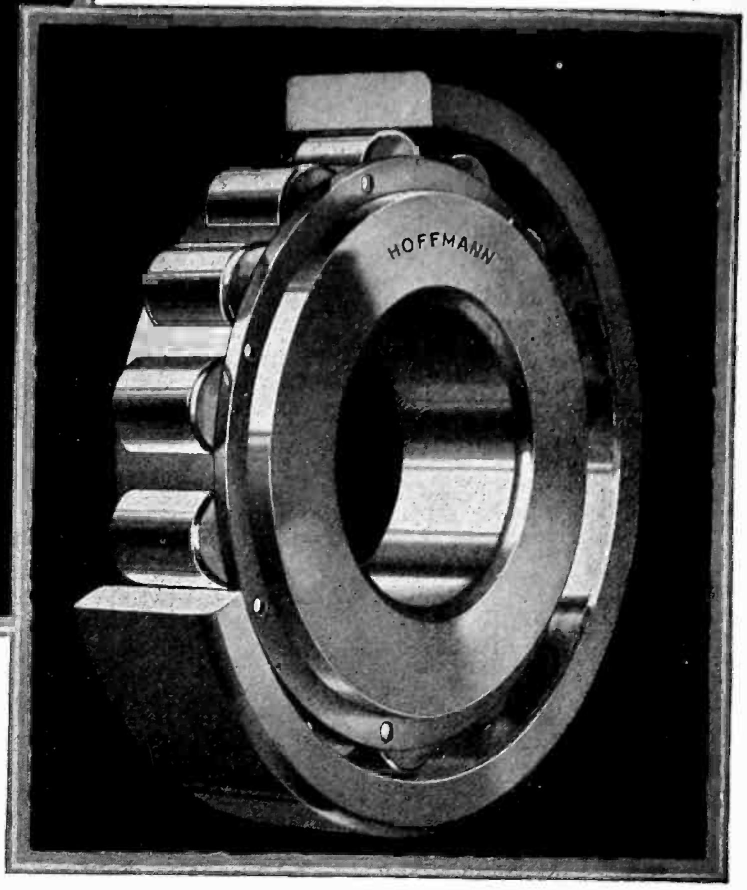
CENTURY ELECTRIC COMPANY
1806 Pine St. St. Louis, Mo.

40 U. S. and Canadian Stock Points and More Than 75 Outside Thereof

Century MOTORS

''THEY KEEP A-RUNNING''





NORMA-HOFFMANN Ball and Roller Bearings are available in a complete range of sizes, covering the anti-friction bearing requirements for all speeds and all loads.

Interchangeable in SIZE

"NORMA-HOFFMANN" *ROLLER* BEARINGS are of the *same dimensions* as standard ball bearings but have *far greater load capacity.* Specify them for the heavy duty shafts; use them for replacement where overloading or continuous duty cuts down the safety factor in using ball bearings.

Made to the same "Precision" standards which have long distinguished the name "NORMA-HOFFMANN", these roller bearings provide long life with a low upkeep and "performance that counts."

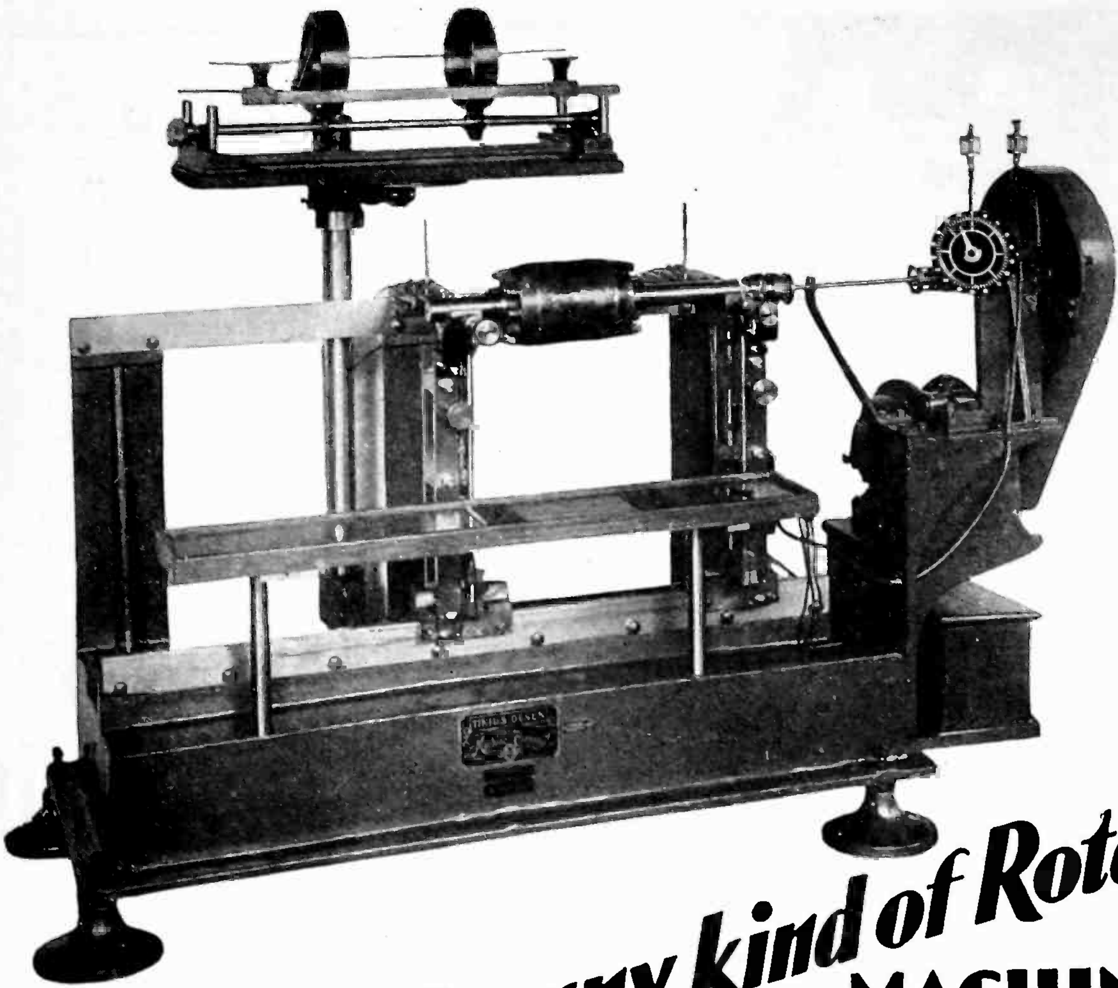
"NORMA-HOFFMANN" PRECISION BEARINGS, after 18 years, are still the preference of discriminating machinery builders and machinery users because ultimately NORMA-HOFFMANNS are the most economical. It always pays to buy the best in bearings. *Our engineers will be glad to consult with you on any bearing problems.*

You'll want the "NORMA-HOFFMANN" Engineering Data Book, load ratings, etc. Ask for a copy.

NORMA-HOFFMANN
PRECISION BEARINGS

NORMA-HOFFMANN BEARINGS CORPORATION STAMFORD, CONN., U.S.A.

N-953



Do you make any kind of Rotating MACHINERY?

Then there is a place for an OLSEN Balancing Machine in Your Plant.

It is practically impossible to balance armatures and rotors for high speed machines correctly on static machines. These parts can only be balanced correctly dynamically on machines such as the Olsen Machine.

The Olsen Balancing Machine operates on the Centrifugal High Tension Spark principle, which is recognized as the most advanced method in the balancing of parts.

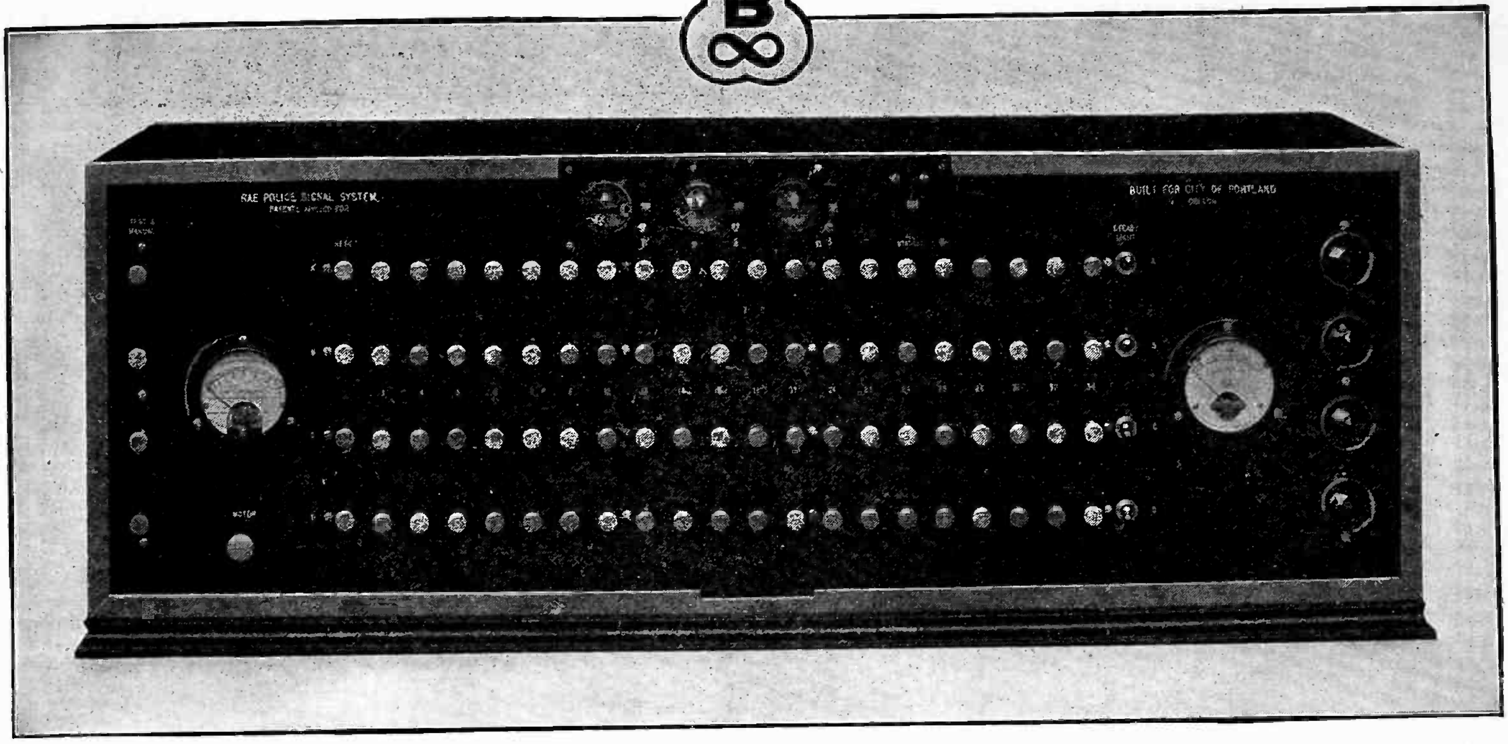
Every power plant should have an Olsen Machine. Rotors, Gears, Spindles, Shafts—any part that rotates should be balanced periodically to minimize operating and maintenance costs.

Write for full details.

"Testing and Balancing Machines for all purposes"

TINIUS OLSEN
TESTING MACHINE COMPANY

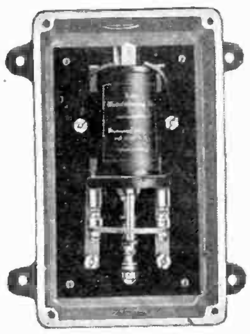
502 N. 12th Street Philadelphia, Pa.



Control Board for Signal System made by Lake Mfg. Co., Oakland, Calif., and below: Relay Unit for Signal System. Bakelite Insulation throughout.

"Never a failure due to faulty insulation" Bakelite Materials used exclusively

SAFEGUARDING lives and property in any community often depends on the police signal system. Called upon to operate continuously — night and day — summer and winter—these systems must function perfectly under any and all weather conditions. To assure this unfailing performance the electrical insulation used must retain its properties unimpaired under the most adverse weather conditions. In the Rae Police Signal System, Bakelite Insulation is used throughout, with "never a failure due to faulty insulation."



All of the master station apparatus is mounted on a Bakelite Laminated panel, 48 inches by 20 inches. The panel is drilled and tapped for mounting the instruments, and has etched lettering to identify the various parts. The relay mechanisms in the individual call boxes are also mounted on Bakelite Laminated panels, and insulated with Bakelite Materials.

In addition to resisting adverse weather conditions, Bakelite Materials provide permanently high mechanical and dielectric strength. They are non-hygroscopic and will not swell or shrink. In both molded and laminated forms they are being effectively used throughout the electrical industry. Write for Booklet 3M, "Bakelite Molded" and 3L, "Bakelite Laminated."

Bakelite Engineering Service—Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resinoids for electrical uses provides a valuable background for the cooperation offered by our engineers and research laboratories.

BAKELITE CORPORATION

247 Park Avenue, New York, N. Y. Chicago Office, 635 West 22nd Street

BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin Street, Toronto, Ont.

BAKELITE

REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

ELECTRITE

A high grade fibre board for electrical insulation.

A material of quality possessing high tensile and dielectric strength.

Tested and approved by the Underwriters' Laboratories.

Pulp Products Department

WEST VIRGINIA PULP & PAPER COMPANY

230 Park Avenue
New York, N. Y.

35 East Wacker Drive
Chicago, Ill.

MICABOND

THE STANDARD MICA INSULATION

THERE are fourteen major qualities that are much sought in mica insulation.

The tests shown below demonstrate conclusively why MICABOND is recognized as the Standard Mica Insulation—

Test No.		No. 104 Amber MICABOND Sample .025 Thick	No. 102 India MICABOND Sample .025 Thick
1	Splittings	1″ x 1″ Area	1″ x 1″ Area
2	Dielectric Strength in volts per mil	1,181	973
3	Surface Resistivity, Megohm ins. x 10^6	Greater than 30	Greater than 30
4	Volume Resistivity, Megohm ins. x 10^6	Greater than 290	Greater than 300
5	Power Factor, per cent	3.2	5.6
6	Dielectric Constant	3.7	5.8
7	Slipping at 500° F.	None	None
8	Compression at 500° F. percent	.9	1.3
9	Density (Sp. Gr.)	2.54	2.53
10	Transverse Strength, lbs.	7.3	10.6
11	Carbonization	Slight	Slight
12	Corrosion, Resin on Copper	None	None
13	Effect of heat, 200° F.	None	None
14	Bond Content, percent	4.8	4.9

These tests were made by disinterested laboratories of high reputation, on standard stock MICABOND.

MICABOND is furnished in sheets, strips, tubes, tape, and specially punched or moulded parts to specification — Ask for complete details.

CHICAGO MICA COMPANY
432 Campbell Street
VALPARAISO INDIANA

FIBROC

BAKELITE LAMINATED SHEETS RODS TUBES

SILENT GEAR MATERIAL

For unfailing insulating efficiency and economical assembly—many electrical manufacturers are turning to FIBROC—Because it will not warp or swell—because it will not deteriorate with age and is highly resistant to acids, oils, steam, water, etc.

FIBROC is the ideal material for innumerable insulating requirements. Punched parts of FIBROC are uniform, clean edged and accurate.

Fibroc is furnished in sheets, rods and tubes, or in the form of special punched or machined parts ready for assembly.

Fibroc silent gear material is furnished in sheets, blanks or in moulded gear blanks with or without metal hubs.

Specify FIBROC on your blue prints.

FIBROC INSULATION COMPANY
510 Lincoln Avenue
VALPARAISO - INDIANA




INSULATORS *made of* LAVA

Lava as an insulating material has great dielectric strength and is therefore approved by manufacturers of electrical instruments and appliances.

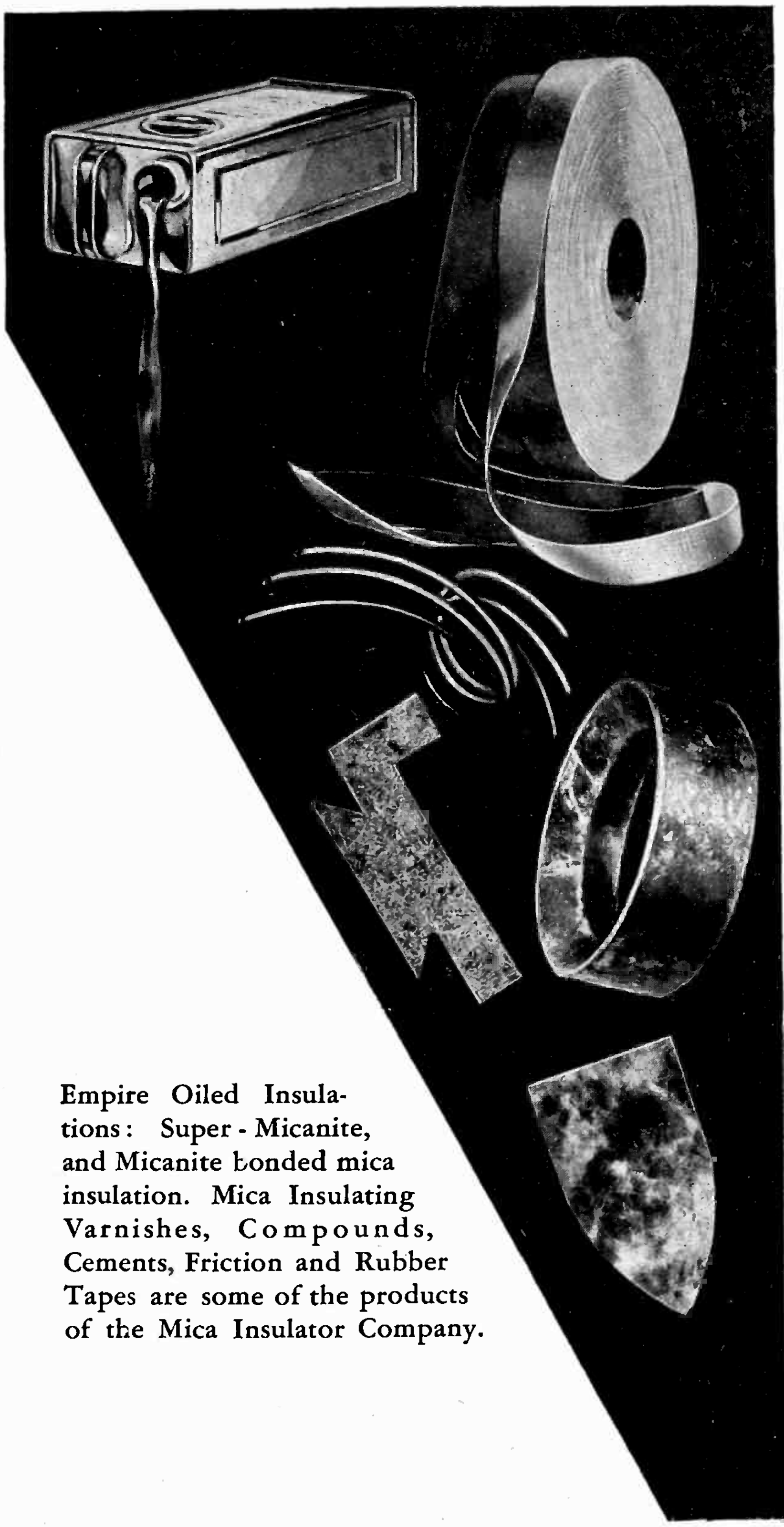
Each lava part made to special design. Let us solve your insulating problem.

AMERICAN LAVA CORPORATION

27-67 Williamson St. Chattanooga, Tenn.

Manufacturers of Heat Resistant Insulators

Helpful Facts *about electrical insulation*



40 pages of useful data for the electrical manufacturer and repairman

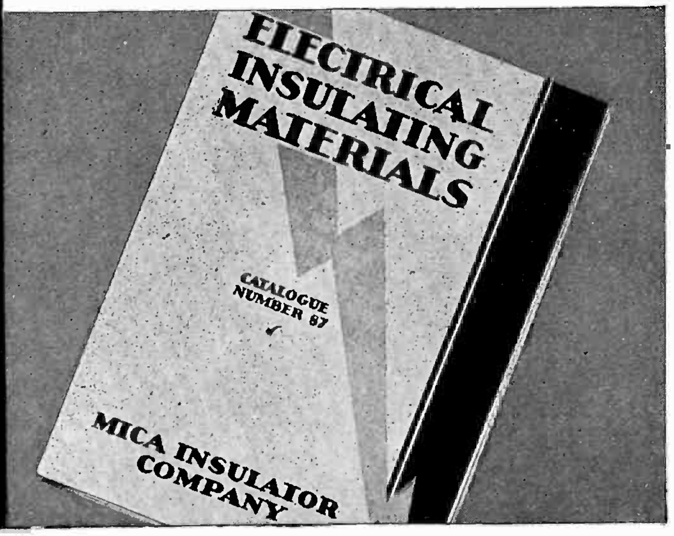
Tables of physical and electrical characteristics amplified by suggested applications for the seventy and more electrical insulations are contained in this new catalog.

It is a handbook that will prove extremely useful to the electrical industry. Copies are now ready for distribution. Write and tell us how many copies you can use.

MICA INSULATOR COMPANY

New York: 200 Varick St. Chicago: 542 So. Dearborn St.
Works: Schenectady, N. Y. London, England
Cleveland Pittsburgh Cincinnati Birmingham Seattle
San Francisco Los Angeles Toronto Montreal

Empire Oiled Insulations: Super-Micanite, and Micanite bonded mica insulation. Mica Insulating Varnishes, Compounds, Cements, Friction and Rubber Tapes are some of the products of the Mica Insulator Company.



PERFECT MICANITE INSULATOR REG. U.S. PAT. OFF.

Electrical INSULATION

PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF.

MICA INSULATION OILED CLOTH INSULATION

A.I.E.E. STANDARDS

THE following approved STANDARDS are available in pamphlet form, at the prices indicated, with a discount of 50% to A. I. E. E. members. Numbers of the Standards Sections should be given when ordering.

1. General Principles upon Which Temperature Limits Are Based in the Rating of Electrical Machinery, (.20);
4. Measurement of Test Voltages in Dielectric Tests, (.30);
5. Direct-Current Generators and Motors and Direct-Current Commutator Machines in General, (.40);
7. Alternators, Synchronous Motors and Synchronous Machines in General, (.40);
*8. Synchronous Converters, (.40);
9. Induction Motors and Induction Machines in General, (.40);
10. Direct-Current and Alternating-Current Fractional Horse Power Motors, (.30);
*11. Railway Motors, (.30);
13. Transformers, Induction Regulators and Reactors, (.40);
*14. Instrument Transformers, (.30);
*15. Industrial Control Apparatus, (.40);
*16. Railway Control and Mine Locomotive Control Apparatus, (.40);
*17f Mathematical Symbols, (.30);
17g1 Letter Symbols for Electrical Quantities, (.20);
17g6 Graphical Symbols for Telephone and Telegraph Use, (.20);
19. Oil Circuit Breakers, (.30);
22. Disconnecting and Horn Gap Switches, (.30);
26. Automatic Stations, (.30);
30. Wires and Cables, (.40);
33. Electrical Measuring Instruments, (.30);
34. Telegraphy and Telephony, (.30);
*36. Storage Batteries, (.20);
*37. Illumination, (.30);
38. Electric Arc Welding Apparatus, (.40);
39. Electric Resistance Welding Apparatus, (.30);
41. Insulators, (.30);
*42. Symbols for Electrical Equipment of Buildings, (.20);
45. Recommended Practise for Electrical Installations on Shipboard (Marine Rules), (1.50);
*46. Hard Drawn Aluminum Conductors, (.20);
*60. Specs. for Tinned Soft or Annealed Copper Wire.
*61. Specs. for Soft or Annealed Copper Wire. (Nos. 60 and 61 published as one pamphlet), (.30);
*63. Specs. for 30 Per Cent Rubber Insulation for Wire and Cable for General Purposes, (.30);
*69. Specs. for Cotton Covered Round Copper Magnet Wire;
*70. Specs. for Silk Covered Round Copper Magnet Wire;
*71. Specs. for Enameled Round Copper Magnet Wire; (Nos. 69, 70 and 71 published as one pamphlet), (.30).

**Approved as American Standard.*

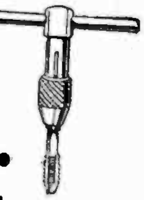
STANDARDS BINDERS

The various sections of the Standards can be kept in bound form with the practical binder which has been designed for this purpose. Capacity of the binder is from 10 to 30 sections or pamphlets. Finished in brown fabrikoid with imprint on stiff back. Price $1.75.

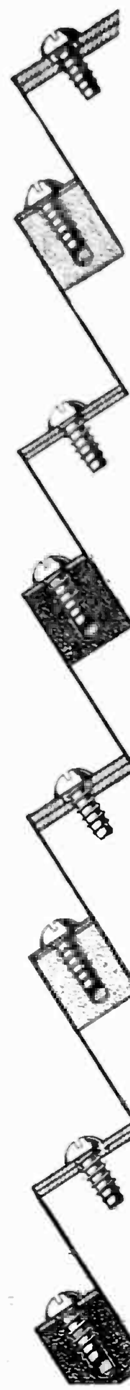
American Institute of Electrical Engineers

33 West 39th Street New York

Fasten thin sheet metal *without* tapping ..broken taps. or tapping plates



Just punch a hole and turn in this Self-tapping Screw



Holes cannot be successfully tapped into thin sheet metal unless a tapping plate or other auxiliary device is used to provide a sufficiently heavy cross section for tapping.

With Parker-Kalon Hardened Self-tapping Sheet Metal Screws secure fastenings can be made to the thinnest of sheet metal . . . easily and quickly. No slow, costly tapping necessary . . . no broken taps . . . no tapping plates. The time, labor and cost of making assemblies is reduced considerably.

Self-tapping Screws cut their own thread in the sheet metal. Just turn them into a pierced or drilled hole with a screw driver.

Assemblies made by such concerns as General Electric, Western Electric, Westinghouse, Cutler-Hammer and many other electrical manufacturers prove that these unique Screws stand-up under vibration and severe service.

With Self-tapping Screws you can cut the time and cost of assembling thin sheet metal or metal as heavy as 10 gauge (0.140″). And for making secure fastenings to slate, die castings, Bakelite, etc., these Screws cannot be surpassed for ease and economy.

How many places in assembling your products can you use Self-tapping Screws profitably? It will pay you to find out. Try the free samples we'll send. Just tell us what you want to fasten.

PARKER-KALON CORPORATION
198 Varick Street New York, N. Y.

Distributed in Canada by Aikenhead Hdw., Ltd., 19-21 Temperance St., Toronto

PARKER-KALON
HARDENED TYPE Z SELF-TAPPING
Sheet Metal Screws

PATENTED
APR. 1, 1919 - No. 1299232 — MAR 28, 1922 - No. 1411184
AUG 14, 1923 - No. 1465148 — FEB 10, 1925 - No. 1526182
OTHERS PENDING

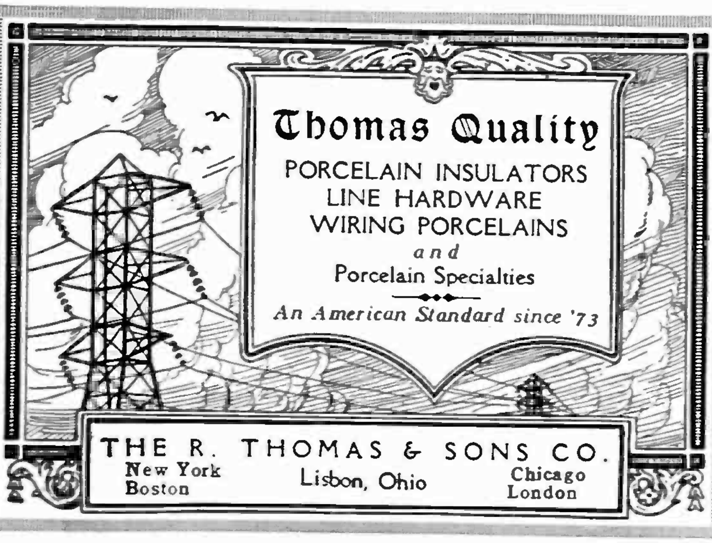
KEARNEY

MANUFACTURERS OF

Preheated Certified Malleable Iron Screw Type Anchors
Outdoor Type Fuse Switches, Disconnecting Switches,
Choke Coils, and Combinations, 7500 and 15000 volts
Aluminum, Copper, and Galvanized Iron Guy Wire Clips
Extension Sleeve Twisters with Interchangeable Dies
Solderless Service Connectors
Expulsion Porcelain Plug Cutouts
Tap Off Clamps

Write for Catalog

JAMES R. KEARNEY CORPORATION
4220 Clayton Avenue - - ST. LOUIS, MO.



'Tis the usual thing—

when faced with the task of filling a position, to turn to friends for friends they may recommend.

Your *best* friend from whom to seek this help is The Engineering Societies Employment Service. They will refer you to the best available talent for your particular need. The service is free to employers.

Send your requirements
to the nearest office of

THE ENGINEERING SOCIETIES
EMPLOYMENT SERVICE

31 West 39 St. New York — 205 W. Wacker Dr. Chicago — 57 Post St. San Francisco

CLASSIFIED
ADVERTISEMENTS

RATES: Fifty cents per line; minimum charge based on use of five lines; maximum space cannot exceed twenty lines. Copy is due the 15th of the month preceding publication date.

For Sale: A. I. E. E. TRANSACTIONS, BOUND VOLUMES from 1913 to 1927, INCLUSIVE, FIFTEEN DOLLARS LOT. ROOM 1907, CHANIN BUILDING, NEW YORK.

SITUATION WANTED: Electrical engineering salesman, 42, technical education, married, twenty years' successful experience in sales and executive work, desires position as sales manager with manufacturer of electrical equipment. Address Box 144, JOURNAL of A. I. E. E., 33 West 39th Street, New York.

WANTED: An established manufacturer of outdoor switching equipment and complete outdoor substations desires a commercial engineer with sufficient experience to plan and make complete proposals in the field. Exceptional opportunity for engineer with proper experience. Address Box 145, JOURNAL of A. I. E. E., 33 West 39th Street, New York.

WANTED: Engineer, 25 to 35 years of age, familiar with design of medium a-c. or d-c. motors. State age, training, experience and approximate salary expected. Address Box 146, JOURNAL of A. I. E. E., 33 West 39th Street, New York.

INSULATORS

CANADIAN PORCELAIN CO., Ltd.
Hamilton—Ontario—Canada

Quebec District Office
612 Transportation Bldg.
Montreal, Qu.

London Office
343 Abbey House, 4 Victoria Street
London, S. W. 1.

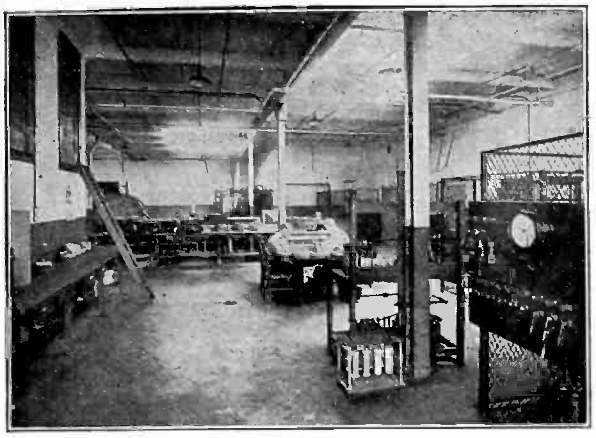
HEMINGRAY
GLASS INSULATORS

The transparency of Hemingray Glass Insulators makes line inspection very simple. The lineman can tell at a glance whether the insulator is intact or not. Hemingray insulators are mechanically and dielectrically dependable, non-porous and uniform in structure. They defy moisture and age.

Send for Bulletin No. 1.

HEMINGRAY GLASS COMPANY
Muncie, Indiana

POWER CABLES
FOR
CENTRAL STATIONS



A corner in our Electrical Research Laboratory

The quality of paper insulated cable depends largely upon the paper selected and the impregnating compound used, but engineering ability and expert workmanship are of equal importance.

Simplex Paper Insulated Cables are made in a factory equipped with the most modern machinery, operated by skilled workmen and supervised by engineers who know how to produce cables that are second to none.

In addition, thoroughly equipped electrical and chemical research laboratories are constantly obtaining new information which is used as the basis for improvement in Simplex Cables.

All the materials used are approved by our electrical and chemical staffs as best suited for the purpose. The carefully selected paper of proper width is applied at the correct angle of lay and suitable tension to produce best results.

After being thoroughly dried it is completely saturated with an approved impregnating and insulating compound.

Lead sheaths are properly applied and completely sealed to prevent moisture and air from reaching the insulation.

To insure highest possible success during construction as well as upon completion of the cables, ample testing facilities keep a check on materials and workmanship.

SIMPLEX WIRE & CABLE Co

MANUFACTURERS

201 DEVONSHIRE ST., BOSTON

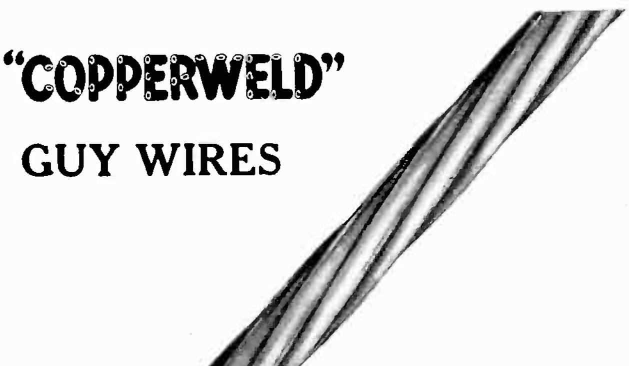
BRANCH SALES OFFICES

CHICAGO, 564 W. Monroe St. SAN FRANCISCO, 390 Fourth St.
NEW YORK, 1328 B'way CLEVELAND, 2019 Union Trust Bldg.
JACKSONVILLE, 1010 Barnett Nat'l Bank Bldg.

For Non-Rusting Overhead Construction

"COPPERWELD"

GUY WIRES



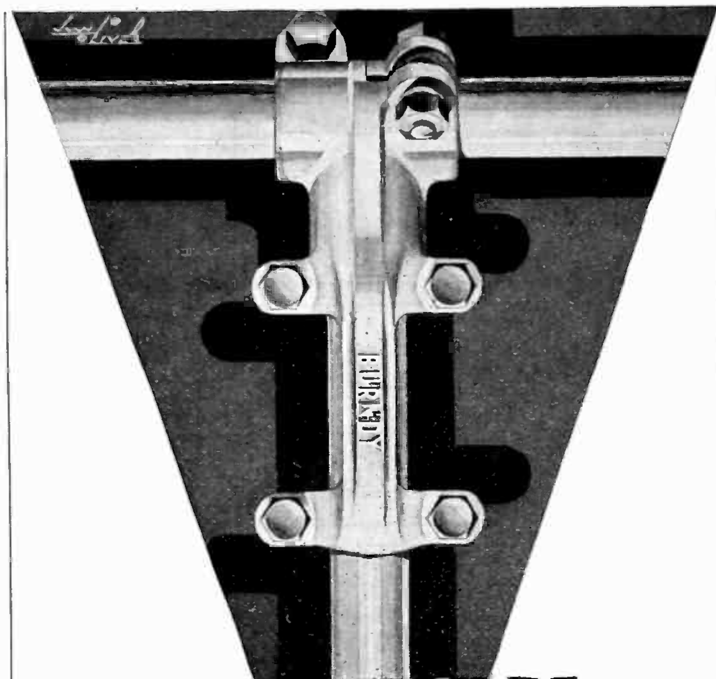
WILL NOT RUST

Copperweld Steel Company

MAIN OFFICE & MILLS:—GLASSPORT, PENNA.

NEW YORK, 30 CHURCH ST. CHICAGO, 129 S. JEFFERSON ST.
DALLAS, 823 S. EDGEFIELD ST. SAN FRANCISCO, RIALTO, BLDG.

IN CANADA: NORTHERN ELECTRIC CO., LTD.



BURNDY CONNECTORS

For Tubing, Cable and Bar

BURNDY ENGINEERING CO.
Incorporated
10 East 43rd Street, New York

PROFESSIONAL ENGINEERING DIRECTORY

For Consultants in the Fields of Engineering, and Related Arts and Sciences

SARGENT & LUNDY
Incorporated
Mechanical and Electrical Engineers
1412 Edison Bldg., 72 West Adams Street
CHICAGO ILLINOIS

STEVENS & WOOD
INCORPORATED
Engineers and Constructors
20 PINE STREET., NEW YORK
Youngstown, O. Jackson, Mich.
Chicago, Ill.

PERCY H. THOMAS
Consulting Engineer
ELECTRIC POWER
Generation—Transmission
Applications
120 BROADWAY NEW YORK

SCOFIELD ENGINEERING CO.
CONSULTING ENGINEERS
Utility and Industrial Plants
Design, Construction, Operation
Valuations and Appraisals
PHILADELPHIA

STOCKBRIDGE & BORST
Patent Law
41 PARK ROW NEW YORK CITY

THE J. G WHITE ENGINEERING CORPORATION
Engineers—Constructors
Oil Refineries and Pipe Lines,
Steam and Water Power Plants
Transmission Systems, Hotels, Apartments,
Offices and Industrial Buildings, Railroads
43 EXCHANGE PLACE NEW YORK

JOHN A. STEVENS
CONSULTING POWER ENGINEER
16 Shattuck Street
LOWELL MASSACHUSETTS

STONE & WEBSTER
Incorporated
DESIGN AND CONSTRUCTION
EXAMINATIONS REPORTS
APPRAISALS
INDUSTRIAL AND PUBLIC SERVICE PROPERTIES
New York Boston Chicago

J. G. WRAY & CO.
Engineers
J. G. Wray, Fellow A. I. E. E. Cyrus G. Hill
Utilities and Industrial Properties
Appraisals Construction Rate Surveys
Plans Organizations Estimates
Financial Investigations Management
2130 Bankers Bldg., Chicago

YOUR CARD in each issue of this publication—12 times a year, will keep your name and specialized service constantly before the electrical industry.

Qualified advertisers in the Professional Engineering Directory are invited to send for rates.

ELECTRICAL TESTING LABORATORIES
80th Street and East End Ave.
NEW YORK

Inspections — Tests — Research

Tests may be used by the purchaser for the following purposes:

(1) To determine the quality of competing samples. This enables the purchase of the best quality for the money.
(2) To make sure that shipments comply with specifications. This makes possible the assurance to the customer that shipments match buying samples.
(3) To furnish an impartial decision in case of disputes between purchaser and manufacturer.

Testing places the whole buying problem on a sound basis.

"Since 1920, you have satisfactorily repaired 1,000 transformers for us"—*writes an Illinois Customer*

This official further states: "Our records indicate you have been repairing all of our transformers — both distribution and high tension. During these eight years we have found, without exception, very high grade work. Your charges at all times have been most reasonable."

Such letters point to the fact that you, too, can depend upon us in every detail for the right kind of a repair transformer job. Let us send you our bulletin and price list every month. It gives full details of our transformer stock of about 4,000 units for immediate delivery — 1 to 1,000 kva., 110 to 66,000 volts. All rewound transformers are given standard A. I. E. E. tests.

WE BUY MODERN TYPE TRANSFORMERS—ANY SIZE—ANY QUANTITY

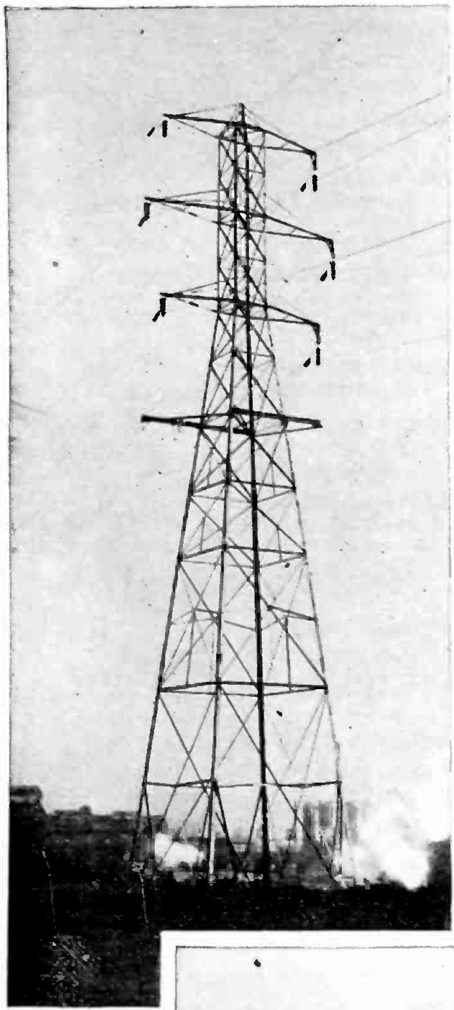
The ELECTRIC SERVICE CO. Inc.
America's Used Transformer Clearing House
212 Walnut Street Cincinnati, Ohio

Classified Advertiser's Index for Buyers

Manufacturers and agents for machinery and supplies used in the electrical and allied industries.

Note: For reference to the advertisements see the Alphabetical List of Advertisers on page 64.

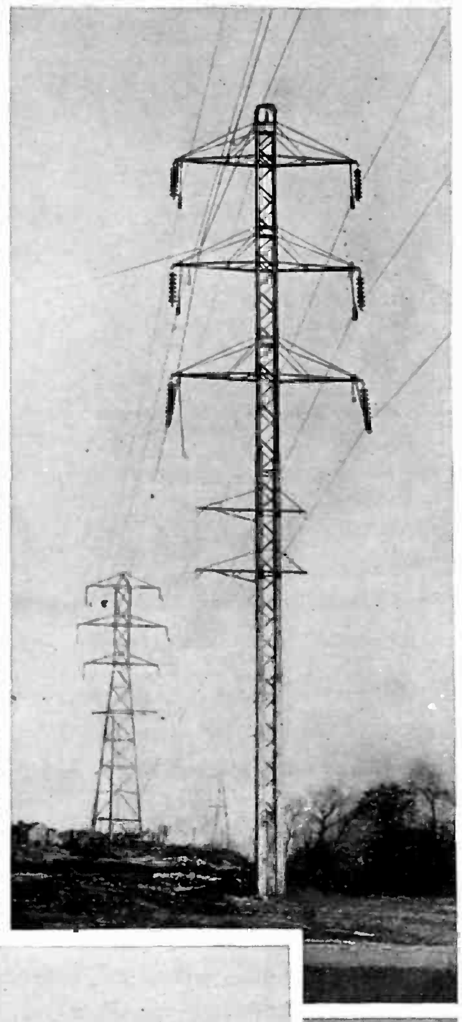
ABCo POLES, TOWERS SUB-STATIONS

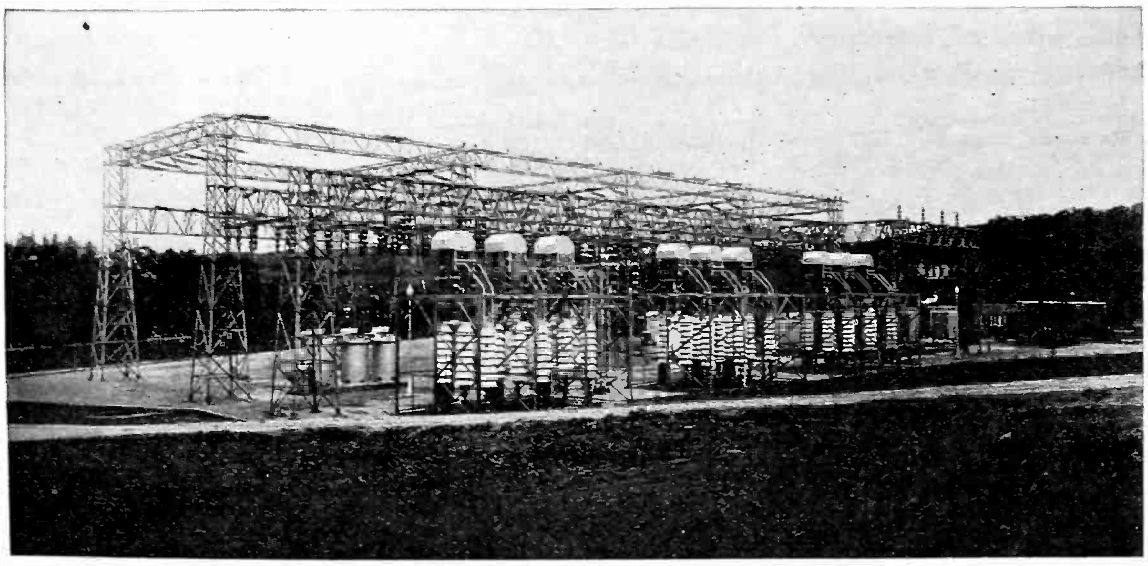


Designed for
Economy in Erection, Maintainence, and Dependability in Service

ABCo poles, towers, sub-stations and other high tension structures are designed by engineers of experience in this work.

Inquiries are invited, especially with respect to designs meeting unusual problems of weather, erection, or transmission.





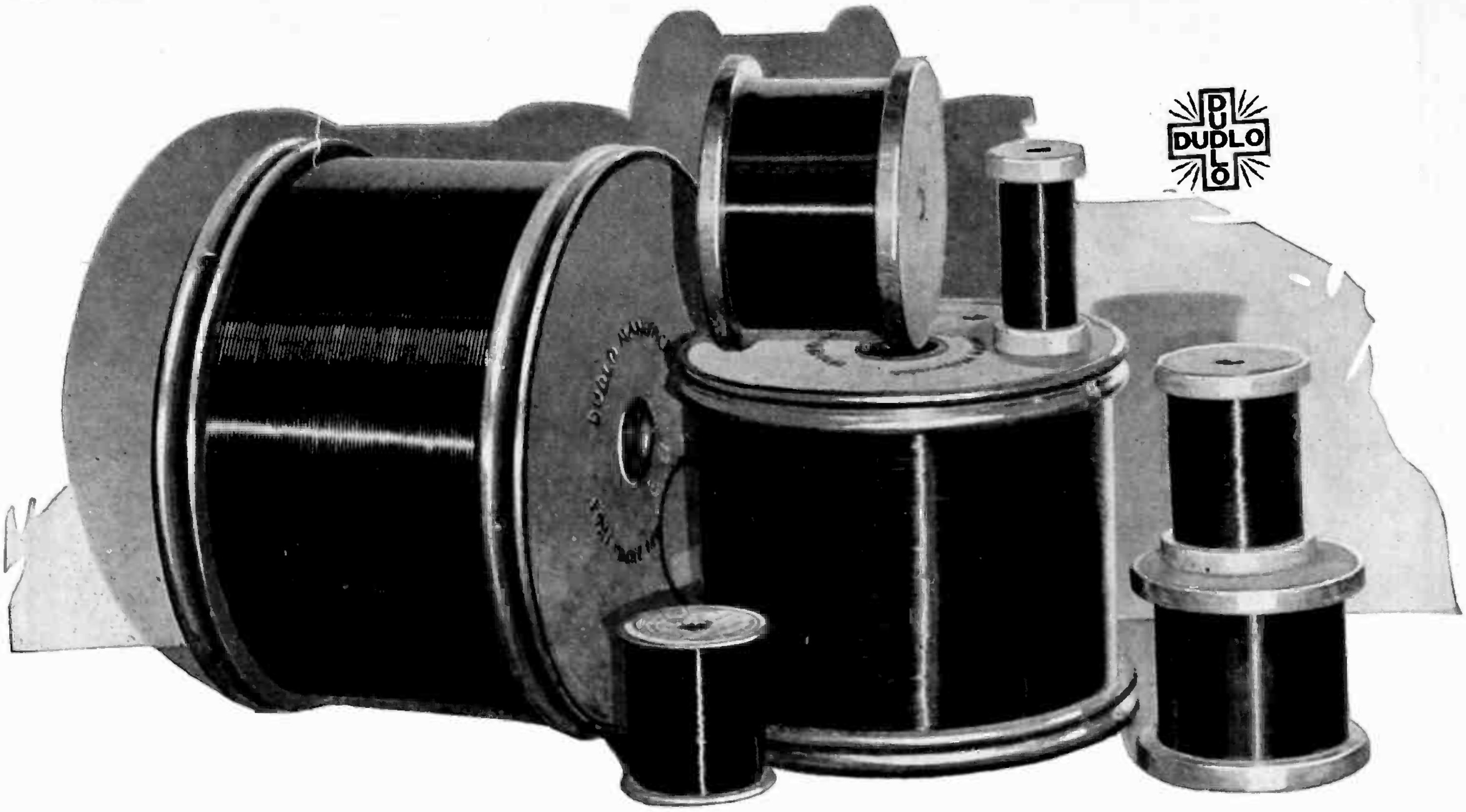
AMERICAN BRIDGE COMPANY

Subsidiary of United States Steel Corporation

General Office: 71 Broadway, New York City
Tower Dept., Frick Bldg., Pittsburgh, Pa.

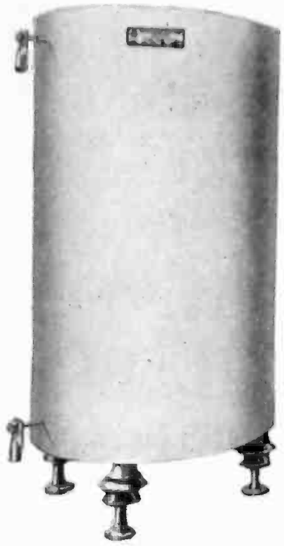
Classified Advertiser's Index for Buyers—*Continued*

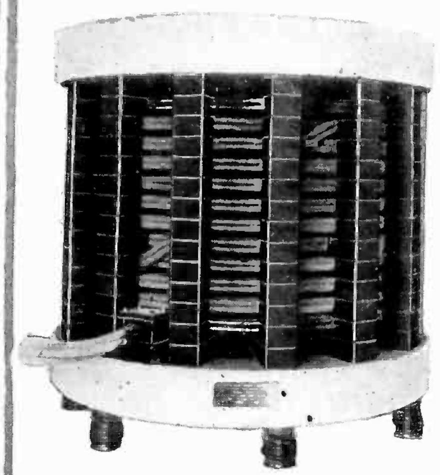
Classified Advertiser's Index for Buyers—*Continued*

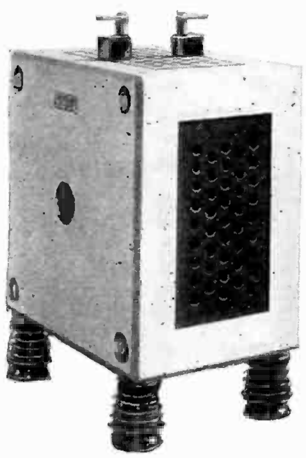


ALPHABETICAL LIST OF ADVERTISERS

(For classified list of Advertisers see pages 58, 60 and 62)







A Complete Wire Service for Radio Manufacturers

MAGNET Wire in a great variety of sizes and insulations; Flexible Lead Wire for many uses; Colorubber Hookup Wire in a large assortment of colors; Special Wiring Harness built to order; Cords cut to specifications and equipped with the Unbreakable Belden Soft Rubber Plug; Special Bakelite Moldings; Coil Windings to order; and Reproducer Cords made to specifications, are some of the items Belden is supplying to many leading manufacturers.

The extensive list of set manufacturers who purchase their wire requirements from Belden is significant proof of the quality of Belden Radio Materials.

Valuable experience accumulated by the Belden Engineering Department in the development of special wires, harnesses, coil windings, and similar products, is at your service.

Correspondence regarding your wire problems is invited.

BELDEN PRODUCTS

Beldenamel and Textile Magnet Wire
Coil Windings
Beldenmold
(Molded Bakelite Products)
Automotive Wires and Cables
Airplane Assemblies
Radio Wires, Cords and Cables
Rubber Covered Wires
Armored Cables
Flexible Armature Wires
Motor Lead Wires
Braided and Stranded Copper Cables
Cotton Sleeving

Belden Manufacturing Company
2316-B South Western Ave.
Chicago, Ill.

Specify Belden