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NOVEMBER
1936

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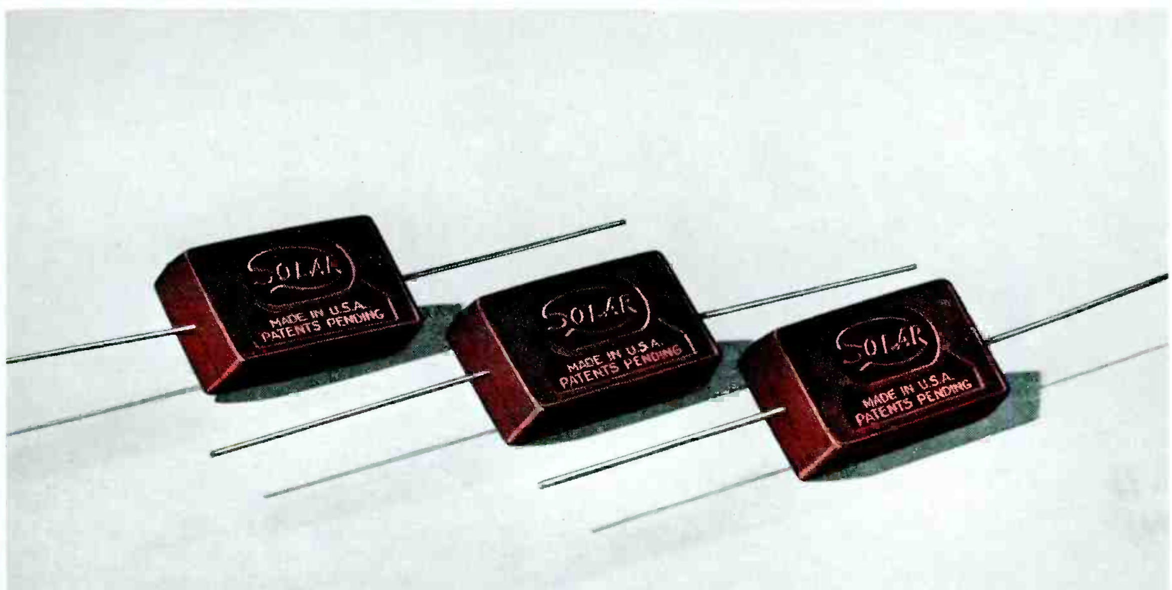

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ELECTRONICS

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Contents • November 1936

COVER:
Rectifier for 50 kw RCA Victor broadcast transmitter

DEPARTMENTS

Volume 9 . . . Number 11

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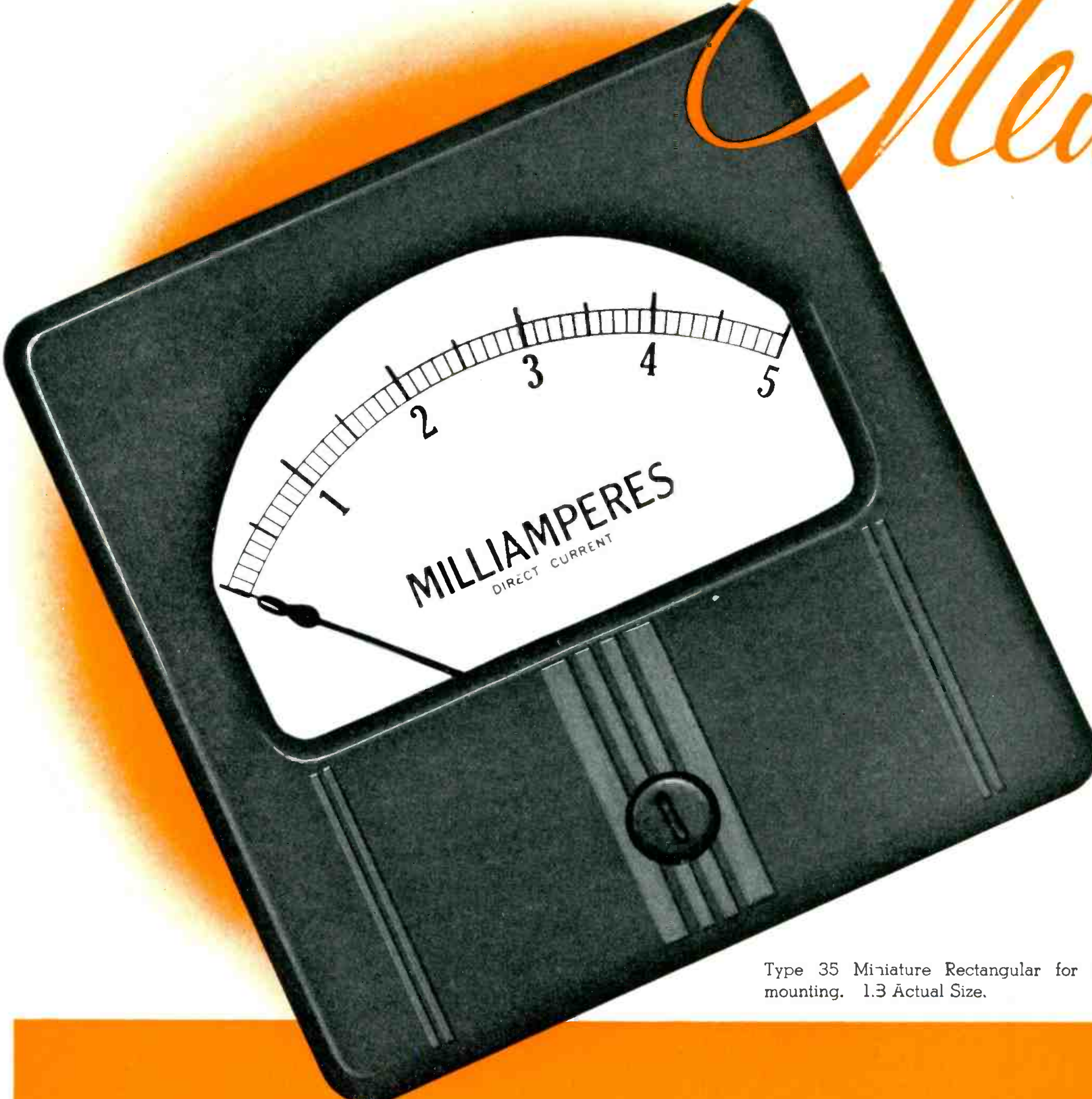
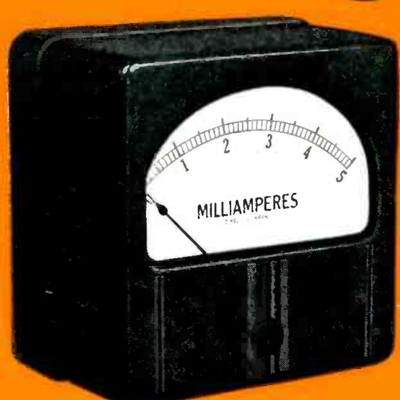
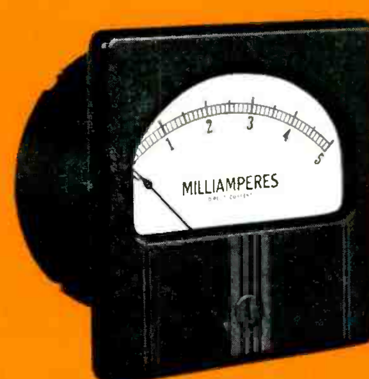


Type 35 Miniature Rectangular for flush mounting. 1.3 Actual Size.



Left—Type 35 Miniature Rectangular for Surface Mounting. The simplicity of line which distinguishes the front of this instrument is standard on all rectangular Type 35 Miniatures.

Right—This Type 35, while retaining the ease of mounting of a round type miniature, assures the desirable appearance of a rectangular.



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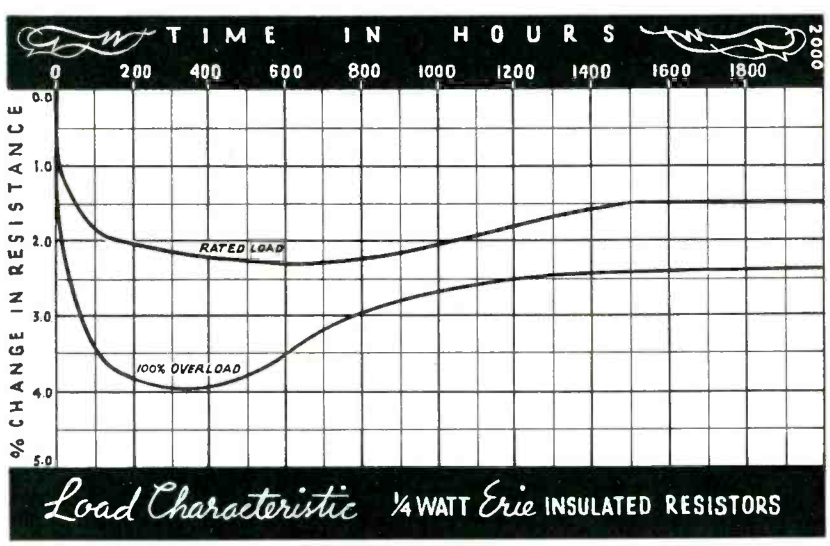
Right—Round Type 35 Miniatures can be obtained in two sizes, 3½-inch and 3⅝-inch. They are only for flush mounting.



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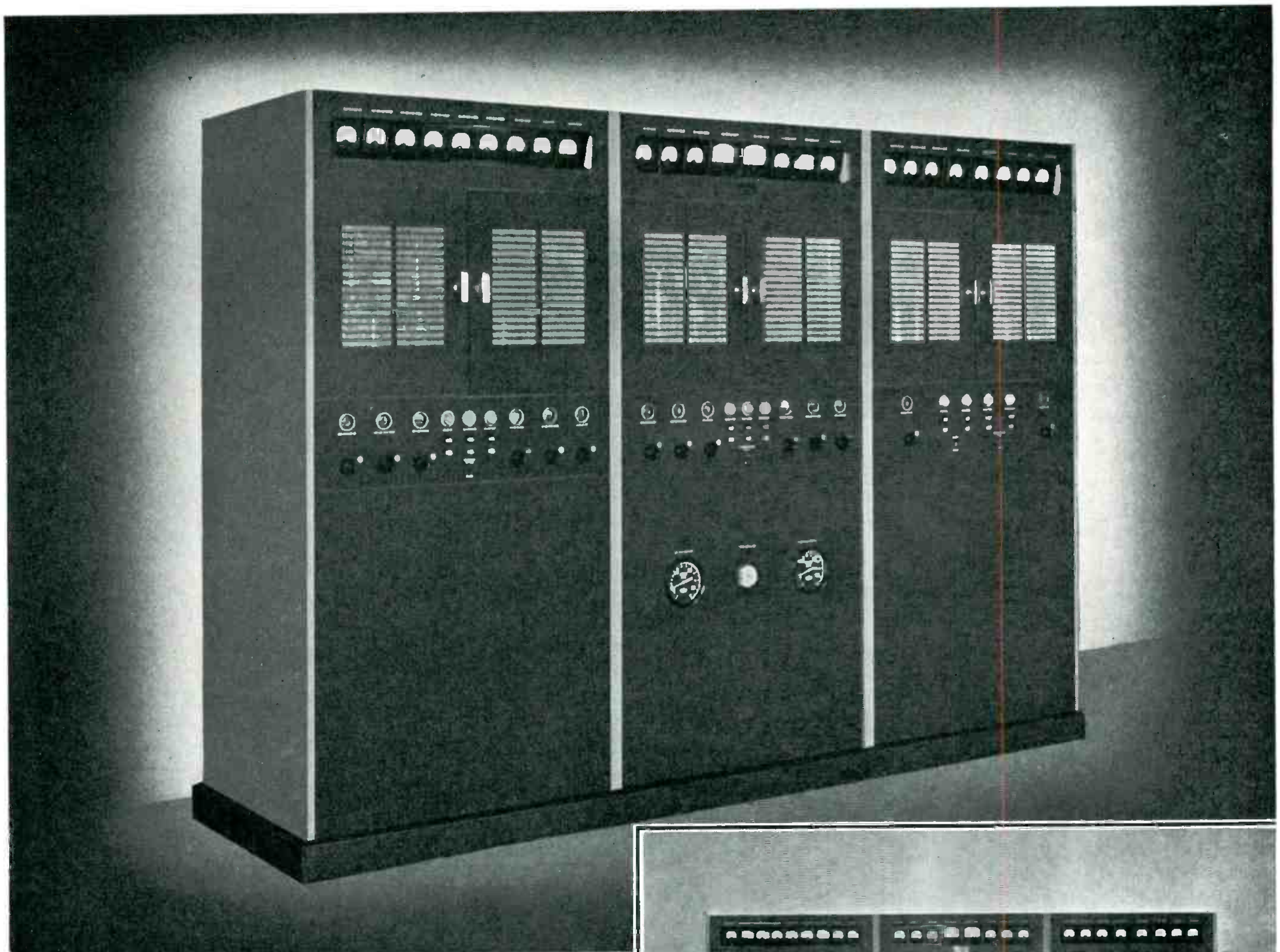

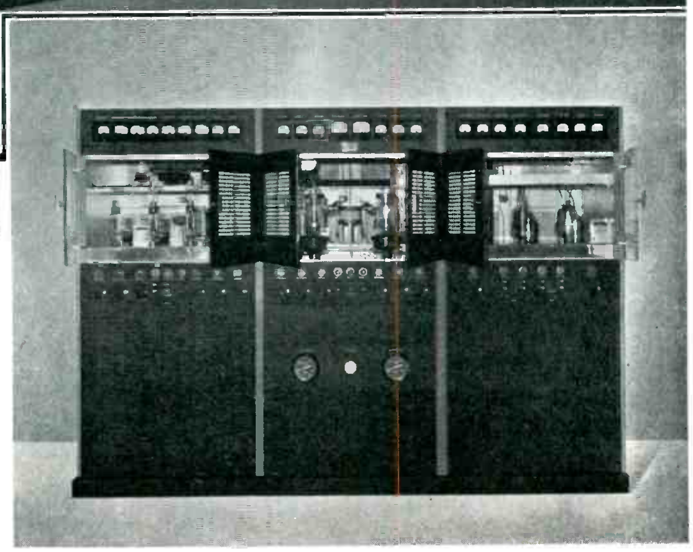

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Photo by H. Armstrong Roberts

No Mean Accomplishment

Another Year and

An Accounting Thereof . . . .

Though not recognized as such except by the few who knew our country's economic history *1934 was a good year for new undertakings.*

The severe business depression had of necessity done its worst. An upward trend already was evident. New and better products were being brought out. Industry and its engineering forces were searching deeply for improved methods and materials with which to lower manufacturing costs.

The time was opportune and the founders of the SUPERIOR TUBE COMPANY determined to set up a plant and organization to function in the field of small tubing only, in many metals

——— to build around a nucleus of men skilled in the industry and with broad experience

——— a personnel of college men and high school graduates quick to learn and ambitious to succeed

——— and to equip a plant with efficient, modern tools, building when not otherwise available those tools needed to meet high standards of quality in merchandise at costs which should create substantial markets for the goods produced.

Now, at the end of our second year, we give you a brief accounting.

We produced tubing to double the footage of our first year

——— added eight industries using large footage

——— added to our technical group men not available a year ago

——— paid out in wages 100% more than in our first year.

• • •

We like to think of our company as among the pioneers of a new era in American industry —to count ourselves with the men who saw in a resting period an opportunity to contribute something of real value to industrial progress.

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HEADQUARTERS FOR FINE, SMALL SEAMLESS TUBING

ELECTRONICS

NOVEMBER
1936

KEITH HENNEY
Editor

Crosstalk

▶ **WELCOME** . . . Mr. Beverly Dudley has joined the editorial department of *Electronics* and the results of his typewriter pounding will materially broaden the range of staff-written material. A graduate of M.I.T. in communication, Mr. Dudley's experience in the field has been secured with the General Radio company and with RCA Radiotron. For a time he was assistant secretary of the I.R.E. and was once an editor on the staff of QST.

The editorial staff now consists of the editor (somewhat worn out after an arduous social session entertaining the engineers of the afore-mentioned General Radio company—see the *Experimenter*, (September-October 1936), Donald G. Fink who joined the staff in 1934 and who has produced many of the feature articles appearing since then, Miss Kae Farrey who is make-up editor and office boy, Harry Phillips who is responsible for the lay-out and general appearance of the magazine, and Mr. Dudley.

▶ **LIMELIGHT** . . . Amateur radio operators have come in for quite a bit of attention in the general publications recently. The *American Magazine* for October has an article "Adventure at your Fingertips" and recently the New York World-Telegram (and probably the other Scripps Howard papers) had a series on the activities of the licensed amateurs. In this latter series your editor came in for publicity, of a sort. This was the result of telling the writer of the series a story of how he (the editor) heard his first wireless signals by means of a kite carrying up wire stolen from the power company. The wind was so strong that the wire was hitched to a cow shed which along with the kite disappeared in a gust of wind during the night. This is a good story (and is true) but unkind skeptics wonder what kind of copper the power company was using, copper that would pull down a cow shed.

▶ **ANNIVERSARY** . . . In this issue we commemorate the 10th anniversary of the National Broadcasting Company by reviewing the activities, personnel and plant of the engineering department. Of this department, some non-technical official is reported to have said that it reminded him of the bathroom—it is necessary but should not be talked about.

Engineering made broadcasting, keeps it going, gives it a future, brass hats notwithstanding. Executives change and with them policies but the results of the engineering department have a complete continuity over the years.

▶ **DATA SHEETS** . . . Several manufacturers have discovered that well-written technical data sheets provide an excellent path to the pocket books of consumers. The Application Notes of RCA Manufacturing (Radiotron) are well known. National Union, Raytheon and Ken-Rad get out occasional technical papers of considerable interest.

Audio Products Company, Los Angeles recently put out a data sheet on the Eimac 150-T amateur tube. Not only does it give the proper working conditions for the tube but it tells how to neutralize the circuit in which it is used, coil winding data, how to key it, etc. Many amateurs operating on an empirical and not very sound technical basis stand to learn much from manufacturers' and dealers' information of this sort. What's more, such data sheets ought to improve business.

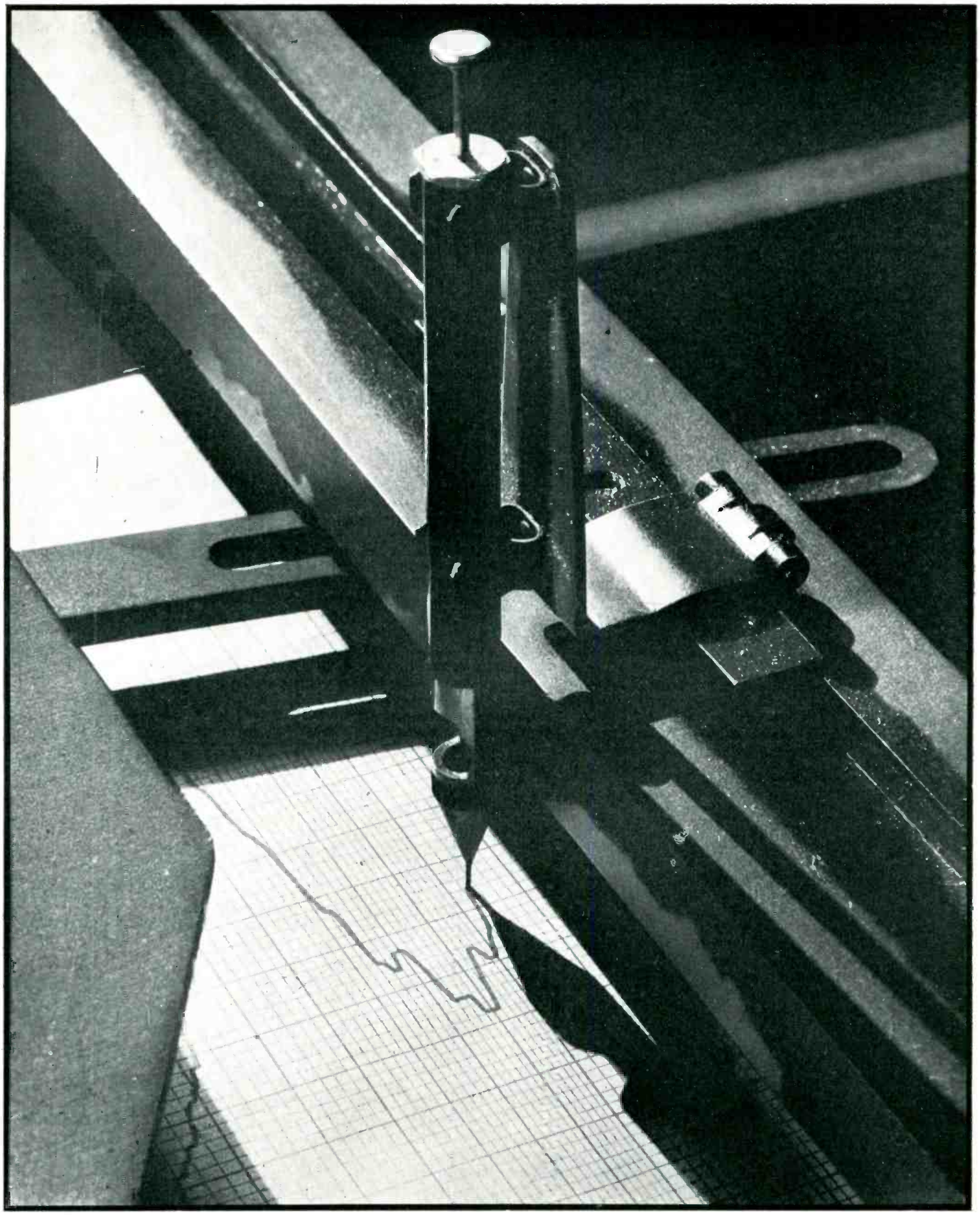
▶ **SHORTAGE** . . . During the late summer a considerable shortage of radio cabinets is reported to have cost the industry some sales. The furniture business seems to be booming, the makers are therefore busy on their own products and not so interested in making cabinets. This does not affect manufacturers who have their own cabinet plants, RCA Victor, for example.

▶ **BLAH BLAH BLAH** . . . New York City has had a sound abatement campaign which, most of the time, seems to be doing some good. People got better sleep, automobiles killed no more people, taxi men had to slow down a bit, and there were other advantages, no doubt. It has taken a political campaign, however, to prove to city people that they like it quiet. At any rate they are kicking about the sound trucks that wander about rooting for this or that candidate. All this is a result of a resolution of the Board of Aldermen granting permission to all political organizations to parade the streets with "vehicles containing bells, radios, amplifiers or bands of music".

▶ **OFF AGAIN, ON AGAIN** . . . There is some feeling in this country that the Europeans are getting ahead of us in the matter of television. This is due to the publicity emanating from abroad as to the excellence of the European pictures.

Engineers who have seen all there is to see on the other side state there is no need for us to worry. All the beautiful demonstrations which make the papers in a big way are undoubtedly done under the best of laboratory conditions. It must be remembered, furthermore, that transmitting television to this nation is somewhat different than it will be to a compact audience like that of the British Isles, or in Germany. Even the British, whose claims to excellence are quite loud, seem to postpone from one day to the next the long anticipated opening of regular television service.

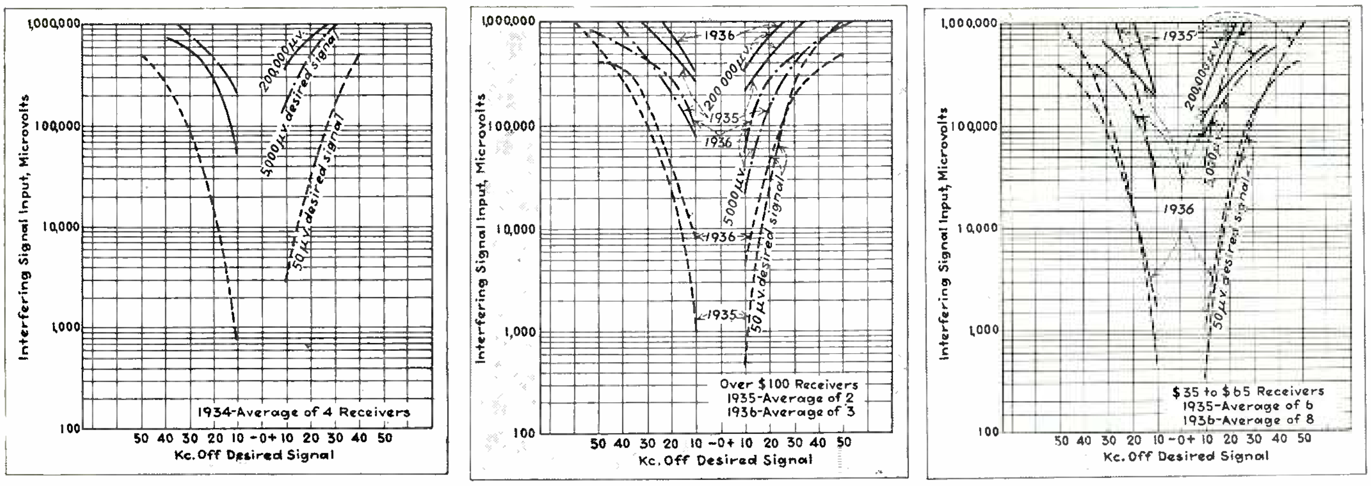
On our own side of the Atlantic the field tests of RCA, of Philco, of Farnsworth are proceeding with care and caution. No one wants this thing to flivver; it must be successful. There are still plenty of problems to be solved before the service will be ready for the public—even in Europe.



Austin Armer

Sound Pressure Record

While a motor drives both paper (above) and the frequency control of a beat oscillator feeding the loudspeaker, the operator follows the motions of the output-meter needle (of microphone amplifier) with a hand lever geared to the recording stylus. Semi-automatic records of sound-pressure response can be made thereby in less than a minute.



Two-signal interference measurements made at 1000 kc. on 1934, 1935 and 1936 receivers

The Case for High Power

Federal Communications Commission at its October meetings hears arguments pro and con—shall clear channels have 500 kw.? Shall regionals have more power? Shall there be more stations? What of the economic plight of the shared-time stations?

ALTHOUGH the Federal Communications Commission had called its October meetings to get information on seven subjects, the hearings developed almost immediately into a clash between those who believe the best way to serve the broadcast public is by many relatively low-power stations and those who believe that high power is the thing. Thus the clear channel people were pitted against the regional and local station owners and operators.

The regionals and locals objected strenuously to the thesis that a clear channel should be occupied by a station of the highest possible power; but at the same time advocated that a horizontal power increase among their own group would be a good thing. The clear channel people want more power; they want removed the present limitation of 50 kw. And they do not seem to object to an increase in power among the other stations. In other words the clear channel group believes that power is the thing.

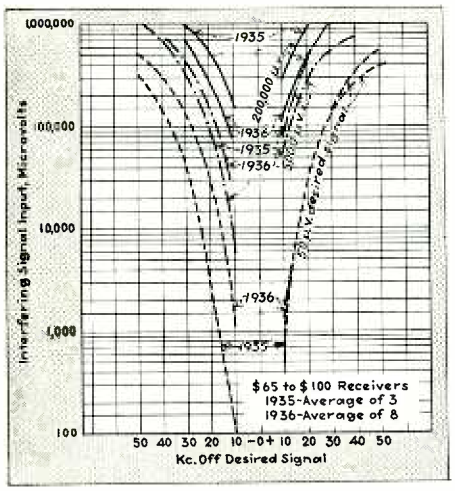
The subjects on which the Commission wanted information were as follows: Classification of stations, allocation of frequencies, standards to determine coverage and the presence or absence of objectionable interference, geographic distribution, standards for essential engineering problems, apparatus performance and the effect of proposals upon any of the above.

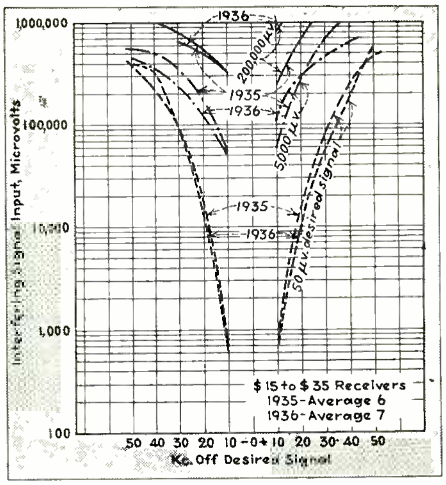
The High Power Argument

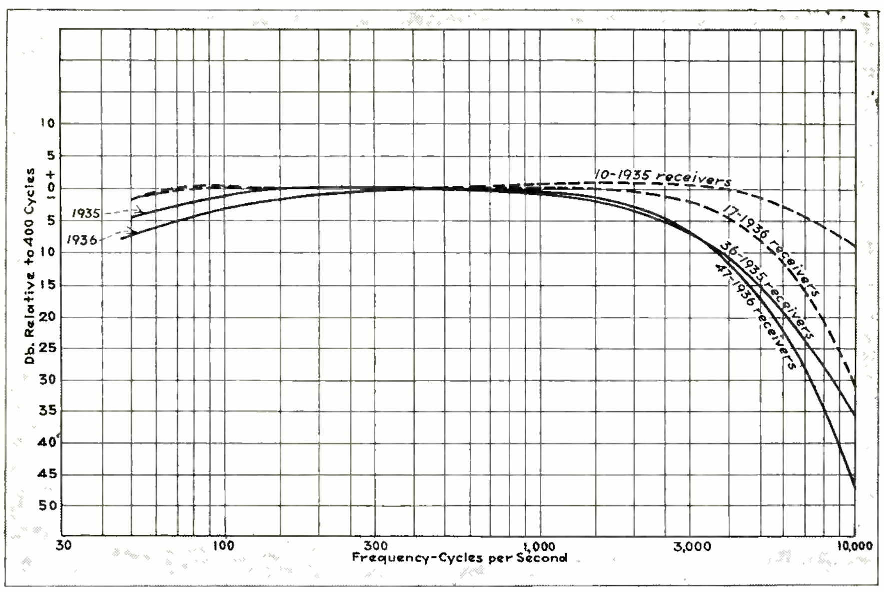
Powell Crosley of WLW was the chief witness in favor of high power. His claims to the advantage of plenty of power follow the conventional arguments that the more power the greater the area covered, the better the signal-to-static ratio, the better the rural listener service. These tenets had been laid down long ago by the engineers as self-evident facts; but WLW's experience was beautiful corroboration of these early theories. Increased power increases the audience, reduces effective noise, overcomes the defects of insensitive receivers, according to Mr. Crosley, and, increases the station revenue so that still better programs can be rendered.

There are now 13 applications pending for increased power in clear channel stations wishing to boost their output from 50 to 500 kw. And if the regionals and local stations have their say, these 500 kw, assignments will not be made. They claim the increased audience secured by a 10-fold increase in clear-channel power is not an economic increase; and that ruin awaits the regionals if 500 kw. is permitted the clear channel frequencies. The regionals, therefore, base their arguments on the economic effect upon themselves; they suggest that some of the present clear channels be taken out of that category and that present interference on the regional channels could be lightened if some of the regionals were permitted to share one or more of the clear channels.

Thus there arose, early in the hearing, the question of whether the clear channels should be permitted to carry 500 kw. instead of a present maximum of 50 kw., whether the lower power stations be permitted a horizontal increase in power, and finally whether the clear channels now in existence should remain clear.







Electrical fidelity of 1935 and 1936 receivers. Dotted curves of variable selectivity receivers in the wide band position

Mr. Crosley stated that the first few months of 1935 had brought in 400 percent more fan mail than the same period of the previous year when operating at only 50 kw. and that five times as many pieces of mail had been received in a 6-month period beginning in October 1935 compared to previous years. He stated that much of this mail came from rural dwellers, who — in the earlier days of radio — were said to need radio more than those in the city. Mr. Lohr of NBC recommended that present 50-kw. limit be raised but stated that he felt that each application should be judged on its merits. Others pointed out the fallacy of operating even a 50-kew. station in such a manner that much of its useful energy is sprayed out over the Atlantic or Pacific ocean. Directional antennas would send this radiation into the homes of listeners with the effectiveness of an increase in station power.

The FCC's own survey (see Cross-talk, October 1936 *Electronics*) was used by the clear channel group that wants more power. This report showed that rural listeners get most of their programs from high power clear channel stations. Many of them mention WLW by name. (In a certain locality in Georgia with which the Editor is familiar, WLW is known as "Crosley". When asked what their best station is they say, "Crosley".)

It is a fact, however, that raising the limit to 500 kw. on the clear channels would have an economic effect upon the whole broadcast picture. It would make necessary a realignment of the networks, according to Mr. Paley of CBS. Some stations would probably be dropped. Stations, not now interested in higher power, would have to make the big investment called for by their competitors' outlay for bigger stations. It was pointed out that so long as broadcasting is maintained by the nation's advertisers who want to cover the most people at the least expense, there will be a fundamental conflict between two propositions. One is to lay down many lines to the near-by listener, the city dweller. This is the advertiser's viewpoint, and therefore must be shared to a large extent by the broadcast owner. The other is the social viewpoint that everyone in the nation, especially the listener remote from city advantages should have a good field strength.

Dr. G. W. Pickard appeared before the Commission on behalf of the regional stations. He spoke of the possible interference in foreign countries caused by 500 kw. stations in this country. According to him South America and Europe would not be pleased with the manner in which our field patterns came into their countries, if the higher power stations were permitted on the air.

He presented charts to show that not much increased audience would be obtained by going to the 500 kw. compared to the present limit of 50 kw. He stated that 98.35 percent of the homes in the country now receive service from the two networks, and that the proposed increase in power would not increase this number of homes very much. An important point, however, is that each of these homes would get a better signal if the transmitter had higher power, and a somewhat better signal is often the difference between a program and a bunch of static.

Dr. Pickard had a new angle on the shared-channel interference now so prevalent. He suggested that regionals on these channels operate with slightly staggered frequencies, say of 17 cycles. At present, of course, these stations are maintained very closely to the same assigned frequency. The difference in frequency is inaudible, but this inaudible beat-note reacts with noise in the receiver to produce an audible flutter. (See *Electronics*, September 1935.) Now if the transmitters were, say, 17 cycles apart, and not on the same frequency, this flutter effect would not appear, according to Dr. Pickard.

Several sets of figures were put into the record to show the cost of 500 kw. compared to 50 kw. There was some disagreement among these figures because those who prepared and exhibited them had different points to prove. Louis D. Caldwell, counsel for the Clear Channel Group, said that a station already using 50 kw. would be in for an outlay of $310,000 to boost this power to 500 kw. The monthly cost of operation would mount from $3500 to $12,000; depreciation per month would climb from $2000 to $4630 making total monthly costs $5500 and $16,630 respectively. These costs are made up of the power bill ($1600 and $6500), the tube replacement bill ($900 vs. $4000), personnel and other costs ($1000 vs. $1440.)

Such additional costs and expenses naturally run up the dollar income value that is necessary to maintain the station. If this income is not forthcoming, program and other costs would have to be reduced, producing a net decrease in the value of the station to the listener.

What of Shared-time Stations?

Here indeed is a knotty problem for the Commission. Full-time stations make money; shared-time stations almost invariably lose it. The problem is to make enough during time of operation to pay the upkeep of the plant during the shut-down hours. Without adequate power and time, a broadcaster has a tough row to hoe. From the public interest this is probably not good, because programs must inevitably suffer. Statistics brought out by former Commissioner LaFount indicate that 97 percent of the full time power (165 stations) is controlled by the three networks. The remaining power is shared among 209 independent full time stations. Their total power is about equal to that of a single 50 kw. station. The shared-time stations have a tremendous handicap in seeking business compared to the big fellows with more to offer.

RMA Presentation

Three resolutions were presented to the FCC by Bond Geddes at the instruction of the Board of Directors of the Radio Manufacturers Association. One stated that the RMA felt it desirable to maintain the clear channels as they now are; that restrictions on power increase on these channels be removed; and that minimum power requirements be established for these channels. A second recommendation concerned the short-wave stations now in operation. RMA feels that short-wave broadcasting in this country is "far behind" that offered by foreign stations. It recommends that restrictions as to the sale of time of these stations be removed and that they be treated as any other standard-wave broadcast station. Finally, RMA recommends that restrictions on the pick-up and rebroadcast of short-wave programs be eliminated, thus providing an additional source of programs for the many low-powered stations on the standard broadcast band.

Engineering Division of RMA made a most interesting and illuminating presentation which dealt with present-day broadcast receivers. This presentation made by L. C. F. Horle is summarized below, and curves giving essential selectivity and tone fidelity data are taken from Mr. Horle's paper.

The fidelity data represented about 85 different receiver models. Unlike the other curves, price considerations did not enter into these curves, since the correlation between price and tone fidelity was not sufficiently well marked to justify any such differentiation.

"It is important to note," stated Mr. Horle, "that the fidelity curves represent the best compromise which the designers and manufacturers of radio receivers have been able to make between truly faithful reproduction, desired by all, and the limitations imposed by the frequency assignment separation of 10 kc. and by radio noise. Experience has shown that any expansion of the acceptance band width of broadcast radio receivers would make performance distinctly less suitable under the conditions of operation now in effect within the pattern of our broadcast frequency assignments and that, unless and until the general noise level is markedly lowered or the general power level of broadcasting is markedly raised or some not now commonly used alternate system of broadcasting of such a nature as to provide more satisfactorily against noise interference, comes into general use, no markedly closer approach to truly high fidelity than that shown in the curves is practicable."

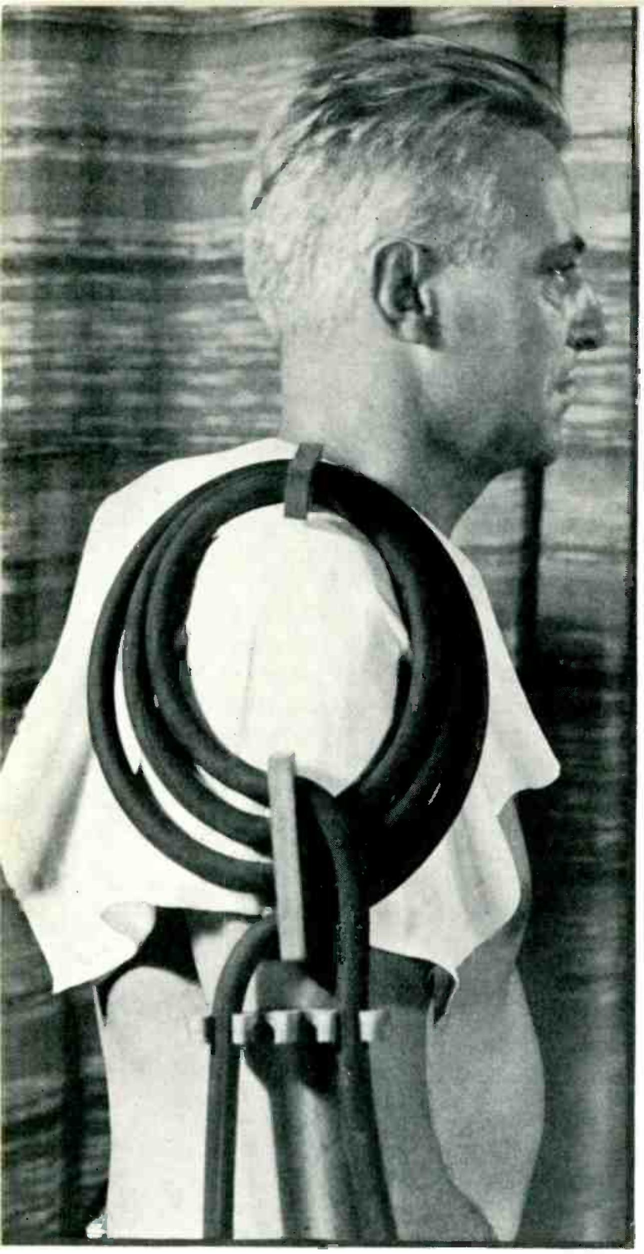
Thus the engineers of the manufacturing section of the industry give evidence that they are on the side of power, actual or effective.

The selectivity curves differ markedly from those ordinarily shown. They were made by a two-generator method, outlined in the I.R.E. standards handbook some years back but not generally used until very recently. The method shows more accurately what happens under present broadcast conditions and with present receivers. Ordinarily a single generator is used. The receiver is tuned to the desired signal frequency. Then the signal generator is adjusted to other frequencies, and the signal from it varied until the receiver gives standard output — 50 milliwatts. As the generator is tuned farther and farther away from the frequency to which the receiver is tuned, more and more input signal is required.

Now 50 milliwatts output is not high enough to accurately portray the virtues of the receiver in the home because the average listener operates the gain control so that considerably more than 50 mw. is produced. Furthermore, present day high gain receivers produce this standard output with very little input voltage.

In the two-generator method, the receiver is tuned to the desired frequency and one of several standard input voltages is turned into the receiver, say 50 microvolts. The gain is adjusted until the 400 cycle output measures the desired value, say 500 milliwatts. Now leaving this desired carrier on, but without modulation, the second generator delivers an interfering signal. It is tuned to various frequencies and its output adjusted until the 400 cycle signal (interference) output of the receiver is 30 db. below the 500 millivolt signal previously secured.

These tests give a more accurate idea of selectivity, overload, and crosstalk characteristics. Similar data were presented before the Commission by Arthur Van Dyck of the RCA License Laboratory for the National Broadcasting Company.



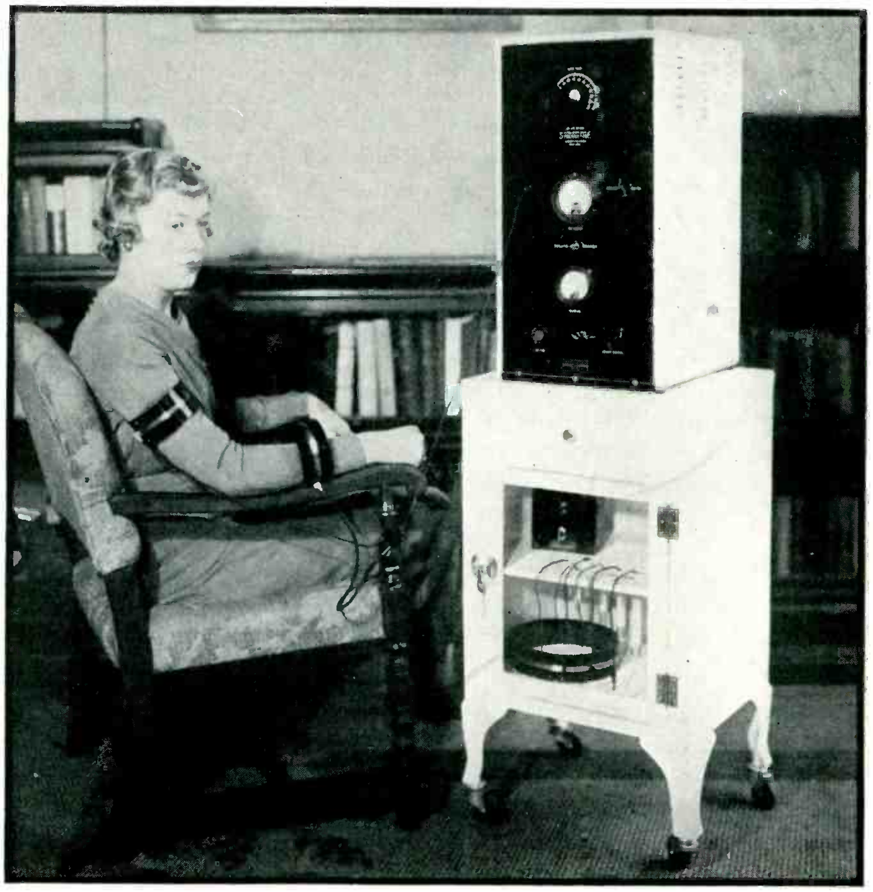
Electron Tubes

Physical therapy provides a rapidly growing outlet for electron tubes and accessory apparatus. Beneficial and harmful effects, technique of application, some engineering details of commercial equipment

DIATHERMY, or the therapeutic use of high frequency current to generate heat within some part of the body, has become of considerable importance in the United States within the past five years. Its development is especially of interest to readers of *Electronics* for two reasons. First, by far the larger portion of diathermy equipment uses vacuum tube oscillators, thereby providing a growing market for tubes and associated equipment. Second, the extensive use of high frequency oscillators of considerable power by physicians, together with the sale of broadcast receivers of high sensitivity and having a frequency range up to 70 megacycles, introduces the possibility of another source of interference to reception.

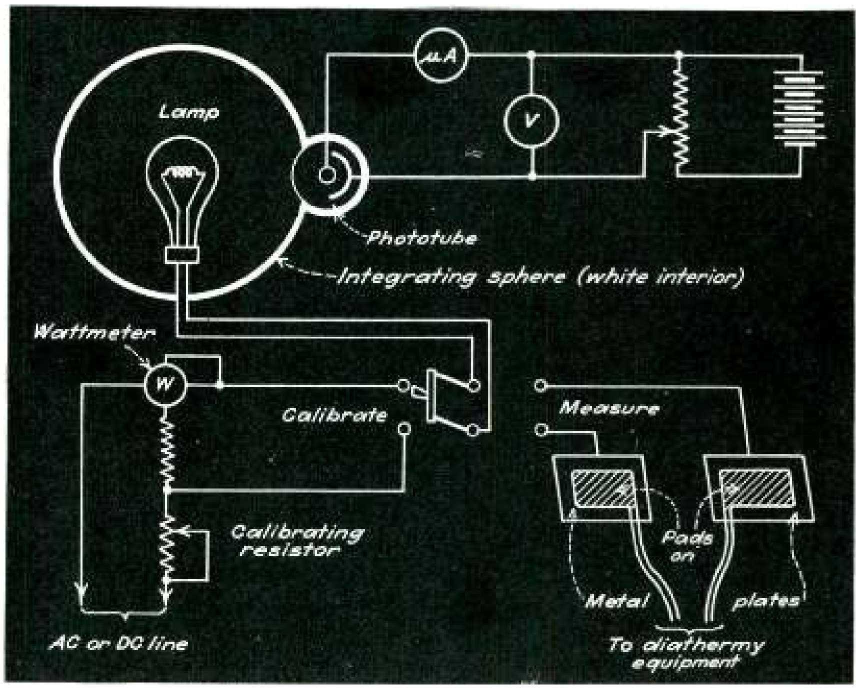
No reliable and accurate data on the present size of the market for diathermy equipment using tube oscillators are available, but it is estimated that more than one thousand units are sold in the United States per year. The price of these units varies from about $100 to $1,100 with accessories with the statistical average at about $400. The units use from one to four tubes, from receiving types to power tubes having a plate dissipation well over a half

Treatment of shoulder by means of coil electrodes. The turns of the coil are held in position with insulated spacing blocks



Cuff electrodes applied for the treatment of the elbow. The high frequency generator at the right is a relatively low power unit

in Diathermy



Photometer method of measuring output of diathermy machines. The lamp, whose rating should exceed the maximum output of the machine, is calibrated with the switch thrown to the left and the proper voltage applied to the phototube. The power delivered by the machine is determined from the calibration by throwing the switch to the right and observing the phototube current

kilowatt, but the typical diathermy outfit uses two tubes and has a power output of about 250 watts.

This branch of physical therapy is a new field of medicine which has not been very thoroughly investigated. As a result, there is a wide variety of conflicting claims and opinions as to the beneficial results, dosage, technique of proper use, and even under what conditions diathermy may be employed satisfactorily. It is well, therefore, to recognize the schools of thought which exist at the present time, before discussing the principles involved.

Three fairly well defined schools of thought may be recognized. The "rightists" or ultra-conservatives are unwilling to accept any claims until they have been experimentally verified and double checked and feel that "it is especially necessary to approach the entire subject with a healthy skepticism to make an impartial critical evaluation of the value of short wave diathermy."[5] This group feels that hyperpyrexia, or the production of abnormally high fever, is the only effect of short wave diathermy which has been definitely and conclusively proven.

The "middle of the roaders" recognize the heating effects of high frequency currents in the body but also recognize that some other effects (which cannot be explained solely on the basis of heat generation) have been attained under certain conditions. But, as a group, they point out that much of this latter work has been done on bacteria in jellatinous suspension or on dead tissue and believe that experiments on beefsteak or amputated limbs (being devoid of circulation and nerve supply) are not even approximately representative of actual physiological conditions in the human body. They are, by and large, aware of other effects of diathermy than hyperpyrexia, but are unwilling to place too much faith in ill performed or isolated experiments.

Finally, there are the "leftists" who aim to prove definite and beneficial effects of growth stimulation or lethal action on bacteria, selective heating effects of various parts of the body, action on blood circulation, and other effects. The more radical of this group assure beneficial results from diathermy applied to the abdomen or the zygomatic arch—and the intervening alphabetical gamut as well—and are characterized more by hyperenthusiasm than by a sober, critical, scientific attitude.

Value of High-frequency Heating

That hyperpyrexia is an important result of the application of short wave physical therapy is generally agreed; indeed it appears to be about the only point upon which there is general agreement. The production of fevers in the body can, however, be effected by a number of agents, and the principal advantages of high frequency currents appear to be that the heat is produced within the body rather than affecting primarily the surface and that no extraneous agents are introduced which might be harmful and make diagnosis difficult.

An important point of heating by high frequency current is the possibility of burns. Ordinarily the tolerance of the patient toward heat precludes the possibility of burns, but in cases where the patient's sensation of heat is underdeveloped it is necessary for the physician rather than the patient to determine the limiting conditions of dosage.

In taking a rational view of the subject, it appears that there are certain factors which are beyond dispute and which must be considered in arriving at a true evaluation of high frequency therapy. The possibility of a system of therapy which has advantages over other methods of producing hyperpyrexia, and which may prove to be an important medical aid must be admitted. That bacteriological, bactericidal, selective thermal effects and other consequences may occur along with hyperpyrexia can be considered as a possibility but hardly as a probability in the present state of knowledge. On the debit side of the ledger must be recognized the possibilities of burns to the patient and of radio interference. Finally, the present lack of knowledge of this subject must be admitted, and a more whole-hearted co-operation between medical men and physicists and engineers than has existed in the past is to be hoped for.

Electrostatic-Electromagnetic Methods

The production of temperature rises in the human body by artificial methods using high frequency oscillators resolves itself into the matter of producing electrical losses in the body. This may be accomplished by producing the losses through the medium of an electrostatic field or an electromagnetic field, and these two methods give rise to different techniques.

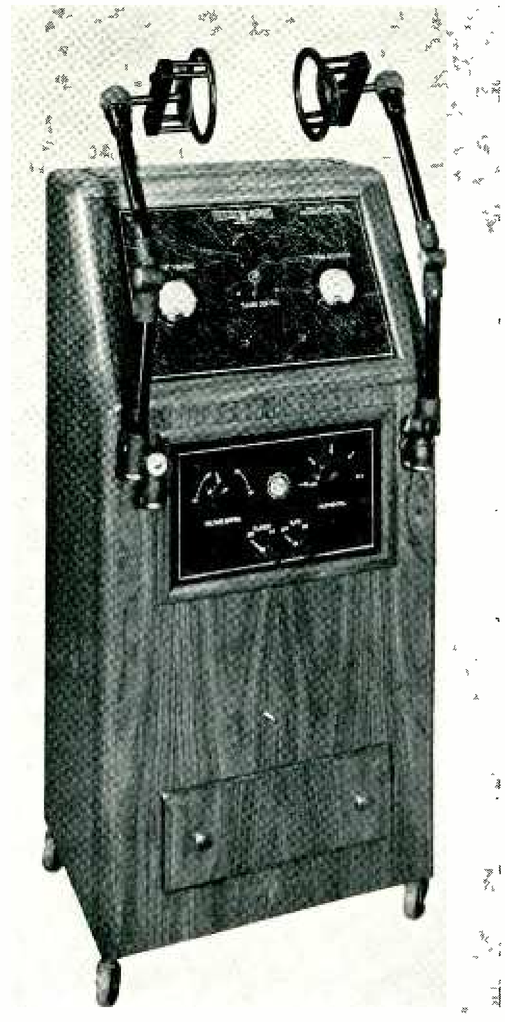
When the electrostatic field method is used, the main losses are the dielectric hysteresis loss, leakage through the dielectric, and I^2R losses in the conducting plates of the condenser. In diathermy, heat is produced almost entirely by the dielectric hysteresis losses in the body. Theoretical and experimental studies[2,5] have been made of the condenser method of producing hyperpyrexia.

The technique involved is to place that part of the body which requires treatment between two insulated condenser plates which are connected to the output circuit of the short wave oscillator. It is usual practice for the plates to be separated from the body either by air spaces or by means of cloth pads. Where the part of the body to be treated presents two fairly flat surfaces which are approximately parallel to the condenser plates, the heating throughout the tissue is relatively uniform since the current density over the area treated is approximately uniform. If the condenser plates are applied in such a way that the current density is not uniform, as might be done by applying them between a relatively flat portion of the body and another portion which has a relatively small radius of curvature, the larger amount of heat sensation will be produced where the current density is the greater.

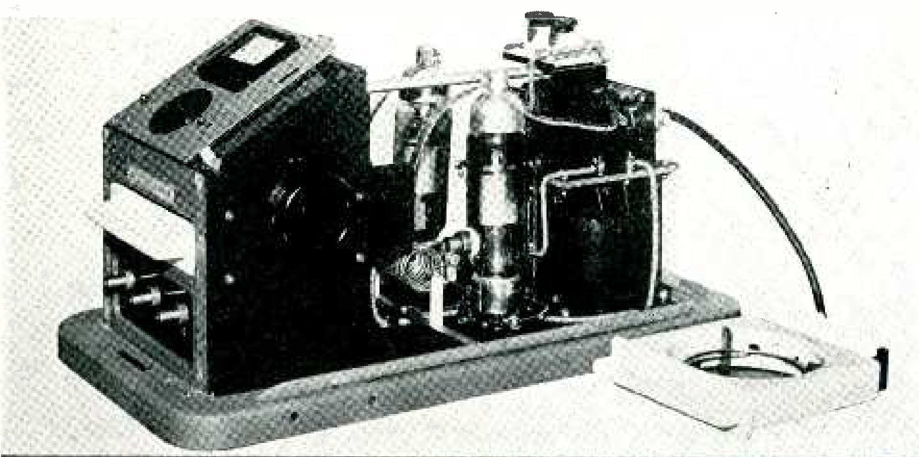
In the electromagnetic field method of producing losses, the portion of the body to be treated is placed in the magnetic field of a coil connected to the output terminals of the short wave oscillator. The losses in the body in this case are the electromagnetic hysteresis current and eddy current losses. In this case, tissue heating depends upon the current through the coil, the number of turns in the coil, and the manner in which the coil is applied to the body. Because of the wide variety of applications to the body, it is common practice for the manufacturers to supply a cable which the physician can form into a coil of the desired size and shape, rather than to provide rigid, pre-formed coils.

In designing equipment for electro-physical therapy, there are several important considerations. First, the oscillator should generate sufficient power to produce the desired heating effects. Because of the present wide differences of opinion it is impossible to state definitely how much power is required. In general a power output of about 300 watts, as measured by the lamp and phototube circuit shown appears to be adequate for all general purposes. Second, the equipment should be simple in operation and give long service without appreciable attention. Diathermy equipment is used by physicians whose technical knowledge of electricity is not very great so that unnecessary controls are likely to be of more annoyance and confusion than good. Third, the equipment should be so built that burns, shock, or effects not intentionally sought by the physician for some specific reason cannot occur. Unfortunately not all of the equipment in the past has fulfilled this obvious condition.[6]

Fourth, the equipment should be so built, preferably, that any desired set of conditions can be reproduced. This requires that the frequency of the oscillators be constant for any given setting of the tuning controls, variations of line voltage must be compensated for, the length of time of dosage should be automatically determined by means of a time switch, and an output meter should be provided to enable the physician to determine relative power in the "patient circuit," even though it may not be feasible to calibrate this meter directly in watts. The equipment should be so built that in any application power is built up from zero to the value desired, and not suddenly applied at a value which might be beyond the tolerance of the patient. Fifth, all reasonable precautions should be taken to reduce radio interference to a minimum. While it is true that diathermy equipment will probably be used mostly during the day when radio reception is at its minimum, and that the radiating circuit is inefficient, it is also true that receivers with high sensitivity and wide frequency range are commercially available and are subject to many kinds of interference already. It is to the benefit of manufacturers of diathermy equipment and physicians to insert chokes in and condensers across the line to prevent radio frequency energy from being fed back



A six meter, 450 watt diathermy machine. Sloping panel contains tuning control, filament and resonance indicating meters. Power controls on lower panel. Unit shown with condenser electrodes



Above: The interchangeable coils permit operation between 5 and 18 meters. The knob on the side of the unit controls output which is measured by the meter. The control just below the meter is a time switch which automatically determines length of treatment. Below: Interior view of half-kilowatt diathermy machine. The power supply is at the right. A portion of the oscillating circuit can be seen to the left of the tubes

into the power line, and to take whatever other precautions may be necessary.

All of the high frequency diathermy equipment with which this article is concerned consists essentially of a short wave oscillator with its associated controls, and with provision to deliver power from the generator to the patient by means of pad or cuff electrodes in the condenser method, or coils in the inductance method of technique. The operating frequency is usually between 10 and 100 megacycles, and the frequency may be fixed, adjustable in fairly wide steps, or, in a few cases, continuous over a certain range. Since the frequency range for optimum physiological results has not been indicated conclusively and the theoretical and experimental work which is available indicates a very broad "peak" (if any), it appears that one frequency is, roughly, as good as any other.

The frequency stability of the oscillators does not seem to be very good, although it is probably satisfactory for the purpose. Some of the equipment is operated with a single tube, some uses two tubes in push-pull but with these tubes in parallel as far as the 60 cycle line is concerned, and sometimes tubes are used in parallel at radio frequencies. A few units supply direct current to the plates of the tubes, but the majority of oscillators are supplied with "raw a.c."

With a load in the neighborhood of half a kilowatt being taken from the line by the tubes on the positive half of the cycle, wave form distortion has been observed which produced an indirect form of radio interference. It would appear that there would be some advantage in operating the plates of the oscillator tubes on both halves of the cycle. This would require a plate voltage transformer of twice the voltage and half the current with a center tap, but the effects of wave form distortion could thereby be minimized.

Some of the equipment commercially available possesses interesting design features which are worthy of mention, if for no other reason than to indicate good practice and what can (and is) being done in this field.

The Adlanco Ultratherm (Siemens and Halske), for instance, is one of the units using a line filter to prevent radio frequency energy from being fed back into the power line. A single tube having a plate dissipation of 600 watts and delivering 350 watts to the "patient circuit" is used. This tube is a tungsten filament triode with a normal filament voltage of 23. A transformer applies 4,500 volts to the plate, a voltage sufficient to produce saturation at the normal filament temperature. The circuit is so arranged that the filament can never be operated above 23 volts, and a filament rheostat is used to control power output. By reducing the filament voltage the power output is varied in very fine steps and the life of the tube is considerably lengthened.

Another piece of equipment which is just being made available (Cardwell) is making a definite aim toward simplicity of operation while at the same time aiming to put the operation of high frequency therapy equipment on such a basis that the physician can reproduce any desired conditions. This unit uses two tubes in push-pull at radio frequencies, but in parallel at 60 cycles. Only three controls are provided and these determine the frequency of the oscillating system, the power output, and the length of treatment. The frequency is determined by changing coils. The power output is controlled by coupling the "patient circuit" to the main tank circuit so that fine adjustments of power output

[*Continued on page 58*]

Improvements in AFC Circuits

Simplified automatic frequency control circuits which provide improved selectivity and satisfactory performance over the frequency band from 540 to 18,000 kilocycles

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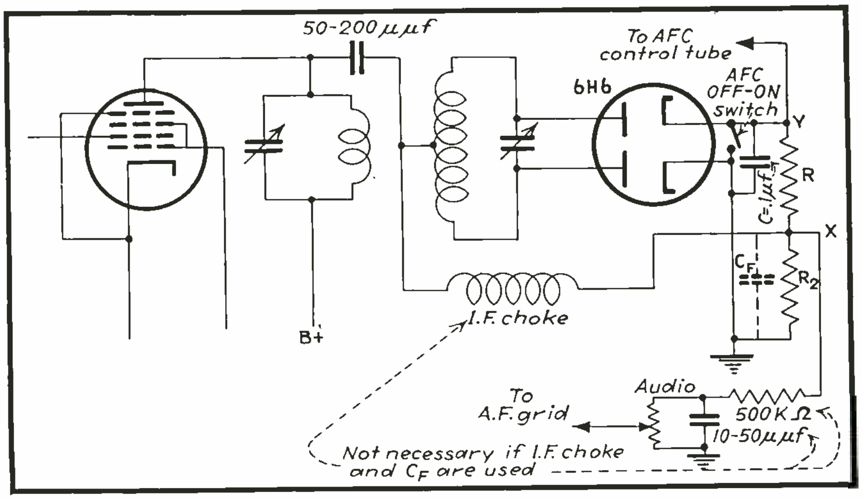

Fig. 1 *AFC discriminator circuit which depends on phase difference between primary and secondary i-f transformer voltages*

SINCE the first disclosure of a really successful system of automatic frequency control,[1] there have been improvements particularly in the discriminator circuit, and also additional types of control circuits have been perfected. Several manufacturers have incorporated AFC in the larger models of their recently introduced lines of receivers. In so doing there developed certain difficulties, measuring technique, and improvements. The difficulties of overall feedback, decreased band tuning ratios, intermittent oscillation, and temperature drift, as well as certain developments in discriminator circuits to yield better selectivity and gain will be discussed.

In Fig. 1 is shown the basic discriminator circuit that has displaced the type using separate side tuned circuits. This circuit was described by Seeley and Foster of RCA License Laboratory at the recent I.R.E. convention in Cleveland. It makes use of the difference in phase between the voltages in the primary and secondary of an i-f transformer. If the two circuits of an i-f transformer are both tuned to the same resonant frequency it will be found that the vector sum of their voltages becomes maximum at a frequency slightly higher or lower (depending on the sign of the mutual inductance) than their resonant frequency. By using the center tapped connection to the secondary either positive or negative mutual inductance relation is obtained and consequently the secondary terminals have i-f potentials with respect to ground that are maximum above and below resonance. The differentially connected diode circuit yields a positive or negative voltage depending on whether the signal is lower or higher than the intermediate frequency. A typical *S*-curve for the circuit of Fig. 1 is shown in Fig. 2.

When the simple circuit of Fig. 1 is used in a receiver having a single i-f stage, it is found that the selectivity and gain as an i-f transformer are poor. In Fig. 4 is given a circuit that gives much better selectivity although the gain is not all that may be desired. In the simple double-tuned circuit where the demodulated signal is developed at the point *X*, it will be noticed that only the primary circuit is contributing to the selectivity when the point *Y* is grounded (which occurs in the usual method of turning off AFC action) and that the secondary contributes little to the selectivity when the AFC is turned on as the selectivity curve would then peak at a point higher than intermediate frequency. The circuit of Fig. 4 gives a desirable stage selectivity because not only the tuned circuit that feeds the audio diode contributes to the selectivity but also the center tapped circuit. Thus three tuned circuits are effective in producing stage selectivity. However gains of higher than 35 are difficult to obtain inasmuch as closer coupling of tertiary to center tapped secondary is limited by the fact that the former acts as an absorption circuit on the latter and so alters the voltage phase relations that an *S*-curve of the type shown in Fig. 3 results.

In Fig. 5 is shown a circuit developed by the writer which does not have the disadvantage of close coupling limitation but on the other hand whose selectivity is intermediate between that of the circuits of Fig. 1 and Fig. 4 This circuit utilizes the rejection of two tuned circuits—the plate and the center, *A* and *B*, respectively. It has the further advantage that no choke is necessary to filter the i. f. in the lead to the audio amplifier as is needed in the circuit of Fig. 1.

The choke shown in Fig. 1 may be omitted provided the point *X* is not bypassed; otherwise the primary circuit will be shorted. A filter consisting of a series resistor and bypass condenser becomes necessary to remove the i. f. from the input to the audio amplifier. This method is objectionable because the parallel combination of R_2 and the filter series impedance to ground act as an additional load on the primary tuned circuit. In the circuit of Fig. 5 it will be noticed that the d-c return lead at X is brought back to the grounded side of the center winding instead of the top. This likewise removes the loading effect that resistor R_2 might have upon the center winding if the alternative were used.

The frequency separation of the S-curve peaks determines to some extent the number of kilocycles of mistuning of a signal for which the AFC will lock in. Once this locking has occurred the control tube effectiveness determines how much the local oscillator may be mistuned and still hold the signal. Peak separation on the S-curve should not be much greater than the receiver overall band width at twice resonant voltage input as otherwise peak discriminator gain is lost. One of the first AFC receivers used a separate broad channel for AFC with peak separations of 14 kc. This allowed lock-in to occur 10 to 15 kc. from the signal frequency — several kilocycles beyond the point where modulation could be heard. There are two advantages of such a large pulling-in action: Very effective dealer demonstrations of AFC can be made to the customer, and wider control allows considerable safety factor for dial or remote tuning devices. The disadvantages lie in the fact that weaker signals 10 or 20 kc. from strong locals cannot be tuned in with the AFC acting. A compromise of peak separation of six to eight kc. provides a locking-in action of about eight kc. from the signal frequency.

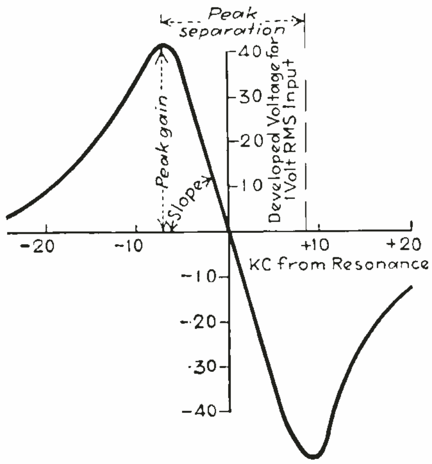

Fig. 2 *Resonance curve for Fig. 1; loose coupling between primary and secondary*

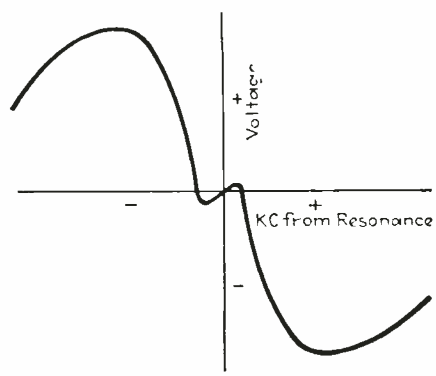

Fig. 3 *Resonance curve for Fig. 4 with close coupling*

In the design of the discriminator transformer there are two factors that regulate the peak separation: the effective Q of the two tuned circuits whose peculiar voltage phase difference is utilized, and the percent coupling between these circuits. A lower Q or a greater coupling increases the peak separation. The effective Q is determined by the actual coil Q and the loading presented primarily by the diodes but to a lesser degree by the i-f amplifier tube plate resistance.

Varying the diode load resistors and the percent coupling likewise affect the gain and selectivity of the stage as an i-f amplifier. In 262.5 kc. design it is found that peak separations of more than six kc. sacrifice selectivity when tuned circuit L/C ratios are high. In 450 kc. design the peak separation is a smaller percentage of the i-f and the compromises are not so limiting.

The condenser C shown in Figs. 1 and 5 improves the diode ac-dc ratio and bypasses hum introduced into

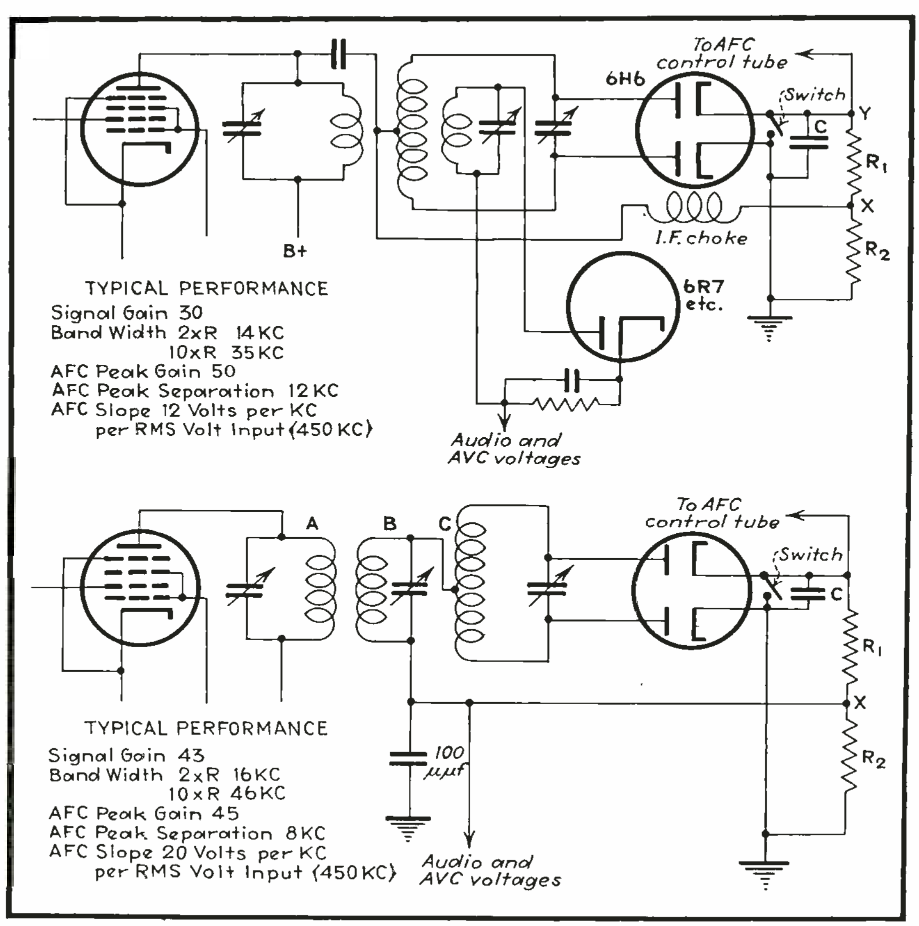

Fig. 4 & 5 *Discriminator circuits with improved selectivity. The circuit of Fig. 5 (below) permits smooth operation over wide frequency band*

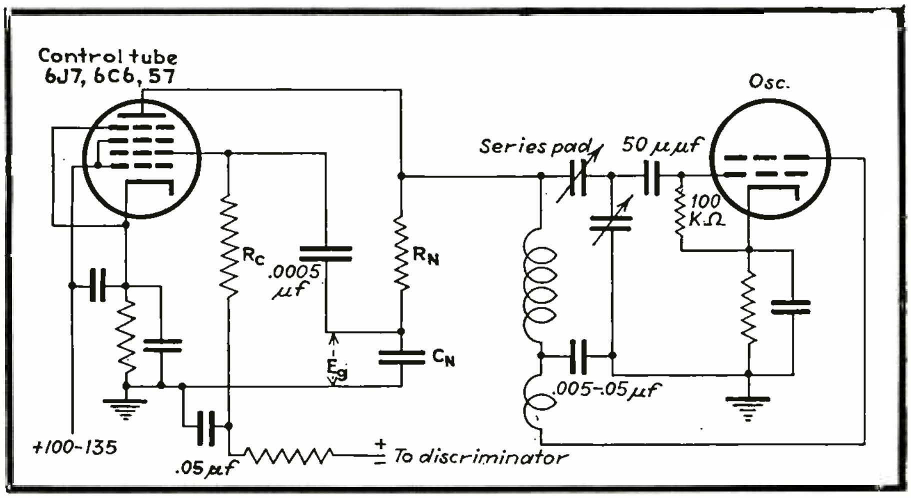

Fig. 6 *Simple control circuit using pentagrid converter*

the oscillator circuit through the AFC system because of induction and leakage between the ungrounded diode cathode and the heater. When a-f voltage is taken from point X and C is not present, only one diode contributes energy to the a-f amplifier. The d-c resistance is then the resistance of R_2 and the a-c resistance is that of R_2 in parallel with the volume control resistance. When C is present the two diodes act in parallel and the d-c resistance is that of the parallel combination of R_1 and R_2. Consequently a considerable improvement in ac-dc detector ratios is obtained.

Factors Affecting Trimmer Condenser Choice

Stability of alignment depends solely upon the mechanical ruggedness of the center-tapped tuned circuit and the variation of its characteristics as a function of temperature and humidity rather than on the other discriminator tuned circuits or the control tube. The trimmer capacity is the weakest link. If compression type variable trimmers are used utmost care must be taken in their choice. It is preferable to use a multiple plate trimmer having thick mica between plates to give a relatively flat curve of capacity vs. trimmer screw turns, and to choose the operating point at least one and one-half screw turns open from the position of maximum capacity. Another alternative is to use a large fixed capacitor and a 10 or 15 μμf trimmer in shunt. However there are very few fixed mica capacitors that have negligible capacity variation with temperature changes. Even so-called "normalized" units that have been subjected to one or more temperature cycles show little advantage over untreated ones.

A ruggedly built air trimmer is probably the best solution to the problem of frequency drift. Although its use will probably double the cost of the discriminator transformer, cost can be kept to a minimum by providing only the center-tapped circuit with an air trimmer.

The Control Circuit

There are numerous types of control circuits most of which have certain disadvantages that are not common to the popular type shown in Fig. 6. This circuit is possibly the only simple one that may be utilized with a pentagrid converter on all frequency bands. The phase shift network comprising R_n and C_n develops a voltage E_g across C_n which lags the oscillator tank circuit voltage by almost 90°. The control tube amplifies this voltage and causes a current to flow in its plate circuit which lags the tank circuit voltage. Hence the control tube acts like an inductance shunting the oscillator tank circuit and having a value, $L_o = \dfrac{R_n C_n}{G_m}$. By varying the mutual conductance, G_m, of the control tube, L_o may be varied.

In designing coils for the oscillator circuit of a receiver the inductance is determined first for an oscillator circuit having no AFC connection. In determining this value of inductance about 20 μμf must be added to the circuit minimum to take into account the output capacity of the control tube, additional wire and switch capacity, and capacity reflected by the larger tickler that will be needed. A value for G_m is then assigned which, in the case of a 6J7 tube, will be that value for a bias of 5 volts with 100 volts on the screen or 6.5 volts with 135 volts on the screen. These bias values are approximately the ones that will give the same percentage change of G_m between cut-off at one extreme and grid current on the other extreme. A choice of 40,000 ohms to 100,000 ohms for R_n and 10 to 20 μμf for C_n will allow calculation of L_o. The oscillator coil inductance value found previously must equal the inductance L_o in parallel with the unknown physical inductance. Calculation using this relation gives a fairly close value for the physical inductance of the oscillator coil, which serves as a good starting point. From this point small changes in r-f and oscillator coil inductances can be made experimentally so that three point crossovers between r-f and oscillator circuits are obtained.

Reasons for the Necessity of a Larger Tickler Coil

A large tickler coil is needed in an AFC oscillator system because of the additional loading on the oscillator by the phase shift circuit and by a resistive component reflected by the control tube plate. This resistive component is equivalent to a resistance, $1/G_m$, added in series with the reflected inductance L_o; or in other words, the reflected inductance has a Q of $\omega C_n R_n$. With average circuit constants this Q is of the order 2 to 8—a rather poor fictitious inductance! Furthermore this Q decreases with frequency and gives additional trouble in oscillator circuits which tend to perform weakly at the low frequency end of the band because of low L/C ratios. On high frequency bands where the physical oscillator inductance is about one microhenry a comparable value for L_o is needed to obtain the same percentage of control that is readily obtained in the broadcast band. Hence an extremely low value of R_n is needed, since C_n cannot be reduced below the input capacity of the control tube. A resistance for R_n of a few hundred ohms would be necessary, but practically a power oscillator would be needed to maintain oscillations.

The amount of control must of course be greatly sacrificed — so much, in fact, that with the use of a pentagrid converter and with tuning ratios of around 3 to 1 it becomes very questionable whether the small amount of control obtained on the high frequency band is worth the trouble. Separate oscillator tubes have four times the transconductance of the oscillator section of a pentagrid converter, and smaller tuning ratios of about 2 to 1 greatly facilitate the maintaining of oscillation across the whole band. It is possible to use the 6A8 tube, however, and cover the band from 540 to 18,000 kc. with a very small overlap if utmost care is taken in reducing circuit capacity and in designing the tickler. The control on the high frequency band will be from 5 to 15 kc, either side of resonance and hence is only of value in reducing apparent fading of high frequency signals caused by oscillator drift due to line voltage variations, but is of no help in tuning. The tickler cannot be made with too many turns as it will couple excess capacity into the tank circuit and may even resonate within the band, thus making r-f oscillator tracking impossible in the vicinity of this resonance.

Tickler Design

The writer has found that winding the tickler over a few layers of glassine or Holland tape placed over the ground end of the tank coil is preferable to winding the tickler bifilar with the tank coil. The choice of various tickler wire sizes (between 30 and 38 gauge wire) helps in the attempt to obtain oscillation over the whole band. It is strongly recommended that an oscillator tube having the lower limit of G_m that may be expected in the field be used during the tickler design and that it should be ascertained if the circuit oscillates readily at line voltages of about 90 volts. Oftentimes a circuit that oscillates satisfactorily at the low end of the band will break into violent intermittent oscillation at the high end because of good L/C ratio. This is usually attributable to a large time constant for the grid condenser-grid leak. A reduction of the grid condenser to as low as 25 $\mu\mu$f will usually prevent this and still be ample for the broadcast band. Condenser gangs of greater than 500 $\mu\mu$f variation will be found of little help in obtaining large tuning ratios, for it becomes increasingly difficult to obtain oscillation at maximum capacity unless complex feed-back with its switching difficulties is resorted to.

Overall Receiver Difficulties

It has been observed that while tuning a receiver with the AFC operating into the low frequency side of a strong local broadcast signal motor-boating occurs. This is caused by a large positive voltage being developed by the discriminator which in turn causes the control tube to operate with little if any

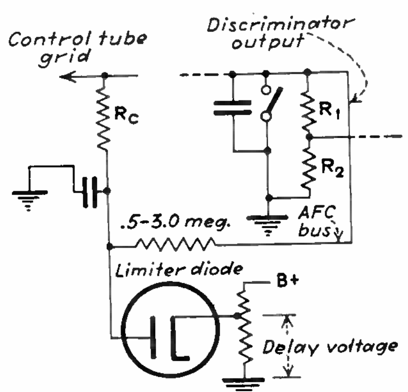

Fig. 7 *Delay diode to limit positive voltage to discriminator*

bias. This causes the reflection of a strong resistive component into the tank circuit thus reducing the oscillator voltage momentarily until the conversion is so low that little signal gets through to the discriminator. The decrease in discriminator voltage then allows the oscillator to return to normal operation and the cycle repeats itself.

Three methods may be used to cure this. A large resistor R_c may be used so that grid current will prevent the grid from going positive. In case motor-boating occurs with even small negative bias either or both of the other two methods may be used. The control tube may be totally or partially self biased (though self bias reduces the control action by about 60 per cent over fixed bias). The last expedient is to limit the value of positive discriminator voltage by the use of a voltage delayed diode across the discriminator bus as is shown in Fig. 7. This diode may be that of a 6R7 audio amplifier which is already self biased a few volts and thus gives ample voltage delay.

Voltage Fluctuations Cause Motor-boating

Overall feedback often occurs through the power supply system when the volume control is near maximum setting, the AFC is not switched on, and a local signal is tuned in. This is due to the power supply voltage fluctuating because of the output tube demand and thus affecting the gain of the control tube. This variation in gain causes the oscillator to shift frequency momentarily and thus sets up motor-boating whose frequency is determined by the time constant of the power supply. By providing an ample filter between the output tube power source and the oscillator and control tube source this may be remedied. With push-pull output systems the speaker field may be used as a series impedance in the power supply filter and the output tubes may be fed from the high voltage side of this field while the oscillator system is fed from the low voltage side. The use of one of the popular 20 to 35 μf electrolytic condensers as the input filter condenser will give sufficiently low hum level for push-pull systems. Another method of preventing motor-boating due to overloading of the output system is the utilization of balancing methods. The control tube cathode may be biased in common with one of the audio tubes or biased by diverting part of the bleeder resistor current through the bias resistor. These schemes attempt to cause d-c cathode, screen, and plate voltages to vary in such a relation that the gain of the control tube is not altered when the supply voltage fluctuates.

REFERENCE:

[1] "Automatic Frequency Control," Charles Travis, *Proc. I. R. E.*, October, 1935, Vol. 23, No. IV, p. 1125.

Sound Wave Stroboscope

A new method of photographing sound waves, which employs electron tubes for controlling the spark discharge that exposes the film. Useful in studying the acoustics of buildings, or the transmission of earth waves

By

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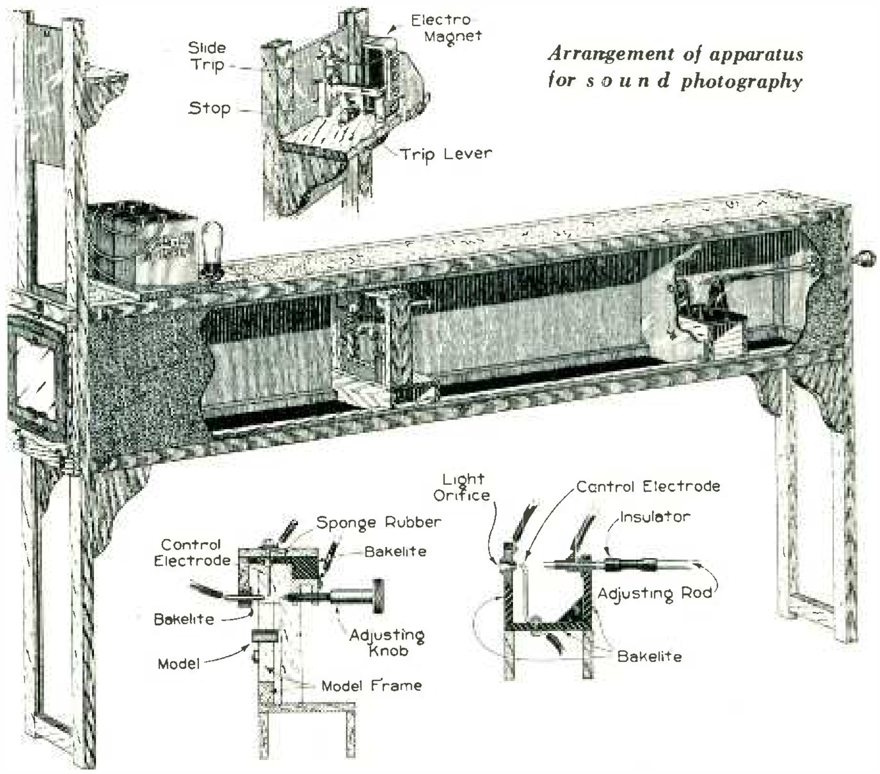
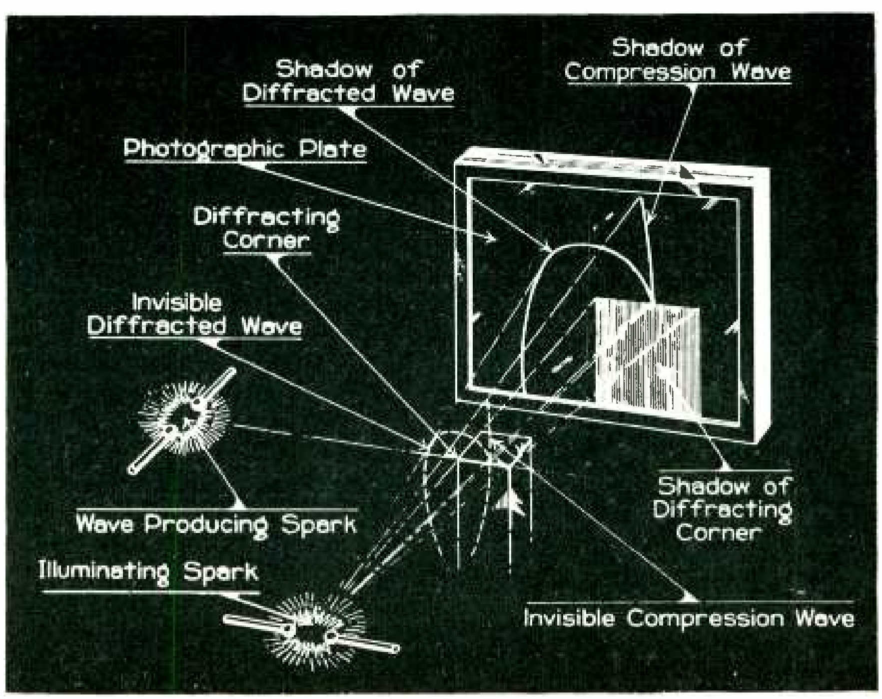
PHOTOGRAPHY of sound waves, or the ability to see them, together with their reflections and diffractions, is always of great interest and frequently of real use. Toepler, Sabine, and Foley have developed the technique for taking such photographs.[1] Delsasso, at the University of California at Los Angeles, both photographed sound waves and rendered them visible by stroboscopic means, on a ground glass screen, so that by operating a control the visible waves could be made to move slowly outward from the source and reflections could be clearly followed.

One important use of such an experiment is the study of acoustics in an auditorium. A small model of a cross section of the auditorium is made and used in the apparatus, with the sound source at the stage. Several photographs are made using the wave produced by a single sound impulse at various times during its travel, and the causes of poor acoustics determined therefrom.



Arrangement of apparatus for sound photography

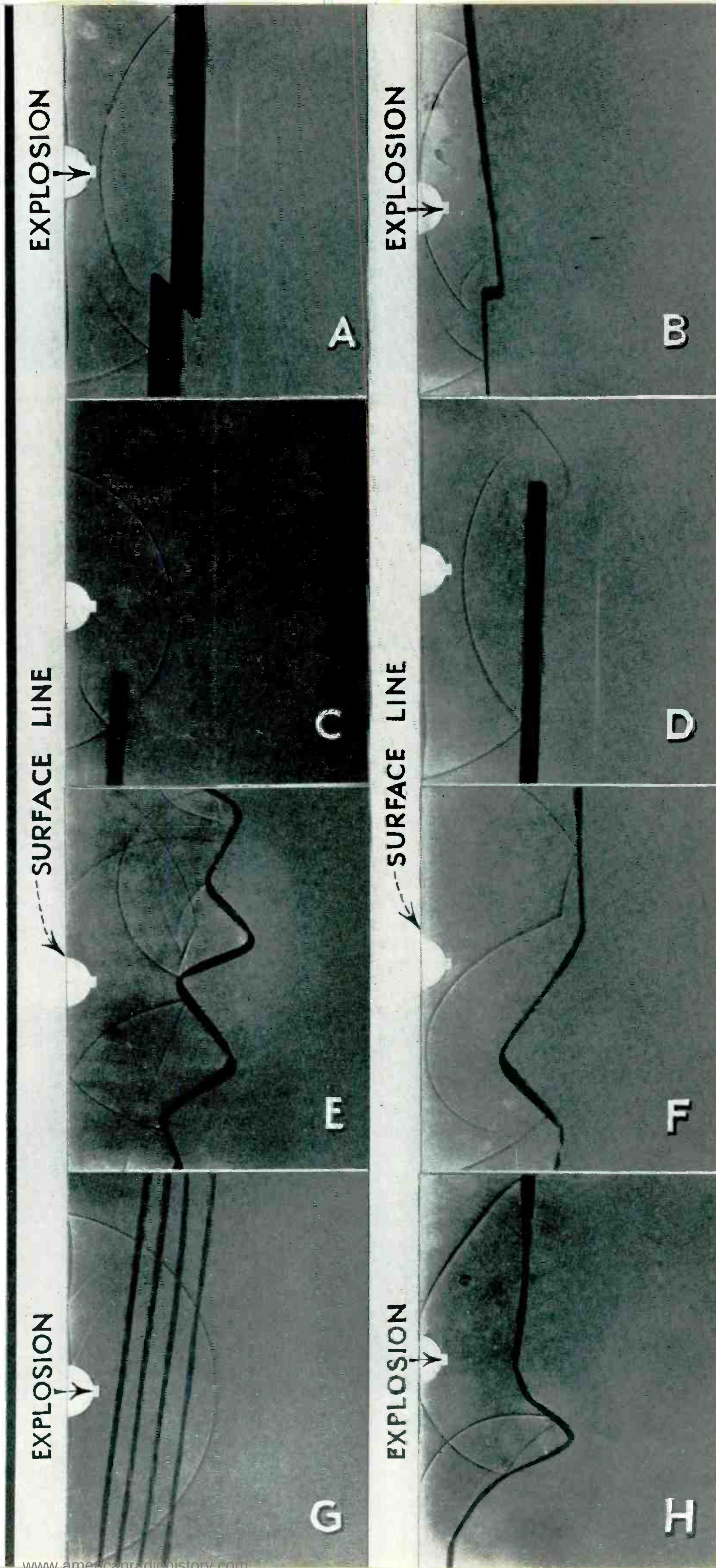


Timing arrangement used in past for sound wave photography

The present work was undertaken in connection with what might aptly be termed underground acoustics, or the study of earth waves, which follow the same laws as sound waves. Geophysical surveys, made in search of oil, are usually directed towards the mapping of underground strata, and the most common method of doing this is to initiate an earth wave by means of a dynamite explosion near the surface and to detect, by means of seismographs, the reflections of this wave returned to the surface by the various strata.

The wave returned to the surface by a single flat stratum is a simple matter of geometric reflection, but all the reflections and diffractions

Sound wave photographs demonstrating geophysics: A, B—Reflected and diffracted waves from earth fault; C, D—Diffraction at end of rock ledge; E, F—Structure representing folding; G — Wire screen (60 mesh) to represent reflections from earth strata; H—Refraction and reflection of sound wave



arriving at the surface from a faulted or folded stratification are not readily separated and identified. A new method of recording and thereafter analyzing the seismograph record by an optical apparatus, which has been in operation for some time, successfully separates all waves and assigns to each its correct angle of arrival and time of travel, even under complicated conditions where several waves arrive simultaneously, or nearly so, their main difference being that of direction. It then remains to ascribe to each wave its cause of return to the surface.

To simplify the explanation of the procedure used in plotting the structure which returns the waves, and to demonstrate the necessity of this new system, it was decided to make use of the stroboscopic sound wave apparatus. Miniature structure models containing faults, synclines, and anticlines could be substituted for the auditoria of the earlier experiments.

A brief description of the apparatus used in the past is in order here. The discharge of a condenser through a spark gap creates an ideal sound impulse for the purpose. Another spark discharge from another condenser is used to illuminate the photographic plate. If a compression wave in the air exists in the path of this light, refraction will cause a shadow on the screen followed immediately by a bright line.

Very short duration of the light is necessary if we are to catch the sound wave "standing still." The discharge of a condenser through a spark-gap provides such a light. In addition, the light must emanate from practically a point source. This may be accomplished by making one of the spark electrodes of annular shape, the useful light emerging

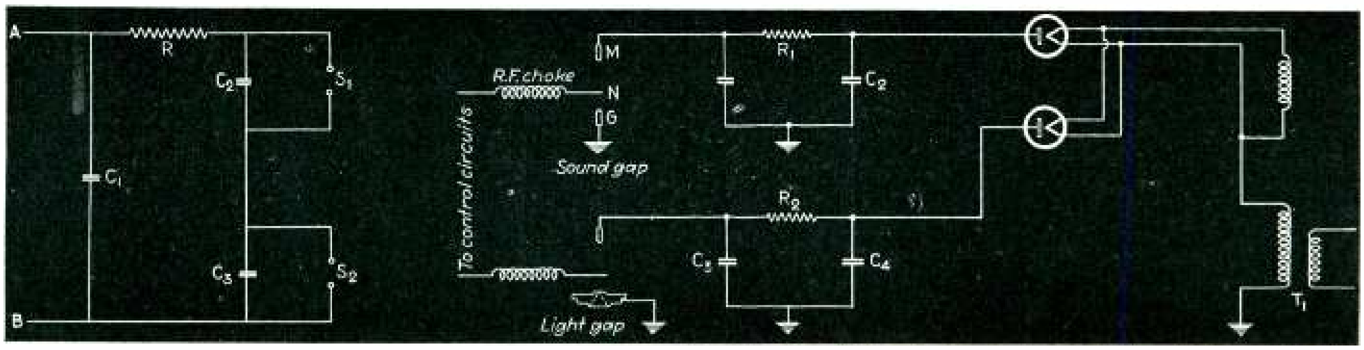


Fig. 1—Timing circuit used in the past. Fig. 2—New spark gap circuits and high voltage source

from a hole about .070 in. diameter. The light spark must lag behind the sound spark by a time interval which depends on the distance the sound wave must travel from its source to the position in which we wish to view it—for example, a distance of 1½ in. roughly corresponds to a time lag of .0001 seconds.

Figure 1 shows the circuit used in the past for accomplishing this timing. The network shown is connected at A and B to a source of high voltage d.c., such as a static machine. Condensers C_2 and C_3 are charged in series, C_2 having about half the capacity of C_3, so that if the spark gaps require equal break-down voltages C_2 will discharge first through S_1. Following this discharge there is a redistribution of energy in the circuit which is retarded by resistance R. In the process, C_3 will have added to its charge an additional amount sufficient to discharge it through S_2, which is the illuminating spark. By varying almost any of the quantities involved, the time lag map be varied.

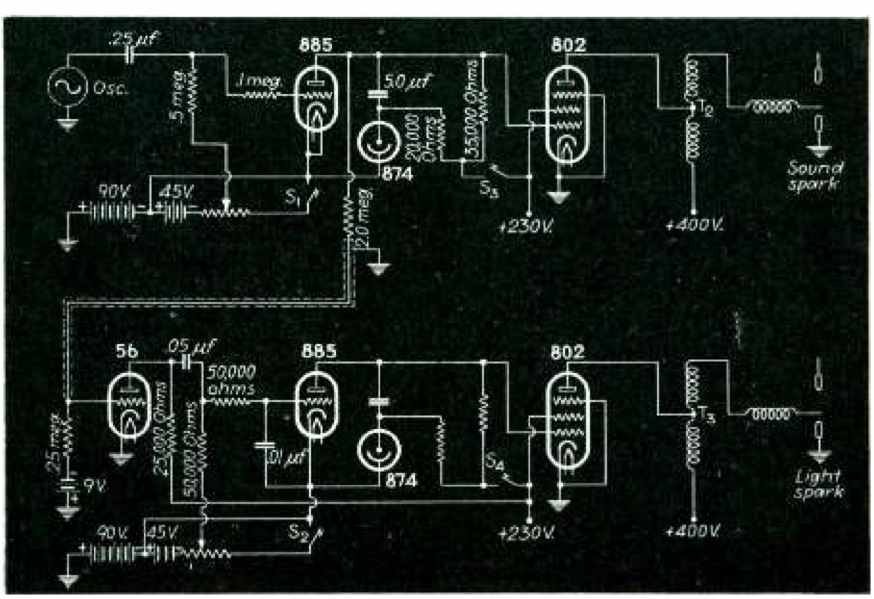
The time interval between the two sparks is affected by the leakage rates of the condensers and wiring, and probably more seriously by slight variations in the condition of the gaps, and the usual experience has been that very great attention to detail and long and patient work are required to produce satisfactory operation. In addition the gap electrodes must be cleaned and polished frequently. Having tried this circuit, the writer has the sincerest admiration for those who made it work so admirably.

The system used by the writer makes use of electronic tubes in a circuit which determines the instant of discharge of condensers which have been independently charged to high potentials. Figure 2 shows the high voltage source and the spark gap circuits. T_1 is a transformer supplying 20,000 volts, of one k.v.a. capacity. The filament winding for the rectifiers must, of course, be suitably insulated from ground. There are several suitable high voltage rectifies but in the present case a pair of 50-watt Eimac triodes were used each with its grid tied to its filament. The average current through each rectifier is about 7 milliamperes. The high inverse voltage did no harm to these tubes. C_1 and C_3 are each 0.012 μf, and C_2 and C_4 are each 0.023 μf (values not critical). These condensers were made by using 3/32 in. thickness window glass 12x12 in. Each plate has a capacity of about 0.0016 μf. R_1 and R_2 are each about one-half megohm, and each consists of a column of distilled water thirty in. long in a glass tube ¾ in. in diameter. Carbon or lead electrodes may be used. These filters serve to partially smooth out the rectified current, and also to delay the recharging of C_2 and C_4, thus preventing a rapid succession of uncontrolled sparks once the gap is ionized.

The control electrode N is placed about ¼ in. from the grounded electrode G. A voltage suddenly applied to N, of opposite sign to the voltage on M, sets up sufficient additional strain to break down the main gap. The control voltage need be only a fraction, say ¼, of that on M, and very little power is needed for the control. In fact, good operation has obtained even when the control voltage was too low to cause a spark of its own. If the large spark is analogous to the dynamite, this control spark is the cap that sets it off.

Starting at the beginning of Fig. 3, an oscillator, having a frequency of four or five cps. and an output voltage of 15 or 20 volts, is coupled into the grid of the type 885 thyratron. This oscillator determines the

[Continued on page 34]



New timing circuit for sound wave photography

A New Welder Tube

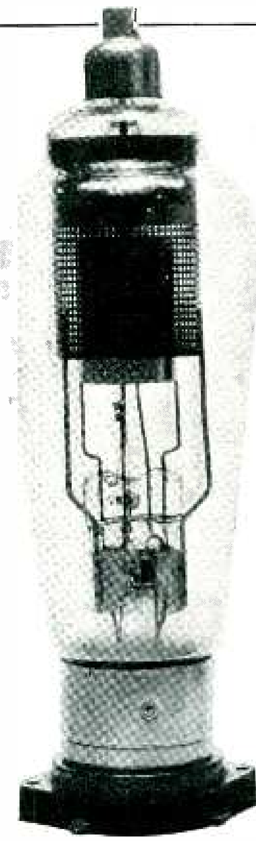
Welding, the bright spot in industrial electronics, requires tubes providing high instantaneous currents for control purposes. This paper describes the development of such a tube by Westinghouse engineers

By D. D. KNOWLES
E. F. LOWRY
R. K. GESSFORD

CERTAIN modern industrial applications of electronic tubes call for very high ratios of peak to average anode current. One of the most important of these applications and one in which this requirement is particularly severe, is the control of resistance welding equipment. In one method of welding timing the hot cathode tube is used to ignite or fire an ignitron which in turn supplies the welding current. In this scheme the hot cathode tube must supply a fairly large current for a very short period each time it is desired to pass current through the ignitron. The firing time depends on circuit characteristics but is frequently of the order of 300 microseconds. Now in a seam welder making 100 welds per minute of three cycles each, the total time the firing tube is required to pass current is only 0.18 seconds per minute or three-tenths of one per cent of the time. If the firing current is 25 amperes the average plate current will be only 0.075 ampere. This is, of course, an extraordinarily high ratio but is a fair example of the requirements put upon hot cathode tubes used for this purpose.

In spot or seam welders where the hot cathode tube controls the welding current directly, the ratio of peak to average is not so extreme but is still very large compared to those of older applications. Under the same conditions as above of 100 welds per minute of three cycles each, each tube would carry current only 1/24th of the time so that the ratio of peak to average would still be about 36 to 1.

Multiphase rectifier circuits usually call for a peak to average ratio of 6 to 1. Since a certain factor of safety is desirable, the cathode capacity should be at least 10 times the average current rating.



The tube itself

In designing a tube for this service a cathode must be provided which has ample capacity to meet the peak current requirements. On the other hand, it should consume as little power as possible. This is especially true in applications like the welding timers where even under conditions of constant operation of the equipment the firing tubes are actually in the "stand-by" condition not less than 95% of the time. The heating time of the cathode too is quite important and must be kept within reasonable limits. In choosing the glass blanks and in determining other tube dimensions it must be remembered that a satisfactory mercury temperature must be secured by means of cathode heat alone. At the same time the tube must be designed not to overheat when the full rated average current at left is drawn continuously.

In designing the KU-676 shown it was the purpose to meet the requirements of the types of service outlined above. This ionic triode has a cathode rating of 5.0 volts 11.5 amperes, an average anode current rating of 6.4 amperes and a peak anode current of 75 amperes. The tube is of more or less conventional design except for the cathode.

The directly heated or filamentary cathode of the edgewound helical type has been chosen because it is pre-eminently suited to this type of service.[1] The average anode current is not sufficient to cause bad temperature distribution along the filament.[2] In the stand-by condition the filament reaches a more uniform temperature over its entire surface than any other type of cathode.[3] Each portion of the filament serves to perform three functions: heater, electron emitter, and radiation shield. By causing each part of the filament to do triple duty the heat capacity and the heating time of the cathode are kept to a minimum.

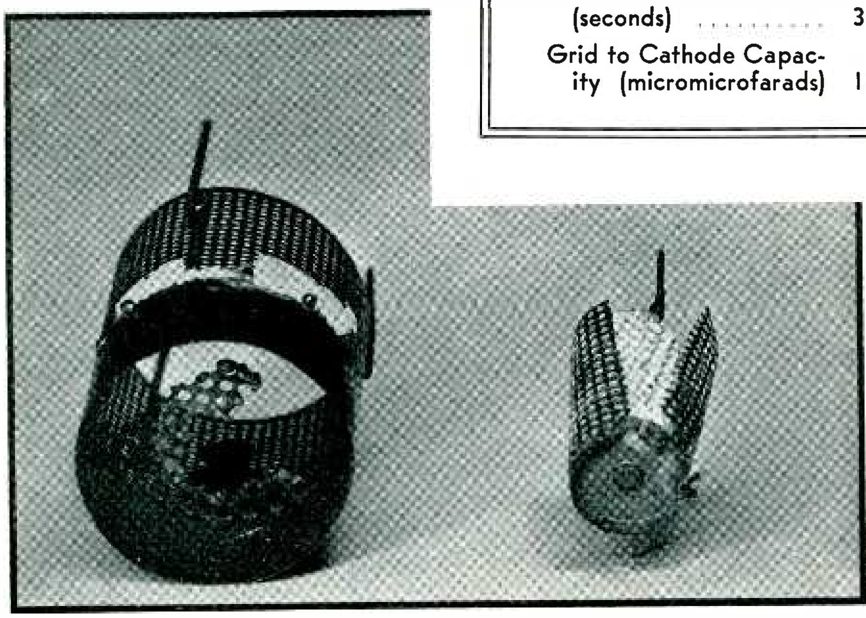
Referring to the cross section drawing shown, the helical filament which constitutes the major portion of the thermionic surface is seen. To prevent any possibility of sagging or side play this filament, which is 25 inches long, is wound on an insulating mandrel. The upper end of the filament is welded to the metal cap. A recess in this cap also anchors firmly the upper end of the insulator (2). The lower end of the filament passes through a narrow slot in the insulating disk into which the lower end of (2) is also inserted.

The filament is completely enclosed by the perforated cylinder which is welded to the cap at its upper end and fits snugly over a shoulder of (4) at its lower end. This perforated cylinder is coated on its inner surface with alkaline earth oxides. Surrounding this structure are the radiation shields, of which (6) is welded to the cap and is peened over the insulator holding it firmly in place. The cathode supports are fastened to the outer shield which is welded to the inner shield at its upper end.

Electrons leaving the filament are forced to pass through the perfora-

GRID-GLOW TUBE, KU-676

Number of Electrodes	3	Grid to Anode Capacity (micromicrofarads)	12
Cathode Potential (volts)	5	Av. Tube Drop (volts)	15
Cathode Amperes	11.5	Maximum Length (inches)	12¼
Cathode Heating Time	5 minutes	Maximum Diameter (inches)	3⅞
Maximum Anode (volts)	1000	Base (Industrial)	4310-F-1
Maximum Peak Anode Current (amperes)	75.0	Base (Top Cap)	3904
Maximum Average Maximum Av. Anode Current (amperes)	6.4	Condensed Mercury Temp.	
Maximum Grid Current at Ignition (μa)	2.5	Recommended	55°C
Load Time Constant T (seconds)	30	Minimum	30°C
Grid to Cathode Capacity (micromicrofarads)	12	Maximum	80°C
		Rise above ambient in still air at no load	30°C
		Type of Cooling	Air
		Gas	Mercury Vapor



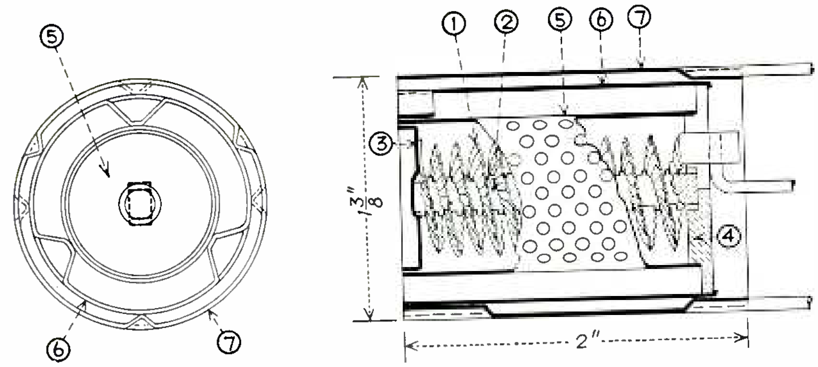
Grid (left) melted away by overload. Cathode (right) unharmed

tions in the cylinder and then upward through the annular spaces between (5) and (6). By this means excellent electrostatic shielding is afforded the active surfaces of this cathode. Heavy current surges which would otherwise strip the coating from the cathode are absorbed by the shielding structure. An excellent example of this protective action happened in this laboratory. An accidental current surge occurred between cathode and grid of one tube of such magnitude and duration that the grid was melted away. The only damage to the cathode was that borne by the cap of the cathode which is also shown. When the tube was opened it was found that the filament surface was intact. This should not be interpreted as a license to overload the tube but rather as assurance of longer life under the usual conditions.

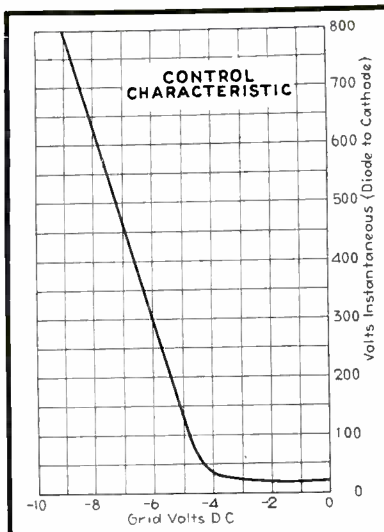
Another property of this structure was recently described in *Electronics*.[1] The cylinder has the properties of a grid with high control factor at zero bias until it becomes heated by radiation from the filament when that ancient bugaboo of the tube engineer, grid emission, appears and the cylinder at once becomes an integral part of the cathode. Here it may be utilized to prevent the tube from starting until the cathode reaches operating temperature without recourse to external time delay relays of one sort or another. It is only fair to say that in this particular structure this property of the perforated cylinder is not useful for short outage times, that is less than 60 seconds, but does protect the cathode satisfactorily when starting the tube up initially. This cathode reaches operating temperature in 3 to 4 minutes but the tube will not carry current in less than four minutes.

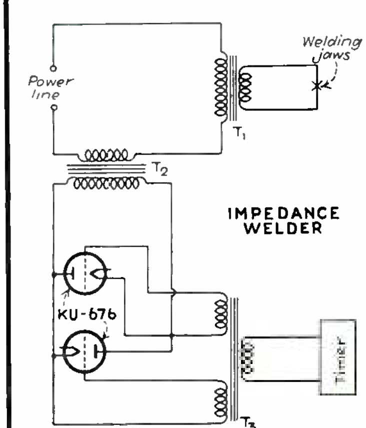
The cathode heating time (in the table) is the maximum time required for the cathode to reach operating temperature. The time consumed in bringing the tube itself up to the proper temperature for operation may be more or less than five minutes, depending upon the ambient temperature in which the tube is located. The tube will pass from 50 to 75 amperes without damage so long as the current averaged over a period of time does not exceed 6.4 amperes and the rate of increase of current is not too great.

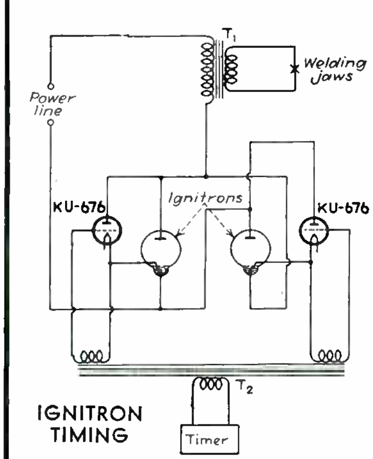
To make this rating complete, however, it is necessary to specify the maximum time over which the current is to be averaged. For example, if this is not specified, according to the definition, the customer would be justified in passing 75 amperes for one hour and zero for 10.7 hours, resulting in an average over the whole period of 6.4 amperes. Obviously, however, the tube would over-heat in one hour at 75 amperes. The maximum time over which the load is to be averaged is called the load time constant and is 30 seconds for the KU-676.



1 Filament
2 Mandrel
3 Metal Cap
4 Insulation Disk
5 Cylinder
6 Radiation Shield
7 Outer Shield







The control characteristic as shown below for an average operating condition in an ambient of 26° C. Being a mercury vapor tube the control curve is of course affected by tube temperature. This effect is directly dependent on the mercury vapor pressure which in turn is determined by the temperature of the glass wall upon which the mercury condenses. The condensed mercury temperature may be as high as 80° C and as low as about 30° C for satisfactory operation.

For higher temperatures, fan cooling may be used and for unusually low ambient temperatures it is sometimes necessary to enclose the tube in a heat regulated cabinet.

The condensed mercury temperature rise above an ambient of 27° C in still air and with filament energy only is about 30° C. With a four ampere average load the rise increases to 35° C and at 6.4 amperes it is 39° C.

The KU-676 may be used within its rating in any application requiring grid controlled tubes of the gas or vapor type but is especially well suited to those jobs that impose relatively high current overloads for short periods. Motor speed control and welding are good examples of such service, especially spot welding.

For welding service, the tube is applied in two different ways, in the impedance type welder and in the ignitron type welder.

The operation of the impedance welder is as follows: voltage is applied to the primary of the welding transformer T_1 in series with the primary of the impedance transformer T_2. The latter is designed so that when the secondary is open the impedance is high compared to that of T_1 so that most of the line voltage appears across the primary of T_2. If now the secondary of T_2 is shorted by starting the two KU-676 tubes the impedance of T_2 becomes very low and most of the line voltage is thrown across the primary of T_1 for the time that the tubes are conducting,—say one, two, or three cycles as the case may be. The duration of the weld is determined by the timer which applies the firing bias to the grids of the KU-676 tubes.

Since the secondary voltage of the impedance transformer T_2 may be say 1000 volts and the two KU-676 tubes will pass as much as 75/1.4 or 53.5 amperes, it will be seen that roughly 50 kw. may be controlled by this means. The time that the KU-676 tubes can carry this current is of course limited to a few cycles per weld but can be repeated as frequently as desired until the average current through each tube equals 6.4 amperes.

For still higher power welding the ignitron timer is used. In this system, as shown in the figure, the ignitrons carry the total current to the primary of the welding transformer T_1. They are connected across the ignitrons between anode and ignitor. When the grids are tripped by impulse from the timer through the grid transformer T_2 current passes through the KU-676 tubes and the respective ignitors are fired. As soon as the ignitron is passing current the voltage across it falls to arc drop and the current through the igniting circuit is reduced to zero. Current through the KU-676 then is in the form of high peaks of only a few microseconds.

In this type of service even with the most severe welding duty there is little danger of exceeding the average rating of the tube since the conducting time is so short.

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[3] Protecting the Cathode of a Mercury Vapor Tube, E. F. Lowry, *Electric Journal*, April 1936.
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S. M. P. E.—Autumn

Sound engineers meet in Rochester, October 12-15; discuss sound, film, acoustics, new apparatus

ROCHESTER, N. Y., which for several years has been the scene of the informal I.R.E. Fall Meetings is again host to the radio engineers this month with a joint meeting of the I.R.E. and the Engineering Division of the R.M.A. Last month the Society of Motion Picture Engineers also held their convention in the "optical center" of the country. At both meetings numerous technical papers on a wide variety of subjects were given, and summaries of a few of these papers are given here.

S. M. P. E.

A Word-Spotting Mechanism

By R. H. Heacock

A word-spotting mechanism which replaces the pick-up needle on a predetermined spot on a phonograph record finds considerable application in broadcast work where transcriptions are used extensively. In the RCA method the electromagnet holding the arm poised above the record has two open circuit release switches in parallel, one of which is a manually operated remote control release button. The second switch is automatically opened each revolution of the turntable by a fixed cam. After three reference readings previously established by the trial and error method have been made, the manually operated release is operated, and the arm is lowered onto the record when the second switch is automatically opened by the turntable.

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A Neon Type Volume Indicator

By S. Read, Jr.

A number of gaseous discharge lamps of the neon type have been used to indicate instantaneous peak aplitudes of audio frequency voltages. When the instantaneous value of the signal voltage increases to the breakdown value, the circuit is adjusted so that the first lamp begins to glow. As the voltage is raised, additional lamps start to glow as their individual breakdown voltage is reached. As the instantaneous a-f voltage decreases the lamps are extinguished in the reverse order. The number of lamps glowing indicates the maximum peak voltage.

Because of the persistence of vision, such a device provides a definite indication of the peak voltage even though the duration of the luminous discharge may be extremely short. Since only half of the voltage actuates the lamps, observations can be made on either the positive or the negative half of the cycle.

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An Improved Reel-end Alarm

By D. Canady and V. A. Wellman

Mechanical methods of indicating the end of films on reels result in scratches and mutilation of release prints, thereby shortening their useful life. An improved indicating device makes use of a phototube to indicate when the end of the film has been reached. The light rays from the light source pass at a tangent to, or across, the film. When the point of tangency has been reached, the film that previously obstructed the light ray allows the ray to reach the phototube, which, in turn, actuates the signalling device. The device is positive in action and automatic in operation and does not produce any undesirable effects.

• • •

Aging of Motion Picture Film

By J. R. Hill and C. G. Weber

A satisfactory accelerated aging treatment for motion picture film consists in heating the film in a dry oven at 100°C. High retention of folding endurance and viscosity, and small increase in acidity are considered indicative of film stability and long life, and are measured before and after aging by physical and chemical tests.

The cellulose acetate film has been found on accelerated aging tests to be much more stable than the more highly combustible cellulose nitrate film. The cellulose acetate film withstood oven aging for 120 days without serious chemical or physical changes, whereas the nitrate film deteriorated beyond usefulness after ten days of the same treatment. Thus the acetate film is much better suited for permanent photographic records than the nitrate film.

• • •

Automatic Recording Densitometer Performance

By M. E. Russell

The Eastman Company recording densitometer, recently described in the "Journal of the Optical Society," has now been in use more than a year and has measured more than 100,000 sensitometric strips during this time. Experience has shown that more reproducible results are obtained with this instrument than by routine visual inspection.

The advisability of using devices of this type in a release print laboratory depend upon a number of factors, such as initial cost, quantity and quality of production, and ease of maintenance.

I. R. E.—R. M. A.

UHF Current Measurements

By John H. Miller

The errors in thermocouple instruments at frequencies of upwards of 100 megacycles are discussed, and it is pointed out that the skin effect errors are the dominant ones. The theory is checked through the use of straight filament incandescent lamps

Meetings — I. R. E.

Radio engineers meet in Rochester, November 16, 17, 18; hear papers on new circuits, tubes, receivers

as comparators between low and high frequencies using a photometer method. The experimental findings on a group of instruments of different makes are given showing the errors to be quite considerable. A correction curve for Weston instruments is shown. Ways and means of solving the problem and making instruments for reasonable currents at frequencies of 100 megacycles or more are explained.

• • •

Commercial Television

By Alfred N. Goldsmith

Some of the major necessary factors in the successful commercialization of television broadcasting are liberal but firm regulations by the Government, the construction of high quality television broadcasting stations, the establishment of interconnecting networks for national program syndication, the development of requisite program material, together with thorough engineering, progressive merchandising, and reliable servicing of the television broadcast receivers.

It is recommended that transmission standards suitable for acceptance over a period of years be promulgated; that commercial television broadcasting licenses in the ultra-high frequency range be granted in due course; that existing broadcasting agencies be encouraged to develop the new field; that the use of the highest available transmitter power be permitted; that interference with reception be systematically reduced; that nation-wide facilities be established; that the term of the station licenses be increased; and that there be a minimum of political interference with the administrative activities of broadcasting organizations. The closest and most co-operative relations with the broadcasting industry are urged, particularly between networks and outlet stations, and between the engineering and manufacturing associations.

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Characteristics of American Broadcast Receivers

By Arthur F. Van Dyck and Dudley E. Foster

In a system of broadcasting, the conditions under which there is freedom from interference depend upon the characteristics of the receivers in use and upon the frequency allocation and power of transmitters. The characteristics of broadcast receivers now in use in this country have been investigated to determine the permissible input and frequency separation for freedom from cross-talk and heterodyne beats and flutter. Other types of interference are also treated and data on the susceptibility of receivers to these types of interference given.

Seven types of interference are described separately with data on the susceptibility of present receivers to each type. Finally there are given quantitative conclusions and specifications covering the relations between signal input, frequency separation, and receiver performance.

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Improvements in Loudspeakers at Low Frequencies

By Benjamin Olney

Response curves showing the performance of a typical cabinet speaker with and without the Stromberg Carlson acoustical labyrinth are given, as well as separate measurements of the radiation from the front of the loud speaker and from the terminal opening of the labyrinth. The behavior of a non-absorbent tube driven at one end and open at the other is discussed and related to the performance of the absorbent-walled tube as actually employed in the labyrinth system.

Measurements of the acoustic driving point impedance on each side of a cone in a conventional cabinet are compared with similar measurements of the labyrinth loudspeaker and indicate that the acoustic damping at low frequencies of the latter system is about 100 times the former.

Comparison measurements are reported for the acoustic impedance of labyrinths with and without sound absorbing linings, and the results indicate that the absorption at low frequencies is unusually large, due probably to the grazing incidence of the sound upon the absorbent material.

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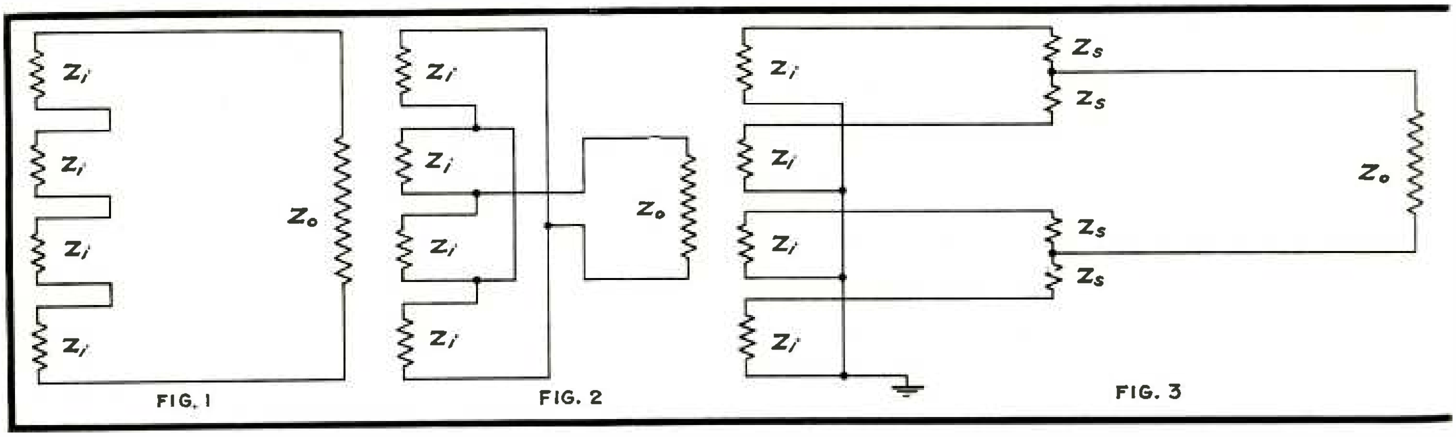
Shot Effect in Tubes

By B. J. Thompson and D. O. North

A new physical picture of the nature of plate current fluctuations in the presence of space charge, together with rigorous analyses of the space charge limited fluctuations in the cathode current of a vacuum tube and of fluctuations in the distribution of current is given.

The first analysis shows that in the case of normal operating conditions with oxide-coated cathodes the cathode current fluctuations are approximately the same as the thermal agitation in a resistor having a resistance equal to the cathode resistance, and a temperature equal to six-tenths of the cathode temperature.

The second analysis explains the results of Seeley and Barden and predicts quantitatively that in a practical case where the space-charge depression of cathode current fluctuations is considerable, and where the screen current is a considerable fraction of the plate current, the plate current fluctuations are greater than the cathode fluctuations and are approximately equal to the fluctuations in a temperature limited current equal to the screen current.



Mixer Circuit Designs

Errors in using mixers are many and easy to fall into. How to avoid these pitfalls—and what happens if they are not escaped

BY R. FRED SMELTZER
Consulting Engineer
Altoona, Pa.

OCCASIONALLY, a circuit or method gains universal acceptance and becomes a part of conventional practice in utter disregard of its fundamental faults. The common mixer circuit is one distinguished by this doubtful honor, perhaps as a result of its introduction at a time when intelligible reproduction was the criterion of performance in the design of communication systems. Its faults are emphasized by the relative perfection of the equipment with which it is today associated, and by the resonant and other effects which accompany its use with reactive and non-linear sources. Some of these defects apparently are classed with death and taxes, while others are more or less disguised by accepted methods of testing.

The common procedure for the determination of the various forms of distortion arising in radio transmitters and public address systems does not include a test of the complete installation as a unit under normal operating conditions, though there may be individual exceptions. As a rule, the largest group of equipment checked as a unit is that which follows the mixer, while the mixer and input channels are checked as separate units. The conditions under which the measurements are made are not always even remotely equivalent to those under which the mixers, remote lines, preamplifiers, etc., are used, since each unit under test is terminated in a resistance of the proper value, and the source possesses a non-reactive internal impedance. The difference in conditions is evident upon consideration of the complex impedances of modern microphones and pickups, and the sensitivity of cable circuits to termination. It will be demonstrated that conventional mixer circuits do not provide for proper matching of impedances throughout, and that compensated circuits can be evolved which eliminate all of the defects of the conventional circuits. Naturally, it will be impossible to cover all combinations of circuits and circuit elements in a magazine article, so a few representative examples must suffice to establish the criteria of design.

The flexibility of the series type of mixing circuit shown in Fig. 1 probably accounts for its increasingly extensive use. Its popularity is the reason for its selection as an illustration, although some purists may believe after reading the balance of the article that a more appropriate selection could have been made.

The demonstration of the existence of impedance mismatches is not difficult. For the sake of simplicity, each channel will be assumed to be properly designed as a unit, so that we need consider only the impedance which it introduces into the mixer circuit. In the case of the sink, this will be the load impedance reflected through the output transformer. The condition for each input channel is that the absolute value of the source impedance as seen through the matching transformer should equal numerically the characteristic impedance of the variable pad. Following conventional practice of design, the impedance of the sink, Z_o, is assumed equal to the sum of the impedances, Z_i, of the input channels, n in number. Thus, with

$$Z_o = nZ_i,$$

we have matched the output channel to its load, but we find on inspection that each input channel is working into an impedance $(2n-1)Z_i$ or, for the four channels shown, each input channel is working into a load equal to seven times its own impedance.

The full-line curve in Fig. 6 shows the response of a microphone with a complex internal impedance when

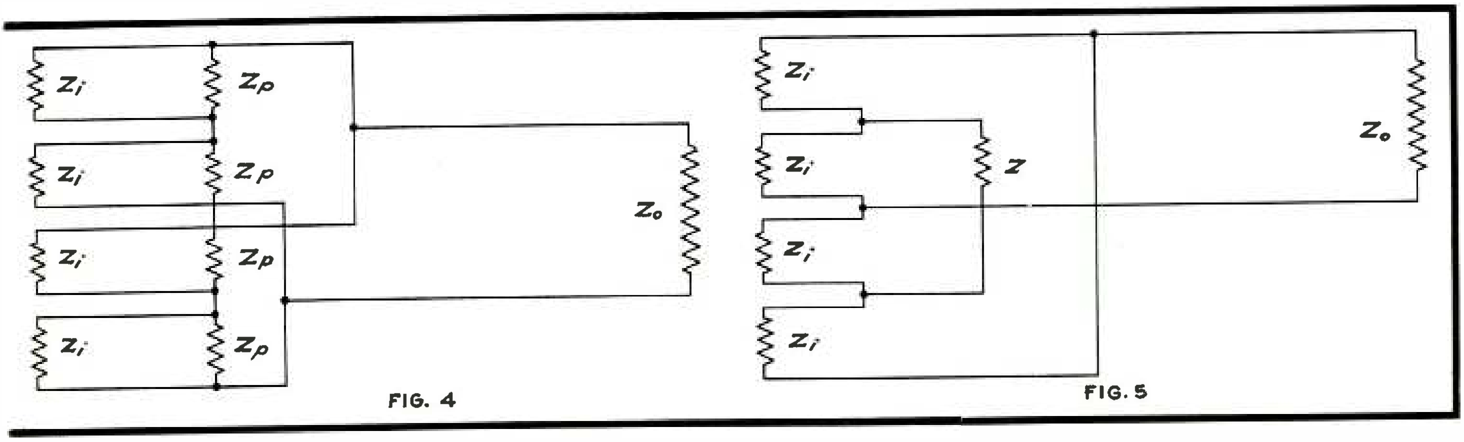


Fig. 1—Simple series type of mixer; Fig. 2—Series-parallel mixer circuit; Fig. 3—Compensated mixer arrangement; Fig. 4—A second compensated type of circuit; Fig. 5—Circuit with added series resistance

working through a mixer of this type, while the broken-line curve illustrates the response of the same microphone and transformers with an impedance adjusting pad between the transformers, and with the primaries of T_2 in parallel. Substitution of another transformer for T_2 to avoid the use of a pad merely verified the curve shown. While running the curve for the mixer, the variable pad in the active channel was set at the point of zero attenuation, and the other three pads were set for zero transmission. The introduction of attenuation in the active channel reduced and shifted the peaks and troughs, but they were still discernible through the operating range normally used. Since it is common practice to operate the lowest level channel with little or no attenuation to keep amplifier noise at a minimum, the curves are decidedly pertinent.

The curve presented is an average specimen; that it is no worse is a tribute to the designers of high-quality transformers. As a general rule, the curve obtained with an amplifier as a source is hump-backed when working into a series type of mixer. The curve which results when working into a series-parallel type is flat, but considerable amplitude distortion may be present as a result of under-loading the output tube. An intervening cable circuit provides a quite different case, however, even when it is loaded or equalized so that it appears to be nearly perfect when terminated in its surge impedance. The combination of an unloaded cable, equalized at the receiving end, with a mixer which does not furnish the correct load for the line transformer, can result in truly startling transmission curves. It is a common, but nevertheless inexpressibly disturbing, experience to find a broadcast transmitter and its associated amplifiers, lines, etc., capable of transmission flat to a decibel or so over its normal audio range, fed through a mixing panel transformer mismatch of seven or nine hundred percent (the usual values).

The series-parallel circuit of Fig. 2, with its variants, is as guilty of mismatching as the series circuit, except that the input channels work into loads below, instead of above, their rated value, when the sink is matched. No general comparison between the two types can be made, and a comparison based on any given source is not transferable to another. However, if any interest attaches to the matter, anyone who wishes to do so may easily compute the mismatches for himself. The series-parallel circuit is principally interesting in that it is a stepping-stone to one of the most valuable compensated circuits.

The conversion is simple, as Fig. 3 illustrates. Series resistors, designated as Z_s, are added to the input channels and the entire system equated to the conditions of matched input and output impedances; that is, Z_t should see its own impedance, or

$$Z_t = Z_s + \frac{(Z_s+Z_t)\left(Z_o + \frac{Z_s+Z_t}{2}\right)}{Z_o + \frac{3}{4}(Z_s+Z_t)}$$

Similarly, Z_o should see its own impedance, or

$$Z_o = Z_s + Z_t$$

Simultaneous solution gives

$$Z_s = \frac{Z_t}{4} \text{ and } Z_o = \frac{5Z_t}{4}$$

(*Continued on page 54*)

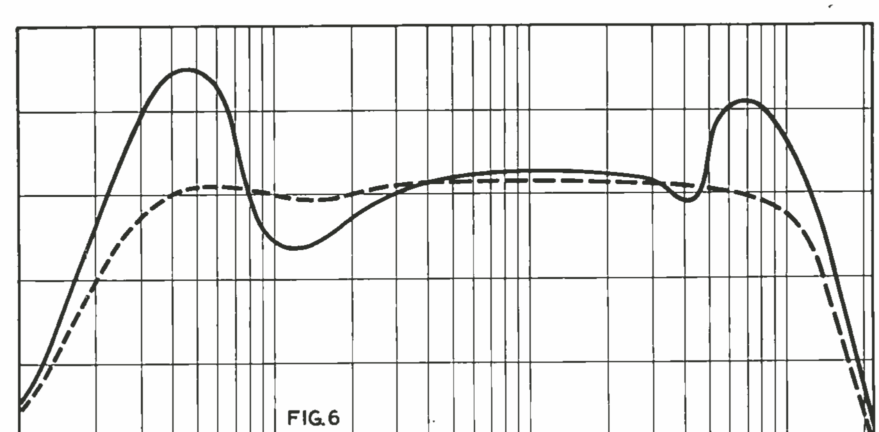


Fig. 6—Response of microphone with complex internal impedance (full line curve) and response (broken line curve) of same microphone and transformers with impedance adjusting pad between transformers and primaries in parallel

Sound Wave Stroboscope

[*Continued from page 26*]

number of sound pictures per second. From the point of view of observing the sound waves on the screen, it would be desirable to have a higher frequency, but steadier operation was found at four or five sparks per second, probably due to the time required for the gap to become sufficiently scavenged of ions from the previous spark.

The plate of a thyratron is connected directly to the grid of the power tube and through 35,000 ohms to the 230 volt point on the power pack. The cathode of the thyratron is 90 volts negative with respect to ground, so that, when the tube is conducting, its plate as well as the grid of the power tube is 75 volts negative with respect to ground, due to the 15 volt drop across the tube. This 75 volts is more than sufficient to cut off the plate current of an 802 power tube with 230 volts on its screen. When the tube is non-conducting the grid of the power tube is positive with respect to the ground, since it is connected through the 35,000 ohm resistor to the plus 230-volt point.

In this latter condition the plate current of the power tube is flowing through autotransformer T_2. At a certain point on the oscillator cycle the thyratron becomes suddenly conducting, shutting off the plate current of the power tube and therefore building up a high voltage across T_2, which controls the sound spark.

To stop the current through the tube, thereby providing that its grid shall regain control in readiness for the next spark, use is made of the Reich[2] circuit, consisting of an 874 voltage regulator tube, a 5 μf condenser and a 20,000 ohm resistance in the thyratron plate circuit, in addition to the 35,000 ohm plate resistance. The values of resistance and capacity determine the time required for "resetting" the thyratron, and should be such that the power tube grid is positive about one-third of the cycle. This permits time for the flux in T_2 to build up fully, yet saves the power tube from undue heating. Incidentally, the 802 tube has to withstand a plate voltage surge many times higher than it is designed for, but in this circuit these tubes have given no trouble.

The autotransformer T_2 must have high impedance and insulation for high voltage. A two to one step-up ratio works out well. A suitable transformer can be made by opening a Model T Ford ignition coil. The secondary is wound in sections which will serve as the two windings of the autotransformer.

The r-f choke is necessary in the lead between T_2 and the spark gap, to prevent the heavy discharge from the condenser from getting back into the control circuits. This point is important. A single-layer solenoid, 2½ in. diameter and 8 in. long, wound with No. 24 D C C wire, in series with a 250-turn honeycomb coil, is used by the writer. Somewhat less would probably do, but has not been tried.

A shielded wire carries the impulse from the first thyratron over to the second circuit, which controls the light spark. A triode is used to change the sign of the impulse and transfer it to the grid of the second thyratron through the resistance-capacity delay circuit connected thereto. The delay time, or in other words, the position of the wave on the screen, may be controlled by varying the bias on this second tube. The remainder of the second circuit is the same as the corresponding portion of the first.

These two circuits were built up separately, each with its own power pack and batteries and located a few feet apart, these precautions being necessary to prevent interaction due to the large surges in each circuit. Undoubtedly with sufficient shielding they could be incorporated in one unit. The low values of resistance used in the grid circuit of the second thyratron were found necessary to prevent it from tripping prematurely, due to the surge caused by the sound spark. For the same reason, the condenser between its grid and cathode should be connected directly to these points with very short leads. S_3 and S_4 should be left open until the thyratron cathodes are heated. Note also that a separate heater winding on the power transformer is provided for the thyratron, and connected to the cathode. This is necessary to protect the thyratron.

For photography, a shutter plate, made of 18 gauge sheet steel, drops by force of gravity; the opening in the shutter exposes the film to one light spark. In the writer's apparatus the dimensions of the shutter and the period of the sparks are such that if the shutter is released just at the time of one spark, it will expose the film completely to the next spark. To provide against variations, the opening in the shutter is about two inches longer than the film.

An 874 tube, in series with the shutter release magnet and a battery, is used, the battery being a little too low in voltage to break down the tube. A small condenser connected across the tube to absorb some of the spark surge seems to be necessary. To trip the shutter, merely touch the tube. A wire from any point on this circuit leading to a point a few inches from one of the sparks may be necessary.

There is probably little or no difference in the sensitivity of different kinds of film to the light from a spark. It is a decided help to sensitize the film by placing it in a box filled with ammonia vapor for about ten minutes. Such sensitizing lasts for an hour or so after treatment. The box has dimensions 10 in. x 11 in. x 60 in. The ground glass screen with plate golder came from an 8x10 camera. The box has a removable side for inserting models and giving access to spark gaps. The box is fairly light tight, is painted dull black inside. Distance from screen to sound gap is 29 in. Distance between gaps is 24 in. The electrodes are of brass.

The writer wishes to thank Prof. Leo P. Delsasso, of the University of California at Los Angeles for many helpful suggestions in this work; Mr. F. S. McCullough for his help in the experimental work; and Mr. Frank Rieber, who suggested the present application.

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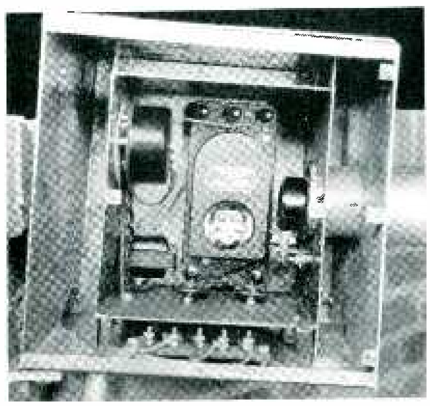
[2] Herbert J. Reich: A Self-stopping D-C Thyratron Circuit, *Electronics*, Dec. 1931, p. 240.

Radio's Past and Future

Owe Much to These Materials

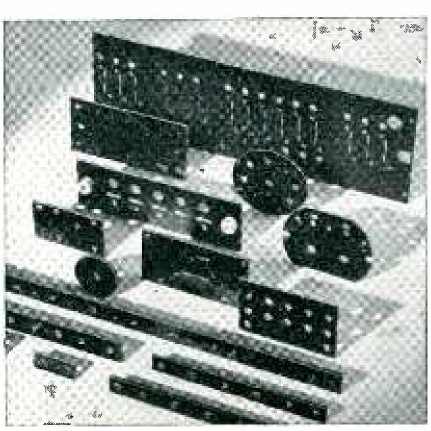
SINCE 1915, when commercial wireless sets were first equipped with Bakelite Laminated panels, Bakelite Materials have played an increasingly important part in radio development.

From this early application, the use of Bakelite Laminated rapidly increased to include scores of vital parts in wireless transmission and reception—coil forms, switch and terminal bases, and mica condenser insulation, to mention only a few. With the introduction and advance of radio, both the number and importance of its applications have multiplied.



Photronic cell cases in lightning arrestors —one of many Bakelite Molded applications in radio transmission.

Cabinet for large table set made from Bakelite Molded.



Bakelite Laminated parts employed in one leading radio receiver.

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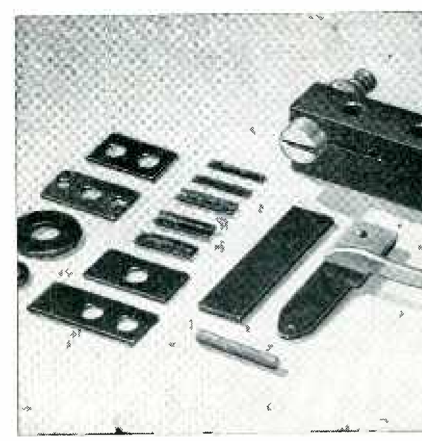
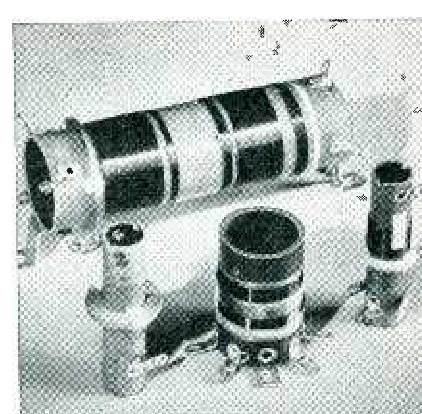


Essential parts of A. P. Wirephoto Receiver made from Bakelite Laminated.



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TUBES AT WORK

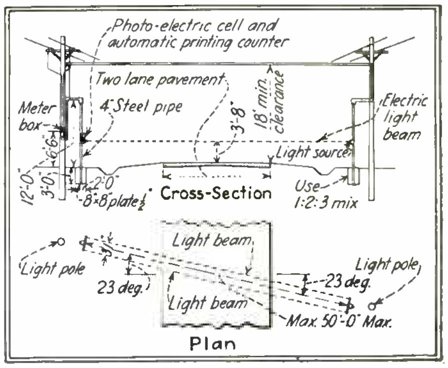
PHOTOTUBE traffic recorders, amplifier with flat characteristics from one to one million cycles, degenerative feedback amplifiers, and 6E5 as bridge null indicator are described

Phototube Traffic Recorders

AN AUTOMATIC TRAFFIC Recorder was developed recently by the Bureau of Public Roads of the Department of Agriculture which is intended to provide automatically and at hourly intervals a record of the number of vehicles passing a given point at any one time. The automatic recorder is designed to count passing vehicles without counting pedestrians. This is accomplished by using two parallel beams of light, three feet apart, directed across the roadway which fall on a pair of phototubes. Interruption of both beams by passing vehicles is necessary to actuate a photoelectrically operated relay which, in turn controls and operates the recording mechanism. If only one beam of light is broken at any one instant, the counting mechanism does not come into operation, so that pedestrians are not counted.

The drawing shows the proposed method of installation. The light beams are directed across the roadway at an angle to minimize the possibility of false operation of the mechanism by extended trunks, spare tires, cab and body of trucks, and other breaks in body arrangements. The recording mechanism used prints on standard adding machine tape once every hour, recording the day, hour, minute, and cumulative traffic total. The number of vehicles passing the point during any hour can then be determined by subtracting each total from the next succeeding total. The method of recording indicates the difference between A.M. and P.M. hours, and also indicates when current failures occur by printing indicating dashes on the tape at proper positions.

The equipment has been designed to operate satisfactorily with the light sources as far away as fifty feet from the phototubes. To render the light beams practically unnoticeable, the light sources are provided with infra-red filters. Provision has been made to insert heating coils which may be turned on at extremely low temperatures, thereby insuring operation

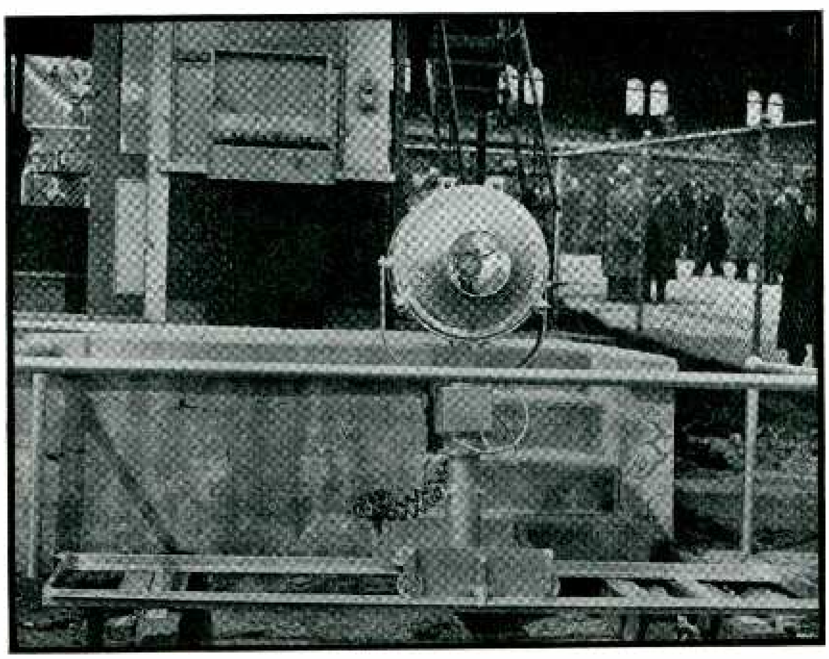


throughout any normal climatic changes. A number of safety locking and precautionary measures have been incorporated to prevent tampering with the mechanism.

The method of counting vehicles is subject to some errors, but these are ordinarily not large, the errors tend to compensate one another, and are not serious. If two vehicles overlap while passing through the light beams they will be counted as only one. On the other hand, horse drawn vehicles, trunks and trailers, and farm tractors may sometimes cause the recorder to count these as two vehicles. These two types of errors tend to compensate one another and since they are not large in the first place, the net error is inappreciable.

The equipment operates entirely from the single phase, 110 volt, 60 cycle power line, and the estimated cost of a complete unit is in the neighborhood of $500, installed.

CHECKING THE SPORT OF KINGS

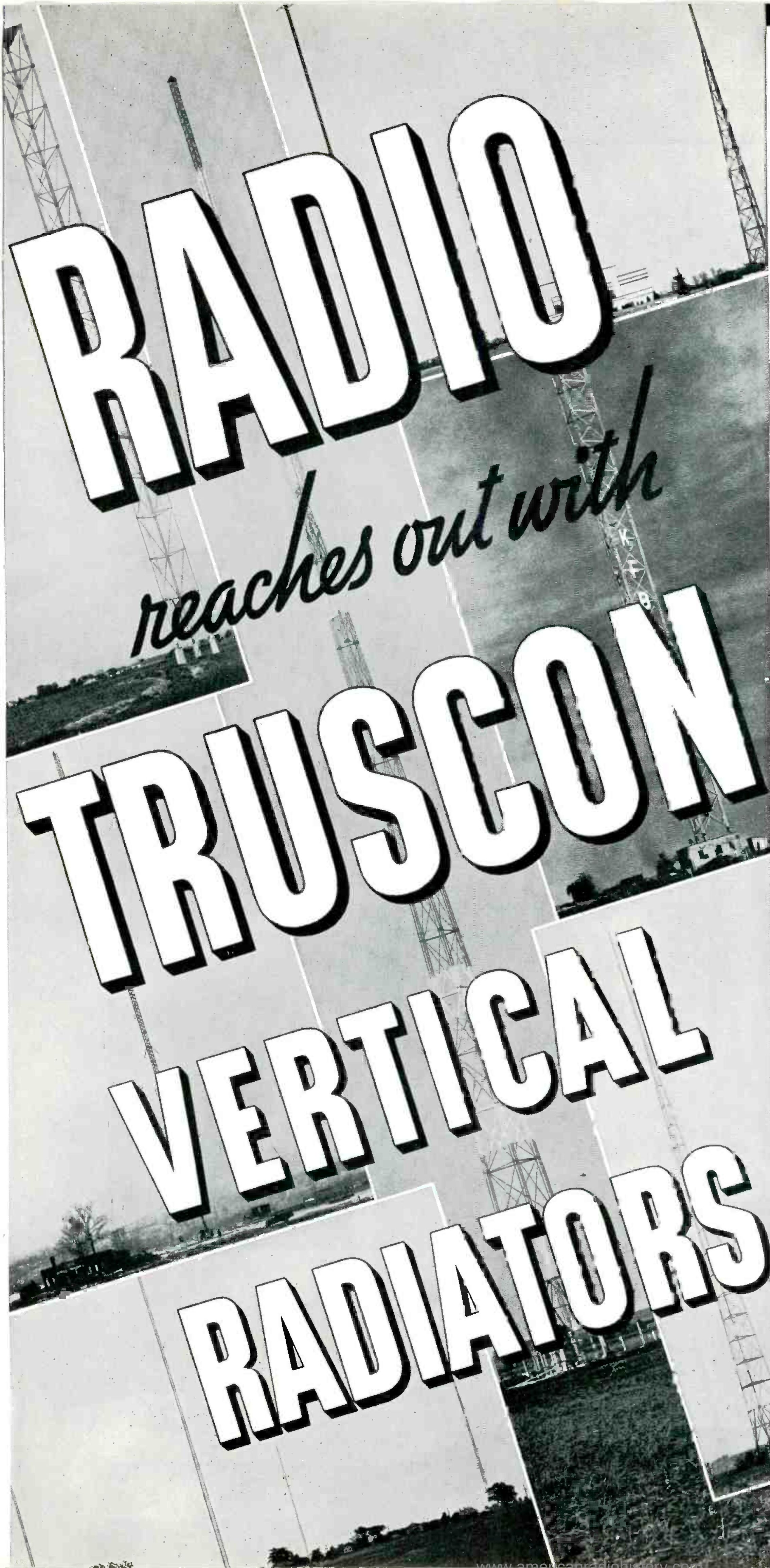


The phototube timer, installed at the Jamaica Racetracks on Long Island, is used to trip an automatic camera at the finish of each race. The camera reveals the winner in closely contested events

Oscillograph Amplifier Covers from 0.2 to 3x10⁶ Cycles

[MANFRED VON ARDENNE] A five-stage resistance-capacity coupled amplifier for use with cathode ray oscillographs, for measurements and television purposes, has been developed in the Ardenne Laboratories in Germany. The amplifier provides an amplification of approximately 2,000 over the extremely wide frequency range from 0.2 cycle to 3×10^6 cycles. All of the tubes used are of the screen-grid variety, and a push-pull stage is used in the output in order to provide symmetrical deflecting potentials and also to double the possible undistorted output-potential amplitude. In order to provide amplification at the very high frequencies which is free from phase distortion, very careful planning of the layout of the parts was required. By means of the construction illustrated in the photograph, the total circuit capacity of a single stage was reduced to 10 micromicrofarads, which, with the input capacity of the tube, provided a total capacity of 27.5 $\mu\mu$fd per stage.

This very low value made it possible to obtain, with the aid of simple correcting methods, an amplification uniform up to a frequency of 3.5×10^6



Greater coverage of primary service area with no increased power input . . . low shunt capacity . . . absence of night fading . . . these are among the many technical advantages of Truscon Vertical Radiators. Structurally, the Truscon self-supporting, vertical antenna system is a tower of strength and beauty, economically designed, mechanically sound and exceptionally resistant to wind pressure. This partial list of Truscon Vertical Radiator installations indicates their wide acceptance:

STATION	LOCATION	TOWER HEIGHT
WDOD	Chattanooga, Tenn.	320'
WADC	Akron, Ohio	350'
WLW	Cincinnati, Ohio	(2) 322'
WDGY	Minneapolis, Minn.	184'
KGHL	Billings, Mont.	558'
WSVA	Harrisonburg, Va.	182'
WTMV	E. St. Louis, Ill.	154'
WMFE	New Britain, Conn.	185'
KTRH	Houston, Texas	375'
WBNX	Cliffside, N. J.	(2) 235'
WIS	Columbia, S. C.	352'
WIS	Columbia, S. C.	260'
WOKO	Albany, N. Y.	180'
WGAR	Cleveland, Ohio	374'
WCOP	Boston, Mass.	227'
WELI	New Haven, Conn.	281'
WJAX	Jacksonville, Fla.	281'
WEMP	Milwaukee, Wisc.	173'
WJJD	Mooseheart, Wisc.	281'
WREC	Memphis, Tenn.	(2) 410'
KOMO	Seattle, Wash.	570'
KFBK	Sacramento, Calif.	334'
WDRC	Hartford, Conn.	308'
WFBC	Greenville, S. C.	375'
KBTM	Jonesboro, Ark.	189'
WIBA	Madison, Wisc.	430'
WIBA	Madison, Wisc.	(2) 195'
WTAQ	Greenbay, Wisc.	(4) 196'
WDAE	Tampa, Florida	238'
WFMD	Frederick, Md.	257'
WSAI	Cincinnati, Ohio	225'
WHBL	Sheboygan, Wisc.	285'
	Canton, China	622'
WSPR	Springfield, Mass.	222'
KFEL	Denver, Colo.	285'
WROK	Rockford, Ill.	238'
WAAF	Chicago, Ill.	231'
WCLO	Janesville, Wisc.	259'
WSIX	Nashville, Tenn.	195'
KFPY	Spokane, Wash.	466'
WSBC	Chicago, Ill.	195'
WTRC	Elkhart, Ind.	174'
	Tallin, Esthonia	645'
WKY	Oklahoma City, Okla.	285'
KMA	Shenandoah, Iowa	488'
KWYO	Sheridan, Wyo.	187'
KRSC	Seattle, Wash.	218'
WNBF	Binghamton, N. Y.	227'
WORL	Boston, Mass.	308'
WCBM	Baltimore, Md.	231'
KLRA	Little Rock, Ark.	300'
KVI	Tacoma, Wash.	444'
KID	Idaho Falls, Idaho	330'
WGRC	New Albany, Ind.	231'
WIRE	Indianapolis, Ind.	(2) 330'
WTAD	Quincy, Ill.	280'
WDWS	Champaign, Ill.	152'
KOBH	Rapid City, S. D.	174'
WILL	Urbana, Ill.	(2) 333'
WEEI	Boston, Mass.	(2) 364'

POLICE TOWERS

WMP	Framingham, Mass. State Police	220'
WQPS	Springfield, Ill. State Police	338'
WQPC	Chicago, Ill. State Police	338'
WQPP	Pontiac, Ill. State Police	338'
WQPG	Sterling, Ill. State Police	338'
WQPM	Macomb, Ill. State Police	338'
WQPD	Duquoin, Ill. State Police	338'
WQPF	Effingham, Ill. State Police	338'
KACD	Atlantic, Iowa State Police	227'
KACC	Fairfield, Iowa State Police	227'
	Terre Haute, Ind. City Police Dept.	154'
	Boston, Mass. City Police	(4) 132'
	Oregon State Police Dept.	(8) 120'
	Dept. of Commerce Lighthouse Service, New York	125'
	Montgomery, Ala. Police Dept.	95'

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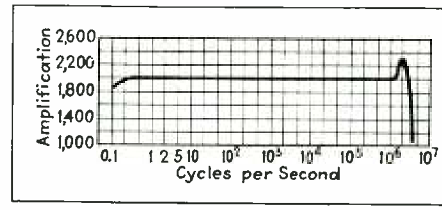
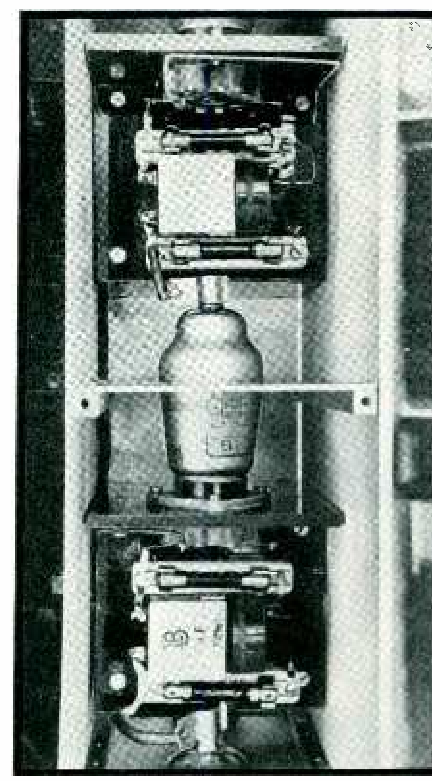
cycles per second. Corrections for phase and amplitude distortion are accomplished by the use of small chokes in series with the anode resistances, and by the use of capacitive bridging of the cathode resistances.

The low frequency response was purposely limited to frequencies not lower than 0.2 cycles per second in order to avoid excessive blocking action and to avoid the effects of thermal inertia of the tube electrodes. At such



low frequencies the internal resistance of the plate current supply cannot be reduced practically by capacitive bridging but if the product of this resistance and the slope of the stage fed from the plate current supply is less than one, no generation of oscillations will occur. To meet this condition the amplifier is divided into several groups of stages, in each group of which the product of the internal resistance of the plate supply and the slope of the



Von Ardenne's amplifier

stage is less than one. This division of stages is obtained by the use of glow-discharge voltage dividers and by the use of separate plate supply for the driver and output stage. By this means the whole amplifier is rendered free from relaxation oscillations. (*The Wireless Engineer*, and *Exp. Wireless* 149, 59; February, 1936).

ENGINEERING AT NBC

The story of the Engineering Department of the National Broadcasting Company, which on its tenth anniversary this month finds itself with the largest technical organization in broadcasting, a business which makes the most exacting demands of any branch of the communication arts

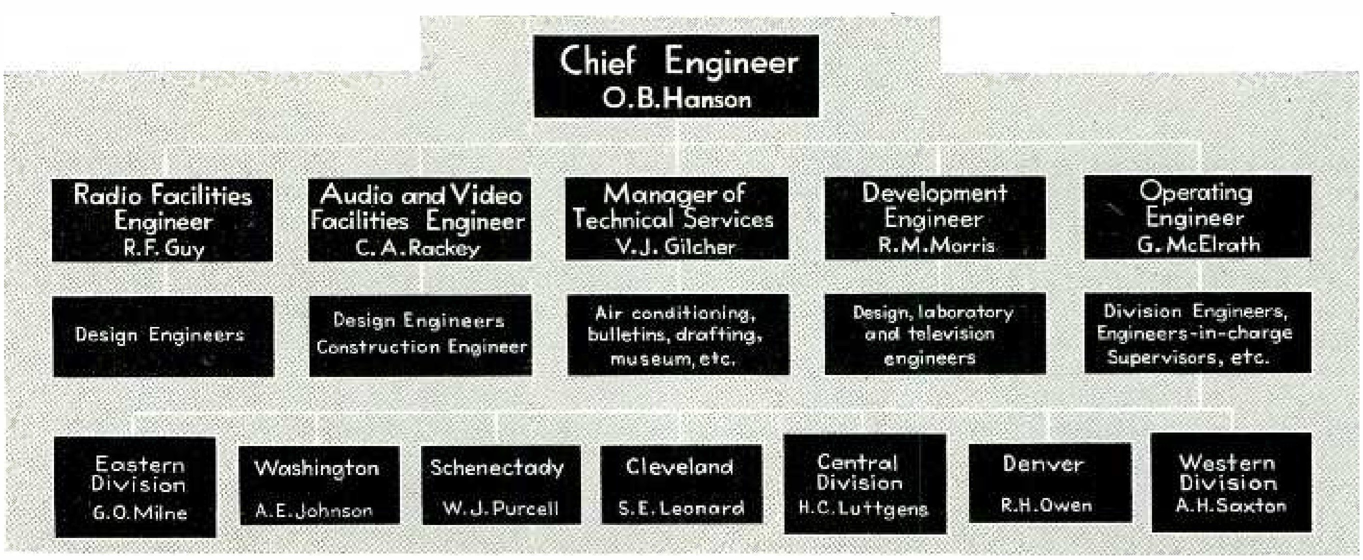
THE National Broadcasting Company is many things to many people. To the great public it is a program service; to the advertising agencies a god-sent source of income; to its employees it is, by and large, a very nice company to work for. But essentially it is a broadcasting business, and as such its function is to entertain and instruct its listeners so well that an income can be derived from them. Talent and programs are therefore most important. But it takes sales and promotion methods and advertising coverage data to show how the programs can be put to most effective use.

Beneath this artistic and commercial structure there must be a *means* to the end that the public shall be served. This means, the technical facilities by which the programs are transferred from artists to audience, is one of the toughest problems in the whole realm of communications practice. The men who supply, maintain, and operate these technical facilities are, of course, the men in the engineering department.

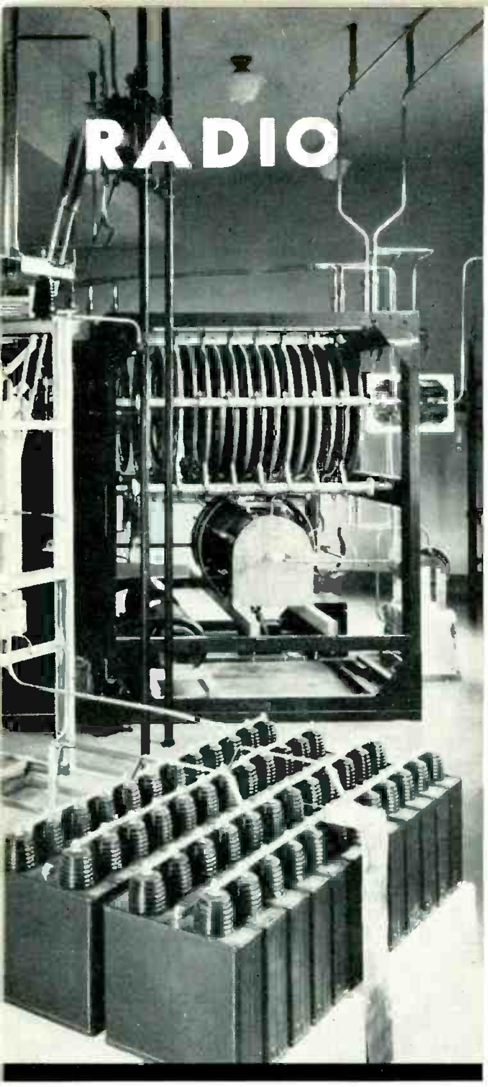
Electronics presents in the following pages the story of the Engineering Department of the National Broadcasting Company, written by the Editors from their close association with NBC engineers, based on a thorough tour of the engineering plant, and presented this month in commemoration of the tenth anniversary of NBC.

NBC's Engineering Facilities

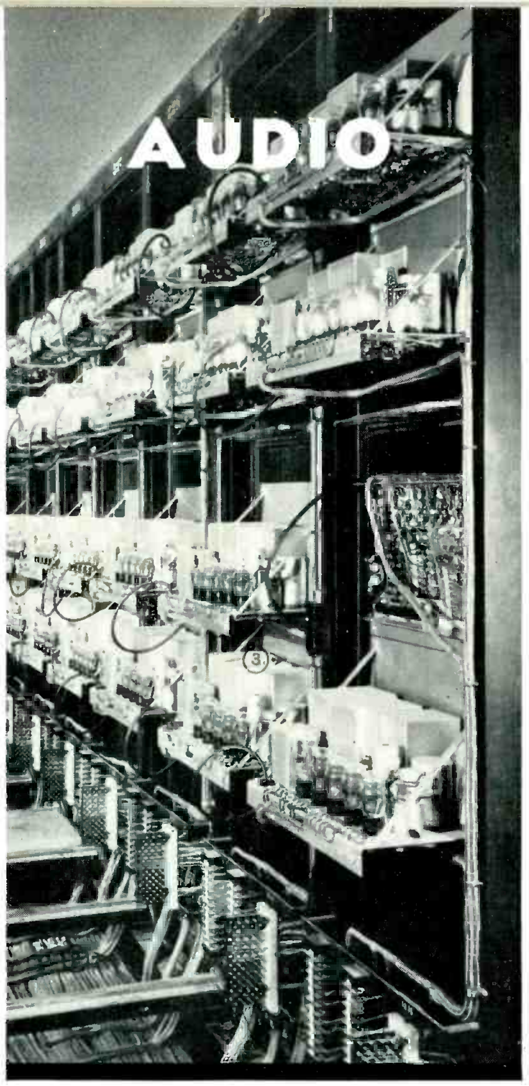
WITHOUT doubt the finest broadcasting plant in the world, as far as program facilities are concerned, is the NBC Radio City equipment in New York. Because these studios originate most of the NBC programs, they are widely known to the public; in fact in six months more than half a million visitors have been taken through them on guided tours. But it must not be supposed that all of NBC is at Radio City. There are ten transmitting stations owned or managed by the Company through the country; and there are large branch-offices, including complete engineering staffs, at Chicago and San Francisco. In Washington, Cleveland, Schenectady, and Denver there are technical staffs for the NBC stations in those cities. In all there are more than 350 employees in the engineering department, scattered throughout the system. During the extensive field-coverage survey completed last year, the field engineers traveled to nearly every city and town in the United States to say nothing of the stretches in between. Throughout the system there are, in addition, a large number of auxiliary units, such as short-wave and experimental transmitters, mobile units, field-strength measuring cars and remote program pick-up equipment of every description. In a word, the Engineering Department of NBC is the largest technical organization in the business, by far. Also, of course, there is the vast system of NBC "associated stations" whose technical staffs are in close touch with the NBC engineers.



The Engineering Department, National Broadcasting Company. This skeleton organization chart was prepared by the Editors from the complete chart in the Chief Engineer's Office



Final amplifier tuning equipment and transmission line at KOA, the 50 kw. NBC station at Denver



Rear view of power amplifiers (a-c operated type) in Main Equipment Room, Radio City, New York

The camera (iconoscope) in operation in the television studio at Radio City. Note the rubber-tired "dolly"

At the head of the Department is O. B. Hanson, the Chief Engineer. To this man, more than any other, is due the credit for the technical accomplishments of the Company. Since its beginning ten years ago, he has directed the technical operations and engineering of NBC. He is responsible directly to the president of the Company, Mr. Lenox Lohr, for the following: Design, installation, operation and maintenance of the technical facilities throughout the organization; the management of a national engineering staff to conduct research and development work on operating problems and broadcasting technique, and to supervise the construction, supply, and installation of equipment; to offer engineering service to associated companies. This is a large order. To cover all these phases of work, even for a single broadcast station, requires the cooperation of several men. In the NBC, because of the magnitude of system, it requires the cooperation of several large groups of men. On five such groups is based the organization of the department.

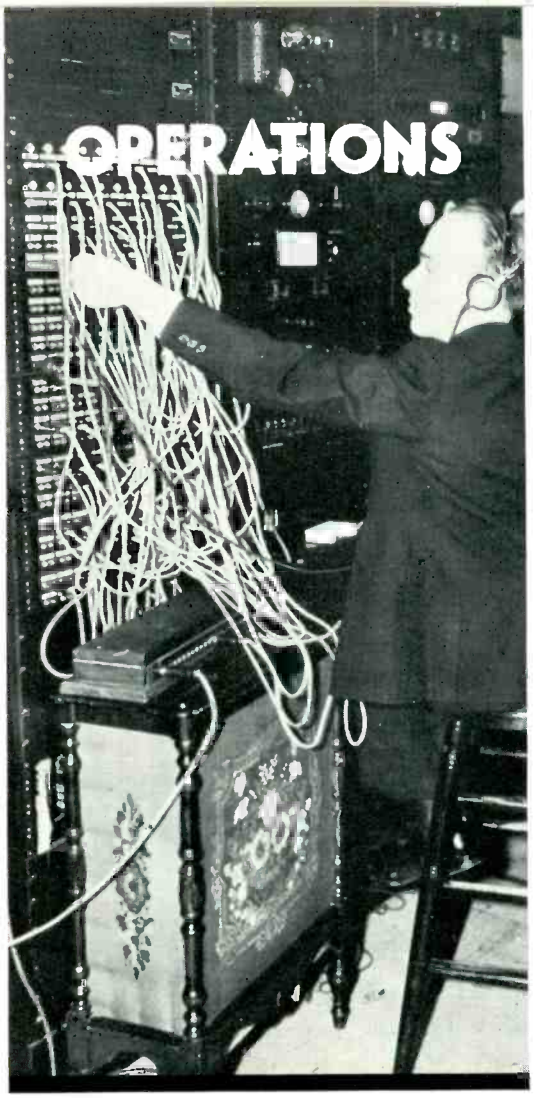
Departmental Organization — Radio, Audio, Video, etc.

UNDER Mr. Hanson, and directly responsible to him, are the five "Group Heads": the Radio Facilities Engineer, the Audio and Video Facilities Engineer, the Manager of Technical Services, the Development Engineer, and the Operating Engineer. This division of responsibility is logical, on the face of it, but the real proof of its effectiveness is simple: it works.

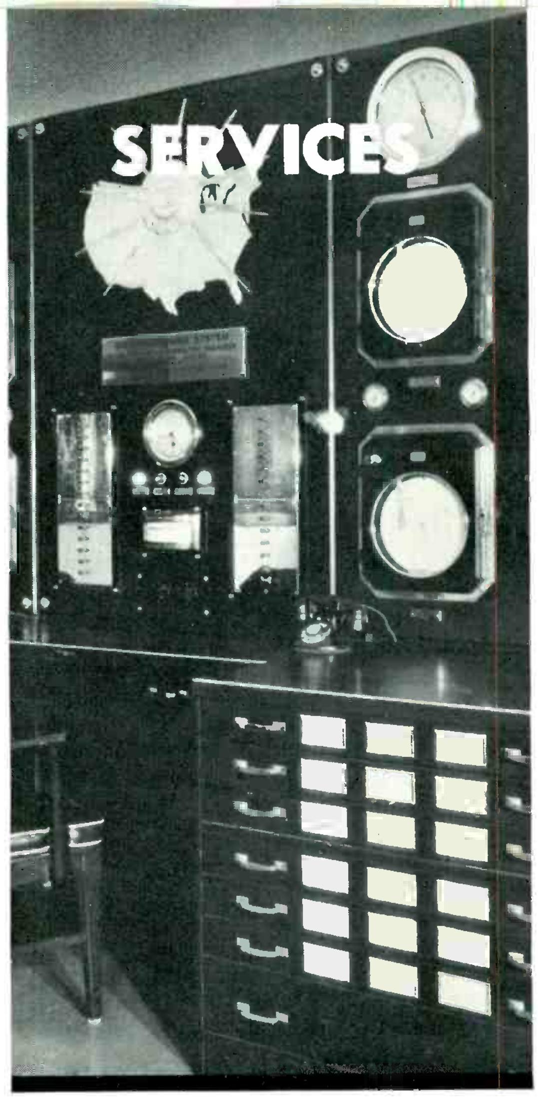
Under each of the group heads is a group of engineers, each more or less specialized in some branch of the Department's work. In the Radio Group are men expert in the design of transmitters and antennas for broadcast, short-wave, and television use; in the audio and video group are men who know studio acoustics, microphones, amplifiers, program circuits, relay switching, power generation for studio and circuit supply, and, lately, video facilities for television.

The Manager of Technical services, among other things, keeps the place going. His men provide air-conditioning, maintain a museum and exhibits, supply drafting and architectural designs, organize engineering reports, order and purchase technical supplies. In the Development group are research experts in all branches of radio, men who can turn out a frequency monitor one month, a microwave transmitter the next, and turn to television development between times.

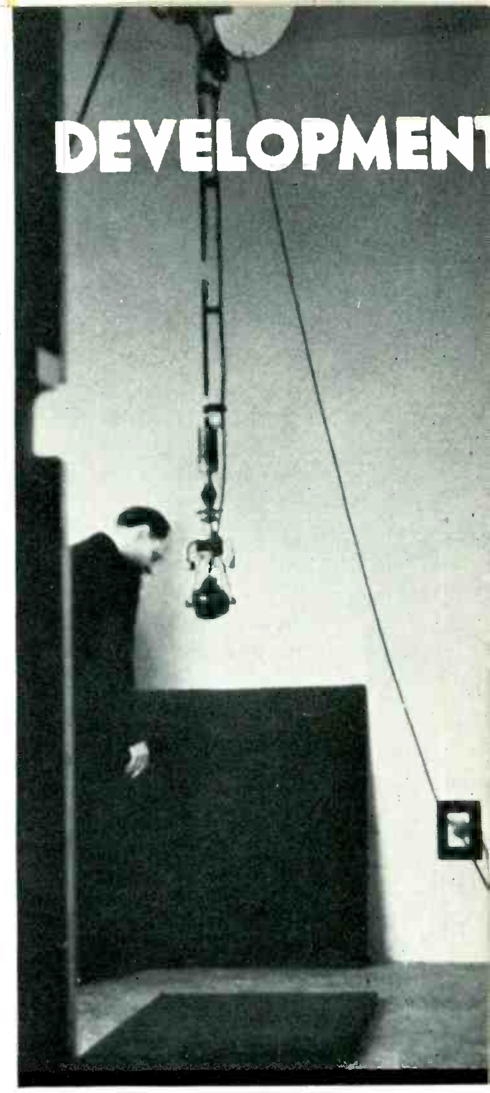
On the shoulders of the Operating Engineer and his men is the burden of operating the facilities supplied to them; this is a task which occupies about 200 men. All the studio engineers, field engineers, station engineers, maintenance and transmission



Test board, Master Control Room, during the Stratosphere Flight. Note complicated patch-cord connections



The main control board, Radio City Air-Conditioning Plant, where Watch Engineers regulate the weather



"Pit-and-the-pendulum". Testing ecoustic materials with a swinging microphone in the reverberation lab

engineers, headed by supervisors, are in this group. In the absence of the Chief Engineer, the Operating Engineer is the head of the Department. In his group all the licenses and special permissions for use of short-wave channels must be handled with the FCC. Under the operating group head are the division chiefs who manage operations in the Eastern (New York), Central (Chicago), and Western (San Francisco) offices.

The Group Heads, with their major assistants, meet every Monday morning in Mr. Hanson's office (see illustration, page 5. The purpose of the Group-Head Meetings, as they are called, is cooperation. The work of one group will invariably involve parts of the work of most of the other groups; if conflicts arise, they are ironed out in the Monday meetings. Plans for equipment and operations which involve the whole department, and which must be solved jointly by all groups, are proposed and thrashed out. From these group meetings, most of which last about two hours, come the plans of the individual groups, and the work is then carried out within each group under the direction of the Group Head.

The Radio Facilities Group

ALL of the radio-frequency facilities of the NBC are under the direct supervision of the Radio Facilities Engineer and his Group. The Group Head is R. F. Guy, whose name ought to qualify him for the job if nothing else did. Ray Guy is a very old hand at the game; in fact his experience in broadcasting goes back further than that of anyone else in the NBC. In the early days when WJZ was the Westinghouse station in Newark, in 1921, Mr. Guy was the chief engineer, station manager, part-time announcer, chief wrangler of the Edison phonograph, and stand-by listener for SOS calls. Since 1929 when the NBC Radio Facilities Group was organized, he has been its head.

Under Mr. Guy are six design engineers, each an outstanding specialist in some part of the radio field. The Senior Radio Engineer is Lester A. Looney who specializes in circuit analysis for transmitters, design, layout work, and so on, although his experience is broad enough to qualify him for every job which the group undertakes. Carl G. Dietsch joined the group in 1931. His specialty is installation and construction work; He was resident engineer in charge of the construction of WTAM, WEAF, WJZ, W3XAL, and WMAQ. William S. Duttera specializes in antenna design and investigation of their properties; the field strength coverage surveys have been among his particular assignments. John L. Seibert is a specialist in high frequency transmitters; he was resident engineer in charge of installing the new Empire State television transmitter. W. C. Lent, who has had much experience as chief engineer of several broadcasting corporations, is the expert on coverage analysis, radio propagation work, allocation problems, and the like. The latest addition to the staff is W. R. McMillan who joined the Group in 1936, after eight years on the staff of WJZ.

The specialties of these men show, in general, the character of the work carried out by the Radio Group. One of the biggest jobs they have tackled is the plans for a 500 kw. transmitter, which are in readiness for execution when, as, and if the construction permit for the WJZ application is granted by the FCC. A recent achievement may be quoted to show the type of job handled. It concerns the reduction of carrier noise in the 50 kw. transmitters from —47 db. to —62 db. It was found that the ripple from the filament supply generators for the big tubes in the final amplifier was causing a motion, under magnetic forces, of the filament itself. By taking a portion of the generator ripple and feeding it into one of the early stages of the r-f lineup, in the proper phase, the noise resulting from the ripple was reduced 15 db., to a point in fact where further reduction is rendered unnecessary.

CHIEF ENGINEER LOOKS AT NBC DEVELOPMENT

NOVEMBER 1936 marks the tenth anniversary of the National Broadcasting Company, Inc. Ten years of intensive development and growth of network broadcasting on a national and international scale. From the small beginning, with limited studio facilities, and comparatively few network stations, we have in ten short years developed the largest network system in the world, thanks to American enterprise and response of the public. To the engineers responsible for the technical advance it seems like twenty years of effort. America is familiar with the great NBC Studio plant in the RCA Building at Radio City, the latest in engineering achievements of ten hard years of research and development. It stands out as a symbol, dedicated to the American method of broadcasting.

Today we stand on the verge of a great new technical development, Television, a word that fires the imagination and stimulates an interest that is insatiable in quest for more knowledge of the subject.

How soon will we have it? what will we see? what does television look like? what will it cost? and numerous other questions are propounded. To some of these questions even we would like to know the answer, and RCA and NBC are endeavoring to find those answers, through the operation of an experimental television system at the present moment.

A television transmitting plant is now in operation atop the Empire State building and studios have been especially built at Radio City to provide experimental programs. Much has been learned of the problems but much more remains to be solved.

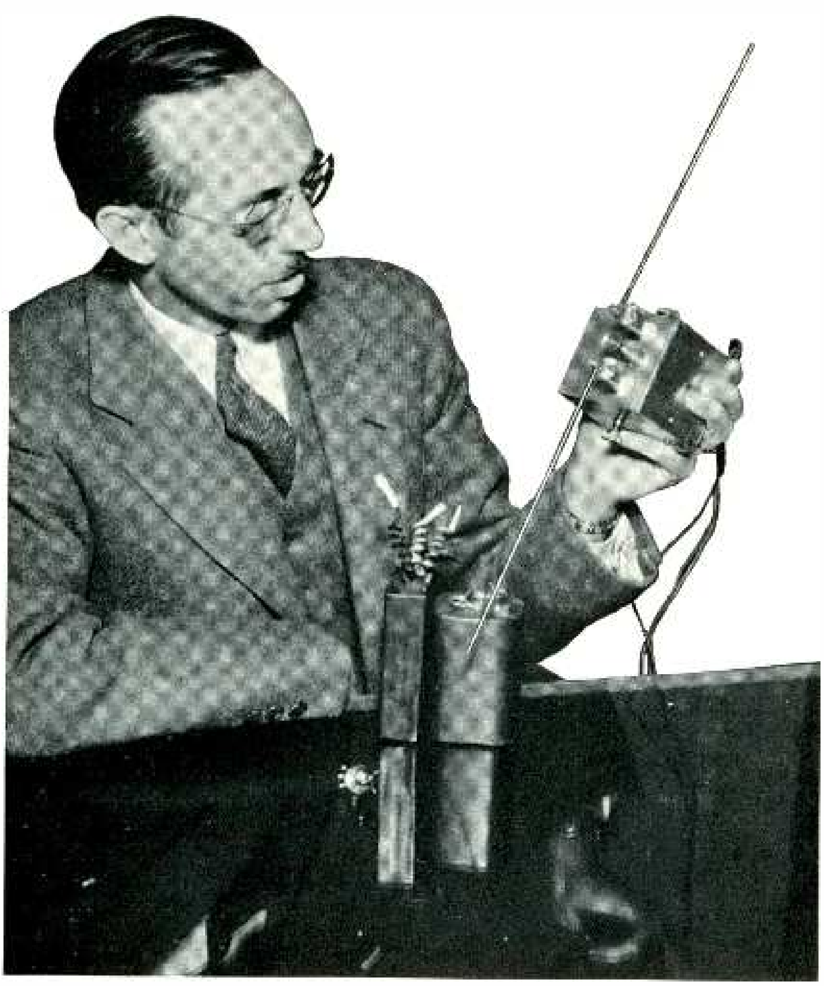
The technical problems of television seem at the moment to be a hundred times more difficult than sound broadcast, but these in time will be solved through continued research and development.

In the not too distant future the day will come when television will be upon us and the radio audience will see as well as hear.

— O. B. HANSON

The Audio and Video Facilities Group

ANOTHER old hand at the game is C. A. Rackey, Audio and Video Facilities Engineer, whose group was in charge, and still is, of supplying all the facilities in the Radio City plant, and in addition was responsible for the construction of The Chicago Merchandise Mart Studios, and studios in Denver and Hollywood. The title "Audio and Video" gives only a partial picture of the work of his Group. In general the group is entrusted with the engineering and installation design of the system from the microphone to the outgoing line which carries the program to the transmitter. In addition to this obvious communications job, there are the problems of providing the proper designs for studio buildings and acoustic treatment, ventilation and air conditioning, light and power facilities and supervision of construction. This last item is not the least important; broadcasting is a highly specialized business, and building contractors have very little appreciation of its needs. All of the studio walls and floors in Radio City, for example, are



Chief Engineer: O. B. Hanson with the miniature micro-wave transmitter (0.2 watt, 1 meter) produced by the Development Group

Monday morning meeting, October 19, 1936: Left to right, Raymond F. Guy (seated), Radio Facilities Engineer; Joseph D'Agostino (behind Mr. Guy), in charge of the Museum and Engineering Reports; O. B. Hanson, Chief Engineer; V. J. Gilcher (standing), Manager of Technical Services; G. O. Milne (seated), Eastern Division Engineer; W. A. R. Brown, Assistant Development Engineer; C. A. Rackey, Audio and Video Facilities Engineer; E. R. Cullen, Staff Engineer, Operations Group; Robert M. Morris, Development Engineer. The head of the Operations Group, George McElrath, was not present at this meeting

"floating" on resilient members, as an aid to soundproofing. Careless nailing, or even dropping excess plaster behind a partition can completely undo this design. The construction staff of the Group is headed by J. G. Strang, who has been in charge of all NBC studio construction.

The design engineers in the Audio and Video Group are five in number. R. F. Schuetz is the expert on speech input circuits, including all the problems of microphones, mixers, preamplifiers, monitoring equipment, and so on. T. H. Phelan, whose specialty is program switching, is responsible for the pre-set relay system in Radio City, which is one of the most complicated examples of relay switching in the world, and the only thing of its kind in broadcasting. B. F. Fredenhall is in charge of power supply problems. In his care are the monster "A" and "B" batteries which supply power for all program circuits except the monitoring amplifiers, and the five 750 kw. d-c generators which supply lighting power for the studios.

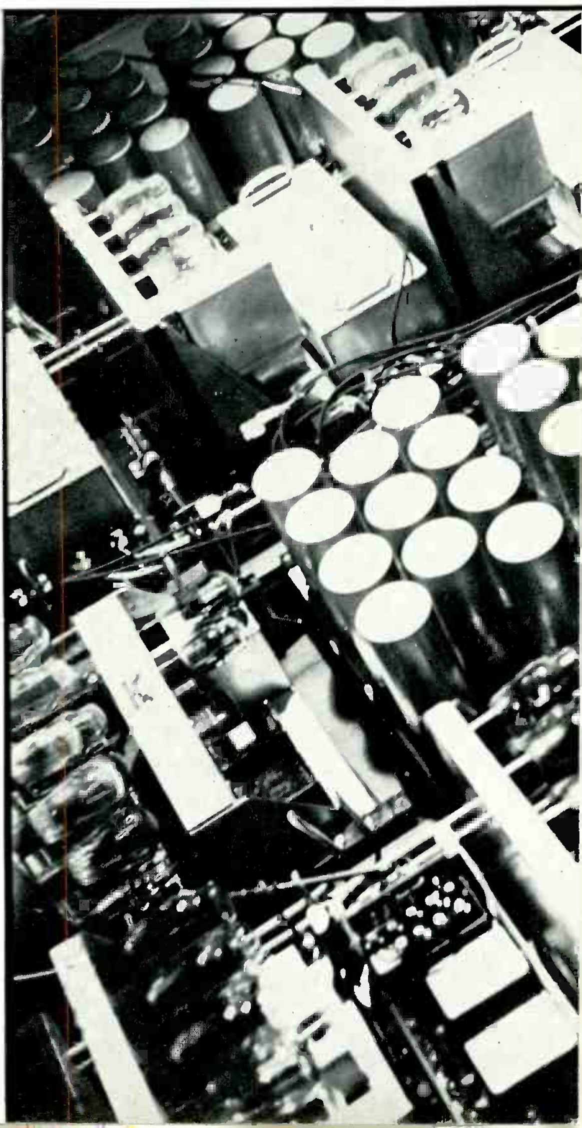
G. M. Hastings is in charge of job information, that is, the preparation of complete instructions by which contractors and their foremen can follow a design as the engineer intended. An example was the reverberation chamber of the Development Group. None of the walls in this room are parallel, to prevent the formation of standing waves. The workmen who built it argued loudly about building a wall that wasn't "true", but they finally did it and departed, sadder and wiser men.

During the past eighteen months, the installation engineering of the television studios at Radio City have added the "video" responsibility. Mr. D. H. Castle is the engineer of the group charged with its television activities. The Audio and Video Group normally consists of these five design engineers, the construction engineer and his assistants. When a large job is in progress, additional engineers are borrowed from other groups. During the Radio City job, the group had 20 members, the extra men having been recruited from the Operations and Development groups.

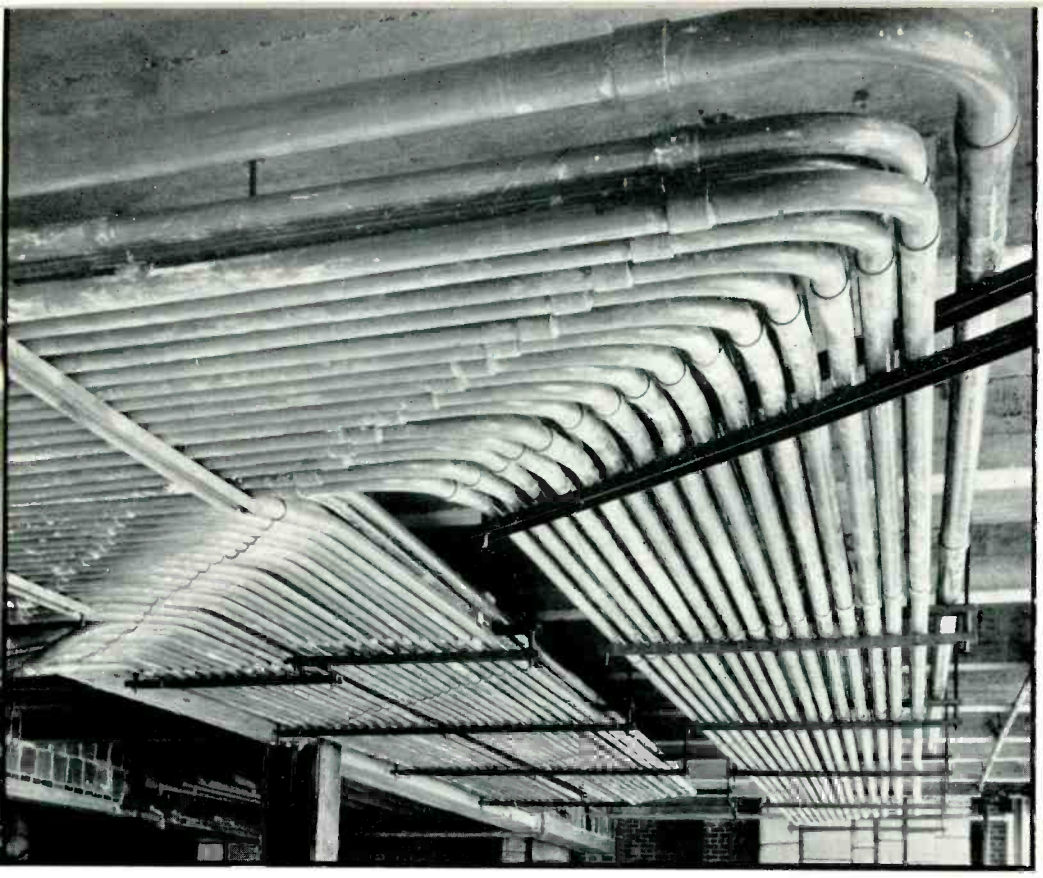
Technical Services

THE Manager of Technical Services is V. J. Gilcher. In this group are performed many services of a technical character, but with one or two exceptions they relate only indirectly to the electronic or communications aspect of broadcasting. Under Mr. Gilcher, for example, is Mr. R. Close, the air-conditioning engineer.

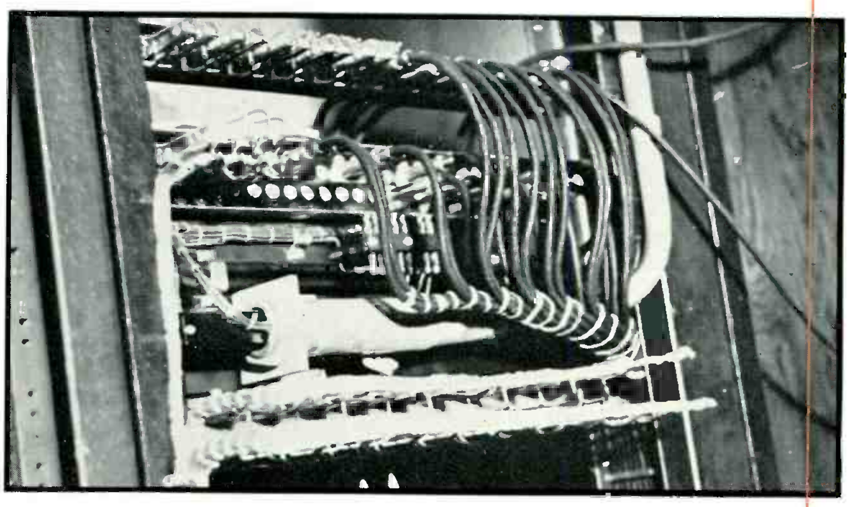
The NBC air conditioning plant, the largest of its kind in the world, is an absolute necessity; without it the windowless, soundproof studios would become unfit for human habitation in short order. Mr. Close has



Video facilities: Television line amplifiers in the main equipment room



Pipes for television: Above, 80 2-inch and 3-inch conduits installed at Radio City in 1933 for future television facilities. Below, coaxial line cords, jacks, and plugs, showing the termination of the Fifth avenue coaxial cable (main equipment room)



a large group of maintenance and watch engineers who keep the plant running. Another of Mr. Gilcher's assistants is W. A. Clarke, who is in charge of architectural design and technical drafting, technical purchases, engineering statistics, cost estimating and records. Still another, A. M. Bacon, is in charge of the service and installation of receiving sets.

Those who have visited Radio City cannot help being impressed by the excellent exhibits on display, which are in themselves an excellent museum of the history and present status of broadcasting. In charge of this museum, under Mr. Gilcher, is Mr. Joseph D'Agostino, who, in addition, is responsible for the preparation of engineering bulletins issued by the Department, and other special assignments. Mr. D'Agostino has for years been collecting vacuum tubes of every kind and description. His collection is today the largest and most complete in the world. Many of his prize specimens, including several original Fleming valves and the only original Lieben and Reiz tube in this country, are in the museum.

ALL technical and engineering work of an experimental character falls to the lot of the Development Engineer and his Group. The Development Engineer is R. M. Morris; he has been associated with the Development Laboratory since its formation in 1927. Bob Morris is not only a good executive and practical engineer, but, like many others in the Department, he loves to take pictures. One of his shots concerning the Stratosphere Balloon, appeared on the cover of *Electronics* in December, 1935. Some members of the Department, especially the Leica enthusiasts, claim it was a lucky shot, that's all.

The Development Group is entrusted with all engineering matters of an experimental nature, including television. The Group has three well-equipped laboratories for researches into radio, audio and acoustical problems; investigations made in these laboratories have been used as a basis for designs used throughout the system. One of the outstanding accomplishments was the highly successful measurements on acoustic-treatment materials, especially since the figures obtained were at considerable variance with other published results. The proof of the pudding was that when the studios were built, the reverberation and frequency response characteristics, which had been predicted by the Development group on the basis of their figures, were found to be the actual characteristics obtained by measurement.

The engineering staff of the Group is one of the largest in the Department. Mr. Morris' immediate assistant is W. A. R. Brown, who has investigated solar and terrestrial effects on short-wave propagation, and who developed the 27-day recurrence cycle which is now used in advance scheduling of international broadcasting. George M. Nixon is the specialist on acoustics, including studio design, sound isolation and noise problems encountered in air conditioning. Allen M. Walsh developed the standard level indicator used throughout the NBC, and has developed standard field amplifiers, and short-wave transmitting equipment. Jarrett L. Hathaway has specialized in microphones, filters, automatic gain control, high-fidelity broadcasting and related audio problems. Wilbur C. Resides developed the ultra-high frequency superhet used for relay broadcast operations, and is now engaged in researches in frequency-measurement equipment. Roland A. Lynn has worked actively with program recording equipment, was active in preparing the synchronizing apparatus now used by WJZ-WBAL and is at present working on loud-speakers. Fred Guber specializes in mechanical design and construction of operating models of all types of equipment.

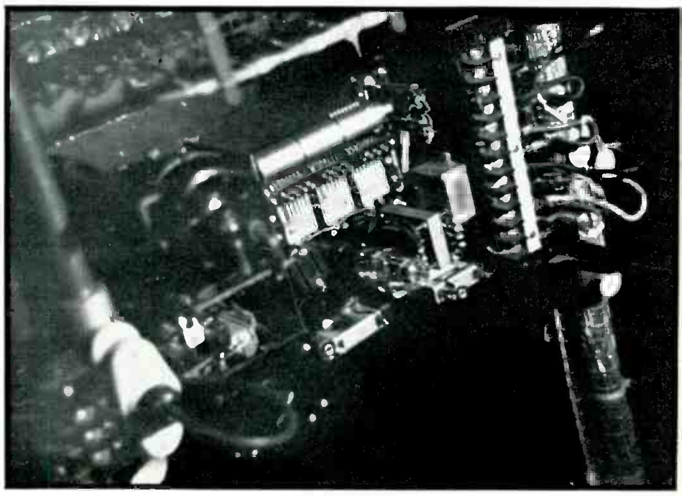
The latest problem to fall in the lap of the Development Group is television, all experimental work on which is conducted under Mr. Morris' direction. Actively engaged in this phase are no less than thirteen engineers. Of them the dean is Robert E. Shelby, the television supervisor, who is engaged in developing operational methods and studio operating technique. Dr. Shelby has had years of practical experience in television; he was in charge of the television plant in the Empire State Building from 1928 to 1935. He cooperated with the RCA Manufacturing Company engineers on the design and layout of the entire Radio City television plant. Thomas J. Buzalski began operating in television in 1930 at the New Amsterdam Theatre studio. Now he is Engineer-in-Charge of the Empire State television transmitter. Ferdinand A. Wankel is developing operational methods, especially on television studio equipment. Robin D. Compton is making a special study of film projection technique for television.

Carey P. Sweeny developed equipment for transmitting from the Stratosphere Flights. Now he is the television transmitter engineer. Richard W. Pickard is the television studio engineer. Harold P. See is likewise in the studio group, but he is also making a special study of outside pick-ups. Albert W. Protzman, an NBC engineer with extensive experience as sound expert for Fox Films in Hollywood, joined the group as television studio engineer with special interest in studio lighting, heat filters, and the pick-up camera technique. Raymond A. Monfort, associated with the film studio, completes the television group operating at Radio City.

At the transmitter in the Empire State Building are two television transmitter engineers, John B. Knight, Jr. and Vincent S. Barker, both of whom came on the job in 1936. Leo E. Phillips and William Yost, comparative newcomers to NBC, are also engaged in television activities.

Short-wave transmitter: Equipment in the gondola of the U. S. Army-National Geographic Society Stratosphere Balloon, designed and installed by members of the Development Group. Through this channel was sent one of the most spectacular contacts on record, between the Balloon and the China Clipper over the Pacific

Below, top: The Rangertone chime, an automatic music box which gives the familiar cue-signal on which switching operations are based. Bottom, a corner of the Acoustic Lab, Development Group, heaped high with sound absorbing specimens.



Above, top: Master Control Desk, the focal point of Operations in the Eastern Division. Check and double-check is the watch-word, as this candid shot shows.

THE Operations Group comes last in this chronicle, but it is far, far from the least. It is, in fact, the largest Group in the Department by a ratio of nearly five-to-one. Its head is George McElrath, who, in addition to being the Operating Engineer of the Company, is Assistant to the Chief Engineer. Mr. McElrath's experience is a very broad one, as well it needs to be, considering the ramifications of his work. He is responsible for technical operating activities throughout the Company, and by that is meant the following: the operating of the studios, the program switching system, relations with the A. T. & T. in connection with program circuits between stations throughout the two networks, operating all the owned or managed transmitters, maintenance throughout the company, relations with the Communications Commission for license renewals, and special permissions for use of short-wave relay and cue channels, arranging for remote (field) pick-ups of special events, making cost estimates of all sorts of special operations, and, finally, doing all these things with the dispatch and precision which the public has come to demand of broadcasting.

The Staff Engineer, who acts as assistant to Mr. McElrath, is Mr. E. R. Cullen, who handles all special assignments, and who manages the "license, permission, and experimental reports" routine with the FCC. One of his jobs is obtaining cost estimates on proposed remote or special-event pick-ups. Many such estimates pass through his hands, but often the cost is too great, and the proposed broadcast never goes on the air.

Each of the Divisions has a Division Engineer, reporting directly to Mr. McElrath, who supervises the operations in the district. In the Eastern area, the Division Engineer is George O. Milne; in Chicago, H. C. Luttgens; and in San Francisco, A. H. Saxton. These men act as the operations heads, and have under them various supervisors, for maintenance, field work, operations, and the station transmitter engineers. Working under the operations supervisor in each division are the transmission, control and studio engineers.

The focal point of the operations system is the Master Control Desk on Radio City. At this point, the senior control supervisor and his assistants have complete control of the system, and hence take responsibility for its actual operation. At "Master Control" take place the following: Program switching from studios to network channels; supervision of technical operations (checking the Traffic Department, the Program Department, the wire chiefs of the A. T. & T. to make certain all cues, wire-routings, etc. are in order); general operations, such as checking and routing incoming programs, making automatic records of volume level; and transmission testing, which involves periodic tests of the wire lines in the network.

This recital of the duties of Mr. McElrath's Group may give the impression that Operations is mostly a matter of dull routine. Nothing could be further from the truth. The Operations Group is, after all, the Group for which all the rest of the Department exists. The Facilities Engineers provide facilities for the express purpose that they be operated, and much of their work is taken up in making them operable.

It is safe to say that the most hectic life in the Department is that of the Division Engineer. The Eastern Division Head, George Milne, is the most consistently busy man in Radio City. Two achievements in his department, illustrating opposite extremes, are the handling of the last Stratosphere Flight pick-up, easily the most spectacular broadcast on record, and the "Case of the Three Tubes". The latter shows how thorough an Operations man can be. Each tube used in Radio City is pre-selected at the factory, then checked by NBC. One day the NBC engineer assigned to tube checking discovered that three tubes he had previously rejected had appeared again in the latest shipment. Back they went to the factory. Then admitted RCA-Radiotron, "We give up. We put those three tubes in just to see if you *really* were checking them."

In the NBC there are many engineering pioneers. Another pioneer since the very early days, Mr. C. W. Horn, heads the Department of Research and Development, reporting directly to the President. Mr. Horn was Manager of Radio Operations for the Westinghouse Company and was responsible for the world's pioneer broadcasting station KDKA. In 1929 he joined NBC to represent the Company in its contacts with the Federal Radio Commission, correlate and expand international broadcasting and deal with broad network problems of a technical nature, such as synchronization. His functions include the evolution of broad programs or ideas, the actual execution of which, when of an engineering nature, are performed by the Engineering Department.

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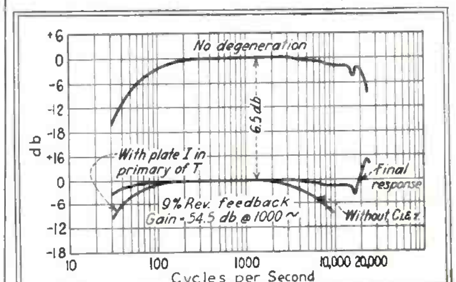
6L6s in a Degenerative Amplifier

By E. F. Kiernan
INCA Manufacturing Division, Phelps Dodge Copper Products Corp., Los Angeles, Calif.

The Following Data was secured during the development of a medium gain, 12 watt audio amplifier for public address work.

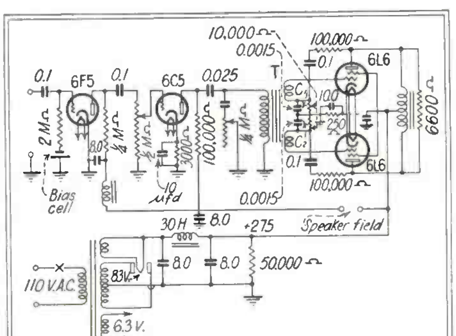
The amplifier was first set up without degeneration; the resultant response was as shown in the curve. The overall gain was +61 db. The curve was continued between 10,000 cycles and 20,000 cycles mainly to obtain reference data for a comparison between the degenerative and non-degenerative circuits. A marked decrease in the response above 3,000 cycles was at once evident with the degenerative arrangement. To lessen the degenerative effect at the high end, bypass condensers C_1 and C_2 were placed across



Amplifier characteristics

the 10,000 ohm feedback resistors. A value of .0015 mfd. was found satisfactory.

Various values of capacity were tried across the two halves of the secondary of the transformer, T, as recommended by some tube manufacturers, but the circuit arrangement shown proved



Circuit of 6L6 amplifier

more satisfactory. The response above 5,000 cycles can be adjusted to the individual requirements by means of the tone control.

Altho the response curves shown may be taken as fairly representative, the characteristics of the transformer, T, will no doubt determine the values of C_1 and C_2.

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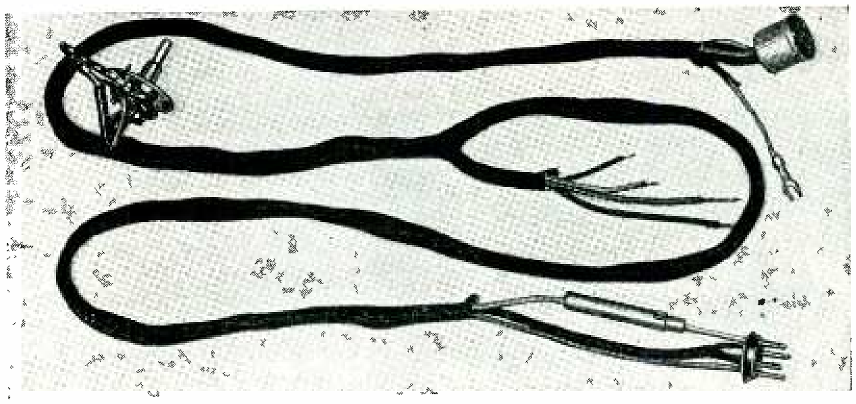

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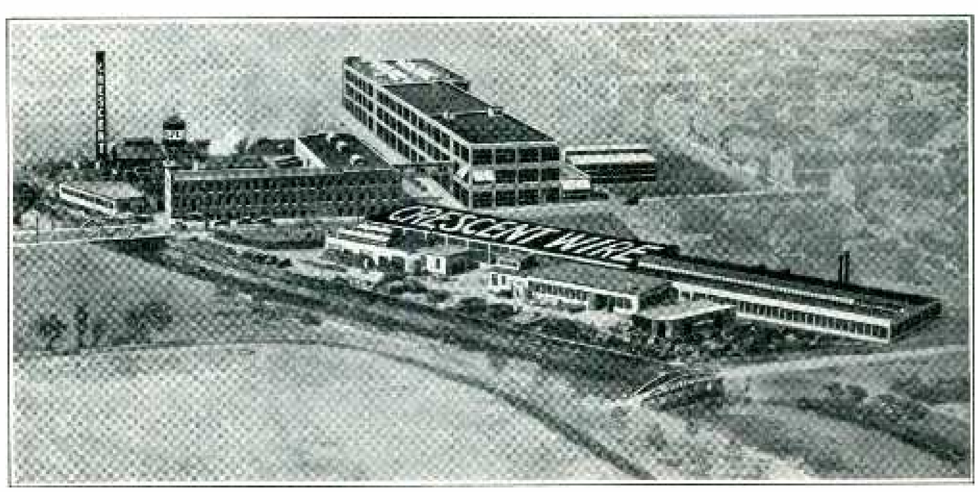

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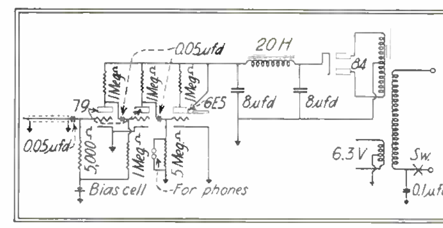
Bridge Measurements With a Visual Null Indicator

THE 6E5 CATHODE RAY indicator tube has been used for some time in factory inspection work as an indicator or for measurement purposes. A commercially available type of instrument, which finds considerable usefulness as a visual indicator for a-c bridge measurements has been developed by G. H. Browning and A. D. McLoed of Tobe Deutschmann Corp.

The schematic wiring diagram of the indicator is shown in the figure. The two triode sections of the Type 79 tube are operated in cascade as a two stage resistance coupled amplifier, and feed the grid of the 6E5 tube. The grid of



the 6E5 operates at zero bias, but the bias for the 79 tube is obtained from a Mallory cell.

In operation as a bridge null indicator, for which unit is suitable for frequencies between 40 and 5000 cycles per second, the output connections of the bridge are connected to the ground and grid of the first amplifier tube through a shielded cable, replacing the usual headset. At the balance point, the shadow of the indicator tube will spread open to about 90°. If desired, aural indications can be made by plugging a headset across the variable grid leak of the 6E5 tube. This variable grid leak also acts as a sensitivity control.

●

Some "Math" Errors Corrected

A NUMBER OF ERRORS have appeared in the article "Winding the Universal Coil" by A. W. Simon, which was published in the October issue of *Electronics*, and which the author calls to our attention.

The left hand side of Eq. (1), page 23 and Eq. (1a) page 67 have a lower case rather than capital s, and the right hand side of Eq. (3), page 23 should have a lower case c. Eq. (2), page 23 should read

$$c \tan \Phi = (\pi d/n) \pm h.$$

In Eq. (14) page 24, and Eq. (14a) page 67, the last term in parentheses should be $(1 + 1/P)$ instead of $(1 + 1/p)$. Eq. (6a) page 67 should read,

$$r = 2m \ (1 + \sqrt{a^2 + b^2}) \ (1 + a^2)$$

and Eq. (17a), page 67, should read

$$r = 2m \ (1 + 1/qN)$$

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Mixer Circuits

[Continued from page 33]

By combining our knowledge of the circuits discussed, we are led naturally to the circuit of Fig. 4, another form of the compensated type. The compensating resistors are here in parallel with the input channels, and are designated as impedances Z_p. The network is equated to the conditions of impedance matching as before. Thus, we have

$$Z_t = \frac{Z_p \left\{ \dfrac{2Z_o \dfrac{Z_p Z_t}{Z_p+Z_t}}{Z_o + \dfrac{2Z_p Z_t}{Z_p+Z_t}} + \dfrac{Z_p Z_t}{Z_p+Z_t} \right\}}{Z_p + \dfrac{2Z_o \dfrac{Z_p Z_t}{Z_p+Z_t}}{Z_o + \dfrac{2Z_p Z_t}{Z_p+Z_t}} + \dfrac{Z_p Z_t}{Z_p+Z_t}}$$

and

$$Z_o = \frac{Z_p Z_t}{Z_p + Z_t}$$

By simultaneous solution, we obtain

$$Z_p = 4Z_t \text{ and } Z_o = \frac{4Z_t}{5}$$

Consideration of the previous circuits leads inevitably to the circuit of Fig. 5, in which a compensating resistor Ξ is included. The circuit is equated to the condition of impedance match, giving

$$\Xi = \Xi_t \text{ and } \Xi_o = \Xi_t$$

The performance obtained from any of these mixer circuits is essentially that obtained when the source under consideration, and its matching transformer T_1, feed the sink through a pad, representing the insertion loss, and the matching transformer T_2. The curves obtained are flat for all sources and good transformers, and therefore, are of insufficient interest to merit printing. Crystal microphones and pickups, velocity and dynamic mikes, amplifiers, remote lines, anything regardless of characteristics, will come through just as well as the transformers permit.

All of the circuits have been shown in the four-channel form to facilitate comparison, simplify equations and meet the dominant need. They are easily adaptable to a different number of channels, but it must be emphatically stated that the proper values for the compensating resistors and load impedance must be computed for each combination.

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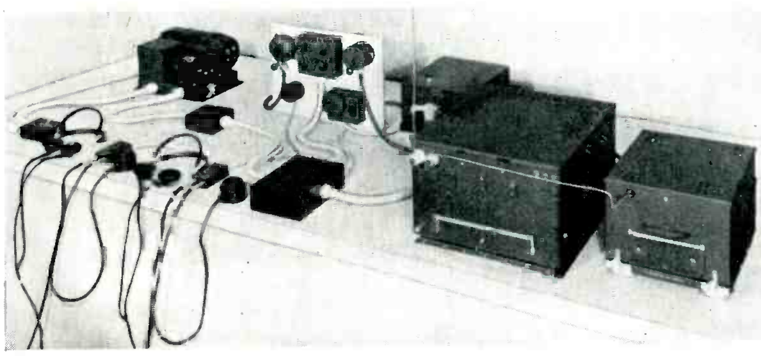
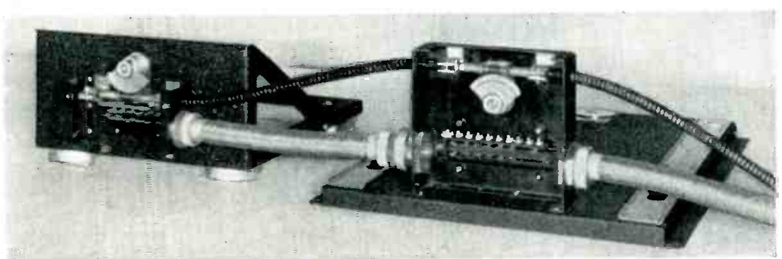


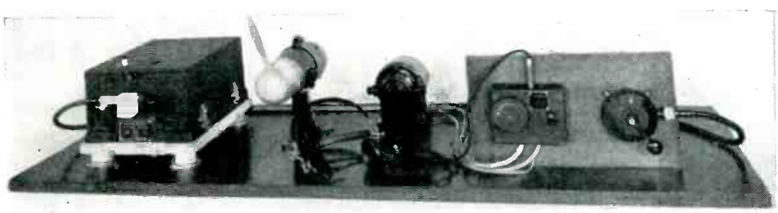
RADIO TELEPHONE EQUIPMENT

Flexible Shafts are used for tuning receiver, transmitter and beacon receiver.



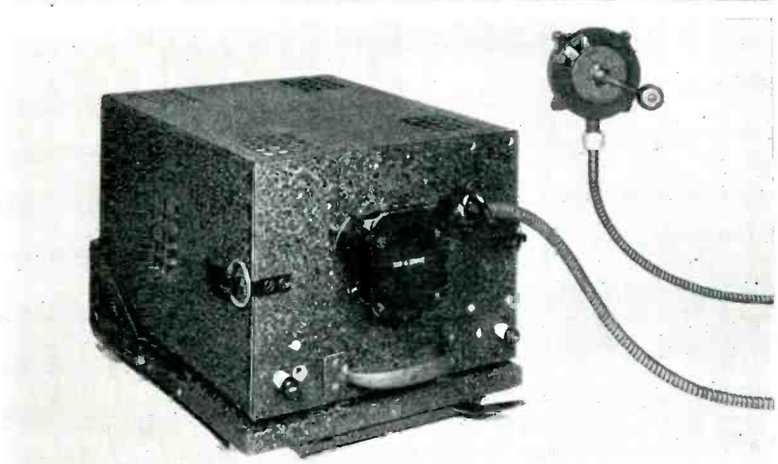
RECEIVER AND TRANSMITTER

Bases of the instruments showing control by main shaft and short coupling shaft.



RADIO RECEIVER

Showing flexible shaft remote tuning control.



RADIO RECEIVER

Another model with flexible shaft remote control.

...We will be glad to supply technical data about our remote control shafting, and assistance in working out applications. Send us details of your problems.

The S.S.WHITE Dental Mfg. Co. INDUSTRIAL DIVISION
10 EAST 40th ST. ROOM 2310 E, NEW YORK, N.Y.

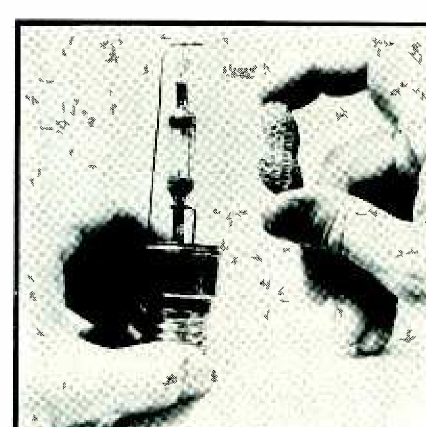
The fact that certain impedances bear a four-to-one ratio in the four-channel device appears to lead many to believe that a six-to-one ratio will be proper in a six-channel mixer, so that computation is unnecessary. The logic of this misconception is not apparent, but it must be scintillating, for it appears often.

The three circuits illustrated are not to be considered a case of needless duplication. For a mixer of four channels, only the one shown in Fig. 5 will permit exact matching with standard transformers, although the others are close enough in this case to require only adjustment of the load of T_2 or the insertion of a matching pad. The circuit which permits the use of standard components is entirely dependent upon the number of channels to be embodied in it, and choice of the proper circuit will be found to be sounder practice than load adjustment or the use of asymmetrical pads. Special cases may require combinations of the fundamental circuits for a satisfactory solution, as, for instance, when the insertion loss is to be kept at a minimum in one or two channels at the expense of the remaining channels. T-pads offer a slight advantage over the ladder type, incidentally.

The insertion losses are normal in a proper design, but one trap awaits the unwary, viz., the possibility of laying out a nicely balanced bridge, with the sink connected at the points of equi-potential. Impedance matching is worthwhile, but infinite insertion loss is disconcerting, to put it mildly.

• • •

PEANUT TUBE



Small bit of mercury in quartz tube forms mans' brightest source of light. A Westinghouse product

Electron Tubes in Diathermy

[*Continued from page 19*]

can be obtained. An important safety feature is that coils cannot be changed until the power output has been reduced to virtually zero. The length of treatment is determined in this equipment, as in some other equipment, by means of an automatic time switch. Since practically the same power output can be obtained for any frequency for which the equipment is designed, it has been possible to provide an output meter calibrated in watts.

Some of the equipment built by the Peerless Laboratories uses a variable condenser for tuning the "patient circuit" to resonance in which the capacitance is varied by changing the spacing of the plates. This has the advantage of providing wide spacing at low capacity where the voltage across the condenser is a maximum, and eliminates troubles from sparkover. Two tubes in a push-pull circuit are used, and an adjustable grid condenser is used to provide proper excitation for both tubes. This adjustment is made at the factory, and the tubes are lettered so that they will be correctly inserted in the proper socket for which this adjustment has been made when the equipment is put into use. As a protection for the tubes, the filament and plate switches are interlocked so that the filaments must be lit before plate voltage can be turned on or off.

Other equipment offers other advantages and points of interest. Some equipment tunes the "patient circuit" to resonance with the oscillator circuit. While this has the advantage of using the generated power most efficiently, many other units seem to get along as well without such a resonance control. As is the case with automobiles and radio receivers, there does not appear to be any one "best" diathermy equipment, except for a particular use and a particular physician, for the advantages of one unit are offset by the equal (even though different) advantages of some other equipment. And, as is the case in purchasing automobiles or radio receivers, the manufacturer's reputation and integrity are the purchaser's best safeguard of satisfactory performance and proper servicing.

In conclusion, it might be interesting to call attention to certain typical diathermy equipment, since it is impossible to list all of the apparatus which is commercially available in this country. The accompanying table indicates the most important characteristics of typical equipment, and has been compiled almost exclusively from catalog data of various manufacturers.—B.D.

Table of Typical High Frequency Diathermy Equipment

Unit	Max. Power Input (watts)	Max. Power Output (watts)	Frequency (megacycles)	Tubes	Weight (lbs.)	Dimensions (in.)	Price (dollars)
1......	2,000	600	50	2 WL-460	90	33×18×16	565
2......	1,500	400	14	2 Osc. 2 Hg. rec.	137	40×21×15	575
3......	700	270	20	2 211-D	55	12×18×13	360
4......	680	300	20	2 FP-197	52	20×12×15	375
5......	200	50	100–75	1 800 1 866	40	23×14×11	320
6......	125	15	110–67	1 RCA-10 1 216-B	11	7×14×9	125
7......	100	10	110–67	1 RCA-10 1 216-B	22	20×9×12	220

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8. "Present Status of Artificial Fever," by Upton Giles, *Arch. of Phys. Ther., X-Ray, and Rad.*, May 1936.

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● You can believe what you actually see—that's why we urge you to send today for the Free Shakeproof Test Ring and discover for yourself why Shakeproof Lock Washers do lock tighter and definitely defy vibration. We want you to particularly notice the exclusive shape of the teeth on each washer. They are twisted and tapered to provide a powerful combination of three vital locking principles, which are: strut-action, a powerful leverage that resists any backward movement of the nut; spring-tension, the force that assures a constantly tight lock; and line-bite, the positive locking action of each tooth—even at initial contact. Shakeproof Lock Washers will prove themselves worthy of being specified for your regular production because they are used on thousands of America's leading metal products and have never failed to give absolute protection against the damaging effects of vibration. Mail the coupon today for your free test ring!

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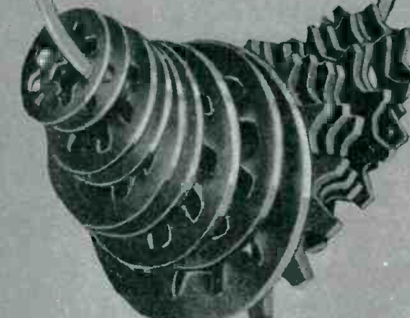
Free TEST RING

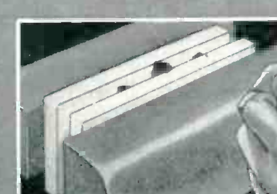


MAKE THIS CONVINCING 3-WAY TEST

STRUT-ACTION

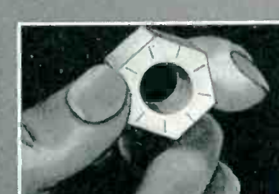
Turn a nut down tight against a Shakeproof Lock Washer—then loosen this nut and, as you push the wrench, feel the powerful resistance set up by the bite of the tapered-twisted teeth—that's Strut-Action!

SPRING-TENSION

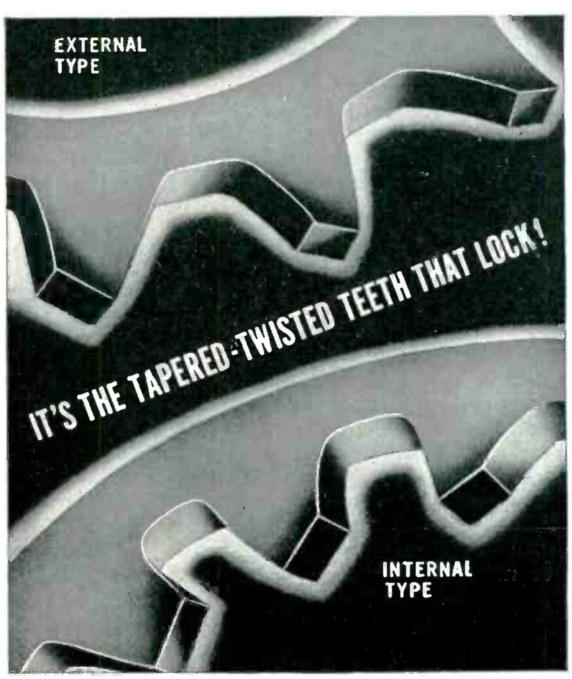


Place a Shakeproof Lock Washer between two pieces of ordinary steel and insert in the jaws of a vise. As you tighten the vise, watch the teeth bite in deeper—keeping the locking action constantly in force—that's Spring-Tension!

LINE-BITE



Examine a nut after it has been locked by a Shakeproof Lock Washer. The marks of the teeth prove Line-Bite!



U. S. Patent Nos.
1,862,486 1,909,476
1,909,477 1,419,564
1,782,387 1,604,122
1,963,800
Other Patents.
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Gentlemen: Send us the FREE Test Ring so that we may test Shakeproof Lock Washers on our own products.

Firm Name ....

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THE ELECTRON ART

PUSH-PULL pentodes for ultra-high frequency operation; and measurements of a-c millivolts, high intensity sound waves and color are in the news this month

Interpreting Oscillogram Patterns

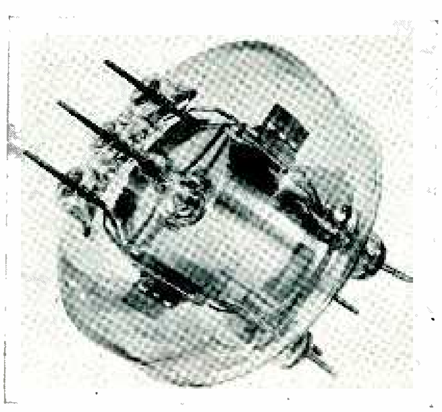
A NUMBER of drawings illustrating the frequency relation between two harmonically related voltages as would appear on the screen of a cathode ray tube are interpreted by Ralph R. Batcher in *Instruments* for September 1936. The importance of the cathode ray tube in electrical analysis makes this a worthwhile article for a good many readers of *Electronics*.

• • •

Pentodes for High Frequency Operation

A NEW VACUUM TUBE of novel construction, and particularly suited for operation at ultra-high frequencies was described at the New York I. R. E. meeting in October by A. L. Samuel and N. E. Sowers of the Bell Telephone Laboratories.

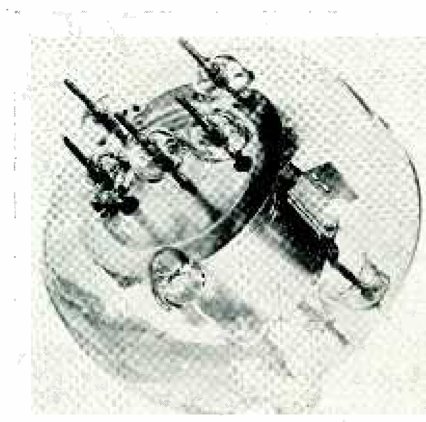
The new tube, known as the Western Electric 240H vacuum tube is, actually, two pentode structures mounted inside the same glass envelope three inches in diameter and two inches long. The elements are connected to the external circuit to form a push-pull arrangement, which, because of the symmetry



The output or plate end of the double pentode. The thorough shielding is accomplished by the metal ribbon cylinder

and tube construction can be used with very short circuit leads. Elaborate provisions have been made for shielding the two sets of elements and the mechanical design is such that the stem leads through the glass envelope are as short and direct as possible. Very small spacing between the elements is provided to assist in the reduction of transit time of flight of electrons, and long insulation paths permit the tube to be used at plate voltages as high as 500 volts.

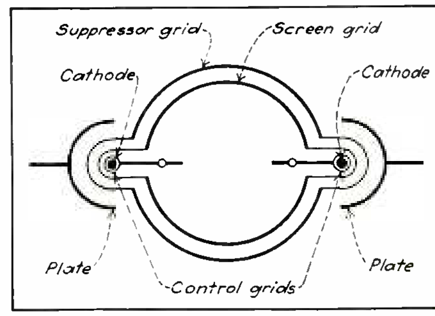
The construction of the 240H tube



The input or control grid end of the tube

is indicated in the cross section diagram. Surrounding the two filimentary cathodes are the two control grid structures whose leads are brought out separately. The screen grids and suppressor grids of both sets of tube elements are common. The sections of these grids which are between the control grid and plate are of course made in the usual wire net or parallel wire grid structure. The remaining portions of these grids are made of solid metal ribbon, as can be seen in the accompanying photographs. To improve shielding, the elements are enclosed at the ends by metal plates which form part of the suppressor grid connection. Leads are brought out through glass stem beads, the circuit connections being attached directly to the lead wires without the use of a socket of any type. This permits the constants of the circuit to be reduced to a minimum. The input and output terminals of the tube are on opposite sides of the "pancake" so that the associated circuit elements can be placed in such a manner as to minimize feedback.

According to Arthur L. Samuel, the tube has an input resistance of 30,000 ohms at 150 megacycles, as compared to 1,000 ohms for a typical tube of the conventional type. At 300 megacycles, the input resistance of the 240H tube is still above 5,000 ohms, and conven-



Section through the middle of the push-pull pentodes

tional tubes are inoperative at this frequency. When operating as a class A amplifier at 150 mc. an output of one watt is obtained. Under these conditions the distortion (largely third harmonic) is 40 decibels below the fundamental. Under these conditions, the stage gain is 20 db. When used as a class B amplifier, outputs of 10 watts are obtainable with a plate efficiency of 60 to 70 per cent.

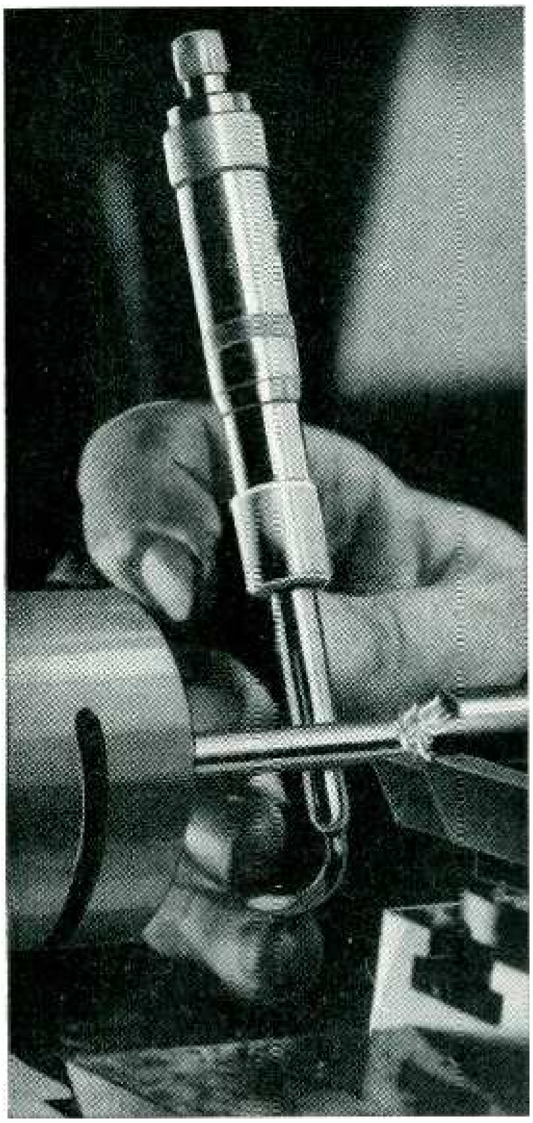
• • •

Spectrophotometer for Rapid Tests of Color

THE SEPTEMBER 1935 issue of the *General Electric Review* contains an article entitled "A New Spectrophotometer and Some of Its Applications" by J. L. Michelson and H. A. Liebhafsky. The spectrophotometer described in this article was developed by A. C. Hardy, Professor of Optics and Photography at M.I.T.

The principal advantages of this "color analyzer" (which was described in detail in the March 1936 issue of *Electronics*) are that it is independent of the characteristics of the light source, phototube, prisms, and all but one of the numerous lenses employed so that its overall precision is quite high, measurements of reflected or transmitted light can be made, and a complete and permanent record of the entire transmission curve for each determination can be made in only a few minutes.

The spectrophotometer is being applied in research and industry to determine accurately and quickly the color permanence of organic finishes, the opacity and reflectivity of vitreous enamels in order to discover the best and most economical constituents, the colorimetric determination of chemical substances, and a wide variety of other problems which are arising daily.



RIGHT

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Evolution of the Direct Current Amplifier

OVER FIFTY ARTICLES on the amplification of direct currents have appeared within the last three years, and two recent reviews (F. Muller and W. Durichen in *Z. Elektroch.* 42:31–43. 1936, P. A. Macdonald in *Physics* 7:265–294. 1936) deal with the progress accomplished in this period.

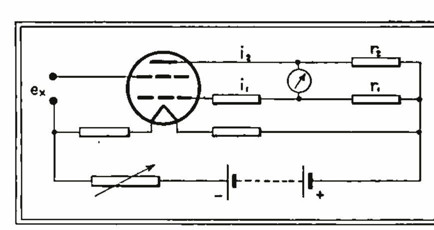
The voltage to be measured is applied between grid and filament of a vacuum tube, the current to be determined is sent across a resistance r placed between grid and filament. In radio receiving tubes, however, the grid current drifts, the best tubes showing a fairly constant drift of one microvolt per second, at least after the first 15 or 30 minutes, the larger number of tubes giving an irregular change.

When, therefore, currents of the order of 10^{-12} amp. have to be measured, the special low voltage, space charge grid tubes, of which the FP 54 of the G. E. Co. was the model, have to be resorted to.

Direct current amplifying tubes
(Electrometer tubes)

	A Volts	SG	B	L_A mA	K_m μA/volt
FP 54 G. E. Co.	2.5	4	6	90	25
T 114 (Germany)	2	4	6	80	30
L. St. R II (Austria)	2.5	4	6	130	30
D. 96475 (W. El.)	1.0	4	4	270	30

The constants of these tubes as developed in various countries lie within narrow limits. Since the grid current consists of various fractions: an electron current, an ionization current, an ion current from the filament, a photo electric current from the grid, an electron current due to soft x-rays from the plate, there is indeed only one way to putting it under more accurate control, the reduction of the filament temperature and of the potentials of the electrodes. Unfortunately this re-

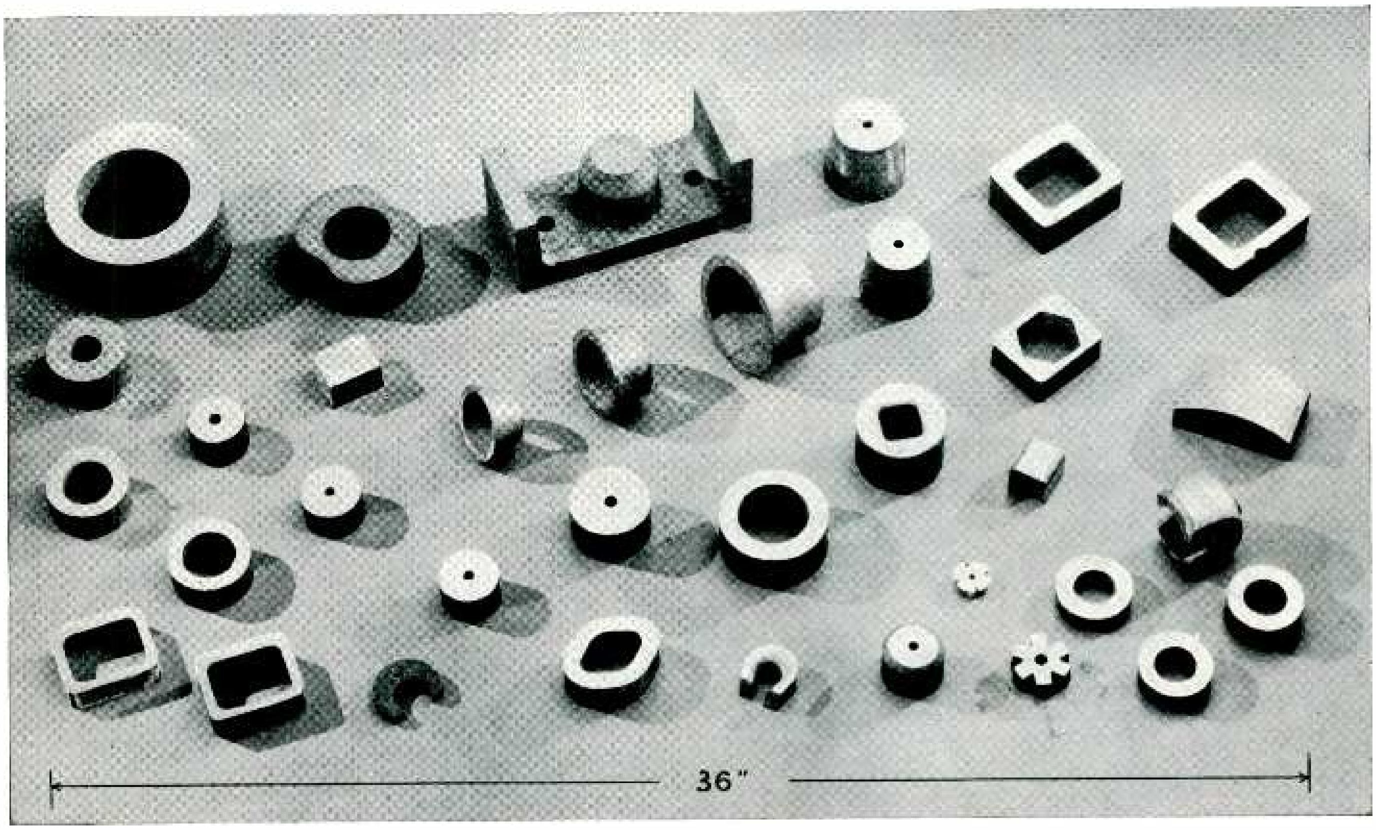


duction brings with it a low mutual conductance Km (indicated in the last column of the table in microamp. per volt), about 30 microamp. per volt, and less, K_{em}, when a load is placed in the plate circuit. The voltage sensitivity (divisions per volt) is

$$S = K_{em}\, s,$$

when s is the sensitivity of the galvanometer used, expressed in divisions per amp. The indicating instrument must thus possess a sensitivity of at least 1/100 microamp. per scale division or 108 divisions per amp if the unknown

What can we do for YOU?*



Made for leading manufacturers of Loud Speakers and Electrical Instruments, these are some of the various forms of

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which we are producing in large volume. Engineering and design suggestions or specifications for cast permanent magnets furnished on request. Quick deliveries in any desired quantities.

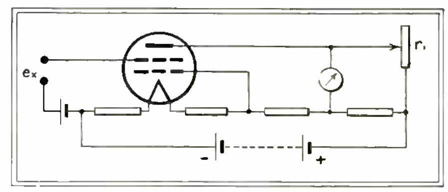
*For instance, auto radio speakers equipped with "Little Giant" Cast Permanent Magnets cut down current consumption—save battery drain.

CRUCIBLE STEEL COMPANY of AMERICA

General Offices: Chrysler Building, New York voltage is to be measured to within one millivolt. The current sensitivity is r times the voltage sensitivity when grid conductance is negligible.

Since it is always advisable to reduce the initial current to zero, by means of an opposing e.m.f. in the plate circuit, bridge circuits in which one or two arms are formed by the resistances between the electrodes in one or two tubes may be used quite naturally in place of the circuits in which the amplified current is measured by an indicating instrument in the plate circuit.

Regardless of the circuit used the zero may shift owing to changes in the emission and structure of the filament, in the heating current and in the potentials applied to the electrodes. These changes may be quite unrelated unless all the potentials are taken from the same potentiometer, the correct value being obtained by resistance placed in the leads to the various electrodes. When properly placed the resistances alone tend to maintain a stable zero. The potentiometer consists of the filament circuit with one resistance, or several resistances, inserted in both leads. Since, moreover, in space charge tubes one portion i, of the current decreasing with increasing potential C of the control grid, goes to



the positive grid, while the main portion, i_2, which increases with increasing C, goes to the plate, two arms of a Wheatstone bridge are naturally present in the tube. Two ohmic resistances r_1 and x_2 and the galvanometer complete the bridge. At the point at which r_1 and r_2 are in the same ratio as the slight increases produced in the screen and plate current caused by a slight increase in the heating current, the galvanometer reading is independent of the heating current.

A drawback of the bridge circuit with one tube is the different nature of the circuits in the bridge. When using two electrometer tubes in two arms of the bridge and one potentiometer, an operating point may be found which is nearly independent of changes in both filament current and plate potential. The influence of the drift of the galvanometer and the difference in grid and plate potential at different points of the filament is now being studied.

An irregular grid potential fluctuation of the order of 10^{-4} volt is suppressed by placing the tube and grid system in an evacuated container. Fluctuations due to the shot effect amount to 7×10^{-5} volt in the grid potential.

For currents above 10^{-12} amp. the UX 222 or GE 232 are satisfactory.

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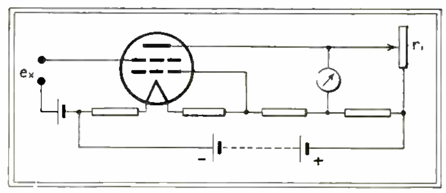

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For currents above 10^{-12} amp. the UX 222 or GE 232 are satisfactory.

"brannon" calls in Parker-Kalon Assembly Engineer

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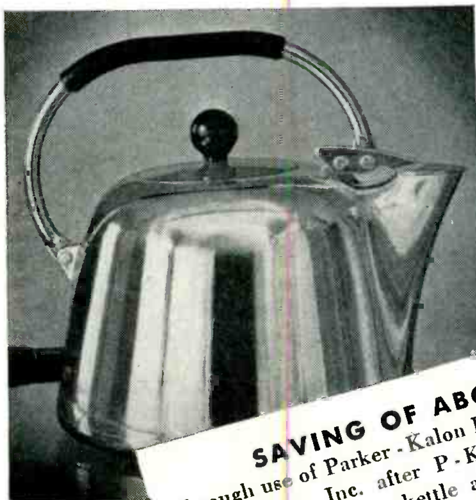
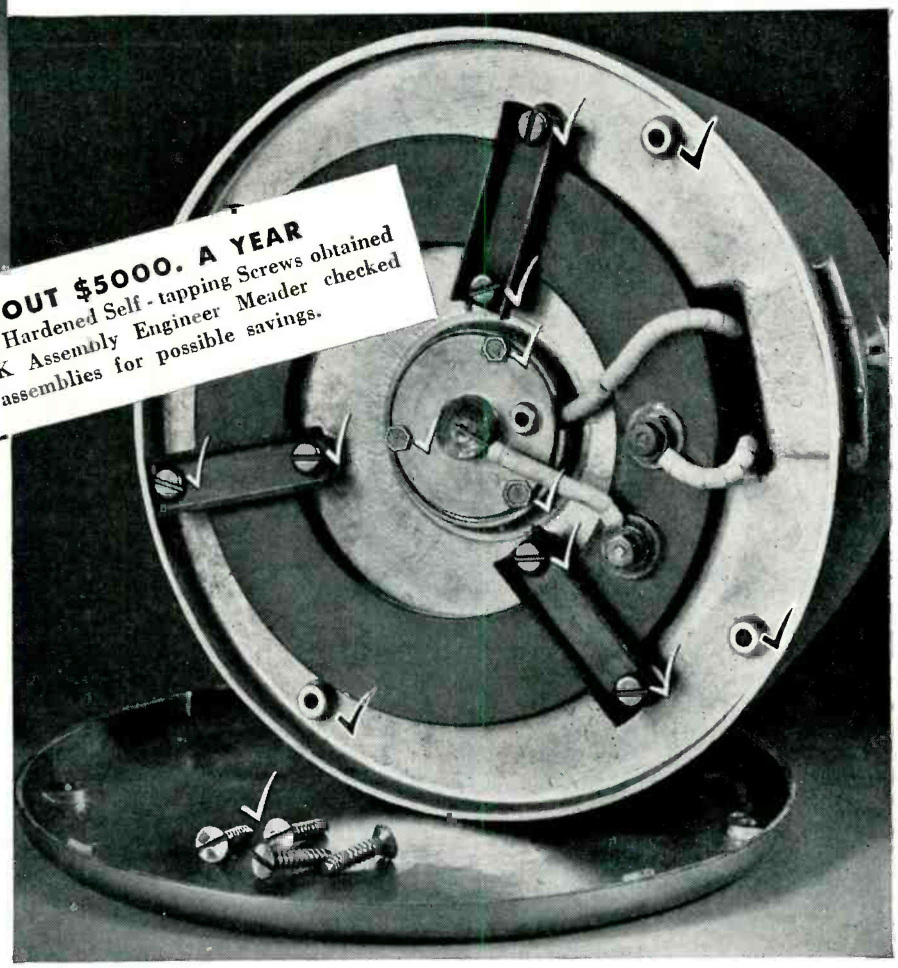
— makes it Better, too





SAVING OF ABOUT $5000. A YEAR
through use of Parker-Kalon Hardened Self-tapping Screws obtained by Brannon, Inc. after P-K Assembly Engineer Meader checked electric tea kettle assemblies for possible savings.

IN attaching the electrical units and fastening the base to the cast aluminum "Brannon Hot-Water-Master", assembly difficulties were encountered which are common where machine screws are used in comparatively shallow and blind holes. Tap breakage was high . . . parts and material too frequently became damaged . . . assembly work had to be done carefully and slowly . . . fastenings lacked holding power, particularly after being removed and replaced a few times.

Many concerns "put-up-with" such troubles, feeling that they are unavoidable. But Brannon, Inc. invited Parker-Kalon Assembly Engineer Meader to go over the assemblies and see whether Parker-Kalon Hardened Self-tapping Screws could be used to eliminate the trouble and bring down costs. The result of Mr. Meader's call paid Brannon well for the effort. It was found that the Hardened Self-tapping Screws . . . easily substituted for machine screws . . . would save from six to seven cents on each kettle, or about $5000. a year. Also, that the fastenings made this modern, simpler way, without tapping or other ordinary difficulties, were actually stronger and unimpaired by repeated disassembly.

Have a P-K Assembly Engineer make a study of your fastenings

On your own metal or plastic fastenings the chances are 7 out of 10 that you could use the specialized knowledge of a Parker-Kalon Assembly Engineer to advantage. Your invitation will bring one of these practical men to consult with you and determine whether you are missing economies which Hardened Self-tapping Screws could effect. His function is service . . . he sells nothing. Write us and we'll schedule a visit at your plant.

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WPA Interference Project

An unusual Works Progress Administration project which has for its purpose the conducting of a survey to locate causes of interference with radio reception has recently been initiated in Newark. The project is financed jointly by the Federal Works Progress Administration and the City of Newark, and will give employment to 45 men and one woman, according to a recent news release of the WPA Information Service.

Those working on the project will be divided into three divisions, an administrative, drafting, and secretarial staff, a field party of five groups of three men each who will spend their time locating the center of radio disturbances, and another field party of fifteen men who will determine the causes of the radio interference.

The field party whose function it is to locate the interference, popularly called "radio detectives" are equipped with ordinary receiving sets operating from loop antennas. The sets are portable, equipped with a headset, and have a volume control and indicating meter which gives an indication of the field strength of the desired signal or the interfering noise. The men in this party will make a complete tour of Essex County, noting all sources of interference. Their findings will be indicated on a type of field strength map which will serve to enable the second field group to determine specifically the cause for the interference.

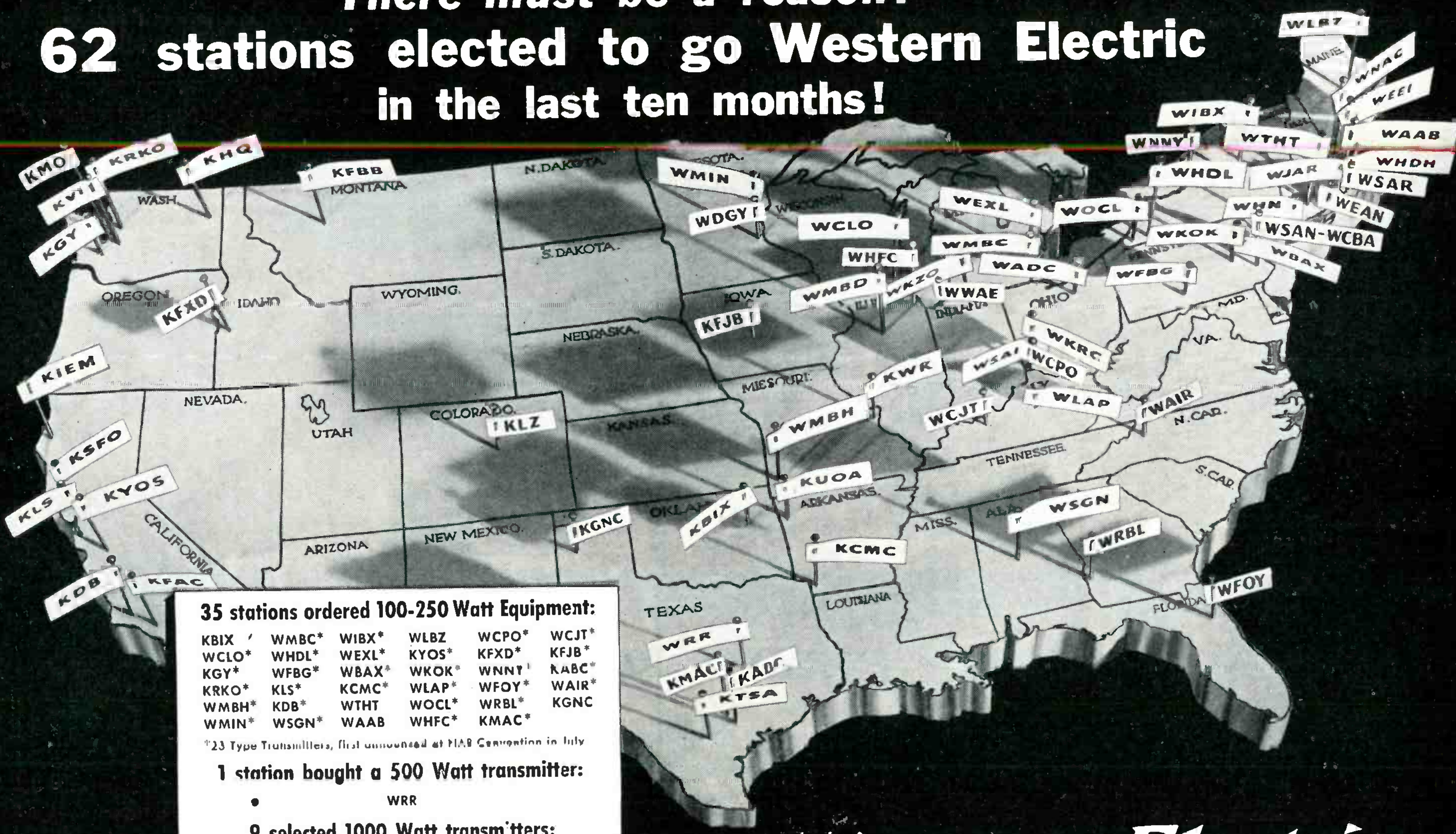
It is the function of this second group to locate specifically the interfering causes, to obtain the necessary co-operation to remedy any existing defects in equipment producing interference, to lend any assistance or make any recommendations which may aid in reducing interference, or, as a last resort, to turn over their findings for whatever legal action may be necessary.

The persons employed for this project will be those who have licenses issued by the Federal Communications Commission, or, in some cases who qualify as electrical engineers, and the survey will be made to detect interference of any kind with radio reception, particularly with short wave police radio communication systems in Essex County. With the growth of radio police systems it is essential that a survey of this type be undertaken so that the proper expansion of police radio facilities may be provided for.

According to information obtained through Public Safety Director Michael P. Duffy, who initiated the project, the organization of personnel and the construction of equipment was well under way by the middle of October. It is estimated that the project will take about six months to complete, and will cost $23,375 of which the city of Newark is contributing $1,942 and the Federal Government the remainder.

There must be a reason!

62 stations elected to go Western Electric in the last ten months!



35 stations ordered 100-250 Watt Equipment:

KBIX	WMBC*	WIBX*	WLBZ	WCPO*	WCJT*
WCLO*	WHDL*	WEXL*	KYOS*	KFXD*	KFJB*
KGY*	WFBG*	WBAX*	WKOK*	WNNY	KABC*
KRKO*	KLS*	KCMC*	WLAP*	WFOY*	WAIR*
WMBH*	KDB*	WTHT	WOCL*	WRBL*	KGNC
WMIN*	WSGN*	WAAB	WHFC*	KMAC*	

*23 Type Transmitters, first announced at NAB Convention in July

1 station bought a 500 Watt transmitter:

WRR

9 selected 1000 Watt transmitters:

KIEM	WMBD	WKZO	WSAR	WSAN
WHDH	WEAN	KFAC	KMO	WCBA

17 stations ordered 5000 Watt installations:

WHN	KVI	WKRC	KHQ	WNAC	WWAE
WSAI	KTSA	WEEI	WJAR	WADC	KLZ
KFBB	KUOA	KSFO	KWK	WDGY	

Western Electric

Distributed by GRAYBAR Electric Co. In Canada: Northern Electric Co., Ltd.

RADIO TELEPHONE BROADCASTING EQUIPMENT

MANUFACTURING REVIEW

News

✦ **Bruno Lange**, well known for his research in light sensitive surfaces and apparatus using photocells paid a visit to this country in October, bringing with him a complete display of the equipment he has built around his "blocking layer" cells. The equipment included the cells themselves, a colorimeter, photoelectric relays, illumination meters, photo-micrographic exposure meters. These instruments can be seen at his American Agents, **Pfaltz & Bauer**, 300 Pearl St., N. Y. City.

✦ **Triad Manufacturing Co., Inc.**, Pawtucket, R. I., announces that Harry H. Steinle has again joined that organization, as vice-president and director of sales.

✦ **Dr. C. F. Burgess**, president of the Burgess Battery Co., Chicago, announces the purchase of the controlling interest in the Thordarson Electric Mfg. Co., of Chicago. The company will continue the manufacture of transformers. **C. H. Thordarson**, founder of the company, is president, and **Jackson Burgess**, vice-president. This arrangement will free Dr. Burgess and Mr. Thordarson for research.

✦ **Rocke International Electric Corp.**, 100 Varick Street, N. Y. C., announces the formation of the U. S. Transmitter Corp. to manufacture all types of communication apparatus. **A. Pleasanton**, formerly of Marine Radio Co. is plant manager and **Frank Edmonds**, formerly of Meissner and United Transformer Corp. is chief engineer.

✦ **Leeds & Northrup Company** has just opened a new sales and service office at Boston, staffed for consulting and sales engineering service to the industry. This new office is located at 422 Chamber of Commerce Building, 80 Federal Street, Boston, Mass.

✦ **Cutler-Hammer, Inc.**, have recently extended their manufacturing facilities to the West Coast with the installation of a plant at 970 Folsom Street, San Francisco, California.

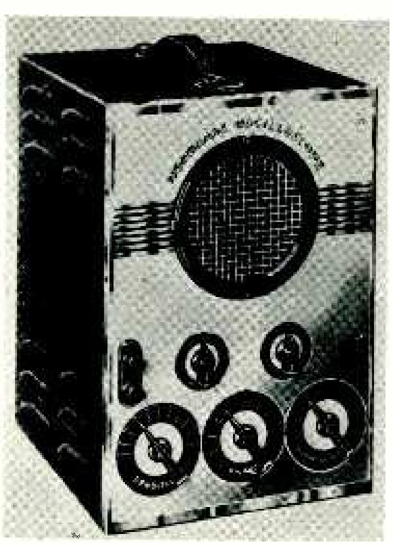
✦ **Continental Motors Corporation**, Detroit, Michigan, announces the appointment of **Mr. John J. Kopple**, 60 E. 42nd St., N. Y. City as Eastern Sales representative.

✦ **Linde Air Products Company** announces the opening of a new district office at 2 Virginia Street, Charleston, West Virginia. **Mr. A. R. O'Neal** has been appointed district manager.

✦ **L. S. Brach Mfg. Corp.** has formed the Lynch Division of their organization, the result of the consolidation of that company with the Arthur H. Lynch organization. Mr. Lynch will join the Brach company in an advisory capacity and Lynch products will be merchandised through the Lynch division of L. S. Brach.

✦ **L. A. Meyerson**, former president of the Morlen Electric Co., Inc., has organized the Electric Amplifier Corp., at 135 W. 25th St., N. Y. C.

New Products



Oscilloscope

A NEW ELECTRONIC measuring device using a gaseous discharge tube to make sound visible has been developed by Sundt Engineering Co., 42-38 Lincoln Ave., Chicago, Ill. The wave pattern is traced on a four inch calibrated screen. The tube used measures 6 inches long and ½ inch in diameter. Filled with neon gas, it has two electrodes 2 in. long by 1/16 in. diameter, set at each end of the tube so as to develop a four inch image. A power generator keeps the tube ignited. Input potentials are amplified and impressed on the power generator. This fluctuating power corresponds to the vertical reflection of the wave pattern. A sweep system is provided by reflecting the image onto a revolving mirror. One microvolt input produces full scale deflection. Price $40.00.

I-f Transformer

THE LATEST ALADDIN POLYIRON core i-f transformer, the Model L series, has been designed to meet these requirements: Stability secured through limiting and selecting the various materials comprising the device. The fundamental change involved is the substitution of iron core tuning. Economy, an important feature, is achieved by careful arrangement of parts. The manufacturer reports that preliminary tests show this device to be adequate to meet service stability requirements in the field. Aladdin Radio Industries, Inc., 466 W. Superior St., Chicago, Ill.

Storage Battery Eliminator

RECENTLY INTRODUCED by the Electrical Products Company, Detroit, Mich., this eliminator provides a 6 volt — 10 amp. filtered direct current from 110 volt alternating current. It is specially designed for laboratory tests, demonstrating 6 volt auto radios and operating small d-c motors, magnets, solenoids, relays and similar apparatus. This eliminator is also made in a model having a 6 volt — 5 ampere output.

Time-tested Dependability

for
METERS . . . INSTRUMENTS, AMPLIFIERS, *etc., that must be* **PERFECT** *in* **EVERY DETAIL**

Note the variety of terminals:
GRID LEAK TYPE
WIRE LEAD TYPE
SOLDERING LUG TYPE

IRC
REG. U.S. PAT. OFF.
Initiative—Resourcefulness—Cooperation to advance the interests of the industry

PRECISION
WIRE WOUND
RESISTORS

NON-INDUCTIVE OR INDUCTIVE WINDINGS
•
PERMANENTLY LOW NOISE LEVEL
•
LONGER LIFE
•
GREATER STABILITY
•
AS ACCURATE AS 1/10 OF 1%

Engineers agree that design and attention to every construction detail are of paramount importance in the making of resistors of a high order of accuracy. That is why, for many years, IRC Precision Wire Wound Resistors have been first choice of discriminating users. Only the highest grade wire, insulation and ceramics are employed in their manufacture. Production is laboratory controlled from beginning to end. Extreme care in details such as wire strain, insulation strain, coefficient of expansion of materials, and perfect balancing of wire per section guards against the weaknesses of ordinary resistors. Moreover, three separate and detailed production tests further insure the utmost in accuracy, durability and long life for each unit.

Write for the IRC Resistor Catalog containing full details.

INTERNATIONAL RESISTANCE COMPANY
401 NORTH BROAD STREET, PHILADELPHIA, PA.
Factories or Licensees in Canada, England, France, Germany, Italy, Denmark and Australia
MAKERS OF RESISTANCE UNITS OF MORE TYPES, IN MORE SHAPES, FOR MORE APPLICATIONS THAN ANY OTHER MANUFACTURER IN THE WORLD

Literature

✦ **Switches.** Catalog of Selector switches for use in replacement and in experimental field. Also includes description of midget replacement controls. A bulletin devoted to the Centralab Switchkit will be available shortly. Centralab, 900 E. Keefe Ave., Milwaukee, Wis.

✦ **Electro-dynamic Microphone.** A pamphlet issued by Transducer Corporation, 30 Rockefeller Plaza, N. Y. City, describing their new product, an electro-dynamic microphone and its characteristics.

✦ **Electronic Tubes.** Information Bulletin on the Westinghouse Sterlilamp, Type WL-782. Description of device, uses, operation and characteristics. Westinghouse Lamp Co., Bloomfield, N. J.

✦ **Electrical Review.** The first issue of Allis-Chalmers Electrical Review, published quarterly by that organization, contains articles of interest to the electrical industry, written by men whose opinions are valued by that industry. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

✦ **Sound Manual.** A book of facts on amplifiers, sound systems and centralized radio by Radio Receptor Co., Inc., 106 Seventh Ave., New York City.

✦ **Radio Products.** A catalog illustrating and describing numerous component parts used in amateur rigs, in repair and service work on broadcasting meters and in the assembly of public address equipment. Bud Radio, Inc., 1937 E. 55th St., Cleveland, Ohio.

✦ **Little Giant Magnets.** Crucible Steel Company's pamphlet on "Alnico" and "Alnic", its newest magnetic alloys. Describes the little giant magnets, and gives demagnetization and energy curves of various magnet materials.

✦ **"Bakelite Molded."** The seventh edition of "Bakelite Molded," published by Bakelite Corporation, 247 Park Ave., N. Y. City, contains detailed descriptions of this product, its characteristics, properties and applications in various fields of industry.

✦ **Engineering Bulletin.** Bulletin entitled "616 Operation Data Showing Effects of Power Supply Regulation," released by Ken-Rad Tube and Lamp Corp., Owensboro, Ky., of value to radio engineers, technicians and servicemen. Available on request.

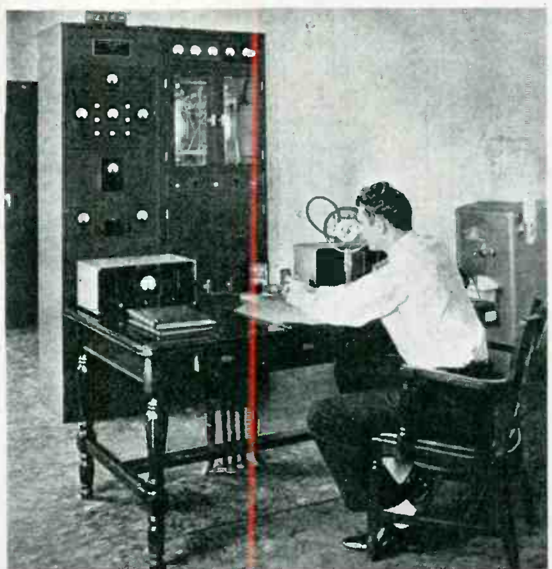
✦ **Permanent Magnet Speaker.** Perm-o-Flux a permanent magnet dynamic speaker described in a three-fold pamphlet. Continental Motors Corp., 12801 East Jefferson Ave., Detroit, Mich.

FROM

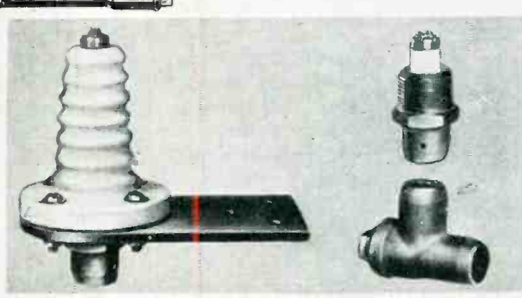
TRANSMITTER

TO *Antenna*

A Complete Installation with ISOLANTITE COAXIAL TRANSMISSION LINE



WESTERN ELECTRIC ultra high frequency Police Radio Transmitter, Station W2XEM, Newark, N. J.



National Newark and Essex Bank Building. Showing location of transmitter and antenna connected by ISOLANTITE COAXIAL TRANSMISSION LINE.

In the rapidly developing technique of radio communication engineers recognize the coaxial transmission line as the most efficient means of conducting radio frequency energy from point to point and from transmitter to antenna.

ISOLANTITE INC. has been closely identified with this development and now announces A COMPLETE COAXIAL TRANSMISSION LINE SYSTEM for ultra high frequency and broadcasting stations.

Write for our complete bulletin on this product. ISOLANTITE INC., 233 Broadway, N. Y. C. Factory at Belleville, N. J.

Sold only through Graybar Electric Company and Manufacturers of transmitting equipment

Isolantite
CERAMIC INSULATORS

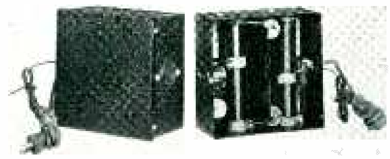
Artificial Ear

Two ASSEMBLIES incorporating the Type 501 artificial ear coupler and associated amplifier have been developed by the Ballantine Laboratories, Inc., Boonton, New Jersey, and are now commercially available. The artificial ear is a physical model of the human ear, simulating its acoustical properties. The conical cavity of the artificial ear simulates the volume of the auricula, or external ear; this is moulded of pure gum rubber, which simulates the elasticity of the ear muscle and aids in obtaining a tight seal with the telephone ear cap. The ear canal is simulated by a canal which is terminated by the diaphragm of a small condenser microphone and a diaphragm, representing the ear drum. Extending behind the drum is a duct connecting to

a coiled pipe about 10 feet in length. This pipe is progressively damped and presents a pure acoustic resistance which, acting upon the rear of the drum, represents the average damping in the human ear. The leak represented in the artificial ear, which may be opened by removing a screw, represents the average leakage between the shell of the ear and the receiver cap which occurs when the receiver is normally held against the ear. The acoustical performance of the telephone receiver is measured in terms of the acoustical pressure, developed at the ear drum. This is measured in the artificial ear by a condenser microphone of special design. The output of the microphone after amplification and rectification, actuates a d-c micrometer, calibrated directly in bars and decibels. The condenser microphone is so designed as to make possible the direct calibration of the output meter in bars. One assembly, Type 502 B, comprises the artificial ear, amplifier, equalizer, rectifier and output meter; also the calibration network. Type 502 A, illustrated, comprises an a-c voltmeter, in addition to those in the 502 B. This is convenient in receiver testing. Both types of equipment require an A source of 6.3 volts, 3 amperes d.c. and two separate B sources, each of 10 and 180 volts. Type 502 A lists at $1685, including voltmeter; Type 502 B, without voltmeter, $1440.

Filter

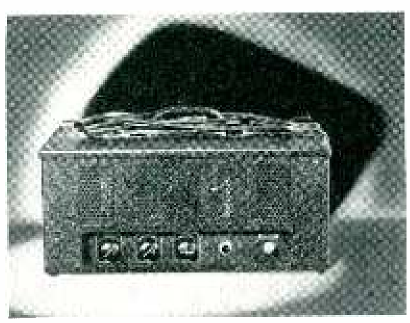
A NEW LINE FILTER to go between a radio receiver and its source of a.c. supply has been designed by McMurdo Silver and is now ready for the market. It is to keep out of the radio, noises which are produced somewhere



on the line. The device is a 4-section filter, has the dimensions of 6 inches square by 3 inches deep, weighs about 2½ pounds, lists at $12. McMurdo Silver Corp., 3354 N. Paulina St., Chicago, Ill.

A-c Operated Microphone Pre-amplifier

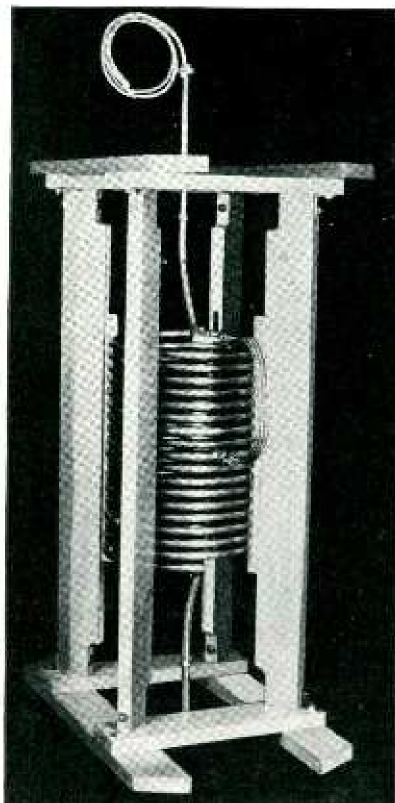
OPERADIO MANUFACTURING CO., St. Charles, Ill., offers a microphone pre-amplifier to mix two microphones of either the velocity or grille type of crystal. It has an overall gain of 65 db. and incorporates electronic mixer and tone control for shading. Two of



these may be used together to form a four-position electronic mixer and pre-amplifier. This is a two stage amplifier with the first stage tubes mounted on cushioned mountings to decrease microphonics. It is provided with a steel case for plug-in connections.

Tobe Windo-pole Antenna

A NEW POLE type antenna, recently patented, is announced by Tobe Deutschmann Corporation, Canton, Mass. This antenna can be readily mounted at 45 degrees, or horizontal to any window sash or sill. Is eight feet when extended and provides ample pickup with modern receiver. It can be located in a noise-free area, resulting in a superior signal to noise ratio. This device is supplied complete with insulated mounting bracket and lead-in strip.



Antenna loading inductor, with tower lighting wires drawn through tubing. Mycalex insulated, mounted in a large weatherproof copper can.

Where to Buy It?

. . . often a puzzling question, to buyers of parts for electronic applications. It has ceased to be so for a great many station engineers, who have learned to come to Johnson for standard and special inductors, fixed and variable air condensers, and a whole host of devices down to the tiniest insulators.

For in coming to Johnson, they get just what they want, built to a high standard of quality, promptly, and at a fair price—all combined with a certain "know-how" that spells SATISFACTION.

Johnson Transmitting Tube Sockets include types for nearly all air-cooled tubes. Catalog on these and other standard parts free on request. We solicit inquiries on special equipment.

E·F·JOHNSON·COMPANY

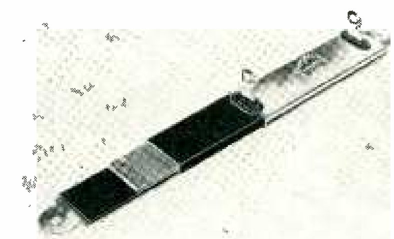
MANUFACTURERS OF *Radio Transmitting Equipment*

WASECA MINNESOTA U·S·A

EXPORT OFFICE—25 Warren St., New York, N. Y.
Cable Address, "SIMONTRICE" N. Y.

Molded-seal Armored Resistors

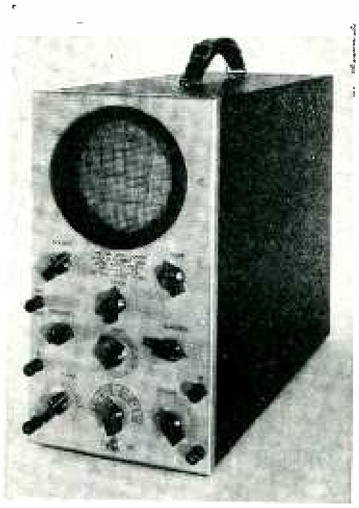
COMBINING THE ADVANTAGE of Bakelite Molded insulation with those of the usual metal jacket, the new Clarostat Series MR wire wound metal-clad resistors are ready for market. The resistance element is fully imbedded in Bakelite insulation molded within the metal jacket. Turns cannot slip.



Moisture cannot reach winding. No leakage. No electrolysis. No air pockets to cause hot spots. Units rated at 5 watts per winding inch when mounted flush on metal radiating surface. Safe overload of 100%. In free air, wattage per winding inch is 2½ watts. Units available in wide range of resistance values, any number of taps, and in lengths up to 10 inches by 13/16 inch wide by ¼ inch thick. Higher operating wattages, made possible by unique construction, mean units half as long as the plain metal-clad resistors heretofore avaliable. Or for the same length, double the wattage.

Announcing!

AN IMPROVED CATHODE RAY TUBE FOR THE DU MONT MODEL 148 OSCILLOGRAPH



Type 148 Oscillograph list price with 5" tube—$106 50

A number of important advances have been made in Du Mont Cathode Ray tubes enabling a greater detail of pattern and uniformity of focus than was previously possible.

These improvements have been accomplished by means of a radical change in the electron lens focus elements making it possible to obtain a much finer trace. The addition of an auxiliary collector and accelerating electrode serves to eliminate errors caused by electrostatic charges on the bulb at the same time provides uniform focus and sensitivity by projecting the electron beam towards the screen at uniform velocity after it has passed thru the deflection plates.

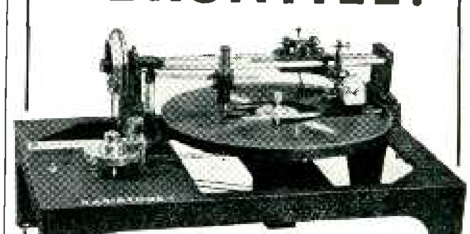
The same high intensity and long life characteristics of Du Mont tubes, as proven in service, have been maintained.

These tubes are also available for use in the Du Mont Type 154 three inch and type 158 nine inch cathode ray oscillographs.

ALLEN B. DU MONT LABORATORIES, INC.

UPPER MONTCLAIR, N. J.
Cable address—New York WESPEXLIN

VERSATILE!



Self-starting synchronous motor, absolute constant speed, quick change from 78 to 33 1/3 speed.

The Radiotone A-16 Studio Recorder will cut 100 or 120 lines per inch, will handle 78 RPM phonograph recording and 33 1-3 RPM electrical transcription use, will record from the inside out or the outside in, has full adjustment for stylus angle and tension. These features mean: EFFICIENCY, ECONOMY, RESULTS! Write Radiotone Recording Co., 6103A Melrose Ave., Hollywood, Calif., for full information.

RADIOTONE PROFESSIONAL RECORDER

Mycalex Sockets

A COMPLETE LINE of Mycalex radio tube sockets is being manufactured by the American Radio Hardware Co., Inc., 476 Broadway, New York. The exceedingly desirable characteristics of

Mycalex at ultra high frequencies makes this dielectric material particularly suitable for use in sockets and other r.f. circuit components. The illustration shows a transmitting tube socket designed for the 204A, 849, 869 and 831 tubes. Large contact area of the terminals combined with their spring action and locking features insures positive tube connections.

In the socket designed for the RCA-803 and RK-28 tubes the dielectric is Mycalex to which is securely mounted heavy re-enforced side wiping contacts.

In addition to the above described sockets, the line also includes Mycalex sockets for the usual glass envelope type of tubes.

Oscillograph

USING A 9-inch tube, type 158 oscillograph of the Allen B. DuMont Laboratories, Inc., makes it possible for laboratory workers to observe the trace at distances up to 40 feet. Two power supplies are furnished; it has linear sweep circuit permitting the observation of waves from 10 to 500,000 cycles. It is a-c operated and consumes 80 watts.

Three new DuMont cathode ray tubes are also available, with improved gun structure and a collector electrode between deflection plates and screen. Code numbers are 34-XH; 54-XH and 94-XH, indicating 3, 5 and 9 inch screens.

Auto Radio Gas Tube Rectifier

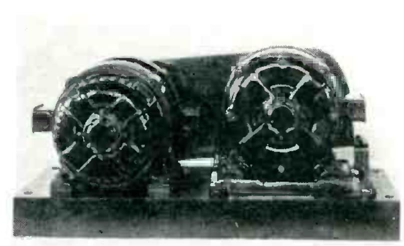
RAYTHEON PRODUCTION, INC., Newton, Mass., announce a new and interesting rectifier for use in automobile radio receivers. This is a full-wave, gas-filled tube of very small dimensions fitted for auto radio, where size counts.

It is known as the OZ47 and the characteristics are given in the table below. The illustration shows the actual size of the tube.

DC Voltage Output	300 max.	Volts
DC Output Current	30 min.	m.a.
	75 max.	m.a.
Peak Plate Current	200 max.	m.a.
Starting Voltage	300 min.	V. (peak)
Voltage Drop (Dynamic)	24 avg.	Volts

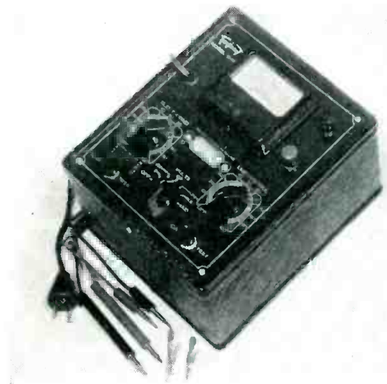
Frequency Changer Set

The Electric Specialty Company, of Stamford, Connecticut, has developed a line of frequency changing motor generators which operate from the 60 cycle supply lines and provide 800 cycles or any other high frequency alternating current for use on the planes. These frequency changers are available in a variety of sizes and ratings which have been designed especially for airport use. Motor generators with direct current motors and with 25, 40, or 50 cycle motors are also available. Only non-corrodible parts are used, the machines are especially insulated for use in the tropics and are designed to operate satisfactorily in the high temperature encountered in the southern part of this country, and Central or South America.



Condenser Tester

MODEL 1240 master condenser is the newest addition to the Triplett line. Results of all tests are read directly on the 3-in. instrument dial. Open condensers and those having high resistance leakages can be determined



with certainty. Available in a.c. and d.c. voltages for breakdown tests up to 1,000 volts, in steps of 20, 60, 200, 600 and 1,000. For the capacity test, accuracy is maintained by a line voltage indicator shadow type. Ranges of the instrument are as follows: Scale A, .1 to 10 mfd.; Scale B, .01 to .6 mfd.; Scale C, .0001 to .05 mfd. There is also a good-bad scale for electrolytics. Triplett Electrical Instrument Co., Bluffton, Ohio.

Literature

✦ **Oscillator Tubes.** A 4-page folder with tube characteristics and performance data of the "United" diathermy tubes. United Electronics Co., 42 Spring St., Newark, N. J.

✦ **Sound Amplifying Devices.** Catalog B-21 published by the Gates Radio & Supply Co., of Quincy, Ill. deals with speech input equipment, remote control apparatus, recording devices and accessories. Available to the engineering profession upon request on engineer's letterhead.

✦ **Laminated Tubing.** A 6-page general folder on grades, physical, chemical, mechanical and electrical properties, shapes, characteristics and standards of quality of Synthane laminated bakelite tubing. A two-color quick reference comparison chart of test values included. Synthane Corp., Oaks, Pa.

✦ **Cable.** A booklet describing and listing the standard types and sizes of Super Service cable, the product of the General Cable Corporation, New York City.

✦ **Nichrome.** A book compiled by the Driver-Harris Company, Harrison, N. J. describing the "Nichrome" group of alloys offered by this organization. Gives heating element data, current temperature characteristics and resistance data.

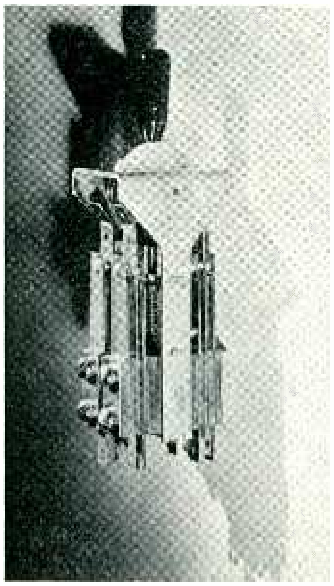
Literature

✦ **Parts and Accessories.** Catalog of radio accessories, servicemen's supplies, transmitting parts, amateur equipment, short wave and television equipment. Current Catalog No. 190, Insuline Corporation of America, 23–25 Park Place, New York, N. Y.

✦ **Electronic Converters.** Broadside on electronic converters, including list of models and individual uses and electronic balugraph chart. Electronic Laboratories, Inc., 122 W. New York Street, Indianapolis, Ind.

✦ **Electronic Tubes.** Westinghouse amplifier and oscillator tubes described in an informative bulletin sent out by the Special Products Department of the Westinghouse Lamp Co., Bloomfield, N. J.

✦ **Microphones.** The 1937 complete catalog of Shure microphones and accessories published by Shure Bros., 215 West Huron St., Chicago, Ill. Data sheets giving complete technical information on each item in the catalog are available upon request to the manufacturers.



Literature

✦ **Radio Products.** A descriptive price list, known as Bulletin No. 260, of the complete line of radio products offered by The National Co., Inc., Malden, Mass.

✦ **Kenyon Engineering News.** Vol. 1, No. 1 of Kenyon's new booklet devoted to the amateur service engineer, sound technician and the experimenter. Copies obtained by subscription. Kenyon Transformer Co., Inc., 840 Barry St., New York City.

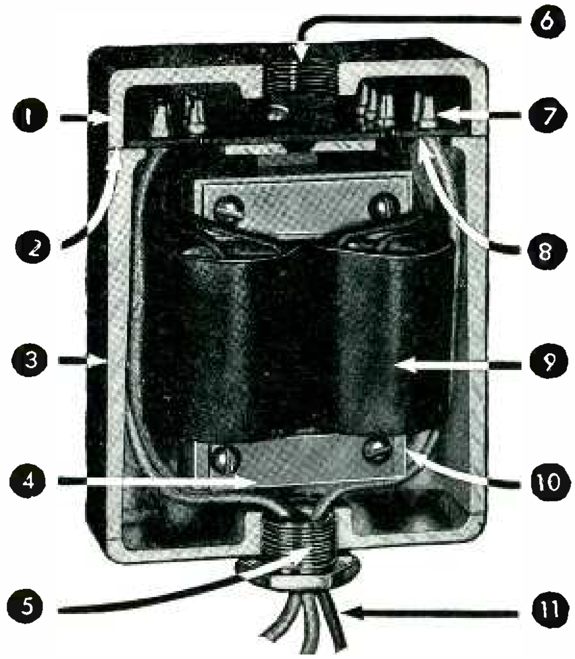
✦ **Condensers.** A booklet of descriptive data on Cardwell condensers. Table of facts about breakdown voltages of air condensers. Allen D. Cardwell Mfg. Corp., 81 Prospect St., Brooklyn, N. Y.

✦ **Sound Advisor.** The first issue of Operadio's publication issued "in the interests of radio dealers and those engaged in Sound and Public Address Work." Operadio Mfg. Co., St. Charles, Ill.

✦ **Condensers and Resistors.** Second edition, 1936 catalog covering a complete line of condensers and resistors for radio and allied applications. New condensers; extensive price reductions. Copies available from manufacturers, Aerovox Corp., 70 Washington St., Brooklyn, N. Y.

PROFESSIONAL SERVICES

THORDARSON *Tru-Fidelity* FEATURES

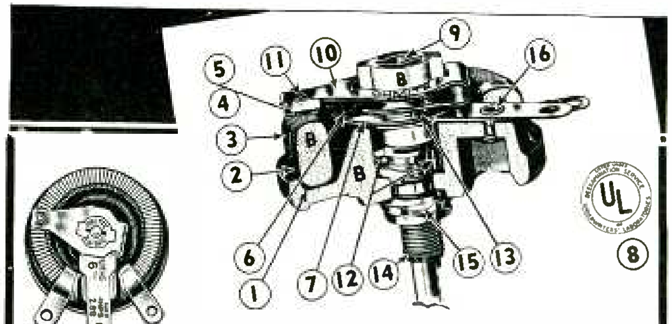


Most Sensational New Idea in Radio

1. **Shield Cap**—No stray pickups in leads—improves appearance—permits reversible mounting.
2. **Ground Fit**—All case joints are ground fit for increased shielding efficiency against outside interference.
3. **Case Body**—Special metal, gives maximum transformer shielding and a closed magnetic circuit at all times.
4. **Non-Magnetic Clamps**—Brackets and clamps non-magnetic metal. Core and coils held in perfect symmetry.
5. **Single Hole Mountings**—Drill one hole in chassis. Pass connecting leads through bushing. Rotating of transformer prevents hum pickup.
6. **Reversible Mounting**—Threaded mounting hole. Fits microphone fixture—for above or sub-panel mounting.
7. **Terminal Board**—Husky mounting lugs for all connections. Terminals will not loosen when soldering.
8. **Sub-Panel Terminals**—Extra row of terminals provides connections for both primary and secondary windings.
9. **Coils**—Dual balanced coils for "hum bucking". Extended frequency range. Capacitive — inductive balance. Low leakage reactance. Distributed capacity.
10. **Core**—Special lamination. High permeability alloy of perfect uniformity. Extreme low frequency response.
11. **Sub-Panel Leads**—Pass required leads from sub-terminal board through bushing. Neat—efficient—effective.

FREE—CATALOGS and BULLETINS
Catalog No. 500 Lists Tru-Fidelity prices, curves, and all specifications.
Catalog No. 400—Comlete listing of all THORDARSON radio transformers except Tru-Fidelity.
Send today for your copy or see your PARTS DISTRIBUTOR.
6L6 amplifier with either Tru-Fidelity or standard THORDARSON transformers. See Bulletin SD-258.

THORDARSON ELECTRIC MFG. CO.
500 W. HURON ST., CHICAGO, ILL.
Demand "Power by Thordarson"



LOOK INTO THE OHMITE RHEOSTAT

A. No organic materials to char or burn.
B. Porcelain core, base and driving hub.
1. Vitreous enamel bond fuses core and base (patented).
2. Rigid bonded winding.
3. Close control—each turn a separate step.
4. Large flat area contact shoe.
5. Metal impregnated shoe material.
6. Shunt pigtail carries current. No current is carried by the tempered steel brush arm.
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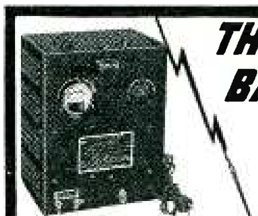

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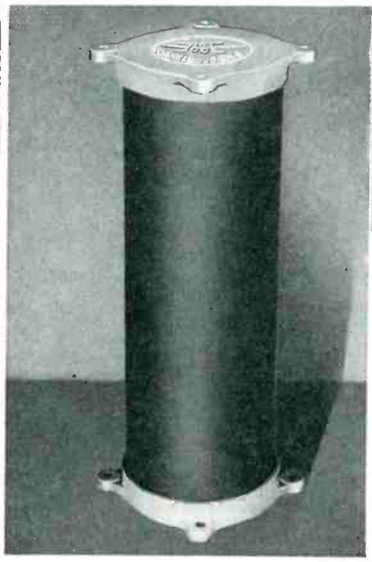

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YEARS of research in the modern Cornell-Dubilier Laboratories have resulted in the perfection of the highest type of ultra High Voltage X-ray Capacitors — ideally suited to the exacting requirements of X-ray Laboratories, research laboratories and medical universities.

A wide variety of capacity and voltage ratings are obtainable by properly connecting the units in series-parallel. A specially insulated, non-metallic tube of sufficient length is used to provide maximum safety from flashover between terminals. Since the tube is non-metallic, the danger of insulation breakdown between condenser and container is entirely eliminated.

Cap Mfd.	D.C. Volts Max.	Half Wave AC 60 Cy. Peak Volt.	AC 60 Cy. Effect. Volt.	Cat. No.	List Price
.005	75,000	50,000	25,000	11-728	$160.00
.01	100,000	70,000	35,000	14-733	217.00
.025	75,000	50,000	25,000	18-733	217.00
.03	100,000	70,000	35,000	21-726A	350.00
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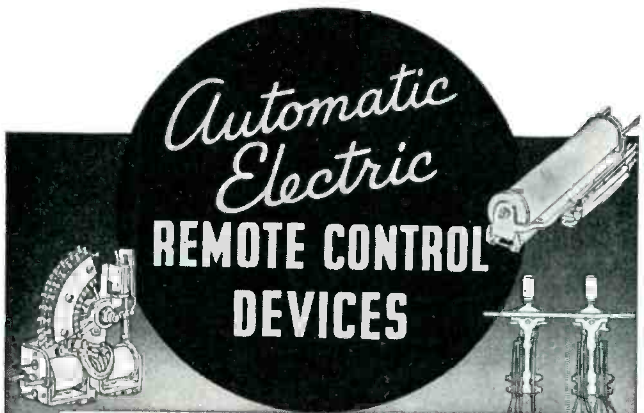
CORNELL DUBILIER

Automatic Electric REMOTE CONTROL DEVICES



We offer a comprehensive line of electrical control apparatus of proved dependability for adaptation to your products or for use in your production processes. Autelco control devices include:

RELAYS: Quick and delayed action types, for A.C. and D.C. circuits, any voltage, any contact combination.

STEPPING SWITCHES: Electro-magnetic multi-contact switches, for automatic selection of electrical circuits.

SWITCHING KEYS: A variety of locking and non-locking types in any desired contact combination.

Also cords, plugs, jacks, signal lamps, sockets, counters, etc. Write for complete illustrated catalogs.

American Automatic Electric Sales Company

1023 W. Van Buren Street, Chicago

INSTANTANEOUS RECORDING *becomes* AN *Exact* SCIENCE

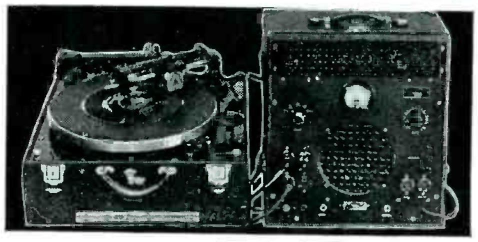
This cutting needle costs only a few cents but if it is defective it will ruin the recording of a big program. Presto engineers never take chances with needles. They examine each needle under this microscope before it is shipped to you.

The microscope magnifies the needle 250 times actual size and projects the enlargement on a screen. The slightest defect shows up clearly. The record blank must have a smooth unblemished surface, uniform in texture.

PRESTO GREEN SEAL DISCS are made in air conditioned rooms, absolutely dust free, where the temperature and humidity are rigidly controlled. No matter what the weather is — rain or shine — hot or cold — each record is the same, each record reaches you in perfect condition.

A PROMINENT ENGINEER recently tested several types of recording equipment for steadiness. On the final test he recorded a pure 1,000 cycle tone, played the record back, listened for "wows", watched the waveform on an oscillograph. THEN HE ORDERED PRESTO EQUIPMENT.

If you plan to install recording equipment
ELIMINATE GUESSWORK—
STANDARDIZE ON PRESTO
Write today for illustrated circulars



World's largest manufacturers of instantaneous recording equipment

Export Department
except Australia and Canada
M. Simons & Sons Inc.
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Cables:
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PRESTO
RECORDING CORPORATION
139 West 19th Street, New York, N.Y.

A ray focusing anode material

Aquadag* Brand colloidal graphite (in water) is now a standard coating on various cathode ray tubes. In its use as a ray focusing anode material, this product has the following four advantages:

1. It is easy to apply.
2. It is economical to use.
3. It adheres equally well to all types of glass.
4. It reduces light reflection because of the dark, matte surface formed on the glass.

Technical Bulletin No. 191B giving detailed information is available gratis on request.

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ACHESON COLLOIDS CORPORATION
FOUNDED [1908] AS ACHESON OILDAG COMPANY
PORT HURON • MICHIGAN

The 1936 Harvard University—M. I. T. Expedition to Ak-Baluk, U. S. S. R., prove again the ruggedness of Astatic crystal microphones under all conditions. They say:
"We received consistent reports of very good quality on our telephonic transmissions. The Astatic microphones received considerable use with weather variations between 30° and 112° F. which did not effect instruments. The K-2 had ample output and was highly satisfactory."

MULTI-UNIT DUAL DIAPHRAGM CRYSTAL MICROPHONE

The Astatic K-2 is the choice of broadcast engineers and public address systems demanding HIGH FIDELITY. It is a NON-DIRECTIONAL crystal microphone, utilizing the exclusive Astatic Dual Diaphragm principle of construction. It possesses a frequency response substantially flat from 30 to 6000 c.p.s. with a true, clear pick-up whether symphony or solo. List Price $37.50.

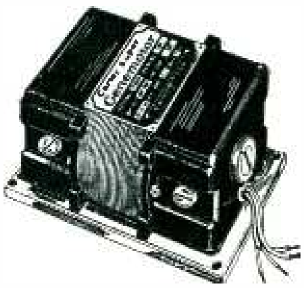
Licensed Under Brush Development Co. Patents Astatic Pend.

ASTATIC

WRITE FOR BULLETIN 61

ASTATIC MICROPHONE LABORATORY, Inc. YOUNGSTOWN, O.
Pioneer Manufacturers of Quality Crystal Products

HI-POWER FOR PORTABLE SOUND EQUIPMENT



The Carter GENEMOTOR supplies the most reliable and economical "B" Power for Class A or B amplifiers from a 6 or 12 volt battery. Output up to 500 volts. Sturdy — Compact — Quiet in operation — Requires no oiling — Guaranteed. Also can be supplied for A.C. output.

Write for Circular

CARTER MOTOR CO.
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TRANSFORMERS

Specializing exclusively in the design of transformers, Acme transformer engineers may be able to show you how your products may develop better performance and higher efficiency with an Acme transformer developed exclusively for your needs.

Send your prints and specifications for detailed information.

Acme ACME Electric

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EMPLOYMENT : BUSINESS : OPPORTUNITIES : EQUIPMENT—USED or RESALE

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Positions Vacant and all other classifications 10 cents a word, minimum charge $2.00.

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INFORMATION:

Box Numbers in care of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads. Replies forwarded without extra charge.

Discount of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH

1 inch $5.00
2 to 3 inches .... 4.75 an inch
4 to 7 inches .... 4.50 an inch

Other spaces and contract rates on request.

An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

COPY FOR NEW ADVERTISEMENTS RECEIVED UNTIL 3 P.M. ON THE 3RD OF THE MONTH (Elect)

POSITIONS WANTED

ELECTRICAL ENGINEER, college graduate, specializing in electron tube manufacturing. Six years of laboratory and factory engineering experience in connection with the manufacturing of all types of radio receiving and transmitting tubes. Desires position as factory or laboratory engineer. PW-95, Electronics, 330 West 42d Street, New York City.

SECRETARY-STENOGRAPHER, college, travelled, linguist, thorough experience radio engineering, test apparatus, editorial terminology accustomed responsibilities. C. White, 1550 East 4 Street, Brooklyn, N. Y.

FOR SALE

ONE General Radio Audio Oscillator cost new $250. Offered at real bargain. Goodall Electric Mfg. Co., Ogallala, Nebraska.

LEGAL NOTICE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

Of Electronics, published monthly at Albany, N. Y., for Oct. 1, 1936.

State of New York
County of New York } ss.:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared D. C. McGraw, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, N. Y. C. Editor, Keith Henney, 330 West 42nd Street, N. Y. C. Managing Editor, None. Business Manager, H. W. Mateer, 330 West 42nd Street, N. Y. C.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) McGraw-Hill Publishing Company, Inc., 330 West 42nd St., N. Y. C. Stockholders of which are: James H. McGraw, 330 West 42nd St., N. Y. C. James H. McGraw, Jr., 330 West 42nd St., N. Y. C. James H. McGraw, James H. McGraw, Jr., and Malcolm Muir, 330 West 42nd St., N. Y. C., Trustees for: Harold W. McGraw, James H. McGraw, Jr., Donald C. McGraw, Curtis W. McGraw. Curtis W. McGraw, 330 West 42nd St., N. Y. C. Donald C. McGraw, 330 West 42nd St., N. Y. C. Anne Hugus Britton, 330 West 42nd St., N. Y. C. Mason Britton, 330 West 42nd St., N. Y. C. Grace W. Mehren, 33 West Grand Ave., Chicago, Ill. J. Malcolm Muir and Guaranty Trust Co. of New York, Trustees for Lida Kelly Muir, 524 Fifth Ave., N. Y. C. F. S. Weatherby, 271 Clinton Road, Brookline, Mass. Midwood Corporation, Madison, N. J. Stockholders of which are: Edwin S. Wilsey, Madison, N. J. Elsa M. Wilsey, Madison, N. J.

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4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of

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this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is. (This information is required from daily publications only.)

D. C. McGRAW, Secretary.
McGRAW-HILL PUBLISHING COMPANY, INC.

Sworn to and subscribed before me this 28th day of September, 1936.

[SEAL] H. E. BEIRNE,
Notary Public, Nassau County. Clk's No. 74, N. Y. Clk's No. 192. Reg. No. 8-B-115.
(My commission expires March 30, 1938)

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Primarily for men who have completed High School or equivalent education, and wish to grow with their profession. Consists of over 50 lessons in book form, each with exercises, exercise answers, and examinations to be graded. Course covers elementary mathematics necessary to handle alternating current circuit theory, a general treatment of bilateral networks, and of unilateral networks. Very reasonable—payable monthly. Write for the information booklet.

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We pay highest prices for your *surplus laboratory equipment as meters, rheostats, bridges, decade boxes, etc.* Submit your lists of what you have to offer.

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Meters repaired, made more serviceable. Conversion to higher sensitivity as high as 10 microamperes for Weston type 1 or 24-57.

Sensitive vacuum thermo couples

For Sale used Weston panel meters, Rawson microammeters, Brown pyrometers.

Reasonable Prices
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2—J. P. Devine Co., Heavy C I Vac. Type Impregnating Chambers, Steam Jktd., Dished Bottom, Hinged Cover, Covered with 2" Insulation, Inside Dim. 60"x32" Deep on 18" Legs, Including Marsh Vac. Gauge, Valves, Piping, etc. Used for impregnating condenser & transformer coils. Over-all Height—72", Over-all Diam.—84", 1" Steam Connections, 2½" Wax Outlet. Cap. approx. 390 Gal. and Approx. Wt.—10,000 lbs. Must sacrifice.

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COMPLETE EQUIPMENT
New and Used for
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Glass Cutters, Spot Welders, Annealers, Flare, Stem, Sealing, and Basing Machines, Vacuum Pumps, Burners
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SPARES

By using our Reconditioning Service on Transmitting Tubes you may have a Dependable stock of Spares on hand at all times and best of all—the Investment is Low.

Why not let us convert your castoff tubes into real High Quality Merchandise for your own Protection and Profit?

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3420 18th St. San Francisco, Calif.

VACUUM TUBE EQUIPMENT

Formerly production units of
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PRICES ON INQUIRY

A. E. LYLE, Johnsonburg, Penna.

DEPENDABLE
New and Used
ELECTRONIC TUBE EQUIPMENT

A complete line of equipment for the manufacture of Radio Tubes, New Tubes, Incandescent Lamps, etc.
Write for Bulletin showing savings from 25 to 75%

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Meters — Bridges — Torsion balances—Inductors — Decade boxes—Analytical balances—Oscillographs —Jagabi rheostats—Signal Generators—Condensers

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HIGH GRADE NEW AND USED
ELECTRON TUBE EQUIPMENT

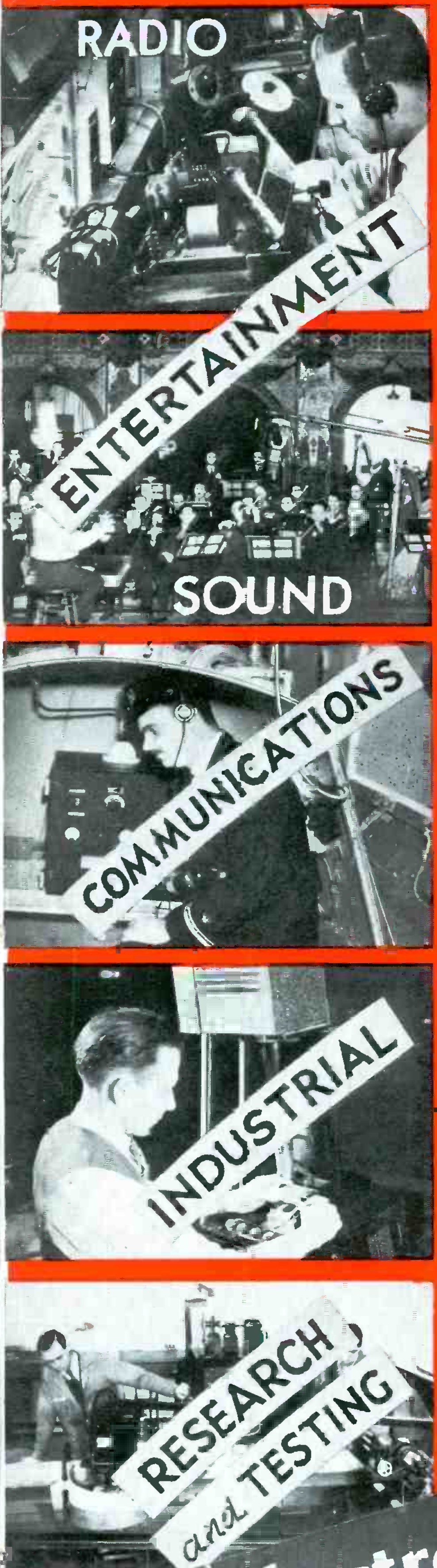
Huge Stock of Equipment of Every Type and Variety

KAHLE ENGINEERING CORPORATION
Specialists in Equipment and Methods for the Manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
941 DeMott St., North Bergen, N. J.

INDEX TO ADVERTISERS

SELL *the* ELECTRONICS MARKETS

on a profitable basis in 1937



What are the electronics markets?

They are TANGIBLE markets made up on thousands of radio, electrical, and industrial manufacturing companies, operating organizations and individuals. They have a community of interest built around the electron tube and its applications in electrical circuits. (Electron tubes include radio tubes, photocells, power, transmitting and rectifying tubes, cathode-ray tubes, etc.)

The growing importance and far-reaching influence of the electron tube and its many applications has created markets that cut a broad path through many industries. All manufacturers in the radio industry, the sound industry, the broadcasting and communications industries, and a horizontal group of electrical and industrial organizations — numbering nearly 10,000 — comprise the important group responsible for the manufacture, purchase, use and sale of some billion dollars ($,000,000,000.00) worth of electronic equipment annually.

How can you profitably reach and sell the key men in this industry in 1937?

Among the subscribers and readers of Electronics are the men who influence the designing, engineering, manufacturing, the specifying and buying of equipment, components, parts, raw materials and accessories—used in radio, sound, communication and associated electrical equipment.

Over 10,000 hand-picked engineers and manufacturing executives subscribe to Electronics (high subscription renewal percentage — subscription price $5.00 a year). Because of "pass-along" circulation—company subscriptions that are routed and those who read the other fellow's copy—Electronics has many additional readers monthly.

Included among Electronics' paid subscribers are 1655 paid foreign subscribers—a most valuable group from the point of view of concentrated purchasing power.

Why advertise in Electronics in 1937?

Electronics is today helping to increase sales and reduce sales costs for the aggressive manufacturers who are advertising their products or services.

Many of these manufacturers have explored and developed new markets and customers for their products through Electronics. Others have strengthened their relative sales position in the industry. Others have announced new products, new sales policies—advertised new services—all aimed to strengthen their personal selling and other forms of sales promotion.

Advertising pays in Electronics because the paper is the recognized leader in its field. Electronics is read by a group of highly intelligent men—and has a circulation that cannot be duplicated in any other single business paper or *economically* reached by any combination of several business, technical or industrial papers.

Electronics is published monthly.

Representation in Electronics every month in 1937 is important. Electronics is published monthly and offers you just 12 SHOTS at our readers during 1937. That's why we say, "be in every issue and concentrate your advertising where it pays and where you get the most for your money."

ELECTRONICS

A McGRAW-HILL PUBLICATION
Established 1930 Member ABC and ABP
330 West 42nd Street New York, N. Y.

An Offer to Manufacturers

If you would like more information about Electronics, we will be glad to have our nearest business representative call — no obligation to you.

If you think your products have a market among Electronics' readers, we will be glad, at no expense to you, to discuss the matter with you and help you, if possible.

We will be glad to send a copy of "Selling the Electronics Industry on a Profitable Basis," circulation information, and advertising rates to any interested manufacturer.

MEET RCA's

NEW CATHODE-RAY TUBE RCA-913

Only 4¾ inches long

HERE'S a brand-new cathode-ray tube only 4¾ inches long, that is of tremendous value to radio engineers, service men, amateurs and school laboratories. The RCA-913 is a high-vacuum, low-voltage electrostatic type of cathode-ray tube with all-metal construction and a fluorescent screen nearly one inch in diameter. The 913 is a low-priced tube that is ideal for use where a larger tube is undesirable—it is particularly adaptable for use in compact, portable oscillograph equipment. In addition, this tube can be built right into transmitters as an integral part, for use in checking circuit operation and measuring modulation percentage.

The RCA-913 needs only a simple power supply—fits into standard applications—operates at a maximum of 500 volts and gives good results at voltages as low as 250 volts—has two sets of electrostatic deflecting plates.

We shall be glad to send you complete technical information free, on request.

$5.60

Listen to "The Magic Key" every Sunday, 2 to 3 P.M. (E.S.T.) on NBC Blue Network

RCA

Radiotrons

RCA RADIOTRON DIVISION, RCA MANUFACTURING COMPANY, INC., CAMDEN, N. J.

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