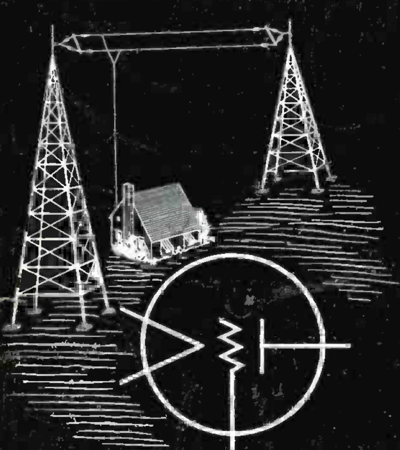
JANUARY, 1933

Radio Engineering



IN THIS ISSUE

THIRTEENTH YEAR OF SERVICE

The Journal of the Radio and Allied Industries

The Depression Helps Us

More concerns are trying Self-tapping Screws — the modern, cheaper means of making secure fastenings And 7 out of 10 trials show a Saving

During 1932 alone, more than twelve hundred manufacturers, seeking a way to lower production costs, asked us for samples of Self-tapping Screws for test purposes. And 7 out of every 10 concerns who tried the Screws found a simple and effective way to save money.

Probably you, too, are faced with the job of making a better product at lower cost. Self-tapping Screws may help you do it. If your product requires fastenings to sheet metal, steel, cast iron, die castings, brass, Bakelite, slate, ebony asbestos, it will certainly pay to try the modern, cheaper means of making fastenings.

Some typical savings in assembly of radios

Unit savings are the same for the scores of smaller radio manufacturers who use Self-tapping Screws, as for the prominent concerns like Philco, Stromberg-Carlson, Zenith, R. C. A.-Victor, and Crosley. So whether you produce one or a thousand units a day, you might equal the following typical economies—

By using Hardened Self-tapping Sheet Metal Screws instead of machine screws for assembling the Wurlitzer Lyric Radio, fastening costs were reduced 31 per cent. Practically all tapping operations were eliminated, saving tap expense, extra labor, and rejections due to stripped threads. Also the assemblies were so strengthened that complaints about parts loosening in shipment stopped.

Zenith adopted Hardened Self-tapping Sheet Metal Screws to replace machine screws for fastening parts to the chassis, and lowered assembly costs by 15 per cent.

After trying Hardened Self-tapping Sheet Metal Screws for a few assemblies, the United Air Cleaner Corporation was so pleased that on later designs they used the Screws for a large percentage of fastenings formerly made with tubular rivets, nuts and bolts, and machine screws.

Get the Money-Saver Test Bag and cut costs in 1933

A few minutes spent in trying Self-tapping Screws may show you how to materially reduce fastening costs in 1933—without changing designs or production routine—and without sacrificing fastening security, for unbiased tests prove that Self-tapping Screws make stronger as well as cheaper fastenings.

Clip the coupon, now. Attach to it a brief description of one or more assemblies. Our Fastening Specialists will tell you whether you can use Self-tapping Screws to advantage, and send a "Money-Saver Test Bag" of samples for a trial.

Which Self-tapping Screw Meets Your Need?

Type "Z" Hardened Self-tapping Sheet Metal Screws
For making fastenings to sheet metal up to 6 ga., aluminum, die castings, Bakelite, etc. Turn Screw into drilled, pierced or molded hole. It forms a thread in the material as it turns in. Can be removed and replaced.

Type "U" Hardened Metallic Drive Screws
This type of Self-tapping Screw is used for making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, etc. Hammer Screw into drilled or molded hole. It forms a thread in the material as it is driven.

PARKER-KALON *Hardened* Self-tapping Screws

PAT. IN U. S. AND FOREIGN COUNTRIES

PARKER-KALON CORPORATION, DEPT. L, 190-198 VARICK STREET, NEW YORK, N. Y.

Tell me whether assemblies described on attached sheet can be made cheaper with Self-tapping Screws. I'll make a "Money-Saver Test" if you send samples and recommendations—Free.

Name and Title..

Company..

Address..

RADIO ENGINEERING

Reg. U. S. Patent Office

MEMBER AUDIT BUREAU OF CIRCULATIONS

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Managing Editor
F. WALEN

Vol. XIII — JANUARY, 1933 — Number 1

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Departments

LOOKING FORWARD

THE president of one of the largest radio retail and sporting goods companies in the east has the following to say about what the year 1933 should see:

"In spite of greatly reduced incomes there is in this country a considerable latent buying power. With returning confidence this buying power will make itself felt and will be immediately reflected in retail sales. I think this depression has gone further than fundamental conditions warrant; that people in general are beginning to believe it and are more hopeful, and that we shall not again see trade conditions as bad as they have been. I expect retail business will be slow for the first quarter of 1933, gradually improving with 1933 a better year as a whole than 1932."

BRYAN S. DAVIS
President

JAS. A. WALKER
Secretary

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Editorial

JANUARY, 1933

RADIO AND THE SENATE

ANACHRONOUS as it may seem it appears that what a Senator from a small, mountain State thinks about the required makeup of the Federal Radio Commission must be reckoned with in large measure.

It is an odd twist of things out of joint that the Senators from the great States New York, Massachusetts, Illinois, California and Louisiana, where radio, in more than one of its useful applications is a subject of commercial importance, should display so little interest or ability in the regulation of this vastly important utility.

One Senator from New York, it is true, has considerable to do with radio—he regularly broadcasts talks to housewives advising them to use a certain kind of flour when baking bread or making flapjacks.

Is it any wonder that one of the main worries of industry is the United States Senate?

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SINGLE TOWER ANTENNAS

HERE and there further ventures are being made with the use of single tower antennas for broadcast stations. Joseph A. Chambers, chief engineer of the Crosley organization has in hand the erection of a vertical radiator tower for WLW at Cincinnati.

With the advent of steel supporting towers or masts it was learned that towers and antennas are component parts of an oscillating system, the effect of antenna proximity to the tower greatly influencing the strength and direction of the radiated waves. The tower being a conducting structure obeys the laws of vertical antennas. Efforts to determine the resonant frequency of towers were handicapped because of the physical dimensions of the metal structure and supports.

In the new designs the desire has been to take advantage of the theorem that as the height of the antenna is increased above a quarter wavelength there will be a decided gain in the low angle or ground waves at the expense of the sky waves. This radiation tendency continues until the optimum height for low angle waves is reached—about a half wavelength.

The first expedient of insulating the tower from the ground made possible an approach to conditions wherein a free, isolated wire oscillates as a half wave antenna.

In the new antenna for WLW the tower will be 35 feet wide at its widest point, tapering uniformly to points at each end.

About 135 tons of steel will be used in the construction. This will rest, on end, on a hollow porcelain insulator, conical in shape, about 5 feet in height, weighing about 300 pounds.

The cost of the new antenna will be approximately $50,000.

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FREQUENCY SPREAD OF RECEIVERS

THE employment of transmitting frequencies representing wavelengths shorter than 200 meters for matter of interest to owners of broadcast receivers, a year or more ago created demand for adapters and converters for attachment to the standard 200-550 meter sets.

The growth of international broadcasting together with the possibility of spreading the present broadcast range to accommodate additional "cleared" channels may in time create demand for millions of radio receivers operating over wider scales.

In the interim converters seem to have quite a vogue. Based on superheterodyne principles, converters are serving this purpose. In those converters in which is incorporated a stage of i-f. amplification the converter-receiver has a gain in sensitivity. Matching the impedance of the mixer tube with that of the input element of the receiver proper is a problem of design because of the variation in input impedance of various standard receivers.

There is in this situation a manufacturing and a sales problem due for consideration on a wide scale.

Donald McNicol

Editor.

CLAROSTATS

for

REPLACEMENT

Much of the difficulty experienced with volume and tone controls can be traced directly to the idea that these controls are comparatively unimportant elements in the radio receiver. This idea has led to the use of cheap, poorly made and untested units which work fairly well for a short time but then become defective and cause no end of trouble.

The service managers' problem has been to find better controls to replace defective units which are giving trouble and causing him to lose his reputation for efficient servicing.

Clarostat volume and tone controls are the result of years of experience in the development and manufacture of efficient, durable controls that take the gamble out of control circuits. While they are inexpensive because of efficient manufacturing methods, no effort has been made to cut costs at the expense of quality. These units have been designed and built to give efficient operation under all service conditions.

For replacement purposes, we have worked out a most practical system of basic volume control circuits and proper units to use in each type of circuit.

Since manufacturers often change the type of volume control used in different lots of the same models or series of receivers, it is practically a physical impossibility to keep a list of replacement volume controls up to date. Much confusion and delay will therefore be avoided if, when ordering replacement controls, you give complete information regarding the name and model of the receiver, and any further information on the circuit used.

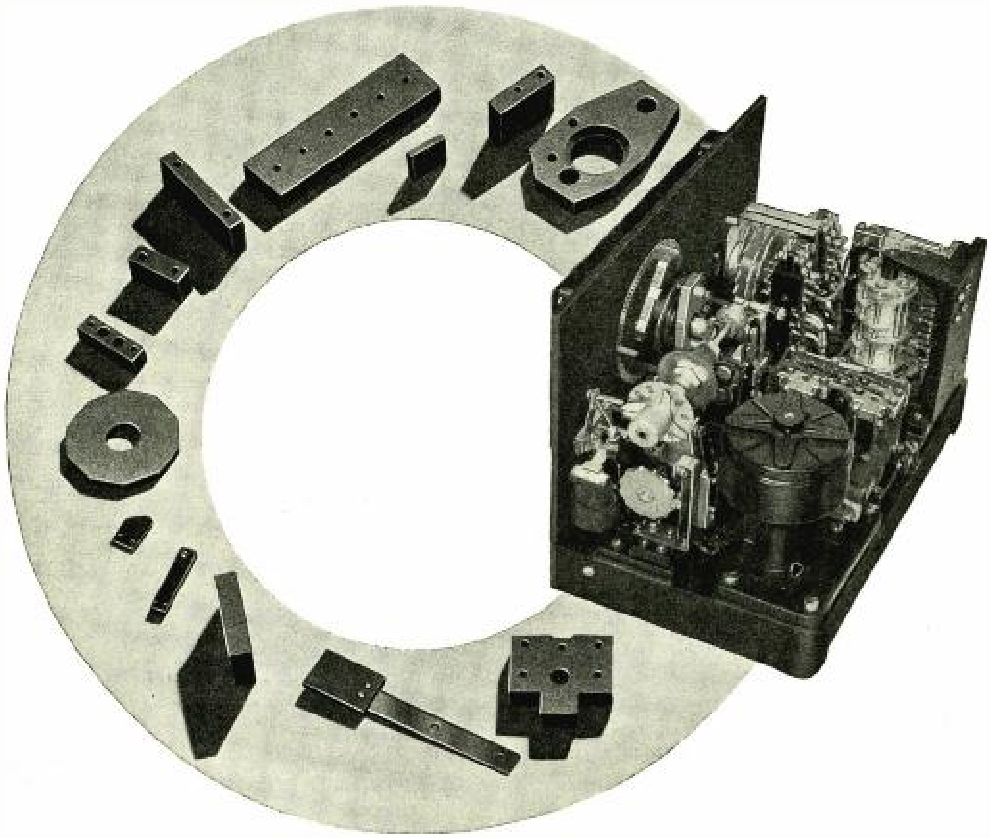
The two controls illustrated above show Clarostat's ability to furnish special replacement units.

Let Us Know Your Control Problems!

CLAROSTAT MFG. CO. INC.

285 NORTH 6th STREET BROOKLYN, N. Y.

15 Textolite laminated parts were used in this timing device



OTHER PRODUCTS:
Textolite molded
Cetec cold-molded

TEXTOLITE laminated, a General Electric product, manufactured in sheets, tubes, and rods, was chosen for the fabrication of these parts because of its dependable uniformity, high dielectric and mechanical strength, and the ease with which it can be fabricated.

An increasing number of manufacturers in the electrical, radio, and electronic fields are using Textolite laminated—it assures positive, dependable operation of their products.

Investigate Textolite laminated. By adapting it to your product, you may be able to effect great savings for your company.

Ask for a copy of GEA-1458. Simply address General Electric Company, Plastics Department, Meriden, Conn.

831-15

GENERAL ELECTRIC

RADIO ENGINEERING

FOR JANUARY, 1933

A bright future for the radio industry

By John Dunsheath

EVERYONE knows that there are many social, governmental and financial problems in process of adjustment, which will require months and perhaps years for their complete solution. But, no one argues that the natural human urge for individual achievement can much longer be denied opportunity. Many well informed economists are willing now to forecast that the year 1933 will see great improvement in the material well-being of a majority of the people.

The radio industry, in its various branches, is fortunately situated. A general recovery of industry will find radio running ahead of various other lines of commercial activity.

Aside from the apparently unavoidable situation with respect to retail prices of radio receivers, there is cause for satisfaction in the continuous increase in the number of receivers in service. This is progress that cannot truthfully be registered by more than a very few commodities.

It is a progress that neither the curtailed budget of the consumer nor the restricted appropriations for research work of the manufacturer have been sufficiently strong to curb. The fact that the radio industry has not been affected more severely by the adversities of the past few years proves that it has outgrown successively the toy and luxury stages and now has taken its place as an indispensable part of everyday life, as much so as the telegraph, the telephone, or the electric refrigerator, according to a survey of the radio industry which has just been completed by R. G. Dun & Company.

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Many indications point to revival of radio business on large scale

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"The back-to-the-home movement, which lowered incomes started, was given its greatest impetus by the radio," the survey continues, "as the home now is about the only place where one can be certain of a good show. An evening which does not offer a choice of nearly $100,000 worth of entertainment is the exception, and there is sufficient variety to the programs to satisfy every one of the 20,000,000 odd listeners, whether tastes run to grand opera direct from the stage, sport news from the ringside, or the President's latest speech. Avid, waiting ears daily are placing more dependence in the radio, which has brought an end to the silence of centuries, and suddenly has put this generation into familiar communication, on an equal basis, with everybody in the world."

Rural Radio

In February, 1931, of the six million farms in the United States, only one-third had radio receivers in the homes. It is estimated that during the years 1931 and 1932, 1,500,000 receivers were sold for farm home use, and for country homes on small acreage. This considerable increase was due not only to the fact that hundreds of thousands of urban unemployed citizens returned to farms, but to simplification of operation of receivers suitable for use where commercial electric power is not available.

Extent of Industry

The latest figures of the Census Bureau, Department of Commerce, show that there are 214 radio manufacturing establishments, which, in 1931, employed an average of 36,330 wage earners; the wages totaling $35,031,461. The cost of materials, fuel and electric power used amounted to $88,380,906, and the value added to manufacture $104,044,265.

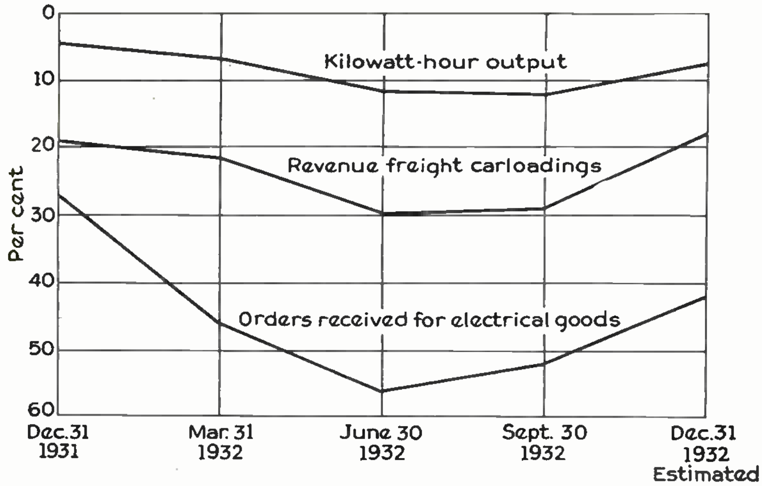
For 1932 these totals sagged somewhat, but not nearly so much proportionately as in almost all other industries. For the year 1933 it is anticipated that there will be consistent gains in all directions.

Spurs to Progress

In the monthly issues of Radio Engineering during the past six months have been reported and described many radio improvements which, with others now in process, will give impetus to sales as buying power improves. Persons both in and out of the radio business realize that radio is a young art; that notwithstanding that astounding advances have been made in ten years, the industry has taken only its first faltering steps toward its ultimate destiny.

Airplane Radio

Radio equipment for the automatic steering of planes which insures the direct flight of a plane to a predetermined destination regardless of the



THE OUTLOOK FOR 1933

By Gerard Swope, *President, General Electric Company*

Possibly the best basis for trying to judge the immediate future is the recent tendencies of the past. For that purpose I know of no better index than the use of electricity throughout the United States. This index is the quickest reflection of business activity because when a manufacturer gets an order he starts a motor to run his machinery and turn out the order, and in the household the increased use of light and appliances may be a reflection of a little more employment or, at all events, better psychology. The accompanying chart shows the percentage relation of each quarter this year with the same quarter of 1931 and indicates there was a decrease in use of electricity in each quarter compared with 1931, but distinct improvement in the last quarter.

Another excellent index of business activities is freight carloadings. When an order is completed and shipped, it is immediately reflected in carloadings. Here the curve is very similar, showing that the low point was reached in the summer of 1932, with a distinctly upward comparative trend for the last quarter.

Orders received by the electrical manufacturing industry, as reported to the Department of Commerce (with the fourth quarter estimated), show a distinct trend in the same direction. Therefore, we are hopeful that this comparative trend will continue upwards.

effects of wind drift is soon to be available. This development together with the phenomenal increase in the use of radio telegraph and telephone equipment for communication purposes in airways operations promises a field for radio products which will be a year-round demand.

Automobile Radio

It is estimated that there is a probable market for 10,000,000 radio receivers for automobile use. The rate of installation of radio receivers in automobiles during the lean years of 1931 and 1932, shows that this added utility is recognized as being worth far more than its small cost. The automobile manufacturers themselves were last to be convinced that a radio receiver installation would be a determining factor in making sales of automobiles. At the present time all automobile manufacturers are giving the subject the same attention they are giving other possible betterments and improvements in car makeup.

Police Radio

It is no longer necessary to argue with police departments that radio signaling between headquarters and police patrol units surpasses in effectiveness any other method of communication. The hundred odd cities now using radio telephone service for police uses testify to the value and efficiency of such installations. That there are several thousand communities now desirous of having police radio is well known. This growing demand will be satisfied when the tax burden eases up, and when municipal departments are able to make savings in other directions, permitting expenditure for police radio without increasing the total department appropriation called for annually.

Raw Products

It is estimated that in a normal radio year the consumption of steel in radio manufacture totals about 100,000 tons, while the copper consumption totals approximately 15,000 tons. To mention only a few of the products which are basic in the manufacture of radio receivers and radio accessories, there is tungsten rod and wire, molybdenum, nickel and nickel alloys, aluminum, bronze, brass, magnet wire, varnishes, cabinet work, insulating materials such as Bakelite, Resinox, Synthane linen, canvas and paper base laminated insulations, fibres, and various other insulating products. Also, flexible shafting, lock washers, lock nuts and screws, elastic stop nuts, self-threading drive screws, transformer iron laminations, and stampings, vacuum pumps, welding machines, flare and basing machines, selvage mesh, filament wire, nickel chrome wire and ribbon, resistance wire, wave regulating and power crystals, lugs, terminals and connection strips, fuses, flux-core solder, bombarding equipment, and all of the numerous elements which go into the makeup of radio accessories. These and many other products now available or to be announced will find wide use in the radio industry of the immediate future.

Exports

The R. G. Dun & Co., survey of radio previously quoted, states:

"With the perfection of short-wave reception and with new broadcasting stations springing up constantly in Europe and South America, radio manufacturers are gaining in their importance to world trade. Sales of American manufacturers abroad have been well maintained, in spite of general commercial stress and increasing import restrictions. Exports in 1931 had a value of $22,600,000, approximately equivalent to those of 1930 and 1929, and more than double the sales of any previous year."

As an example of what excise and import duties do in foreign countries to restrict sales of American radio products (in countries where American products are favored), take the case of Poland. Prices in Poland at the present time are: output choke coils $2.00, ordinary loudspeakers $10.00 to $17.00, output transformers $7.10 to $12.00, 3-watt resistors $0.45, gang condensers $14.00 to $22.00, matched set of 3 r-f. coils for midgets $4.80, and so on. In Poland there is a vast undersold radio market waiting for the arrival of complete receivers and parts of modern design and range, at prices comparable with those in America plus reasonable duty.

One large American manufacturer (Atwater Kent) is reported to be doing a fair business in Ireland and England. selling complete receivers. The tariff walls, however, are stifling, and if the international economic readjustments now being talked of result in a renewal of interchanged commerce, the market abroad for American radio products should be of large magnitude.

Broadcast Equipment Market

The Bureau of the Census, Washington, D. C., reports that in 1931 were manufactured on order in the United States 1,106 radio transmitters, including all associated equipment. The factory price of the equipment totaled $2,400,257.

The number of microphones manufactured totaled 10,225, with a factory value of $187,035.

Radio transmitting tubes for the year

totaled approximately 62,562, the factory value being $1,410,188.

Noteworthy improvements in this equipment are the availability now of mercury-arc rectifiers of 230-kw., 13,000 volt; 500-kw., 15,000-22,000 volt, and 40-kw., 15,000 volt capacity. There is no doubt that station replacements will provide a market for modern equipment of this type.

The conservative New York Trust Company has just issued a statement based on a thorough analysis of the broadcast industry, in which it is stated:

"Broadcasting is still a new industry and is subject to the constant changes which science and research are bringing. The industry, as organized at present, will probably form the basis for the commercial development of television, which is already an actuality on a limited scale. Perfection of television, with its myriad of possibilities, will possibly open up a new field to the manufacturing industry similar to that enjoyed during the past decade by the makers of radio receiving sets and mechanical refrigerators. At the same time it may necessitate the investment of millions of dollars in new television equipment by the broadcasting industry.

"The future in this respect, of course, depends largely on scientific progress. So far as the immediate outlook is concerned, while dollar sales of receiving sets have not been maintained, the income of the broadcasting industry, particularly of the larger companies, has not receded, even during the period of depression. Consequently, as long as the broadcasters continue to fill the public demand for entertainment and the advertisers' demand for increased sales, it is reasonable to believe that the industry will continue in a prosperous condition."

On its part RADIO ENGINEERING can say that at the present time there is a sharp increase in the number of inquiries daily received asking for information about radio materials, parts and accessories. These inquiries are from all parts of the country and are from going concerns of dependable standing. All indications point to the conclusion that the "bottom" was reached about June, 1932, and that the swing upward has set in. How far it will swing upward, and how rapidly, will depend upon how soon and how generally American business senses the immediate possibilities, and how well it rises to the occasion.

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Reducing noise interference†

THE reduction of interference noises or man-made static is an important factor in the sale of modern radio, particularly in the congested areas. Many people in these sections refuse to have a radio in their homes because of the electrical noises which are invariably present when the listener wants to hear a favorite program.

There are several known facts about radio noises which should be thoroughly understood by every radio dealer and serviceman before he tries to talk intelligently to a customer on the subject.

1. Regardless of advertised claims, there is no method or device known to radio science which will eliminate natural static. Static is produced by electrical interference in the atmosphere, and is carried through the air in much the same way as radio from a broadcasting station. It can be reduced in some instances by means of a tone control.

2. Man-made static is produced by various kinds of electrical machines and motors, trolley lines and high tension power lines. It can be reduced in most cases and in many instances can be completely eliminated by filtering, shielding, and by proper erection of the aerial.

3. Man-made static which is picked up on the flat portion of the aerial cannot be eliminated any more than natural static except by moving the aerial farther away from the source of interference, or by suppressing the interference at its point of origin.

4. Man-made static cannot be eliminated by connecting any kind of a device to the power cord of a radio receiver. This type of interference is radiated from the particular power line in which the interfering noise originates. It is carried through the air and is picked up in the aerial and lead-in wires just the same as any other radio signal. A certain amount of this noise does come in on the power line to the radio set, and can be suppressed.

5. The only correct way to eliminate man-made static is to suppress it at its source. For example, radio noises produced by an automatic oil burner can be reduced by placing a suitable filter unit at the motor and automatic switch terminals, but the same filter would be worthless if placed at any other point in the power line.

6. Shielded lead-in wire, either with or without impedance changing devices to reduce losses, will not eliminate or even reduce man-made static which is picked up in the aerial. For this reason, a shielded lead-in is of little or no value in reducing noise in the average home installation. The only condition under which shielding has any effect in reducing noise is where the lead-in wire passes close to interference-carrying power lines, either inside or outside the building. A greater percentage of this noise is picked up in the lead-in wire than in the aerial wire; thus if the lead-in is shielded by means of a grounded metal covering, the interference will be reduced.

7. Ordinary shielded lead-in produces a definite loss in signal strength for which compensation must be made in the form of a higher and longer aerial to afford greater pickup of signal.

8. A good outside aerial installation produces less interference noise in the receiver for a given volume of music than a faulty installation or an inside aerial. This is true of every radio from the cheapest to the most expensive. With a good aerial, the radio set can be operated at a lower volume control setting for a given volume in the speaker than it can with a poor aerial. This means that the receiver does not have to work so hard to bring in the signal. Hence the amount of interference noise which is picked up is reduced proportionately.

Summing up all of the above points, it is obvious that the noise of natural static cannot be eliminated, but that the performance of any radio set can be improved from a noise standpoint by the correct application of filter units and the use of a good aerial installation, in some cases with shielded lead-in wire.

It is unnecessary in all cases to go to an elaborate installation using shielded lead-in. As a matter of fact, such shielding is ordinarily required only in large apartment buildings or hotels. Radio reception for demonstration purposes could be improved in practically every dealer's store because in almost every case the store is located in a business district where radio noises are at their worst. By erecting the aerial high above these noises, and by shielding the lead-in wire, better reception will result. Philco has always advocated the use of shielded lead-in wire in such installations.

The important things to remember in your home installations are that the aerial picks up less noise when run at right angles to power and trolley lines than when it is parallel with such lines; that a carefully installed outside aerial installation always gives superior performance to a small installation; that electric power companies and street car companies are always willing to cooperate in correcting faulty power equipment which produces radio noises.

†By engineering department of the Philco Radio & Television Corp.

Metal-clad mercury-arc rectifiers in broadcast stations

Power for large broadcasting stations is now efficiently derived from stationary rectifiers, replacing rotating generators.

By Paul R. Sidler*

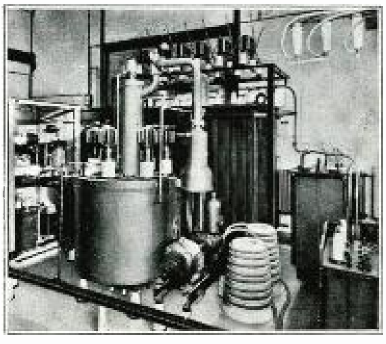
ONE of the main obstacles which stood in the way of the rapid development of transmitting stations for radio telegraphy and telephony, consisted in the difficulty of generating high-voltage direct-current for feeding the amplifiers. The range of desirable voltages for this purpose covers 10,000 to 30,000 volts d-c.

Following the line of designs which had been developed in the early years of this century for high-voltage d-c. power transmission over long distances, radio engineers first resorted to rotating d-c. machines, several of them connected in series to obtain the desired voltage. While these attempts fostered a remarkable improvement in the construction of high-voltage d-c. generators, resulting eventually in modern machines with 6,000, 8,000 or even 15,000 volts generated in one unit, this solution could not be regarded as entirely satisfactory from technical viewpoints. Motor-generators of this description, furthermore, involve considerable costs and have a comparatively low efficiency. The chief drawback of rotating machinery used in radio transmitting plants, however, lies in the fact that such sets are not immediately available as stand-by in the case of a disturbance, a consideration which is of the utmost importance in modern broadcasting practice. If, in the course of a broadcasting program, the service is interrupted for several minutes—and such an interruption is unavoidable when rotating machinery must be started up and connected—the consequences would be unbearable, both for the operator of the station and for the listeners.

A remarkable improvement in these conditions was brought about by the application of thermionic tube rectifiers, this apparatus being capable of withstanding to a certain extent the short-circuits inherent to the service and at the same time allowing of immediate setting to work. It is a good argument for the qualities of this type of equipment, that it is extensively used in broadcasting stations all over the world and particularly in this country. Unfortunately the economical aspect is much less satisfactory, as the costs of upkeep for thermionic rectifiers are large. In fact the average life of such tubes is limited to about 5,000 hours, which corresponds to about one year of broadcasting service. Other disadvantages are the comparatively low efficiency and the large space required as the capacity per unit is rather small, so that a considerable number of such rectifiers must be connected in parallel to satisfy the power requirements of the average modern radio plant.

In their search for equipment, which would provide adequate service combined with low operating costs, engineers naturally looked with keen interest upon mercury-arc rectifiers, which had been applied with success in other fields of power conversion. The first step in this direction was taken in 1929 by the Marconi Wireless Telegraph Company, Ltd., in London, who decided to install a Brown Boveri metal-clad high-voltage mercury-arc rectifier in their research laboratories at Chelmsford, England. This rectifier was designed for a d-c. output of 400 kw. at voltages of 9,000, 10,000 and 12,000 volts. This plant, represented in Fig. 1, gave very satisfactory operating results during the whole period of three years since its first setting to work. The outstanding advantages of metal-clad mercury-arc rectifiers in this new application became at once apparent. High efficiency is combined with the possibility of immediate putting into service by merely closing the oil circuit-breaker and with the capacity to withstand heavy short-circuits without the slightest trouble. The life of such a power rectifier is practically unlimited.

Fig. 1. General view of the complete rectifier plant at Chelmsford, England.



In the laboratory in Chelmsford the set was subjected to greatly varying load conditions, ranging from the normal operating point at 230 kw. and 13,000 volts to as low an output as 30 kw. at 7,500 volts. The various voltages can be adjusted at no-load by taps on the transformer, but in addition, lower or higher values can be obtained by varying the primary voltage.

The same device for the elimination of the ripples in the voltage can be used, as is customary for thermionic tubes and in fact, no difference in the smoothed output can be noticed at Chelmsford, where both types of rectifiers are alternately used for research purposes.

High Voltage Conditions

The layout of such a mercury-arc rectifier installation is by no means more complicated than similar plants for railroad or industrial purposes. In some instances the elements of the installation must, however, be adapted to the high-voltage conditions. In the rectifier itself special attention must be given to sufficient clearings between the anodes, the anodes and the steel tank

*Resident Engineer, Brown, Boveri & Co., Ltd.

and the cooling dome. In view of the comparatively low current the duty of the water cooling system of the rectifier is considerably reduced and water cooling can even be dispensed with entirely under certain circumstances. The high-vacuum pump must be cooled by water and here some special measures were necessary, as this pump is at the same potential against earth as the rectifier itself. In order to avoid any possibility of corrosion in the cooling water apparatus, the rubber hose which is used as water duct to and from the pump, is placed in a number of windings around porcelain insulators. This arrangement has proved entirely satisfactory and has been adopted in all subsequent installations of this kind. In Fig. 1 these porcelain insulators may be seen to the right of the rectifier.

The auxiliary apparatus for the rectifier, such as rotary vacuum pump set, etc., are mounted on insulators and supplied with power through an insulating transformer. The rectifier transformer is of normal design, except that the secondary winding must be specially insulated. The interphase transformer is placed in the negative pole and connected to earth, so that no particularly high insulation is necessary.

The operation of the first equipment proved so successful, that the Marconi Wireless Telegraph Company has since equipped a number of modern broadcasting plants with mercury-arc rectifiers. The Swiss National Broadcasting Station, at Beromuenster, has since March, 1931, operated a rectifier of 270 kw., 12,000 volts. In the new Polish high-power radio plant at Warsaw, two rectifiers, each of 500 kw., 15,000 volts, have been installed, and have given excellent results in service. The broadcasting station of the Irish Free State at Athlone, near Dublin, equipped with two rectifiers each of 230 kw., 13,000 volts d.-c. was first used to transmit the features of the Eucharistic Congress in Dublin in June, 1932.

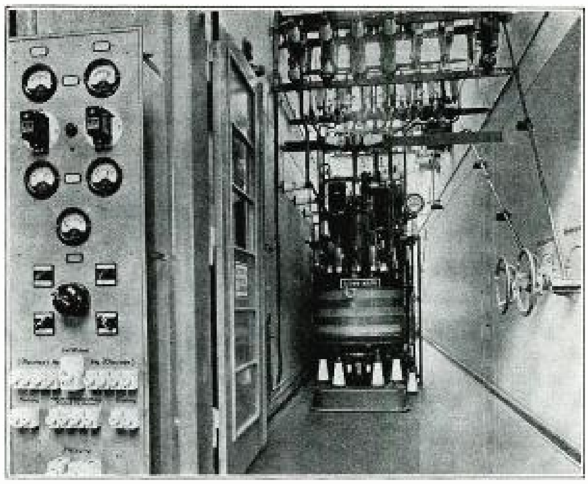


Fig. 3. Brown-Boveri high-voltage mercury-arc rectifier, 500 kw., 22,000 volts d-c., for broadcasting station in Hungary.

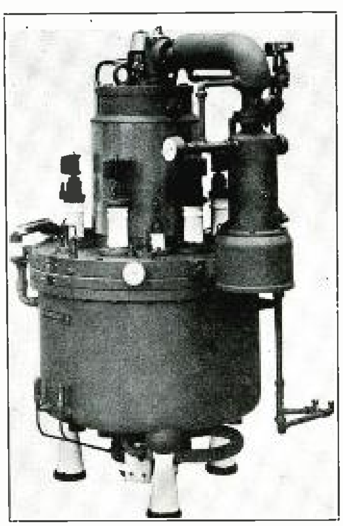


Fig. 2. German Post Administration, 560 kw., 13,000 volt rectifier at Zeesen Radio Station, near Berlin.

Aside from these equipments used by the Marconi Wireless Telegraph Company, mercury-arc rectifiers have been extensively adopted in all the new stations of the German Post Administration. Eight transmitting stations use this type exclusively, ranging in output from 200 kw. to 1,170 kw. with a uniform operating voltage of 13,000 volts. Fig. 2 shows the high-voltage rectifier of 560 kw. with switch-gear and control panel, installed at Zeesen, Germany.

A 40-kw. Installation

Mercury-arc rectifiers for broadcasting stations have proved equally satisfactory in high-power plants as in stations of rather small capacity. The smallest installation of this kind, 40 kw. at 12,000 volts, is in operation at Genoa, Italy. Another radio plant of 60 kw., 15,000 volts—Monte Ceneri—is now being installed near Lugano in southern Switzerland.

Following the recent requirements of steadily increased output, the trend in the power supply of amplifiers is towards still higher voltages. Thus the latest European high-power transmitting station, which is being constructed by the Standard Electric Company in Hungary, will be equipped with a rectifier of 500 kw. and 22,000 volts. This apparatus with built-on high-vacuum pump at right is represented in Fig. 3.

In recent times considerable progress has been made towards a prevention of back-fires in mercury arc rectifiers by controlled grids. This grid, located near the anode in the path of the arc from anode to cathode, is energized by a definite voltage of given polarity and, apart from a protection against short-circuits and resulting back-fires, such an arrangement provides the possibility of voltage regulation over a wide range.

It is only natural that this improvement should also have been applied to rectifiers for broadcasting purposes, thus increasing their usefulness, and consequently all the rectifiers of the most recent installation, including the one shown in Fig. 3, are provided with controlled grids.

The wide acceptance of high-voltage mercury-arc rectifiers for transmitting stations—the number of such plants has reached 16 with 25 rectifier units installed in the short period of two years—and their successful operation prove conclusively that this type of converter seems to be best suited for the particular requirements in the radio field and there is every reason to believe, that mercury-arc rectifiers will replace rotating machinery and thermionic valve rectifiers to a steadily increasing extent in the years to come.

(Mercury-arc rectifiers of Brown-Boveri design, previously built for commercial purposes, such as are furnished in this country by the Allis-Chalmers Manufacturing Company, have now been developed for radio broadcasting purposes, supplying current at voltages up to 22,000 volts per rectifier.)

Design of radio-frequency coils

By S. W. PLACE*

IN the design of r-f. coils, we wish to obtain the maximum possible gain per stage, and in case of coupled circuits, the minimum amount of attenuation. The matter of size chassis, number of tuned circuits to be used, and size of r-f. or i-f. coil with its shield, are all directly related to the final selling price of the set. In general, the larger we can make the coil, the better the gain per stage. We are directly limited here, however, particularly so with the midget models so that we must keep coil dimensions within certain limits. The circuit requirements, that is the number of tuned circuits, number of tubes, etc., having been determined, the next problem is to realize the best possible performance in the matter of gain and selectivity, taking into account the cost and space limitations of the set. From a cost standpoint, it is generally better to use more relatively poor tuned circuits than fewer tuned circuits of high gain, and generally we realize more selectivity and gain in the end by so doing.

From the theoretical standpoint, we wish to design a coil that will have a minimum of resistance for the inductance value that must be used with the available tuning condenser to cover the frequency band. The sharpness of resonance is equal to the ratio of the inductive reactance to the resistance. Expressing the inductive reactance by the term $2\pi fL$ (ωL) and dividing by the resistance R, we have the expression

$\left(\frac{\omega L}{R}\right)$, which we can see is the reciprocal of the phase difference of the coil. The larger this value, the better the coil. We therefore wish to minimize R which is not a constant but which varies with frequency f. Stating it another way, for a given value of inductance L and frequency f, we wish to so design the coil that its resistance R will be a minimum.

Let us examine Nagaoka's empirical formula for the inductance of a single layer coil. The following terms apply: L is inductance in microhenrys; a is radius of coil measured from axis to center of wire; b is length of coil; n is number of turns of wire in length b, and K is a function of 2a/b

$$L = \frac{.03948 \times a^2 \times n^2}{b} \times K.$$

A few values of K are given for various useful values of 2a/b.

2a/b	K	2a/b	K
.3	.8838	1.0	.6884
.4	.8499	1.10	.6673
1.70	.5649	2.80	.4452
1.80	.5511	3.00	.4292
.5	.8181	1.20	.6475
.6	.7885	1.30	.6290
.7	.7609	1.40	.6115
.8	.7351	1.50	.5950
.9	.7110	1.60	.5795
1.90	.5379	3.50	.3944
2.00	.5255	4.00	.3654
2.20	.5025		
2.40	.4816		
2.60	.4626		

Although the formula takes no account of the skin effect and capacity effects on the inductance, one effect tends to balance out the other, and for the average coil this formula is probably accurate enough.

Method of determining the gain per stage, and minimum attenuation.

From this formula we could point out the following: that the inductance varies as the square of the number of turns of wire for a given length of winding; also for a given number of turns of wire, the shorter the length of coil, the greater is the inductance; and, for a given total length of wire to be wound, the greater the diameter of the winding the greater the inductance. This last statement is not strictly true on account of the (2a/B) factor in Nagaoka's formula. It has been found that a ratio of diameter to length of 2.46 gives the optimum value of inductance obtainable with a minimum length of wire. There are probably other considerations to be drawn from this formula but those discussed are the most important.

Dimension of Coil

Suppose we have decided upon the use of a r-f. coil 1¼ inches diameter. We will also assume that the variable condenser capacity, plus the fixed circuit capacities of the tuned circuit in question, is such that a coil inductance of 240 microhenrys is required. If we assume several values of length of coil b and then solve for n we get a fairly accurate idea of the actual length of coil needed, taking into consideration the diameter of the wire used plus ten per cent, as the pitch or distance between turns. It has been found that anything heavier than No. 28 B. & S. gauge wire is impractical to use on account of the size of coil produced. Assuming that we have decided upon use of No. 30 B. & S. gauge wire, we find its diameter to be .010 inch. Looking back over the calculations we take the nearest value of n which when divided into b most closely approaches the required pitch distance of .011 inch. Several trials will give a fairly exact value for n. These calculations, of course, assume that no coil shield is to be used. The effect of the coil shield is to reduce the inductance of the coil so that it is now necessary to add more turns of wire to bring the inductance up to the required value. It has been found advisable to make the coil shield at least twice the diameter of the coil so that it will not be necessary to add an excessive number of turns to compensate for the effect of the shield. The average increase in the number of turns amounts to about ten per cent where necessary to compensate for the effect of the shield, and this, of course, means an increase of the R terms by approximately ten per cent, resulting in that much poorer coil.

Matching

Probably the best approach to matching the secondary inductance to the condenser is that of cut and try. In other words, with a given size wire, coil diameter, and assumed pitch, we try various numbers of turns until we find the correct number corresponding to the required inductance as found by measurement, or the required frequency range when connected to the variable condenser plus the fixed circuit capacities. Nagaoka's formula was given simply because it is a useful formula for empirical calculations, particularly so where no measuring equipment is available.

Formulas for the calculation of inductance of intermediate-frequency coils, generally layer wound in criss-cross fashion, are quite complicated and not always accurate. However, knowing the intermediate-frequency and the

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range of the trimmer condenser capacity, we can figure the required inductance to give this frequency from

$$L = \frac{25,350 \times 10^6}{c \times f^2}$$

where L is in microhenrys, c in microfarads, and f in cycles per second. The design is more or less a cut and try proposition, the inductance depending upon the shape of the coil as well as number of turns.

Coming back to the subject of "sharpness of resonance," it was stated that we should minimize R. Coil resistance is made up of the ohmic resistance of the wire to which are added losses due to skin effects, eddy currents, and dielectric losses, thus making the r-f. resistance always higher than the d-c. resistance of the coil.

Circuit resistances at 1,200 and 600 kc. are given for various coil shapes and wire sizes along with the d-c. resistance of these coils, showing the effects upon r-f. resistance of various sizes of wire, coil diameters and lengths of windings. All inductances are approximately 240 microhenrys.

Description of coil	R-F. resistance at 1200 kc. ohms	R-F. resistance at 600 kc. ohms	D-C. resistance ohms
150 turns No. 30 E on 1 inch diameter form	13.3	8.80	4.00
112 turns No. 30 E on 1¼ inch diameter form	11.3	7.95	3.50
138 turns No. 31 E on 1 inch diameter form	13.8	8.95	4.80
145 turns No. 33 E on ⅞ inch diameter form	14.5	10.95	7.30
110 turns No. 26 d.s.c. on 1½ inch form....	10.8	7.05	1.50
Bank wound 2 layer 10 strands No. 41 E litz wire on ⅞ inch diameter form..	8.8	6.45	4.40

R-F. Resistance

We find from a study of the foregoing data, a decided increase of r-f. resistance at 1,200 kc. and 600 kc. over the bare d-c. resistance. This increase of resistance is due to three causes—skin effect, eddy currents, and dielectric losses. Briefly, the skin effect is spoken of as the tendency of high-frequency currents to travel on the outer surface of the wire, the effect increasing with frequency. Eddy current losses are those losses introduced into the coil by the presence of the conductor in the field of the coil and, of course, are greater for heavier conductors than small ones. The Eddy current losses are generally more than overbalanced by the reduction of skin effect due to the larger area of the bigger wire. The third item, that of dielectric losses, is more important than is generally realized, and this will be discussed a little later. From this data, we note from the first three coils measured, a better form-factor, in case of the 1¼ inch diameter coil results in a lower R than is obtainable with a 1 inch diameter coil of the same inductance. We also note a further advantage by use of No. 26 B. & S. gauge wire on a 1½ inch coil form. A further decided advantage in coil resistance is obtained by use of 10 strand No. 41 E. Litz wire even though wound on a ⅞ inch diameter form. The advantage of this kind of wire lies in the reduction of both skin effect and Eddy current losses, and for this reason the use of bank windings is permissible, allowing a still further reduction of R.

Dielectric Losses

Dielectric losses are represented by the resistance added to the tuned circuit on account of power absorption by the coil form and insulation of the wire. This power absorption is due either to poor dielectric material or to moisture present in the coil form and insulation of wire. If a good grade of Bakelite tubing is used, the losses from this source will be negligible. If enameled wire is used for winding the coil and it is finished off with a good grade of lacquer, there will be very little loss here. However, very serious losses can occur, when cotton or silk criss-cross windings, which are inductively coupled to the r-f. coil, are not thoroughly impregnated right after having had the moisture thoroughly driven out by heat treatment. These types of windings pick up moisture very readily and hold it. Lacquer dip treatments are not sufficient and the writer has found the best treatment is that of dipping the winding or whole coil in cerowax right after removal from oven. Some results of tests of r-f. resistance at 1,200 k-c. show increases of from 50 to 1,000 per cent on coils with these unimpregnated windings placed in inductive relation to the secondary. In every case after thoroughly drying out and impregnating, the change of r-f. resistance of the secondary was found negligible when coupled to the impregnated coil.

In conclusion, a few notes on the manufacture and test of r-f. coils might not be amiss. Nothing but a good grade of Bakelite tubing should be used. By this is meant, tubing with a low power factor, high insulation resistance, and low moisture absorption qualities. Good Bakelite tubing will not warp, or change in shape and size under conditions of heat and humidity, a thing of great importance where inductances must be matched. Bakelite tubing should be furnished ground to plus or minus two thousandths of an inch of the required diameter. This will generally obviate all necessity of individually adjusting each secondary to the required inductance, as it has been found possible to wind tubing, on which the diameter is closely held, to an inductance tolerance of less than plus or minus one per cent. Another factor of importance in obtaining uniform coils is the necessity of some space between turns. This should be at least ten per cent of the diameter of the wire so that with variations in the diameter of wire, from spool to spool, there will be no change in total length of coil for a given number of turns and therefore no effect on the inductance. In the matter of test, a beat frequency oscillator in which two oscillators, each tuned by a condenser, are made to beat together into a common detector, one oscillator being set as a standard, the other being tuned by the coil under test, is probably the most accurate way of matching the secondaries. By calibrating the tuning condenser across the coil under test, marking the point at which the standard coil tunes, and allowing a certain number of divisions each side of this point, we can pass or reject all coils coming within or outside these limits. Coil couplings and coil resistance can be checked for relative values by connecting a vacuum tube voltmeter across one of the windings inductively coupled to the secondary and passing all coils that give voltmeter readings between certain limits.

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RADIO ROOM ON SHIP IN DUMMY CHANNEL

A UNIQUE feature of the radio equipment of the new White Star liner *GEORGIC* is that the radio room is in the dummy funnel. The installation provides for long-distance radiotelegraph communication on long and short wave lengths, in addition to the equipment necessary to comply with the regulations for the safety of life at sea. This includes an emergency transmitter and lifeboat radio equipment.

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ARGENTINA TO HAVE NEW BROADCASTING STATION

Radio Station LR 5, "Radio Excelsior," is in the process of constructing a new modern transmitting station in Buenos Aires. The equipment was designed and built by the Marconi Company. The station will operate on a frequency of 10,000 kilocycles and will be situated on a plot of 40 acres fifteen miles from Buenos Aires. Towers will be 700 feet in height. The station will be inaugurated early in 1933.

A signal generator for the new receiver tests

By A. E. Thiessen*

THE last few years have seen some great advances in the electrical design of radio receivers, particularly since the superheterodyne principle has been so widely adopted by many manufacturers. Both the type and technique of receiver measurements have undergone many changes since then, due partly to the general improvements in receivers and partly to the additional tests necessary with superheterodynes.

In measuring broadcast receivers a new method of measurement, the so-called two signal generator test, is receiving wide acceptance. With this method, two standard-signal generators are employed, one of which delivers to the receiver, through a dummy antenna, what is termed the "desired signal." This signal is a carrier to which the receiver is tuned and represents the program that is being listened to, to the exclusion of all others. Then, in order to determine how successfully the receiver eliminates the other undesired signals, a second signal generator is set up and also connected to the receiver. Its frequency is variable over a wide range and it represents any channel which might possibly interfere with the desired signal.

The requirements for the generator of the desired signal are very simple. Only three or four test frequencies distributed in the broadcast band are necessary. The three test frequencies recommended by the I. R. E. committee on standardization are 600, 1,000 and 1,400 kilocycles. Its amplitude need be adjusted to only three standard input voltages. Those recommended by the committee are 50, 5,000, and 200,000 microvolts, representing weak, medium, and very strong signals. Modulation at about 30 per cent at 400 cycles is desirable for preliminary adjustment of the receiver.

The interfering signal generator is necessarily more complicated. In the first place, its frequency should be variable between approximately 100 and 5,000 kilocycles. Its frequency calibration should be good (incidentally, the frequency calibration of the desired signal generator does not need to be particularly precise since it can be checked against the other instrument which must be calibrated). The frequency modulation must also be reduced to a low value; and the last and most important requirement is that its output be variable between 0.5 microvolt and 1.0 volt.

The method of making the test is simple. The desired signal is set at one of the test frequencies, for instance, 600 kilocycles, and adjusted to give an output amplitude of 50 microvolts. It is modulated so that the receiver may be tuned to it; the receiver's volume control is adjusted to give the standard 50-milliwatt power output. Once tuned, the modulation is turned off so that only the carrier is applied on the desired channel. The interfering signal generator is then turned on and its frequency is varied across a considerable frequency range. In most cases this should be about 100 kilocycles on each side of the desired channel.

The average user of broadcast receivers will find that, if his set is delivering an output power of 50 milliwatts, an interfering signal having a power of 50 microwatts is objectionable. On this assumption, the amplitude of the interfering signal is adjusted as it is swept across the undesired channels until an interference test output, that is, 50 microwatts, is observed from the receiver under test for points spaced every 10 kilocycles in the interference band. A curve can be plotted indicating the amplitude of the interfering signal necessary to give the 50-microwatts interference output. During

*Engineer, General Radio Co.

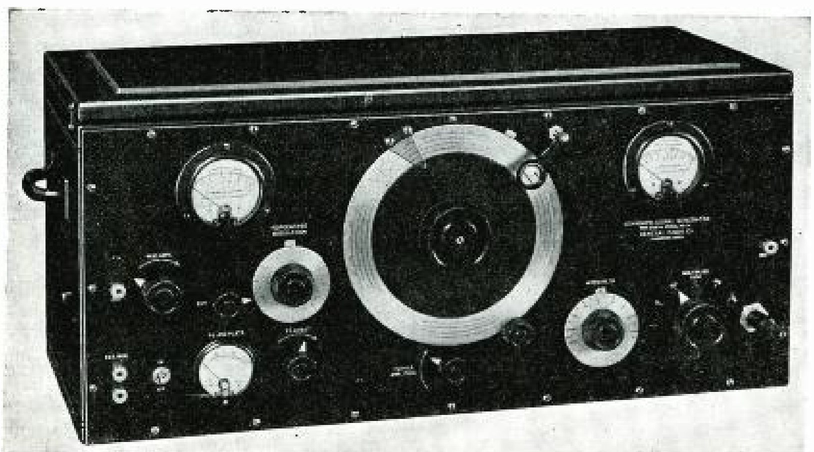

Fig. 1. Panel view of a Type 603-A standard-signal generator. The meters read the filament and plate voltages, modulation voltage, and carrier amplitude. Note the large frequency-control dial.

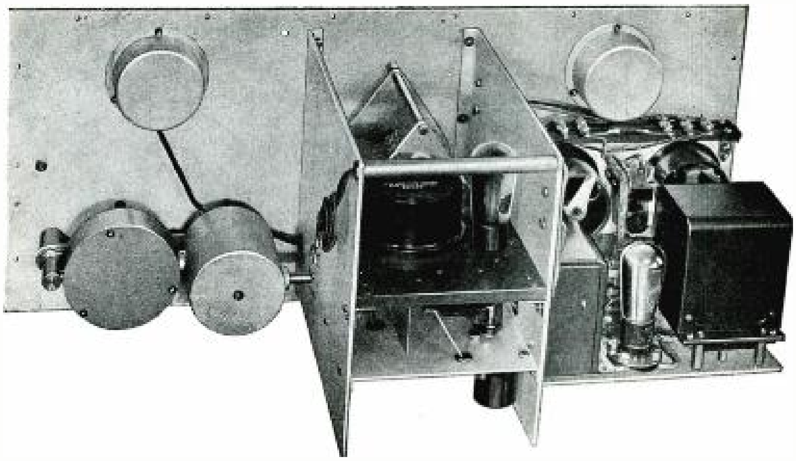

Fig. 2. Rear view of the Type 603-A standard-signal generator with the cabinet removed. The left-hand compartment contains the attenuator system and shielded thermocouple meter. The attenuator is divided into two sections, each housed in an aluminum casting.

all of these tests, the percentage of modulation of the interfering signal is kept at 30 per cent at a frequency of 400 cycles. The test may also be repeated with the amplitude of the desired signal increased from 50 to 5,000 and 200,000 microvolts.

One of the problems in the design of superheterodyne receivers is to eliminate various cross modulations which occur between the received signals and the local oscillator, particularly at the image frequency of the local oscillator. Other interference is due to direct pickup in the intermediate-frequency amplifier. In order to determine the magnitude of this type of interference, a so-called "whistle interference test" is used. The tests are conducted the same as those described above, except that the interfering signal is unmodulated. Its frequency is varied across a wide band embracing the frequency of the intermediate amplifier and extending considerably above the frequency of the desired signal to include all possible points of cross modulation. In order that the audio-frequency system of the receiver shall not affect the test, a whistle when it occurs is adjusted to a frequency of approximately 400 cycles. The amplitude of the interfering signal generator is varied until the interference test output of 50 microwatts is obtained. Occasionally, it may be desirable, but it is not necessary, to vary the interfering signal by a very small amount so that the whistle frequency covers several points in the audio-frequency spectrum.

The requirements for the interfering signal generator are such that with a few additional controls it will also measure other important receiver characteristics. For instance, the overall sideband response of a receiver can be determined by adjusting the frequency of the external audio modulation on the signal generator and noting the output-frequency characteristics of the receiver. The signal generator is set at one of the test frequencies in the broadcast band and 30 per cent modulation at 400 cycles is applied. The gain of the receiver is adjusted so that the 50-milliwatt standard output is obtained. The audio modulation is varied from about 40 to 5,000 cycles and the output power from the receiver is noted at various frequencies.

In making a test of this sort, the output load for the receiver can be either a rectifier-type meter having a resistance corresponding to the impedance into which the output tubes are designed to work, the output transformer having been removed or its secondary opened; or it may be a high-resistance output meter connected across the voice coil of the dynamic speaker. In the latter case, however, changes in the voice coil impedance due to its frequency characteristic and motional impedance will enter into the measurement. If the receiver is equipped with a tone control, the effect of this control on the frequency characteristic can also be observed.

Often it is very desirable, particularly when using pentode output tubes, to investigate the effect of various load impedances on the performances of the tubes. The General Radio type 583-A output power meter has an impedance which is variable between 2.5 and 20,000 ohms. It can be used either in place of the voice coil of the dynamic speaker or the primary of the output transformer. The difference in power delivered to varying loads for a given modulated radio-frequency input to the receiver can be noted by the various settings of the impedance switch.

With the general requirements in mind of the standard-signal generator necessary for the above tests there has been developed the type 603-A standard-signal generator. This instrument is intended to have the utmost flexibility. It is not restricted to the measurement of receivers in the broadcast band, but its frequency range has been extended to include most of the frequencies now in general use for radio transmission. As specifically applied to the requirements of the interfering signal generator and for the generator to be used for measuring the audio-frequency response, the type 603-A standard-signal generator has the following characteristics. The frequency range between 100 and 4,400 kilocycles is covered by five coils. Two of these cover the broadcast band and have a combined range from 420 to 1,900 kilocycles. The output voltage is continuously adjustable from 0.5 microvolt to 1.0 volt.

The ability to set and reset the carrier frequency of a standard-signal generator is of considerable importance. In order to facilitate this, a large and accurately engraved tuning dial is used. It is 8 inches in diameter and engraved around 270° of its circumference with 600 divisions. A magnifying glass is provided so that parts of a division may be read easily to improve the accuracy of setting. Fifths of a division can be very easily estimated. In the high frequency portion of the broadcast band, the coil has a range from 850 to 1,900 kilocycles. The tuning dial has 600 divisions. This means a frequency change of about 1,750 cycles per division for the coil span of 1,050 kilocycles. Estimating fifths of divisions, the tuning can be set easily to within 350 cycles. The tuning condenser, incidentally, is straight-line frequency so that linear interpolation is possible.

The internal modulation system consists of a 400-cycle audio-frequency oscillator which delivers sufficient power for 90 per cent modulation of the carrier. Its frequency is adjusted within ± 20 cycles. The modulation percentage is continuously variable and the accuracy of calibration is such that when set for any given modulation it will be correct to within 10 per cent of the percentage of modulation, using either internal or external modulation at 400 cycles.

The frequency characteristic of the modulation system is good and external modulation can be used with considerable accuracy over a wide frequency range. The highest audio frequency that can be used will depend upon the frequency of the carrier being modulated. The highest audio frequency that will produce an effective carrier modulation within 1 decibel of the modulation meter indication is about 1.5 per cent of the carrier frequency. On low-frequency coils, this is the limiting factor. On higher-frequency coils, the radio-frequency filter and audio-frequency meter in the modulation circuit limit it to about 6,000 cycles for an error of 1 decibel, or 10,000 cycles for an error of 2 decibels.

Very low power is required to modulate the instrument. Modulation at 30 per cent is obtained by a power of about 60 milliwatts. The impedance at the external modulation terminals is about 5,000 ohms.

The design of a flexible and accurate signal generator involves several important considerations. Two of the outstanding ones are the design of an attenuator that will operate successfully over a wide range of radio frequencies, and the reduction of stray fields to such a level that they do not enter into measurements when using the signal generator at very low output voltages. The attenuation system of the type 603-A standard-signal generator is such that essentially no measurable errors creep into its attenuation characteristics at frequencies up to and through the broadcast band. Some errors are involved in the actual direct-current calibration of the resistors and errors inherent in the direct-current d'Arsonval meter used with the thermocouples. These aggregate about 3 per cent. At 10,000 kilocycles, the error in the attenuator becomes measurable and amounts to about 7 per cent, which, together with the other errors mentioned above, give a total error at this frequency of perhaps 10 per cent. At 25,000 kilocycles, all errors total to about 20 per cent. By a careful design and layout of the oscillator and attenuator circuits, together with good shielding and use of toroidal coils in the oscillator circuit, the leakage is reduced to a point where it cannot be measured unless a highly sensitive receiver is connected directly to a multi-turn pickup coil, which is placed within a few inches of the panel of the instrument. These fields are in general so small that they do not affect measurements at 0.5 microvolt, even when using an unshielded receiver.

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Accuracy of broadcasted matter

ON a broadcast network one evening recently a lecturer propounded the question: Who first discovered radio? The speaker then proceeded: "It was not Marconi, nor Clerk Maxwell, nor Hertz. Preceding all these by nearly half a century, the first actual radio experimenter was the pioneer American scientist, Joseph Henry, who at Princeton in 1840 transmitted radio impulses several hundred feet without connecting wires.

"In Henry's own words, written when he was world-famous as secretary of the Smithsonian Institution of Washington, here was the experiment he performed in 1840—the world's first radio flash:

"'When the discharge of a battery of several Leyden jars was sent through a wire stretched across the campus in front of Nassau Hall, an inductive effect was produced in a parallel wire, the ends of which terminated in the plates of metal in the ground of the back campus, at a distance of several hundred feet from the primary current, the building of Nassau Hall intervening. The effect produced consisted in the magnetization of steel needles."

If the magnetization of steel needles situated in the field of a charged wire constituted the discovery of radio, then Savary, in 1827 (thirteen years before Henry), made the discovery. In Prof. A. M. Mayer's biography of Joseph Henry, page 480, a statement of Savary's work may be found. Further along in the same work appears the statement: "In 1842, Henry, apparently ignorant of this research of Savary, went over the same ground. . . ."

The broadcast station might of course be excused for not checking the accuracy of the broadcast matter in advance inasmuch as the lecturer was announced as a former Federal Radio Commissioner.

The same lecturer in a broadcast on the evening of December 18, credited Joseph Henry with being the inventor of the electric telegraph. The citation is of Henry's experiment in 1831, when he strung a mile of copper bell-wire around the walls of one of the upper rooms of the Albany Academy. He used a battery, a wire circuit and an electromagnetically operated bell.

Morse's First Demonstration

Morse's first demonstration of his electromagnetic telegraph was made in 1835. Morse was a portrait painter. Joseph Henry was professor of natural philosophy at Princeton University from 1832 until 1835 and later. It seems rather unfair to say in 1932 that Henry in 1831 had any idea that he had invented a telegraph system.

In Professor Mayer's biography of Henry, Henry is quoted as saying: "The principles I had developed were applied by Dr. Gale to render Morse's machine effective at a distance." Professor Mayer adds: "Observe that Henry does not claim to have had any part in rendering Morse's machine effective when near the battery."

Communication engineers well know that the broadcast lecturer's statement that Henry "transmitted radio impulses several hundred feet without connecting wires," was erroneous; that the effect was due to induction and not to radio, as radio is understood in informed circles.

In 1912 Prof. Pupin delivered an A. I. E. E. paper on "The Debt We Owe to Henry as a Scientist." In this paper he said: "The cause of Henry's success is due to his complete understanding of Ohm's law, discovered in 1827. Barlow did not understand it because it did not exist when he made his experiments in 1824, and Wheatstone did not understand it in 1837, because the law was made in Germany, and Wheatstone was an Englishman. Henry had no international prejudices."

In Prof. Mayer's biography of Henry it is stated (page 488): Henry's researches were based avowedly on a thoughtful study of the work and theory of Ampere in 1820-21, and of the galvanometer of Schweigger (of the same date) as applicable to the electromagnet of Sturgeon of 1825. At that time no writer or physicist (including Henry) had any conception of the consequences of Ohm's law. This law, unknown to Wheatstone, Faraday, or Roget, could hardly make its way abroad in a foreign tongue, and reach Henry at Albany. Professor Pupin in his enthusiastic admiration for Professor Henry has on more than one occasion permitted himself to attribute to Henry inventions that Henry in his lifetime never claimed, nor which his early biographers ever claimed for him.

RADIO ENGINEERING believes that broadcast matter of an historical nature should be as accurate as printed records properly authenticated. The broadcasting companies should see to it that Jack Pearl's Munchausen line is not followed by speakers who essay the role of historians of science.

New vacuum tubes and their applications†

By Dr. A. W. Hull*

Counting Electrons

LET the smallest tube lead the march in review. It is a special pliotron, designed to measure currents smaller than any yet detected. It goes by the name, Pliotron FP-54.

In principle, the FP-54 is like any grid-controlled high vacuum electron tube; but in structure and operating characteristics it is entirely special. An extra "space-charge" grid, maintained at 3 volts positive with respect to the filament, holds back the small but pernicious current of positive ions emitted by the filament; the normal plate voltage is 6 volts, grid bias 3 volts, thoriated-tungsten filament, temperature 1700° K, plate current 40 microamperes. These conditions are essential to the avoidance of grid-currents, which may consist not only of insulation leakage and positive ions from the hot filament, and from residual gases. but of high-speed electrons from the filament, photo emission from the grid due to the light of the filament. and electron emission caused by X-rays generated by the impact of electrons on the plate.

The present sensitivity of this new tube is slightly better than that of the most sensitive electrometer. over which it has an enormous advantage in sturdiness. In amperes this sensitivity, i. e., the smallest current that can be measured, is

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ampere. The ampere is evidently an inconveniently large unit for our purpose. In terms of the smallest known unit, the electron, the sensitivity is approximately six electrons per second.

It counts cosmic rays. It measures, in cooperation with the photoelectric cell, the light from distant stars, being able at present to detect the light from a star of the 14th magnitude. It records the fragments—neutrons, protons, and alpha particles—of atomic nuclei smashed by high-speed ions. The structure of these atomic nuclei, the 92 hitherto indivisible elements of atoms, appears to be the next objective of scientific research, the next nature-fortress which science aspires to storm.

Measuring Nerve Messages

Next in review comes another impracticable tube, likewise diminutive in function and ordinary in appearance, known as PJ-11 (Fig. 1). It measures voltages ten times smaller than could be detected before. It, too, is a device of most ordinary structure and form; a simple three-element tube of standard size and construction. Its special feature is good vacuum—naturally invisible.

Good vacuum is a relative term. The vacuum of 1880, used by Hittorf and Crooks, was about 1/1000 atmospheric pressure. It was sufficient to reduce the sparking potential between electrodes 1 cm. apart from 30,000 volts to about 300 volts. At this pressure electrons have long free paths and easily attain speeds at which they ionize the atoms they strike, and ions and electrons play about equal roles in carrying the "glow-discharge" current. Such glow-discharges have found many applications—for rectification, relays, illumination, television.

The "good vacuum" of 1900 was one thousand times better, viz., about 1/1,000,000 atmospheric pressure. Electrons in such a vacuum only occasionally meet atoms, and the ions formed by these encounters contribute only a fraction of a per cent to the current. The current through the vacuum might be called a pure electron current, since at least 99 44/100 per cent. of it consisted of electrons. This vacuum was good enough to enable Lenard and others to solve the mysteries of photoelectric emission, J. J. Thomson to discover and identify the electron, and O. W. Richardson to discover the laws of thermionic emission. It enabled Fleming to invent the Fleming valve, and DeForest the audion.

Langmuir, in 1912, made a new discovery. The so-called pure electron currents of Richardson and others had always been limited by the electron emission of the filaments, the only known limiting factor. Langmuir, having a new and better filament material, tungsten, to play with, decided to test this limitation to the limit. He tried a tungsten filament with an emission of 100 amperes and obtained a current of only 1/100 ampere. Why? He had discovered a new limitation, which he found to be caused by the mutual repulsion of the electrons in the vacuous space, and which he termed space-charge limitation. Briefly stated, electrons repel each other, according to Coulomb's law, for charges of like sign. Hence, they march across the vacuum in very open array, far enough apart to see with the naked eye.[1] But, Langmuir discovered, this space-charge condition is present only in a Langmuir-pure electron discharge, 100 times purer than that of Richardson. For it is the electron-attracting effect of the presence of positive ions, not the current they carry, that is important for space-charge. A vacuum so good as to give a negligible positive ion current, e. g., less than ¼ of 1 per cent. of the electron current, may have as many ions present as there are electrons, since the ions move several hundred times more slowly than electrons. In such a vacuum the space-charge limitation, due to electron repulsions, is entirely lacking. It is just this vacuum, and its freedom from space-charge limitations, that is utilized in the thyratron tube.

The importance of this distinction lies in the fact that the whole foundation of amplifying action rests on space-charge. As long as tubes were merely rectifiers, like the Fleming valve, pure current was a sufficient specification of vacuum. With the advent of amplifiers, pure space-charge became the fundamental criterion.

Tube Noise

Part of the "tube noise" we now understand and recognize is fundamental. It is due to the graininess of electricity. It is obviously impossible to have a

Fig. 1. Type PJ-11 pliotron.

†Delivered at the meeting of the American Institute of Mining and Metallurgical Engineers at Buffalo on October 6, 1932. Abstract.

**Assistant Director, Research Laboratory, General Electric Company, Schenectady, N. Y.*

1The average distance apart of electrons in an ordinary receiving tube is about 1/100 mm., which is the diameter of the filament in a standard 15 watt Mazda lamp.

smooth flow of anything that is made up of finite grains, like electrons. This so-called "shot-effect," the irregularity of the patter of electrons on the plate, can be calculated and measured, electrically. It is equivalent, in an ordinary amplifying tube, to an input signal of about 1 microvolt. We must accept this as a fundamental limit to the smallness of signal that is worth amplifying, since anything smaller will be hissed down by the shot-effect.

But there are other tube noises, which are particularly evident at frequencies below 1,000 cycles, that are 100 to 1,000 times larger than the shot-effect. These, the worst of them, at any rate, have now been traced to bad vacuum, to ions produced in the still-residual gas of ordinary amplifying tubes. The cure was more vacuum. The result is the PJ-11, with a low-frequency input noise level of less than ½ microvolt (practically all shot-effect), as compared to about 10 times this value for the best tube previously available.

No one knows what will be done with this modest addition to the tube family. The possibility of amplifying and observing things ten times smaller than before suggests new discoveries.

Power Pliotron Tubes

Radio transmission has made available a fine line of power pliotrons, from 5 watts up to 500 kilowatts. But the field has been too small for quantity production, with its simplifications and economies. There is now appearing on the horizon a need for power pliotrons in industry. High-frequency heating of metals; high-frequency heating of people—at present for producing benign fevers that have been found effective in the treatment of paresis and arthritis; eventually, perhaps, in lieu of coal; Sterilization of milk, grain, fruit, bulbs; production of ozone; these are possible markets.

Chemical Analysis

X-ray chemical analysis has many unique features. As a qualitative analysis it is infallible, i. e., the presence or absence of the characteristic lines of an element in the spectrum is absolute proof that the element is or is not present to the extent of a fraction of a per cent.; it supplements chemical analysis, being especially applicable to elements of high atomic weight, from aluminum to uranium, which are least easily analyzed by other methods; for some of the rare elements it is the only reliable method; and the results are easily interpreted, since the number of lines in the X-ray spectrum is so small that they are readily identified.

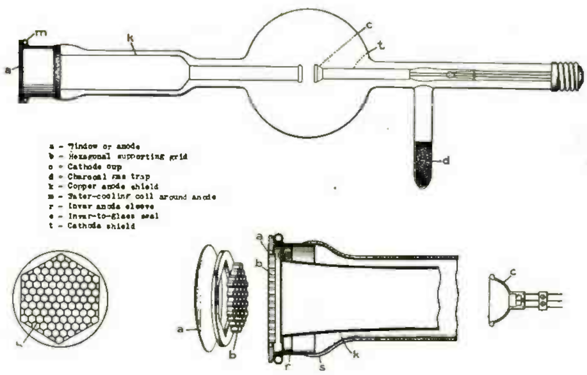

Fig. 2. Diagram of Coolidge cathode ray tube.

But the technique of this analysis has been tedious. There has been no satisfactory way to obtain X-rays from the specimen except to put it inside the X-ray tube.

The problem has been solved by the new cathode ray tube, which makes it possible to produce X-rays in air. A cathode, similar to that in an X-ray tube, focuses a beam of electrons on an aluminum window that closes the tube. Parts of the window are stamped very thin (Fig. 2), so that the electrons pass through without appreciable resistance into the air, and travel several inches in air before they are stopped. The substance to be analyzed is placed near the window, which is grounded. Electrons emerging from the window strike the sample and excite its characteristic X-rays. These are resolved into a spectrum by the X-ray spectroscope, and the characteristic X-ray spectral lines are photographed, or are measured electrically by an FP-54 Pliotron.

Electric Eyes

The photoelectric cell during the past five years has done most of its growing, stimulated by the small but important application in talking movies. The result is the caesium phototube, known as PJ-23 (Fig. 3), 100 times more sensitive than previous cells, with the important property of being able to see red—for there is much more red light than blue in the world.

The special importance of this new electric eye is as a teammate for another new tube, the thyratron. By itself, the PJ-23 is scarcely able to do any useful work. It gives a response of only 40 microamperes, at best, when illuminated with one lumen of electric light, which is about the amount it receives from a 50-watt lamp at a distance of 6 inches. This current is too small to operate reliable relays, even slow ones. But it is ample for the grid of the thyratron, its giant mate. Together they are a high-speed, high power team, ready to contract for any type of electric service where reliable, quick action is required in response to light signals.

The Thyratron

The thyratron tube is a grid-controlled arc discharge device. Like the pliotron, it is a "three-element tube in which the flow of electrons between cathode and anode is controlled by voltage applied to a grid." But it differs from the pliotron in two important respects. The first is "purity." The electron current in the pliotron must be very pure; the presence of a few positive ions spoils the space-charge—limiting repulsions on which its whole action depends. The electron current in the thyratron, on the other hand, must be 100 per cent. impure, i. e., it must have as many positive ions as electrons. Electron repulsions are so completely neutralized by the presence of the positive ions that 10,000 times as many electrons can be crowded into the space; there are between 10^{12} and 10^{13} electrons per $cm.^3$ in the current stream of the thyratron, compared with about 10^9 in the pliotron. Hence, the thyratron can carry larger currents with lower voltage drop—amperes instead of milliamperes, with a few volts, from 10 to 18, between anode and cathode, instead of hundreds of volts.

The second fundamental difference between the thyratron and pliotron is that the grid of the thyratron only partially controls the current flow. It can control only the starting of the current. After the current has started, the grid is nearly powerless; under ordinary circumstances it neither controls the magnitude of the current, nor stops it. But if the current stops, the grid can prevent it from restarting, or allow it to re-start, at will. Inability to control the magnitude of the current is not a limitation, for this control must necessarily be sacrificed to obtain efficiency—the two are mutually exclusive. Inability to stop the current is a limitation, though not a serious one, since the rectifying action stops the current whenever the anode voltage reverses. Such reversal takes place periodically in many circuits as, for example, when alternating voltage is used for the anode; and when it does not, can always be made to take place by starting another thyratron.

The reason that a negative grid ordinarily cannot stop or control the discharge is that it attracts to its neighborhood enough positive ions to neutralize exactly its own negative charge, so that its negative influence extends only a short distance. It will always insulate itself in this way if there are positive ions in the space, but cannot it there are no positive ions. Hence, in order to regain control, the discharge must be stopped only long enough to allow the ions to diffuse to the walls. This time varies, according to grid mesh and vapor pressure, from about 50 to 200 microseconds.

A typical thyratron is shown in Fig. 4. The FG-17 is the simplest type. It has an oxide-coated filament, like the ordinary pliotron, but its grid is larger and farther removed from the filament. The reason for this is two-fold. First. closeness is less necessary than in the pliotron, because the current is not limited by electron space charge. Second, distance is desirable in order that the grid should remain cool enough not to emit electrons; since electron-emission by the grid is both more serious than in the pliotron, and more likely to happen, because of the larger current. The FG-17 is designed to furnish and control an average current of ½ ampere, at any voltage up to 2,500. The gas needed for the positive ions is furnished in this, and in other thyratrons, by a drop of mercury located in a cool place at the bottom of the tube, giving a vapor pressure between .005 mm. and .020 mm. Thyratrons containing argon at .050 mm. pressure are available for low voltage applications.

The largest thyratron available is of the mercury arc type, with a pool of mercury as cathode. The anodes and grids are placed in side arms, with shields and baffles to protect them from mercury spray and from each other. Each of the 12 anodes is capable of carrying 4,000 amperes maximum, and the whole tank has a continuous current rating of 5,000 amperes d-c., with overload capacity up to 14,400 amperes for 1 minute, at d-c, voltages up to 1,500.

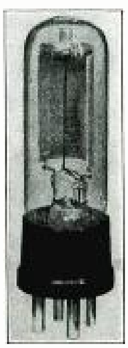

Fig. 3. Type PJ-23 photoelectric tube.

Power Applications of Thyratrons

In another field thyratrons promise new services. This field is power conversion. Thyratrons cannot generate electric power, but they are ideally adapted to the task of converting it from one form to another, which they accomplish without motion, noise, or wear. These transformations include: changing direct current to alternating (inverter operation); alternating current to direct (rectifier); direct current at one voltage to direct current at another voltage, higher or lower (d-c. transformer); alternating current at one frequency to another frequency, e. g., 60 cycles to 25 cycles or vice versa (frequency changer); correcting power factor (static synchronous converter); and replacing commutators on motors. In this last application thyratrons not only offer an ideal solution of the commutator problems of over-commutation, speed limitation, arcing and wear, but also offer new motor characteristics, since the thyratron commutators can be made conducting or non-conducting at will by controlling their grids.

These power applications, involving large and expensive units, are necessarily slow in development. The only installations thus far are of a laboratory nature. They include: a 400 kw. rectifier and inverter, taking power from an 11 kv., 40-cycle a-c. line, rectifying it to 12,500 volts d-c., and inverting this d-c. to 60 cycle a-c., which is used to run a 400 kw. rotary converter; a 500 kva. rectifier-inverter unit operating at zero power factor on a 4,000 volt a-c. line, acting as a synchronous condenser; a 3,000 kw. mercury-cathode thyratron, taking 3,000 volt, 80 cycle power and converting it into 25 cycle power; and a 400 horsepower synchronous motor operating at variable speed, with thyratron commutators.

The Phanotron

There are two types of gas-filled, arc-discharge rectifiers, whose electron emission is furnished by a hot cathode. One is the well-known Tungar; the other the new phanotron.

In the Tungar rectifier the large tungsten filament, used as cathode, is made to yield an abnormally high electron emission, about ten times as much as in high-vacuum tubes, per unit of area, by heating it to an excessive temperature. Enough argon gas is added to prevent evaporation of the filament at this high temperature. It is found that the gas pressure needed to give this protection is above 1 mm. of mercury, and that the life of the filament improves with increase of pressure up to about 5 cm., which is the pressure used in the Tungar.

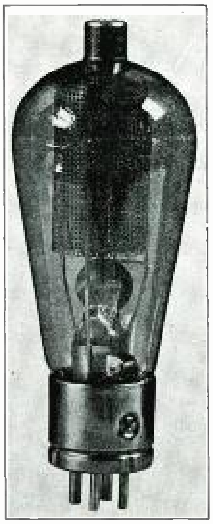

Fig. 4. Type FG-17 thyratron.

This high pressure in the Tungar imposes two limitations: the voltage that can be rectified is low, because the sparking potential of argon at these pressures is only 200 volts; and the current is limited by the concentration of the arc, which tends to overheat the filament. These limitations apply to the whole range of useful pressures, from 1 mm. to 10 cm.

Both of these limitations are absent at very low gas pressures, between .005 mm. and .05 mm., and this amount of gas is found to be sufficient to furnish the required positive ions, which are needed to neutralize the electron space-charge. The life of the cathode, however, is very short at these low pressures, if it is operated at Tungar temperature; and if operated at normal temperature its efficiency is unsatisfactory.

This problem has been solved, in the phanotron, by providing a cathode of ample size, so that it can be operated at "normal" temperature and still furnish the required emission; and so constructing it that its heat loss is small, taking advantage of the fact that electrons in an arc-discharge can go around corners, while heat-radiation must go in straight lines.

The development of police motor-car radio

By Harry E. Thomas

In the past year there has been renewed interest in police radio. After the first experiments in automobile radio in 1930, the initial enthusiasm spent itself, after practical problems and difficulties had been attacked, so that during 1931 and early 1932 a partial lapse in this field was quite in evidence. Perhaps as much as anything, the uneconomical character of automobile radio in its maintenance and upkeep served to cause police departments to regard the new communication system not as highly as first possibilities indicated they might.

In 1930 and 1931, the operation of old style tubes proved rather a heavy tax upon both filament supply batteries and dry B batteries; power output was also hardly adequate even with the automobile pentodes. B batteries under twenty-four hour use were an expense amounting yearly to thousand dollar figures in cities of any size. New designs using superheterodyne circuits, although giving sensitivity of the desired degree, had other features ruling them, somewhat undesirable under some conditions.

Parallel to this lapse in interest due to technical and practical difficulties, there has been, however, a growing recognition of the utility of police radio. Its ease and speed of control and features of economy have become more evident and a sound basis for requesting appropriations is being developed. The Federal Radio Commission in compiling the results of one year's operation in fifty police radio controlled departments find that one arrest results from every ten calls; that in large cities prompt police action recovered $250.00 worth of stolen property per day; that efficiency of contact and personal protection is greatly improved; and that economy of operation over the foot patrolman system is definitely a result even with the present rather meager coverage. The average time required to get patrolmen to the scene of trouble is three minutes from receipt of a telephone call. The possibility of economy is evident when it is learned that one car with two patrolmen can cover 10,000 people, whereas under foot patrol supervision one man is allowed for 600 inhabitants. With the efficient operation of the radio system in larger cities such as New York, Chicago, Detroit, Philadelphia and many of less magnitude, the close of 1932 sees police radio arousing general interest on the part of most cities and states and it does not require a severe stretch of the imagination to believe that its use will rapidly become general.

The growth of police broadcast may be said to date from the development of motor-car radio, through which it was proven that satisfactory reproduction could be obtained in a moving automobile.

The first police receivers were motor-car sets adapted to short-wave reception and most of the first sets were home-made by local radio men. It was soon found, however, that while an auto receiver which was used only occasionally or a few hours a day would give satisfactory results, the requirements of police work, involving practically constant use, demanded a product especially designed and built for this service.

The year 1932 sees police radio again on the upgrade due partly to this acceptance and partly due to the following technical advances:

1. Circuit design.
2. Eliminator advances.
3. Tube development.

Circuit Design

Superheterodyne circuits for fixed frequency receivers were extremely hard to adjust and when adjusted the oscillator in particular proved sensitive to almost any change of circuit condition. Even temperature change caused oscillator shift of great enough magnitude to completely render reception impossible while such things as filament voltage change, run down B batteries and humidity differences had nearly equal influence. This difficulty obviously pointed towards two avenues for remedy. First, stabilization of existing circuits by broadening the intermediate-frequency amplifier response, or by automatic compensation in the oscillator circuit itself. Second, by design of a tuned radio-frequency receiver to equal performance of the superheterodyne. The latter design development will be described further on.

Eliminator Advances

A problem that has bothered police department engineers is the source of supply of B current. Dry type B batteries under constant use need to be replenished frequently and this expense is considerable. Several types of B eliminators of the vibrating variety will not stand up under continuous service. The rotating type of eliminator built on the lines of a magneto with permanent magnet field seems to be the answer and promises a considerable saving in cost over the batteries or vibrators.

Tube Development

New tubes of the low filament drain type have for more than a year been used for increased efficiency. A single pentode delivering one-half watt at an expenditure of ten milliamperes gives hardly enough radio output level above the noise attendant to higher automobile speeds necessary in suburban districts. Class B output averaging four watts may be obtained due to design advances in automobile tubes made recently. Such output at very little average battery drain over the single pentode is a very obvious advantage. In addition, full automatic volume control (with noise suppression features possible) is much more easily obtained through use of the new double diode triode tubes.

These three features of design are consummated in operating design of one of the police new radio receivers.* Together with the stability maintained in this receiver are incorporated the double diode triode detector tube and class B output tubes; optional use of either dynamic or magnetic speaker are also provided and through experience gained in the past, a mechanical design of a great servicing efficiency has been attained.

This receiver has seven tubes—three type 239 radio frequency amplifier tubes, a type 85 Duplex diode triode detector and automatic volume control, a first audio frequency driver tube (type 89) and two type 52 class B output tubes.

Sensitivity

The overall sensitivity of the receiver through a dummy antenna with an output of one hundred milliwatts is one microvolt or less. On the usual I. R. E. standard this could be rated as a receiver of one-half microvolt. The average gain per stage is around twenty, while the step-up using the series capacity R. F. L. antenna system equals forty. Stable gain of this receiver has been obtained by careful shielding of all grid, plate, and screen leads preventing tubes having relatively high potential radio frequency from coupling back to the antenna. Incidentally, a great deal of overall stability exists through a correct proportioning of the audio-frequency and radio-frequency

* *American Bosch Model 113.*

amplification; this is done in part by the use of a double diode triode detector and a driver first audio tube.

Volume Control

Two controls, one for volume and one for sensitivity, exist upon this receiver. The sensitivity control consists of a potentiometer in series with the cathode of the first two radio-frequency tubes. This control is located on the control head as is the audio-frequency gain control, which is a potentiometer in the grid circuit of the 89 driver tube.

Audio-Frequency Output and Loudspeaker System

The driver 89 tube is transformer coupled to the type 52 output tubes and their output in turn applied to a step-down transformer the secondary of which is connected to accommodate a permanent magnet dynamic speaker while the audio impulse desired for a magnetic speaker is taken from the primary of this transformer. Under extreme conditions, as much as seven watts has been obtained from this receiver without objectionable overload, while under average conditions there are four watts of power at the loudspeaker terminals.

Power Consumption

The total drain of the filaments of this receiver is 2.1 amperes, while under normal operating conditions, total plate current runs from 25 to 30 milliamperes. The receiver is designed for optional use with either the BD6-180 Magmotor or one 135 volts of B battery. The drain on the A battery under extreme conditions amounts to about one-half ampere additional.

Physical Adjustment

Tuning of the receiver is from the bottom of the chassis and consists of five adjustable trimmer screws. These are accessible through holes in the cover plate which are covered by plug buttons. From the standpoints of physical arrangement, mechanical construction and electrical performance, this receiver was designed especially for continuous service and the conditions of operation involved in police work. The entire chassis is mounted in a strong metal housing and so arranged as to be firmly attached from the outside. The housing has four mounting hooks for engaging to a rugged mounting plate which bolts to the car frame or dashboard panel. The entire chassis is mounted in inverted position so that dirt and moisture usually coming from above cannot obtain access to the set through the cover.

Attachment of the loudspeaker, control head and the Magmotor or B batteries is made at the bottom of the chassis, through holes in the cover, by means of plug ended connection cables. The antenna connection is also made to the bottom of the receiver and is clamped in place by a sliding hook. Disconnection in servicing the receiver merely requires pulling out three plugs and the antenna cable, and sliding the entire chassis upward so that the four hooks disengage from loops on the mounting plate.

General

This receiver has two classifications dependent on its tuning range. It has fixed tuning for each of the police channels. The lower frequency model is tuned mid-band around 1712 kilocycles while the higher frequency police band is cared for by tuning at mid-band around 2000 kilocycles. It has been found that fixed tuning is most applicable to police work in point of service and dependability and that tuning should be kept inaccessible to the operators using the receiver.

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FAKE PRICE CUTS

ACCORDING to the report of the Federal Trade Commission, dated December 17, a distributor of radio receivers, after being investigated by the Commission's agents, agreed to discontinue the use of any lists setting forth fictitious prices purporting to be the regular retail prices at which the products were intended to be or were sold in the usual course of business.

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SHORT WAVE BROADCASTING

THE British Broadcasting Corporation, on December 19, inaugurated a new era in radio broadcasting when the powerful twin short-wave transmitters at the new Empire Station at Daventry, England, were formally opened. Appropriate ceremonies and programs heard throughout the world marked the opening. Each transmitter has carrier output of 20 kilowatts and is capable of working on 6 wavelengths between 13.9 and 49.6 meters.

To provide transmissions at convenient listening times for various regions of the British Empire, five zones have been provisionally named for broadcasts and have been designated as follows: one, Australia; two, India; three, South Africa; four, West Africa, and five, Canada.

The seventeen antennas, built around a hilltop site, give the station the appearance of a giant pin cushion. Eleven of these antennas are directional and six, omni-directional. Thirty thousand feet of cable are used to link up the apparatus and sixty gallons of water per minute are circulated around the transmitters for cooling.

The apparatus for this British Empire station was manufactured and installed by Standard Telephones & Cables, Ltd., a subsidiary of the International Standard Electric Corporation, which is a company of the International Telephone and Telegraph Corporation.

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SHIP RADIO OF TODAY

LT. VITTORIO ROLLANDINI, chief radio officer of the new 50,000-ton Italian liner "Rex," announced, when the vessel steamed into New York harbor recently on her maiden voyage, that "on this ship more space is devoted to radio than on any other passenger ship afloat."

Three lifts are provided especially for the purpose of bringing first-, second-, and third-class passengers up to "Radio Central," as the spacious accommodation which houses the equipment is called.

The "Rex" is equipped with seven wireless transmitters and associated receiving apparatus, all built in the Marconi works at Genoa. Four of these transmitters and receivers are lifeboat sets. The two telegraph transmitters are designed for communication on any wave from 18 to 5,000 meters. The receivers cover a wave range from 12 to 30,000 meters. The receiver used for long-distance telephony is a superheterodyne using 37 valves. All the instruments are mounted in shock-absorbing cradles or are suspended from the ceiling by large coil springs. This precaution is necessary, especially with short-wave apparatus, to protect the various parts from the vibration of the ship's engines and the shock of heavy waves. The direction-finder is installed in the chart room, adjacent to the bridge.

As the "Rex" approached New York, direct telephone communication was established with Genoa, and the operators turned around and immediately established communication, also by direct 'phone, with the Italian liner "Santo Rosso," which was then tied up in Shanghai harbor. The call letters of the "Rex" are ICEJ, and Lieut. Rollandini has under him a staff of six operators.

Radio tubes without filaments

IN a paper delivered before the Institute of Radio Engineers the evening of January 4 by Dr. August Hund, a member of the research staff of Wired Radio, Inc., Ampere, New Jersey, a new type of radio tube was described and its various features discussed. This tube is distinguished by the absence of a filament and depends for its functioning on gas ionization. It is said that it performs all the functions of the modern thermionic tube.

Two general types of tubes have been developed, one which makes use of conduction of negative ions, the other, operating on the negative resistance principle similar to the Poulsen arc. Both types of tubes have been made to function as oscillators, amplifiers, modulators and demodulators.

The operating characteristics of the tubes were given and discussed. Several forms of amplifier tubes working on both the ionization and negative resistance were described. Also different forms of tubes having both external and internal modulating electrodes were shown and their mode of operation discussed.

The use of both types of tubes as oscillators in connection with piezo-electric crystals was described. An interesting method of generating three-phase oscillations by means of the negative resistance form of tube operating on the relaxation principle, in conjunction with a piezo-electric rod was described. In this system a standing wave was created on the rod and two voltages with the proper phase difference between them are taken off the rod by means of amplifiers.

The tubes have been operated in their various capacities over the audio and radio frequency ranges extending into the ultra high frequency field. The use of the tubes in multi-channel transmitting and receiving equipment was also described.

The absence of a heated filament opens up the question of life of such tubes. Dr. Hund has had tubes in continuous operation for many hundreds of hours and stated that he saw no reason why the life of the tube should not be almost indefinite.

The simple construction of the tube and the absence of the necessity for high evacuation and the use of inexpensive gas, it is stated, should lead towards an inexpensive device.

It was stated that at a later date it was expected to present additional information to the Institute discussing more in detail actual operating characteristics of different types of this filamentless tube which may be used in the place of standard hot cathode tubes now on the market.

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SPEAKER PATENTS POOLED

MAGNAVOX, Jensen, Utah and Lektophone have pooled their speaker patents and are bringing suit against department stores that sell sets using speakers that infringe the patents of the combine. Actions have already been filed against certain retail stores.

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RADIO OPERATIONS OF ROYAL CANADIAN SIGNALS

During the fiscal year ended March 31, 1932, The Royal Canadian Signals had in operation 24 radiotelegraph stations and five radio beacon stations. Installation of short wave equipment at each of the North West Territories and Yukon stations increased the efficiency of the service and permitted schedules to be maintained between Winnipeg and Edmonton for the transmission of traffic to Ottawa. Frequencies found to be suitable for use in other parts of Canada over similar distances were not found to be entirely satisfactory on this system.

At Ottawa the low-powered experimental short-wave equipment has been replaced by a Marconi 2 kw. set, which has greatly added to the efficiency of the station. An R. C. A. F. photographic expedition to the Belcher Islands, Hudson Bay, in 1931, maintained contact with Ottawa, thus proving the practicability of using light weight portable equipment for communication with isolated detachments operating in the northern hinterland. Low powered short-wave transmitting and receiving sets have been issued to divisional signal units located at various points throughout Canada.

The total number of messages sent, including government and commercial, over the various systems of the Royal Canadian Signals for the year ended March 31, last, was 37,718. Gross receipts totaled $36,943; net receipts were $33,012.

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BRITISH ORDER MICRO-RAY EQUIPMENT

A MICRO-RAY equipment giving radio communication on the shortest wavelength employed at any radio station in the world, has been ordered by the British Air Ministry for use in connection with cross channel flying services. The equipment will be manufactured at the Hendon, England, factory of Standard Telephones and Cables, Ltd. Operation will be on a wavelength in the neighborhood of fifteen centimeters; transmitting and receiving aerials will be less than one inch long. Micro-rays oscillating at a rate of about two billion times a second are generated in a special micro-radio tube. These oscillations are led through the tiny transmitting aerial and are then concentrated by a combination of mirrors into a fine pencil of rays, which are thrown into space from a circular reflector, about ten feet in diameter. This reflector is focused on to a similar reflector at the receiving station. The station will be located at Lympne Airport, near Hythe, England, and will operate in conjunction with a similar installation ordered by the French Air Ministry to be situated at St. Inglevert aerodrome, nearly seven miles southwest of Calais.

▲

IMPROVED MAGNETIC ALLOYS

NICKEL-IRON alloys of high magnetic permeability contain silver and manganese. Copper and silicon may also be present, but chromium is specifically excluded. It is claimed that the addition of manganese with silver improves the working properties of the alloys in the process to which they are subjected during the manufacture of wire, strip or powder. In addition to giving improved working properties the manganese acts as a deoxidizer. Composition: Nickel from 25 per cent. to 80 per cent., iron from 15 per cent. to 60 per cent, silver from about 0.05 per cent. to 10 per cent, copper up to 10 per cent. and managanese from about 0.1 per cent. to 10 per cent. These alloys are in two series: (a) Those low in silver and suitable for the production of wire and strip by hot working processes. (b) Those with silver contents exceeding 0.5 per cent. and particularly suitable for the production of powder by a pulverizing process. Typical alloys are cited and heat treatment is specified.

Callender's Cable and Construction Co., Ltd., and Beckinsale, S. British Patent 355,456. 1931.

A chronological history of electrical communication —telegraph, telephone and radio

▲

This history was begun in the January, 1932, issue of RADIO ENGINEERING, and will be continued in successive monthly issues. The history is authoritative and will record all important dates, discoveries, inventions, necrology and statistics, with numerous contemporary chronological tie-in references to events in associated scientific developments. The entries will be carried along to our times.

▼

Part XIII

(485) Alexander Bain dies. (Born in Scotland, 1818.)

(486) Heinrich Ruhmkorff dies. (Born in Germany, 1803.)

(487) Thomas B. Doolittle, of Bridgeport, Conn., has hard-drawn copper wire made at the works of the Bridgeport Brass Company, for telephone purposes.

(488) In July a two weeks' railroad employees' strike on the Baltimore and Ohio, Pennsylvania, Erie, and Big Four Railroads requires the presence of troops with artillery. During the strike 300 persons are killed, 3,500 cars are burned and 125 locomotives destroyed.

(489) Alfred Smee dies. (Born in England, 1818.)

(490) Two underground cables, 2,200 feet long, with thirty conductors each are laid down in New York City.

(491) The Mexican Telegraph Company is planned by James A. Scrymser, of New York, to lay submarine cables across the Gulf of Mexico.

(492) Thomas A. Edison experiments with paper-carbon filaments for incandescent electric lamps.

(493) Johann Poggendorff dies. (Born in Germany, 1796.)

1878 (494) Dr. Byrne, of Brooklyn, N. Y., improves the form of the Grenet primary battery.

(495) The American Speaking Telephone Company, controlled by the Western Union Telegraph Company and the Gold and Stock Telegraph Company, is formed to operate under the Edison patents. Eighty-five exchanges are established. (Within a year the company retired from the telephone field by arrangement with the Bell Telephone Company.)

(496) The first commercially equipped telephone exchange is installed, at New Haven, Conn.

(497) Sawyer and Man invent a carbon-pencil electric lamp, the glass chamber of which is charged with an atmosphere of nitrogen gas.

(498) W. D. Sargent, of Washington, suggests the use of selenium in bringing about visualization of articulate speech by telephone.

(499) T. A. Edison engages Francis R. Upton as mathematician to assist in determining the electrical requirements of lamp filaments and the required circuit properties for electric lighting.

(500) Professor Hughes, of London, introduces a light-contact microphone transmitter.

(501) Norvin Green becomes the fifth president of the Western Union Telegraph Company, April 22. (Remained until his death in 1892.)

(502) Charles A. Cheever patents (October) the first telephone switchboard combining the essential elements of the existing Western Union telegraph pin-switch, and of the early hotel annunciators. (Patent No. 208,463.)

(503) Antoine C. Becquerel dies. (Born in France, 1788.)

(504) For street lighting purposes in the United States the "electric candle" invented by Paul Jablochkoff, of France, in 1876, is experimented with. The "candle" consists of two carbon rods fixed parallel a slight distance apart, with an insulating material between them, the latter being consumed at the same rate as the carbons.

(505) A telephone transmitter invented by Francis Blake introduced in service in the United States.

(506) William E. Sawyer, of New Hampshire, aided by Albon Man, develops a system of incandescent electric lighting based on Sawyer's patent granted August 14, 1877 for "an improvement in electrical engineering and lighting apparatus and system." The incandescent conductor is of carbonized paper.

(507) First electric light service is installed in St. Louis, Mo., Carl Heisler imports a Gramme a-c arc light machine from Paris. The installation included twelve Jablochkoff "candles" in four sets of three each.

(508) The Edison phonograph is publicly exhibited.

(509) Bremer employs electrodes of carbon and mineral compounds in arc lamps.

(510) Congressman James A. Garfield has telephone connection made to his residence in Washington. (Garfield was the first president to use the telephone.)

(511) Transposed telephone line wires are employed in Great Britain.

(512) The New England Telephone Company is organized, February 12, in Massachusetts, with a capital of $200,000.

(513) The Bell Telephone Company is organized, July 30, with a capital of $450,000.

(514) Joseph Henry dies. (Born in the United States 1797.)

1879 (515) Doctor Foucault patents a method of manufacturing cables in which a tin-foil wrapping is wound around each insulated conductor. The foil wrapping being connected to earth when the cable is in service.

(516) Gramme develops a satisfactory two-phase alternating-current eight-pole dynamo with a revolving field and a stationary armature.

(517) Willoughby Smith suggests the employment of distributed inductive shunts along cables in order to increase the speed of telegraph transmission.

(517) Willoughby Smith suggests the employment of dis-London.

(519) Hughes discovers the phenomena on which depend the action of the coherer used later in systems of radio telegraphy.

(520) The New York City telephone directory is printed on a card listing 252 names of subscribers.

(521) Doctor John Hopkinson calls attention to methods of plotting curves; later called "characteristic curves" by Marcel and Deprez.

(522) Arc lighting machines in use this year are operated at fifty volts per lamp; twelve lamps in series on a circuit.

(523) The Baltimore and Ohio Telegraph Company is organized.

(524) The Western Union Telegraph Company appoints H. H. Eldred superintendent of telephones, June. On November 10, an agreement is entered into with the National Bell Telephone Company. (See 1911).

(525) Stephen D. Field, of Stockbridge, Mass., makes improvements in electric motor drive for street cars.

(526) William Fothergill Cooke dies. (Born in England 1806.)

(527) Joseph W. Swan, in England, produces an electric incandescent lamp.

(528) James Clerk Maxwell dies. (Born in Scotland, 1831.)

(To be continued)

CATALOG OF MODERN APPARATUS

The General Radio Company, Cambridge, Mass., has issued a new catalog describing and illustrating that company's high grade line of resistance devices, condensers, inductors, frequency and time measuring devices, oscillators, amplifiers, bridges and accessories, standard signal generators, meters, a-f. and power transformers, switches, dials and accessories.

▲

ERIE MULTI RESISTOR

If a resistor is to be used on very high voltage the resistor must be made longer to prevent breakdown.

The Erie Resistor Corporation, Erie, Penn., has developed a new design particularly for this purpose, in which the resistor element is made in the form of rings connected in series to get a very long resistor in a small space. Taps may be brought out at as many points as desired.

This same construction may be used having several insulated sections combined in one unit, or each ring may be used as an individual unit separately connected in its own circuit.

▲

RECEIVER COIL COMBINATIONS

The General Manufacturing Company, 8066 South Chicago Avenue, Chicago, Ills., has just issued pamphlets illustrating and describing coil requirements for various types of radio receivers, including tuned radio frequency and superheterodyne.

▲

NEW RADIO ACCESSORIES

Jenkins and Adair, 3333 Belmont Ave., Chicago, Ills., are distributing new bulletins listing improved radio and sound accessories.

1-F lists a new line of precision audio-frequency coils. 5-A is on the subject of mixing and gain controls, while No. 31 lists piezo crystals and crystal equipment.

Of particular interest to the broadcaster is the new M-8 bridging transformer for coupling between the 500-ohm station bus and a public-address system. The M-100 input transformer for a moving-coil microphone amplifier, is another new item as is sets of class B amplifier transformers listed on page 2 of bulletin 1-F.

▲

TRANSMITTING TUBES

The Broadcast Engineering Company, 170 Bruce Street, Newark, N. J., announces a new line of radio transmitting tubes, power amplifiers, mercury vapor rectifiers and photo cells. The company also rebuilds and repairs all types of transmitting tubes.

▲

FILTERMATIC MOVES

The Filtermatic Manufacturing Company, formerly in Philadelphia, has moved its factory to 6913 Dittman St., Tacony, Pa. The company manufactures variable and tapped condensers.

NATIONAL UNION LABORATORIES DEVELOP "SPRAYED MICAS"

The Engineering Laboratories of National Union Radio Corporation, after many months of experimentation, have perfected a new method of reducing electrical leakage across the mica used in radio tube manufacture. An engineering bulletin just released gives an insight into the "sprayed mica" development.

Mica is used as a spacing member by all tube manufacturers, and, almost universally, trouble is experienced with electrical leakage across the mica. It is general practice to clean this mica as well as possible before it is sealed into a tube; but even with scrupulous attention given to cleaning, tubes can be and often are manufactured with electrical leakage between the tube elements which the mica is used to space.

The engineering department of National Union some time ago set out to devise a method of preventing the occurrence of leakage. After a great deal of experimentation a method or process has been devised and is now being used at the National Union factories.

The tubes which are now being manufactured by National Union using what we call "sprayed micas" are Types '27, '36, '37, '39, 55, 56 and 59. On examination, the sprayed mica is readily noticeable on any of these tubes. It is a white coating covering a strip of the mica in certain tubes and covering the entire mica in others.

The use of sprayed micas has proven a much more satisfactory means of preventing electrical leakage in tubes than any other method tried. National Union tubes are believed to he the only tubes being manufactured with sprayed micas at the present time.

▲

ELECTROLYTIC CONDENSERS

Electrolytic condensers of improved characteristics are announced by the Dubilier Condenser Corporation, New York City. These new units now in production are claimed to incorporate a special treatment of the aluminum foil, resulting in a tougher, more durable and quicker reforming dielectric film, as well as a radical departure from the usual forming technique, resulting in conserving the electrolyte for a longer service life.

NEW LINE OF D-C. METERS

The Beede Electrical Instrument Company, Penacook, N. H., has introduced a new line of d-c. milliammeters 0-1 to 0-25 ma.

The improved design of the moving coil assembly permits a greater simplicity of construction than has heretofore been possible in the art. This results in unusual ruggedness, high accuracy and freedom from interference of dust and foreign matter. The meter is perfectly balanced in all positions, and the moving system is exceptionally well damped. From the mounting of the sapphire bearing to the construction of the magnet, the materials, workmanship and design conform to the highest quality and most improved practice. Accuracy is guaranteed within 2 per cent.

▲

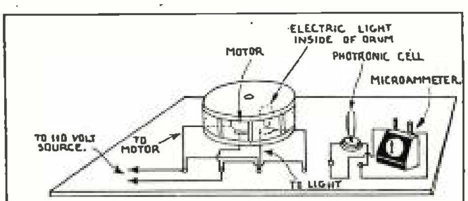
"ELECTRIC EYE" EXHIBIT AT COLUMBIA UNIVERSITY

The Department of Physics at Columbia University is sponsoring an extremely interesting exhibit of various light sensitive devices. Several important new photocell applications are also on display. One portion of the exhibit is devoted to the many different variations of light sensitive cells. Over fifty cells are on display. Each cell is readily identified by means of an explanatory card.

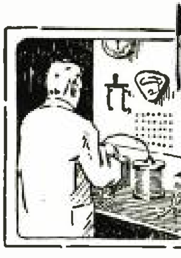
One of the most interesting cells shown, is the Weston Photronic cell, which generates its own e.m.f. when it is exposed to light. This cell is of the front wall type. It is electronic in its character, employing a highly sensitive disk which transforms light energy directly into electrical energy, without the use of any auxiliary voltage. Its response to light variations is instantaneous and sufficient current is developed to directly operate relays without auxiliary apparatus or battery.

Another feature of the exhibit is a Weston model 607 Photronic relay. This consists of a Photronic cell, a Weston sensitive relay and a power relay mounted on a black panel and connected as a working unit. The action of this device is especially clear due to the fact that all circuit connections between cell and relays are traced in colors on the panel. A 4½-volt battery is used to energize the power relay. A small electric light is placed in front of the Photronic cell.

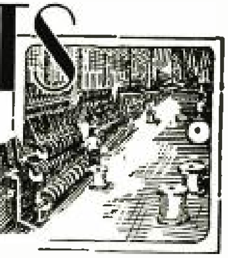
Paper test unit.



— EXPERIMENTAL PAPER TESTER — SHOWING USE OF PHOTRONIC CELL FOR MEASURING RELATIVE TRANSLUCENCY OF VARIOUS GRADES OF PAPER. —



NEW DEVELOPMENTS OF THE MONTH



SPECIAL MODEL CARDWELL VARIABLE CONDENSERS

The Allen D. Cardwell Manufacturing Corporation, 81 Prospect Street, Brooklyn, N. Y., has announced three new special model variable condensers.

The Midway "Featherweight" band-spread condenser, shown in Fig. 1, is available in two stock sizes, each consisting of a low capacity section and a high capacity section, built into the well-known Midway "Featherweight" frame. Each rotor is controlled by a separate shaft. A ball bearing between the inner ends of the two shafts, in addition to end plate bearings, prevents end-play and permits smooth, uniform operation. Like all other Midway models, this condenser is light and compact. It is arranged either for shelf or for panel mounting and is equipped with a positive, non-mutilating rotor lock on the high capacity section. Fig. 1 serves to illustrate both models of the "Featherweight" band-spread condenser, Model 517

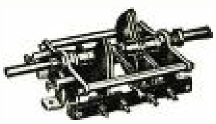


Fig. 1.

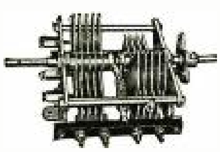


Fig. 2.

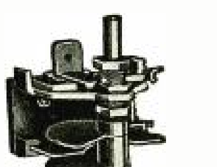


Fig. 3.

has a 25 μμfd. section and a 50 μμfd. section, Model No. 518 has a 25 μμfd. section and a 100 μμfd. section. Other combinations are available on special order.

Another interesting new Cardwell condenser is shown in Fig. 2. This is the type 516 double end condenser. This model is built into a standard size Cardwell frame and has two separate rotors and stators, each rotor being controlled by its own shaft. A rotor lock is provided on one section for fixing the rotor at any desired point. A ball bearing between the inside ends of the rotor shafts prevents end-play and insures uniformity of rotation. The model 516 condenser has a capacity of 90 μμfd. per section. It is of stock size and has nine plates, double spaced in each section. It may be mounted on a panel or on a chassis shelf.

Fig. 3 illustrates the new Cardwell type 519 neutralizing condenser for 852 tubes. This is a compact three-plate condenser, having extra wide spacing. One rotor plate is readily removable, if so desired, leaving a two-plate variable condenser with adjustable air-gap.

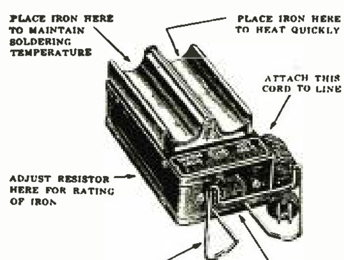
A positive non-mutilating rotor lock is provided on the No. 519 condenser. This condenser is designed either for panel or for shelf mounting. It is insulated with Mycalex.

▲

NEW SOLDERING IRON STAND

G-M Laboratories, Inc., 1735 Belmont Ave., Chicago, have announced a new type of soldering iron stand that effects a saving of 30-40 per cent in power consumption and overcomes many of the principal soldering troubles. The most serious difficulties in soldering work result from an overheated, dirty iron, and much defective soldering results from the tip of the iron becoming pitted and corroded from excessive heat. By keeping the iron, when not actually being used, at just the right soldering temperature, the G-M stand corrects this trouble and the tip of the iron will remain well tinned for weeks.

The G-M soldering iron stand has two cradles. When placed in the left-hand cradle the iron receives only sufficient voltage to keep it at the minimum and yet proper soldering temperature for immediate use. The result is a material saving of power and greatly increased life of the heating element. When the iron is



either in actual use or is placed in the right-hand cradle, full line voltage is automatically applied to keep the iron up to temperature. The elimination of overheating with all its attendant evils together with the saving in power consumption are features which more than justify the cost of the stand.

▲

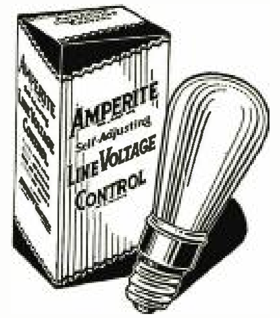
SCREW BASE AMPERITES

The Amperite Corporation, 561 Broadway, New York, will shortly release for sale a screw base unit.

The continuous demand for a voltage regulator with a standard screw base prompted the development of the new Amperite series.

Not only is the base new, but the regulating characteristics are far beyond anything put on the market before.

The familiar radio tube amplifies voltage variations—therefore has an amplification factor. An Amperite regulator decreases line voltage variations—therefore has what may be termed "de-amplification" factor. Instead of 15, obtained by the old series,



the new series will absorb 25 times as much voltage as an ordinary wire. In other words, an Amperite regulator will decrease voltage variations 25 times faster than an ordinary resistance.

The following will be of great help to service men and engineers: By actual test it has been found that the wattage consumption of radio sets averages 0.1 ampere per tube. Thus: A 7-tube set draws 0.7 ampere and therefore Amperite 7-A-5 is recommended. A 9-tube set draws 0.9 ampere and Amperite 9-A-5 is recommended, etc. The exceptions to the above rule are sets using —250 tubes. Like the bakelite base, the new screw base Amperite can be used on all 110 or 220-volt sets.

▲

ARCTURUS DEVELOPS NEW SAFETY MERCURY VAPOR RECTIFIERS

A new form of safety rectifier has been developed by Arcturus where the unavoidable arc-over cannot cause damage to any part of the receiver. This tube automatically disconnects itself from the circuit when arc-over occurs, precluding damage to the transformer or fuse.

These new tubes have been designated as the Type AF which replaces the type 82, and the Type AG replacing the type 83. The electrical and operating characteristics of these new safety rectifiers are identical to the tubes which they replace.

This arc-over, or flash-over, is not indicative of a faulty rectifier or set. It is an inherent limitation of gaseous rectifiers, regardless of the skill and care taken in manufacture. In fact, the tube may operate perfectly until the time arc-over occurs. Such a condition impairs set sales and usually results in costly repairs, service calls and possibly repossessions.

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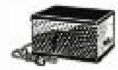

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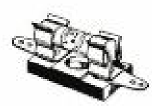

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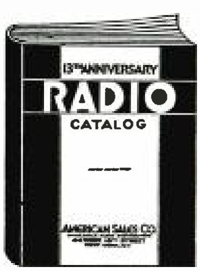

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4 D.C. Current Ranges	Capacity measurements. .001 to 10 mfd.
4 A.C. Voltage Ranges	Output Meter
Resistance measurements of 1 ohm to 3 megohms	

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Transformers
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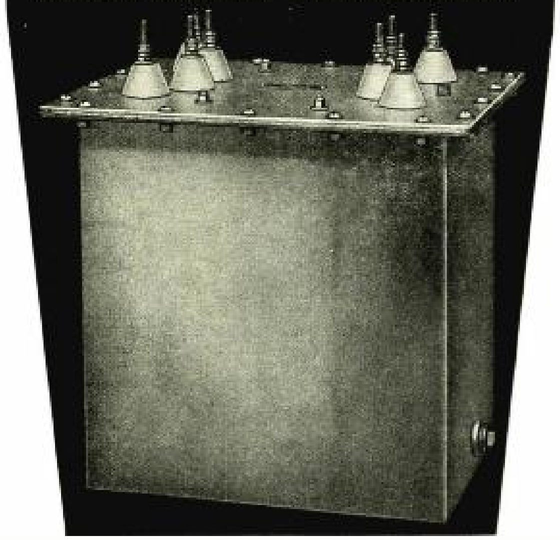

Output transformer for use between push-pull, class "B" stage using 204-type tubes and a class "C" amplifier. Operating level + 50dB; primary 1500-1500 ohms; secondary 4750 ohms; tested at 15,000 volts; oil insulated.

FOR six months AmerTran engineers have been studying all problems associated with Class B Amplifiers. With this experience as a background a complete line of audio-frequency transformers (input and output) has been especially designed for use with tubes suitable for Class B operation.

Large output transformers for use in Class B Amplifiers of broadcast transmitters are of the design illustrated above and have the following features:

1. **Oil immersed with Isolantite bushings. This permits insulation testing at a voltage which is considerably in excess of any peak which might be experienced in actual practice.**
2. Welded aluminum tank provides complete r.f. shielding.
3. Wire used in primary and secondary windings is of a size which insures low d.c. resistance and ample current capacity.
4. Primary sections are balanced within 0.5% and the same phase angle exists in each section.
5. Core laminations of the best quality high-permeability alloy are operated at a low density.
6. Coil structure insures low distributed capacity, low capacity coupling, and high inductance coupling.
7. High efficiency insured by excellent regulation, constant input impedance, and unusually satisfactory frequency characteristics throughout the band of 30 to 10,000 cycles.

Complete information on transformers for use with a specific type of tube will be mailed promptly on request.

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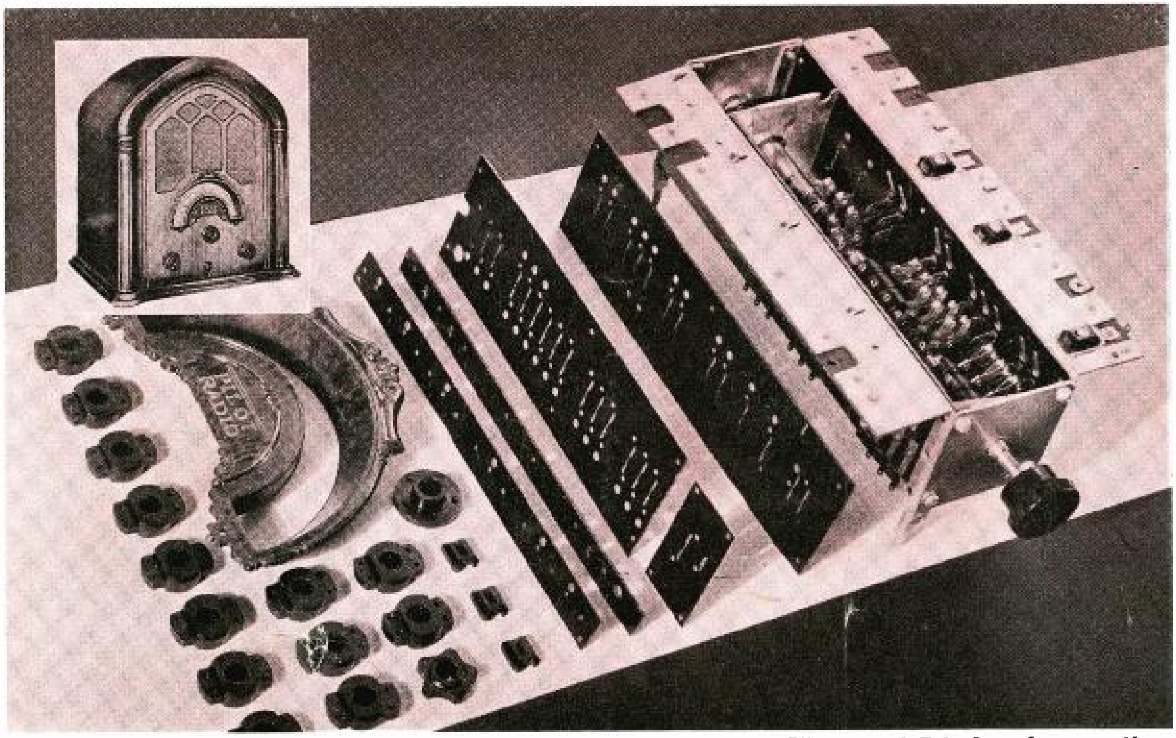
All insulation *in Pilot change switch is of Bakelite Materials*



DRAGON Radio Receiver, change switch and parts of Bakelite Molded and Laminated. Pilot Radio & Tube Corp., Lawrence, Mass.

EIGHTEEN Bakelite Molded parts for mounting contact blades, and five punched strips of Bakelite Laminated complete the insulation parts of this Pilot Radio change switch. Bakelite Materials covered every insulation need—nothing else was required.

The switch is used in the Pilot radio receiver, and on the walnut cabinet, Bakelite Molded in a duotone walnut effect is used for dial frame and control knobs. The rich color and finish of these parts harmonize perfectly with the walnut cabinet. Whether in the Molded, Laminated or Varnish form, Bakelite Materials possess ideal properties for use as insulating materials in the electronics industry. Strong, highly insulating, non-corrodible and non-hygroscopic—these materials give constant and dependable service for a long period of time.

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