electronics

radio, sound, communications and industrial applications of electron tubes • • • design, engineering, manufacture

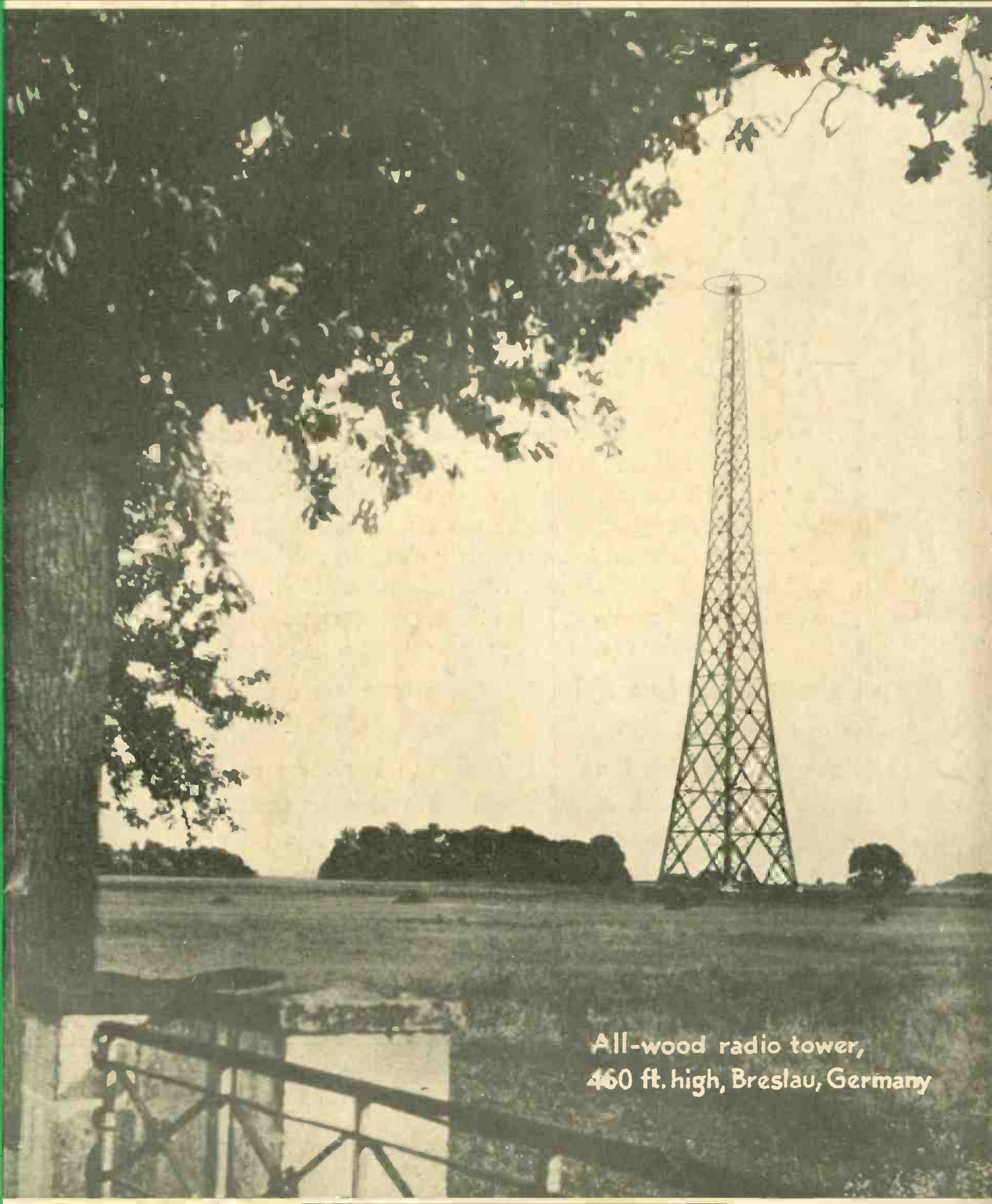
Federal Communications Commission

Raw materials for vacuum tube manufacture

High-fidelity— economics and technique

Cathode ray tube circuits

Shield grid thyratrons



All-wood radio tower, 460 ft. high, Breslau, Germany

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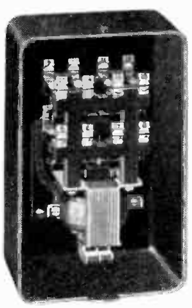

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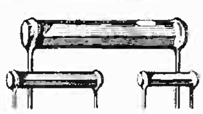

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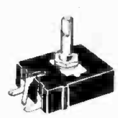

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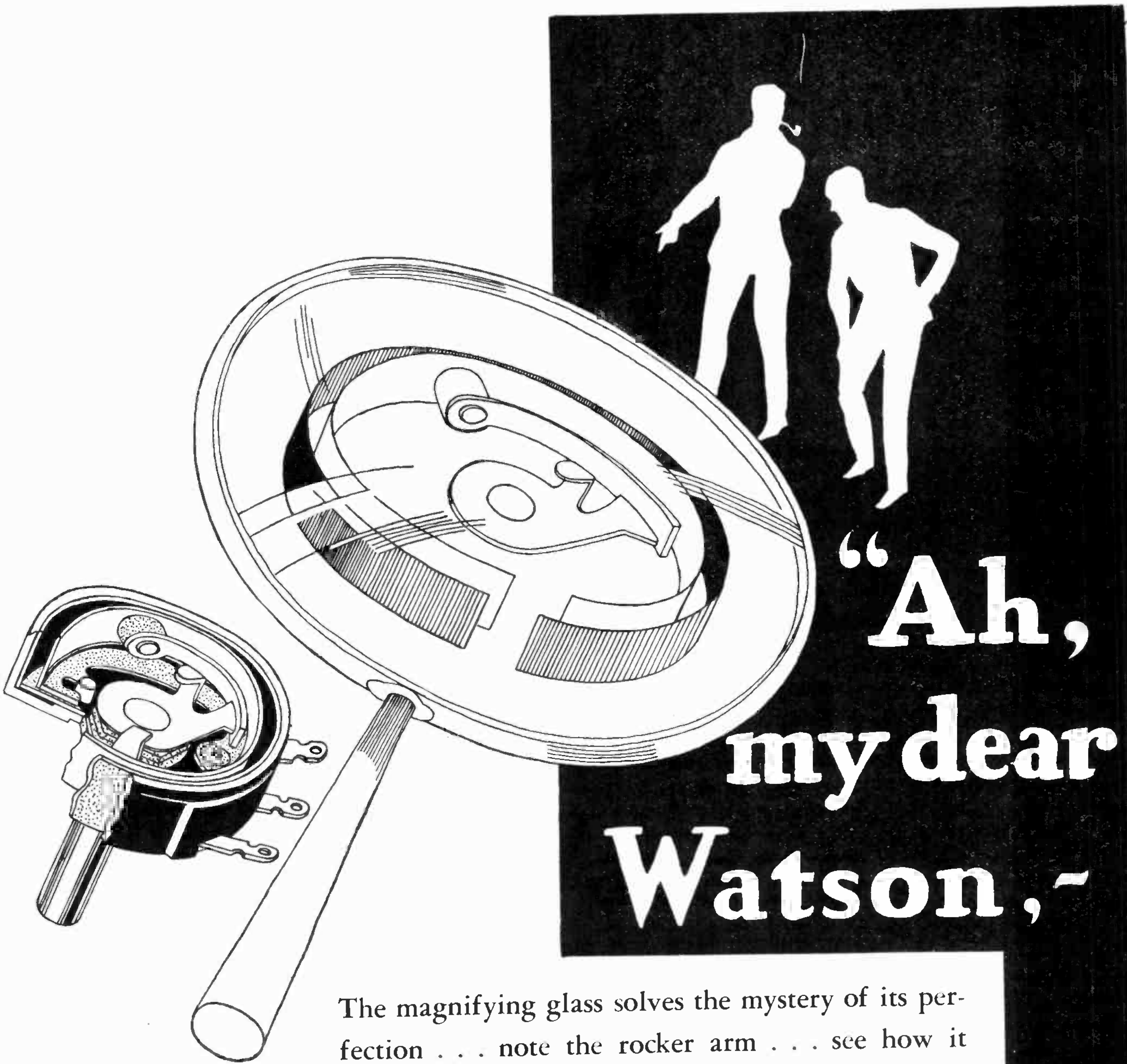

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CABLE ADDRESS PELMALLO

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electronics

McGRAW-HILL PUBLISHING COMPANY, INC.

New York, April, 1934

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Better fidelity---better business!

THIS QUESTION of high fidelity in radio-broadcast systems—from transmitter, through all channels to receivers—needs to be looked at first of all from the purely practical business viewpoint of increasing sales volume and restoring profits to radio manufacture.

EXPERIENCE in allied fields has shown that as realism and fidelity improve, the industry proffering the improved service also prospers. The motion-picture industry is an example. Introduction of sound, extending the illusion of realism, resulted in doubling the box-office response. And successively new steps in quality improvement have been taken, raising the fidelity of reproduction. Audiences now demand this high fidelity in sound-track reproduction, and no theatre manager would willingly go back to the earlier quality limits—limits which unfortunately still restrain radio.

SURVEYS of recent radio sales show that the unit price per set is still slowly falling. Something is needed to turn this unit price trend around and send it again climbing, if the public is to be adequately served and if the industry is to make a profit. The broadcasters and the advertisers also have a stake here, if radio broadcasting is to continue as a great art.

NEW and improved services will keep radio sales going, and will send unit prices up again. Several such improvements and extensions are now under consideration by the industry. But the one of most immediate use and promise is *high fidelity*.

RADIO LEGISLATION

Bill establishing new Federal Communications Commission has even chance of passage before adjournment

A BILL to repeal completely the present radio laws, and to set up in their place a new basic radio law containing details contrary to the consensus of radio-engineering opinion, in addition to creating the Federal Communications Commission, has been introduced in Congress by Senator Clarence C. Dill, of Washington. On the House of Representatives side, the bill introduced by Representative Sam Rayburn, chairman of the House Committee on Interstate and Foreign Commerce, merely sets up the consolidated Federal Communications Commission as asked by President Roosevelt, but without affecting or amending the radio law itself.

Considerable criticism has followed the introduction of the Dill bill, both from members of Congress and from radio men, as it had been understood that the authors of the bills would agree in substance on their contents, and that no controversial features would be introduced at this session. Senator Dill, however, surprised all hands by coming out with a proposed law departing widely from the conditions named by the President, and incorporating certain of the Dill pet provisions which the Senator from Washington has sought to have injected into radio administration over the past four or five years.

The Dill bill, for example, would spell the doom of the "clear channels" over which American broadcasting now reaches millions of farmers. Long a foe of clear channels and high-power broadcasting, Senator Dill would take discretion on this point out of the hands of the radio supervisory authority and its engineering advisors, and would by law expressly permit the duplication of stations on clear channels at distances of 2,200 miles, with the proviso that the second station on the channel would not be charged to quota! (This obviously would be a convenient arrangement for Fifth Zone stations on the Pacific Coast, from which Senator Dill hails. On account of sparse population, these states already enjoy a quota advantage of nearly three to one, as compared with states in the other four zones; now the kindly Dill bill would grant such states additional facilities on choice wavelengths to the destruction of great interior areas of good broadcast service, yet without penalizing the Pacific Coast states on their other station allotments.)

License period cut to one year

The Dill bill would also cut the legal license period for broadcast stations from three years to one year, yielding to the Dill bugaboo that sinister interests will otherwise get control of the broadcast channels.

Departing from both the spirit and letter of the grievous Davis amendment of 1928, of which Senator Dill was the principal advocate at the time it passed, taking radio facilities from the more highly developed communities and spreading them throughout the zones, proportionally to population (with particular advantages to Fifth Zone stations), the author of the Senate bill now expressly provides that additional 250-watt stations may be licensed in any state, wholly *without* regard to quota limitations or to the requirements of good broadcast allocation.

Fines of $1,000 a day for violation of commission regulations are also specified in the new re-written radio law of Senator Dill, imposing onerous burdens upon broadcasters and other radio men deemed guilty of infracting orders of the regulating authority, which is also both judge and prosecuting attorney. Elaborate provisions are also made with respect to political speeches and

THE FEDERAL COMMUNICATIONS COMMISSION

Its make-up as outlined under the Dill and Rayburn bills now before Congress. The provisions of these bills are parallel on the following:

Only four commissioners to be of same political party

Chief engineer, general counsel, etc., to receive $9,000

Commissioners' salaries $10,000 each; with assistant at $4,000

Communications Commission to render annual report to Congress

Radio division to cover broadcasting, amateurs, and mobile services

No commissioner shall be financially interested in radio or wire services

Telephone division to cover voice communication other than broadcasting

Commissioners' terms seven years; removable by President for misconduct only

Telegraph division to cover record communication by radio, wire or cable

Seven commissioners, appointed by President and confirmed by the Senate

Two commissioners assigned to radio, two to telegraph and two to telephone divisions

BEFORE CONGRESS

Senate Committee studies Dill proposal to repeal existing radio statutes and substitute special legislation

the discussion of public questions by speakers over the broadcast channels, thus further complicating the situation here.

The Senate bill sponsored by Chairman Dill is 98 pages in length; the Rayburn bill is 67 pages long, and is virtually identical with the Dill bill in that part providing for the new Federal Communications Commission, the only difference being in the thirty-odd pages providing for the repeal and substitution of the basic radio law by the Dill offering.

Senate committee threatens new draft

Even the members of the Senate and of Dill's own Committee on Interstate Commerce have protested against the new conditions imposed by the Senate bill, and some of the members of the committee have threatened to report in a new simplified bill in the Senate, drafted along the lines of the House bill. Such a simplified bill would be non-controversial and would stand a better chance of passage at this session, in the opinion of those charged with carrying out President Roosevelt's administration policies.

On the other hand, there is the feeling in Washington that with so many major issues to be fought out in Congress and with so much major legislation to be passed during the few remaining weeks of the present session, even the non-controversial features of the bills, as exemplified in the Rayburn draft, will have only a fifty-fifty chance of passing at this sitting of Congress. Of course there have been many precedents where an administration measure of this kind has been passed suddenly and with very little preliminary debate, but there seems to be a feeling among those in the know "on the Hill" that the Dill measure has no chance of passing at all this session, while the odds on the Rayburn measure are about even for and against its enactment, before Congress packs its bags and retires home to mend its individual political fences.

Broadcasters protest that President intended no new legislation now

Hearings have been held on the Senate measure, and the National Association of Broadcasters, though the chairman of its legislative committee, Henry W. Bellows, former Federal Radio Commissioner, pointed out that the Dill proposal to redraft the radio law at this time was quite outside the conditions imposed in the President's message (*Electronics*, March, page 94), which specified that the new FCC be set up to take over "authority in radio *now* lying in the Federal Radio Commission, and with such authority over communication as *now* lies with the Interstate Commerce Commission." Dr. Bellows pointed out that President Roosevelt had in mind the transfer only of *present* authority, under existing law, but with the added provision that the new Commission investigate the operations of companies and "recommend to Congress additional legislation at the next session."

One of the changes contemplated in the Dill bill, according to the NAB brief, would undermine the whole legal structure which seven years of work have painstakingly set up; another would convert the administrative Commission with quasi-judicial functions, into a criminal court with wide powers of summary punishment; while a third would deny to the Commission the right of solving technical and engineering problems on the strength of technical evidence.

THE SENATE BILL INTRODUCED BY SENATOR DILL

Besides paralleling the Rayburn bill before the House, in setting up the new Federal Communications Commission, as outlined opposite, also:

- Requires Congress to legislate on purely technical matters
- Undermines whole legal structure of past radio administration
- Reduces broadcast license period from three years to one year
- Eliminates right of appeal to the courts from decisions of Commission
- Endangers financial stability of radio by setting up short-term licenses
- Allows duplication of broadcast stations on "clear channels" at 2,200 miles
- Denies to Commission right to solve technical problems on technical evidence
- Sets up new, untried legal background for new Communications Commission
- Allows licensing of additional 250-watt stations without respect to quotas
- Authorizes new Commission to impose fines of $1,000 a day, for violations
- Repeal of existing radio laws, and substitution therefor of new radio legislation

Raw materials in vacuum tube manufacture

By E. R. WAGNER, Ph. D
Consulting engineer

"TRADITION" — says Dr. Wagner, "still plays a large part in vacuum tube manufacture. Materials are used and treated by rule-of-thumb methods often carried over from lamp practice. Secret formulas still control the coating of filaments and cathodes, and methods of cleaning one metal are often applied to metals new to the tube art, with the result, frequently, that the new metal is condemned."

The discussion that follows is intended to clarify some of the existing misunderstandings, to explain some of the less well known causes of trouble, and to discuss the relative merits of the various materials used in the manufacture of vacuum tubes.

Plates. The plate must be made of a conductor that does not evaporate appreciably during the outgassing process. Its melting point must be high enough to withstand bombardment without loss of shape. The available metals that meet these specifications are few, and are still further limited by the requirements of price and simplicity of handling. Platinum would be an excellent plate metal, were it economically possible to use it. Tantalum is also good plate material, but is too costly. Molybdenum is used in the more expensive tubes because of its ability to run red hot for long periods of time without deterioration. Graphite anodes have recently been used in power tubes, but are as costly as are those of molybdenum. Iron and nickel alone remain available for the ordinary receiving tube.

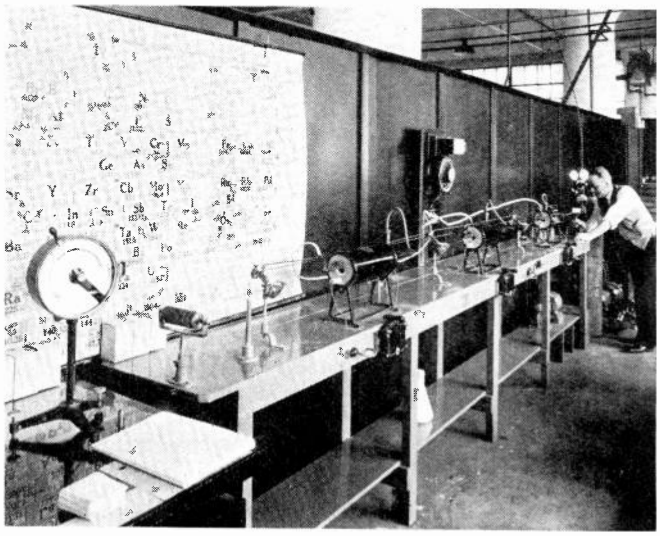
Nickel is easily cleaned and withstands considerable exposure without becoming unfit for use. It resists oxidation at room temperature and is easily stamped and welded.

Iron is more recent, and is displacing nickel to a considerable extent in the cheaper tubes. Pure iron has a lower specific gravity than nickel, and its price is sufficiently low to make an iron plate of .005" stock cheaper than that of a nickel plate of the same dimensions. Iron oxidizes more readily at ordinary temperatures and this oxide layer is the source of trouble if allowed to remain. In fact, iron was considered "gassy," and this attitude prevented its use, until it was found that the surface layer of oxide was the source of the gas, and means were devised to protect the metal from oxidation between the time the plate was cleaned in hydrogen, and the time at which it was to be mounted.

Grids. For rigidity and all-around excellence, molybdenum is at the top of the list. Its use in ordinary tubes was made impossible by the drop in the price of tubes, but it still can be used in specialties. It keeps its shape under bombardment even in .005" diameter, and is easily cleaned. Nichrome (chromel, tophet, chrome-nickel, etc.) has good rigidity but is difficult to clean and is better suited to round than to flat grids because of its stiffness. An iron-nickel alloy has largely replaced nickel because of greater rigidity after hydrogen treatment, and also because of cheapness. Pure iron possesses no advantages over nickel except that of price. Manganese-nickel is used to some extent, being somewhat stiffer than pure nickel. This manganese nickel is also commonly used in welds for grid and plate supports, although for a long time, it was the victim of superstition, and was considered "bad" for the tube. Then during a period when nickel was scarce it was widely used in place of pure nickel—and no one noticed the difference.

Treatment of materials

Metal parts are usually fired in hydrogen at a temperature of 1750°-1800° F., regardless of the nature of the metal. The result is that nichrome is still dirty after hours of this treatment because chromium oxide is not reduced by hydrogen. This fact is usually overlooked. Molybdenum parts,—especially plates,—should be treated at from 2000°-2100° F., to insure complete cleaning. Moly grids are cleaned at 1800° F. for one half-hour, but the quality of the tube is not affected if



Typical filament coating set-up found, repeated many times in every vacuum tube plant a trace of oxide should remain. The oxide, in this case, is reduced at 1800° F. but the rate is slower than at 2100° F., and is possible only because of the small surface that needs cleaning.

Carbonized parts should not be treated in hydrogen at all. Hydrogen plus carbon, in contact with nickel, at the temperatures used, forms a complex hydrocarbon that makes the surface behave as if it were greasy, and a gassy tube frequently results. The proper treatment is to burn off any oily matter that may occur on the carbonized part by placing it in the furnace, in air, (*not hydrogen*), for not over five minutes at from 1600°-1800° F.

Nickel sleeves, used for cathodes, are treated in hydrogen at 1800° F. for fifteen minutes before spraying. This insures a clean surface and proper adhesion of the coating.

Filament wire or ribbon is sometimes treated in hydrogen before coating. This is a precaution that should not be necessary since it is done by the filament manufacturer, and may result, in the case of the very fine filaments, in too great a degree of annealing and consequent loss of strength. Since the object is to clean the surface, prior to coating, it is best accomplished in the furnaces of the coating machine by oxidizing the surface lightly in an atmosphere of carbon dioxide. Any grease present is burned off.

FILAMENTS. The smaller tubes, except the 99, 01A, 20 and 22, still use pure nickel, either as wire or ribbon, for filament. Because of its high electrical conductivity, nickel is almost the only metal that can be used in the 30, to secure a radiation anywhere near the 4 watts per sq.cm. of surface required to maintain even low red heat. All other metals and alloys suitable for use as filaments have much higher resistance and are too cold at operating wattages to give appreciable emission.

Silicon-nickel is available for the larger tubes and is an excellent metal base for the coating. It sometimes happens, when converting the carbonates of the coating to oxides, that too high a temperature of conversion is used, so that the silicon of the alloy reacts with barium and strontium oxides to form barium and strontium silicates, which cover the surface with a hard and glassy material, rendering the filament inoperative. The tube then has "no emission."

An alloy of cobalt and nickel, containing about 40 per cent cobalt, has recently come into use, and is very satisfactory, especially for power tubes and rectifiers, where mechanical strength is required. Cobalt nickel has almost four times the cold resistance of pure nickel, and twice that of silicon nickel. Like nickel, and unlike silicon nickel, it has a high temperature coefficient of resistance. Since it contains no acid forming element, such as silicon, it may be heated to a higher temperature than silicon nickel, and better conversion of the coating to oxides takes place. A more gas-free tube results and, apparently, higher emissivities are obtained.

The indirectly heated cathode is apparently well on the way to displacing ordinary filaments. Its advantages are many. It not only gives more uniform electron velocities, but also possesses greater mechanical strength and rigidity than does the coated filament.

The heater is almost invariably of pure tungsten wire, threaded through an insulator made of pure, fused magnesium oxide. The quick-heater type of cathode frequently has the insulating refractory directly applied to the wire, using a very small amount of talc as a flux, and applied with nitrocellulose lacquer by means of a spray gun. The lacquer is baked off in hydrogen at a temperature of about 1700° C. (3100° F.). The talc sinters and the magnesium oxide is bound to the wire.

Welders—a hundred of them, in the Grigsby-Grunow plant assembling the elements of electron tubes

Another type of quick heater uses a double spiral of tungsten wire, and a magnesia plug that is so grooved that it can be threaded into the spiral. This prevents short circuits between adjacent turns and between heater wire and sleeve. The hot wire is thus directly exposed to the metal sleeve that carries the emissive coating instead of being surrounded by a mass of material through which heat must be transferred before it reaches the active surface.

The metal sleeve, or tube, that carries the active coating, is always of pure nickel. Since we are not concerned with direct heat by passage of the current, we need not consider resistance or temperature coefficients but merely the suitability of the metal as a carrier of the active coating. Nickel serves admirably for the purpose and probably will continue to do so, since its cost, per tube, is negligible.

Methods of coating cathodes

This process has been shrouded in mystery, and many supposedly wonderful formulas have been developed. They are unnecessary. The cardinal points for successful coating are cleanliness of metal surface, purity of lacquer and solvents, and suitability of the barium-strontium carbonates used. The barium-strontium carbonates should contain approximately 1 per cent of sodium or potassium carbonate, for best results. When the coating is heated, the barium and strontium oxides that result do not adhere to the metal. The sodium or potassium carbonate, by virtue of a low melting point, sinters the other particles together, but is not present in large enough quantity to clog the pores between particles. This is very necessary. If too much alkali is present, the surface of the cathode is covered with a melted mass that prevents any electron from escaping.

Pure collodion cotton (U. S. P.) is easily obtained from any drug supply house, or chemical manufacturer. With this as a base, the tube maker can control his spraying mixture without paying a fancy price for lacquer that may not be suitable. It comes in tin containers moistened with alcohol. The alcohol does not injure the lacquer, but must be determined before we can weigh out a definite quantity of collodion cotton. By weighing out about 10 grams of the moist collodion onto a watch crystal, or into a dry beaker, and placing it in a drying oven for a half hour at a temperature that does not exceed 100° C., we drive off the alcohol, and by weighing the dried cotton, we find the loss in weight and calculate its percentage. The weight of dry collodion per gram of moist collodion is thus determined. The usual alcohol content is around 20 per cent, but varies, and will also change with frequent opening of the container.

The most suitable solvent is pure amyl acetate. By dissolving 1.5 grams of dry "cotton" in 100 cc of pure amyl acetate, we have a suitable lacquer for our purpose. To prevent too rapid drying, a small amount of a less volatile solvent is added. Usually, ethyl oxalate is used, —not over 10 cc of it per 100 cc of lacquer.

A suitable mixture for cathode coating is as follows:

50 gm	barium carbonate
50 gm	strontium carbonate
200 cc	1½% lacquer (as described above)
20 cc	ethyl oxalate

This mixture must be ground in a clean ball mill until uniform. The time of grinding is dependent upon the rate of rotation of the barrel. A small mill, rotating at about 60 RPM, or at such speed as will permit the pebbles to fall back through the mixture after being carried part way up the side of the barrel, is suitable. The number of pebbles must be the same each time, as well as the rate of rotation and size of the charge. Usually, an hour of grinding is sufficient. The mixture is then strained through clean cheesecloth to remove lumps, and is ready for spraying.

For this purpose a hand frame that holds about 50 cathodes is commonly used. A small spray gun, using from 50-60 lbs. of air pressure is suitable. Lacking compressed air, a tank of compressed gas such as carbon dioxide or nitrogen may also be used, in conjunction with a pressure reducing valve. The operator can tell, after very little experience, just how much lacquer to apply at a time. Too heavy an application will cause it to run. The sprayed cathodes should be placed in a warm oven, at a temperature between 80° and 100° C. for an hour, before using them in the production of tubes. They should have gained about 5 milligrams of coating per square centimeter of surface sprayed, when weighed after drying in the oven.

Material entering into cathodes must be accurately weighed and gaged

Mounting problems

Everyone who has ever been associated with tube manufacture knows how essential is cleanliness. Tubes can be spoiled during the assembly process by careless handling. The trouble is usually greasy fingers, especially obnoxious in filament or cathode mounting. While cotton gloves are commonly used, they must be changed frequently, or they are as bad as are bare fingers. Tweezers for holding the filament are not always convenient. The simplest remedy is to have a dish of strontium carbonate—from the coating department—within reach of the operator who mounts cathodes or filaments. Barium carbonate should not be used since barium compounds are poisonous. An occasional dip or dusting of the fingers will greatly decrease troubles due to contamination in mounting. Care must be taken, when mounting cathodes, to prevent any of this powder from settling on the insulator, or on the heater wire where it may cause peculiar noises usually blamed on "static."

Similiarly, dirt or grease on the grid may cause "gas" to appear in the tube, and is best avoided by care in mounting, together with a preliminary washing of the grids in ethyl acetate, ethylene chloride or pure carbon tetrachloride. Mixtures of any or all of these solvents are also excellent grease removers.

[Editor's note—Dr. Wagner in a concluding article will discuss other items of importance in tube manufacture, for example, getters, proper exhaust, etc. This will appear in an early issue of Electronics.]

DISCOVERERS STILL!

OUR principal asset in radio is still the unknown, the uncharted ocean of science which no man owns, and over which each radio engineer who sails,—a ten thousandth edition of Christopher Columbus,—may sail a discoverer still.

—OWEN D. YOUNG

ELECTRONIC AIDS FOR THE BLIND

Photocell guides and "talking books"

The American Foundation for the Blind, 125 East 46th Street, New York City, has been conducting experiments with photocell guides, enabling blind persons to follow light-beams down halls and across corridors. In the type shown, the blind girl carries a photocell which operates a buzzer as long as the "electric eye" is in the lighted safety zone.

The "talking book" below, is a combination radio set and amplifier phonograph, which it is hoped to furnish to the blind at $35. Already $100,000 has been appropriated by the Federal Government for the production of standard works of literature in these long-playing records, to be distributed through 24 Braille libraries. J. O. Kleber is conducting the electronic research.

The talking book will use special records running 18 minutes on each side. It is quickly convertible into a radio set

High fidelity— economics and technique

A SUPERFICIAL estimate of the technical problems involved in transmitting and receiving a much wider band of audio frequencies and thus to improve, generally, the broadcast system does not reveal all of a rather complicated picture. Such an estimate would incline one to believe that the engineer had merely to widen the band so that frequencies from 50 to 8000 cycles were transmitted equally well, to increase the dynamic range and to reduce distortion of various types and origins. But there are other problems, not the least of which involve present standards of public taste in radio and all of which involve economics.

At the outset it is fair to state that certain engineers and sales people are not certain that high fidelity receivers can be sold at a profit, and that since profit is uncertain, these individuals doubt the need for great interest in such receivers. Furthermore it has been publicly stated more than once that the public has proved its distaste for high fidelity systems by purchasing boom-boom receivers in vast quantities and would be left very cold by the finer shadings of timbre or the elements of naturalness secured only through the transmission of a wider band of frequencies.

Nothing can be more reasonable than to have doubts regarding the profit possibilities of high fidelity receivers. The industry has no previous experience to gage by;

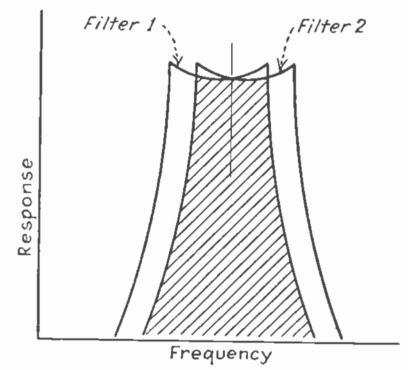


Fig. 1—Effect of mistuning filters; shaded area shows true response of receiver

but it is seldom indeed that a manufacturer or an industry knows in advance that it has a sure-fire profit making proposition. The only way to find out is to try it.

The argument that the public has developed an exclusive taste for rhythm is rash; to state that listeners do not want to hear frequencies above 3000 cycles controverts the experience of composers and musicians for several hundred years. The public has not rejected high quality receivers; it has purchased millions of units of very low tone fidelity simply because it wants music, as cheaply as possible, and has bought avidly what was offered it.

The public has never heard a truly high fidelity receiver; and it is unreasonable to believe that the listener would turn his back on wide-band music in favor of a 1933 radio—under good receiving conditions.

The first problem—noise

Ideal listening conditions are necessary to realize the benefits of a wide-band receiver; this involves high signal-to-noise ratios. Thus the attempted sale of high-fidelity receivers will bring the industry face to face with two aspects of a problem it has consistently side-stepped; this is the problem of noise. One obvious solution is to increase the level of the signal, by higher power or by moving the transmitter closer to the listener. The second method calls for decreasing the noise by equipping every electrical appliance, every elevator and street car and automobile with anti-noise devices.

The immediate market for high-fidelity receivers, then, will be limited to those listeners living close to a transmitter. To enlarge this market will involve an industry campaign to improve the average signal-to-noise ratio.

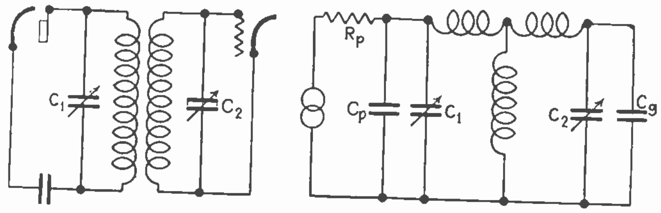


Fig. 2—Tuned transformer and its equivalent network

To obtain a band-width of 50 to 8000 cycles at the loud speaker requires the solution of a number of design problems which at present are given scant attention. First of all the band-width must be built into the receiver; and throughout the life of the receiver it must be maintained. It is of little value to create a design which is unstable or which may narrow its band after a few weeks or months of ageing, humidity, or temperature effects.

The fewer the number of independent selective circuits therefore which must be maintained in tandem, the more likely it will be that the set will be stable. Secondly, the selective circuits should be designed so that small changes in the constants will not materially affect their alignment. If this is not possible it should be easy to realign the set and restore it to its original condition.

The superheterodyne receiver using two or three selective circuits is superior to a tuned radio frequency receiver requiring four or more circuits for the same selectivity. Furthermore variables in the bandpass filters of supers may be checked in the factory and fixed, while in the t-r-f set the ganged variable condensers must maintain their alignment throughout the entire arc of rotation. Moving parts are usually less likely to maintain their adjustment, assuming equal design skill. A bent plate on a condenser may ruin the band-width over a portion of the range.

In providing the wide band, it must be planned for in the design of the filters. With tuned transformers this simply requires a change in the coupling coefficient until the desired band is obtained. However, it is essential that both the primary and secondary be tuned to the identical frequency and the coupling be adjusted to exactly the right value. Suppose, however, that this

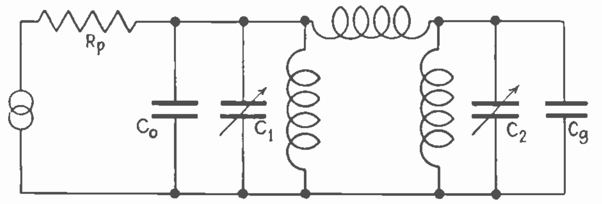


Fig. 3—The Pi network giving identical characteristics as Fig. 2

is done for each individual unit, and then a number of these filters are connected in tandem. It is not to be expected that all the resonances were placed closer than perhaps a few hundred cycles. Then, unless transformers are selected so those which are tuned high are matched together, there will be a narrowing of the designed band-width before the receiver ever leaves the factory. It is quite possible that variations between sets might run as high as 1000 cycles.

Furthermore, it is necessary that the oscillator track identically with the tuning condenser. If this difficult requirement is not met, there will be a shift of the intermediate frequency from its correct value in certain parts of the tuning range of the set. Some stations will be received with a wider band than others. In addition, since the second detector is not supplied with equal amounts of each sideband, the resulting quality may be impaired even inside the band, due to phasing of the components of the two sidebands.

For this difficulty apparently there are only two solutions, independent controls for the oscillator and preselector, or the provision of exactly accurate tracking together with such mechanical and electrical design as will insure the maintenance of this correspondence throughout the life of the receiver. The first is a trend away from single control, and in the hands of an inexperienced user, may result in even poorer results. The second alternative may prove quite expensive.

After a set has reached its owner it may not be used

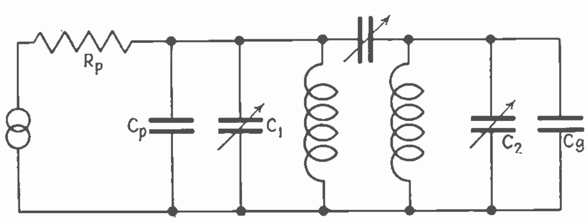


Fig. 4—Another transformation of the original tuned transformer

with the tubes with which it was originally lined up. Or if this condition is met originally it is certain in the course of its life to be re-equipped. Different tube capacities across the usual design of bandpass filter will result in a mistuning of the primary and secondary with a consequent shift in the characteristics, and narrowing of the band. However, this effect of tube changes is probably minor in comparison with the variations which may be encountered if cheap make-shift condensers are used to tune the transformer. These are subject to all the vagaries of temperature effects upon the dielectric used and all the tricks which dirt and dust can play.

Many of these difficulties can be avioded by a redesign of the filters. There are several types of circuits which may be used in a superheterodyne receiver. Figure 2 shows the ordinary coupling transformer and its equivaent T network. It can be seen that the capacities C_1 and C_2 are affected by the tube capacities. Furthermore, the mutual impedance is dependent upon the accurate maintenance of the spacing between the two coils. Unless high precision is maintained in manufacture and mechanical stability is well taken care of, the coupling may vary from transformer to transformer. This is more likely to be true where the coils are mounted on a rod and slid into place as a manufacturing adjustment, than when they are wound in slots in a spool. This, however, is expensive and may lead to many rejections.

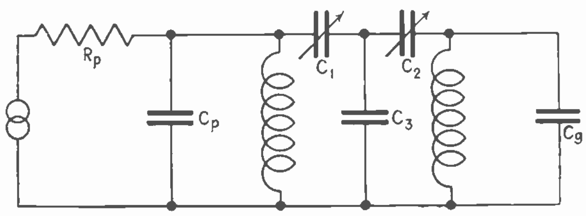


Fig. 5—Capacity coupled band-pass filter in which C_3 controls the width of the band passed

Identical transmission characteristics may be secured with other configurations. Figure 3 shows the result of changing the T network of Fig. 1 to a Pi network. This circuit requires three coils instead of two. Adequate shielding is used to make their coupling unimportant. The two condensers are the same as were previously required and present the same difficulties. The coupling is through a fixed coil which presumably can be maintained somewhat more nearly constant than the coupling between the two coils of the transformer. It is possible to redesign this filter using capacity coupling in place of the transformer as shown in Fig. 4, with the advantage of lower cost for the small variable condenser than for the adjustable coil.

In Fig. 4, however, the condensers form a Pi network which may be converted into a T network as shown in Fig. 5. This circuit seems to have several advantages over any of its other equivalents. In the first place, the tube capacities are no longer vital elements in the tuning. This is largely controlled now by C_1 and C_2. The chief effect of the tube capacities is to increase the apparent inductance and the effective resistance of the coils. It is not to be expected that this will be a major effect. The band-width of the system is set by C_3. This will be found to turn out to be a rather large value and may be quite stable with temperature and humidity. To preserve the stability to an even higher degree, a portion of condensers, C_1 and C_2, may be formed of small fixed condensers with the smallest possible trimmers to adjust for necessary variations in manufacture.

Since the band-width is controlled by condenser C_3 a simple noise control circuit is available; it will only be necessary to make C_3 have several steps connected to a switch which the listener can control at will. Listening to a local high power high-fidelity station he can leave the amplifier "wide open," and on weaker stations or during periods of high noise he can decrease the band-width by changing the effective value of C_3.

Power supply and linear time axis for cathode ray oscillographs

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Scientific and research laboratories have long used cathode ray tubes for investigating many special problems because the tubes lend themselves to many different types of work. Engineers, on the other hand, have not used so extensively the modern successor to the Braun tube because they have not appreciated the improvement in modern tubes and the simplicity of the associated equipment.

Furthermore the power supply for a cathode ray tube circuit is not at all complicated; it must furnish high voltage at low current drains and at values of ripple voltage dictated by the problem under investigation. For example, Fig. 1 represents a half-wave rectifier with a condenser to smooth the output voltage. Here R represents the combined effective load of the tube and the voltage divider. The tube is of the high vacuum type.

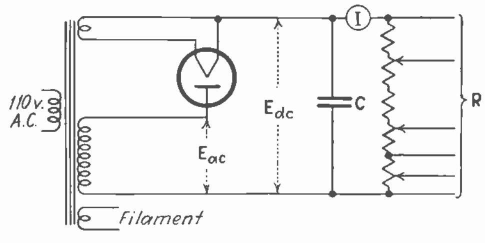


Fig. 1—Simple rectifier-filter circuit for power supply

The transformer must supply a peak voltage approximately equal to the desired rectified d-c potential. This value is based on the assumption that the charging of the condenser takes place during a small part of the a-c cycle and that the d-c current taken from the condenser is small enough so that the condenser voltage stays practically constant throughout the cycle. This assumption is justified if a low value of ripple is required.

The value of condenser C depends on the amount of

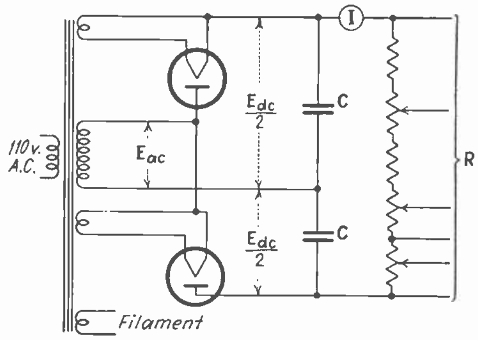


Fig. 2—Voltage doubler for producing higher voltages when desired

ripple that can be tolerated which, in turn, depends on the application of the cathode ray tube. A ripple of one per cent generally indicates sufficient filtering. When the allowable ripple as well as the current and voltage requirements of the cathode ray tube are known, a suitable voltage divider may be designed.

The condenser charges over a short portion of the cycle and discharges over the balance of the period. When small ripple values are required, only a very small portion of the cycle is used in the charge process because the d-c potential is so very nearly equal to the peak a-c voltage that current is rectified only at the crest of the a-c wave. The time of charge may therefore be neglected and the time of discharge assumed to be for a full cycle, say one-sixtieth second.

Derived from the equation for current flowing from a charged condenser through a resistance the expression for the ripple voltage in per cent is $\frac{1-\epsilon^{-t/RC}}{2\sqrt{3}}$

With time t equal to one-sixtieth second and various values of C as parameters, the curves of Fig. 3 were plotted. These curves show the ripple for any value of resistance and capacity as a percentage of the d-c current, or voltage. The error due to assuming time t equal to the time of one cycle is negligible for the range of these curves. For greater values of ripple the actual time must be known before this calculation may be made.

For low values of ripple the following equation is convenient:

$$\text{Per cent of } I_r = \frac{t}{2\sqrt{3}\,RC}$$

The values as calculated agree satisfactorily with measured values and may be used as the basis of practical

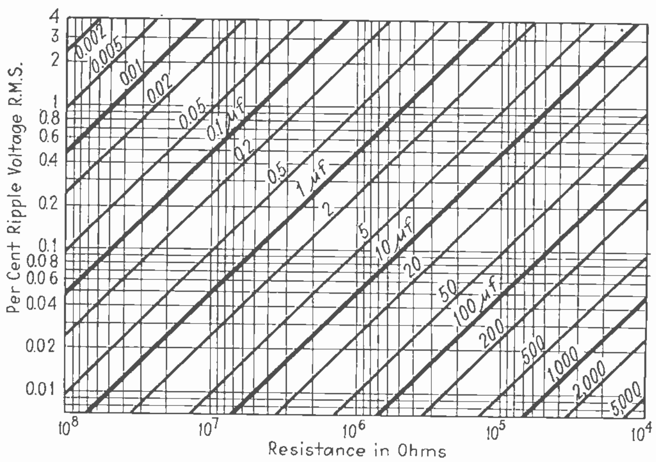


Fig. 3 — Relation between ripple voltage, condenser capacity and load resistance of rectifier-filter

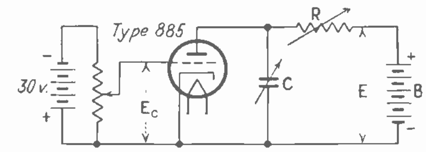


Fig. 4 — Simple sweep-circuit oscillator with current-limiting resistor

design. As an example of the use of Fig. 3 assume the ripple value must be kept less than 1 per cent and the effective resistance R must be as low as 10^6 ohms. The value of condenser C as shown is approximately 0.5 μf.

When the transformers available will not deliver sufficient voltage in the half wave circuit the voltage doubler circuit shown in Fig. 2 may be employed. For example a transformer supplying 700 volts RMS produces a peak voltage of 990 volts. This transformer in a voltage doubling circuit will supply nearly 1980 volts rectified d-c.

In the voltage doubler each half-wave rectified supplies current independently to a common load. The charge takes place twice each cycle, that is to say, once each peak of the a-c wave. This shortens the effective discharge period to half of the corresponding period in the half-wave circuit. The effective condenser required is half of that required for the half-wave circuit. This means that each condenser is equal to the single condenser used in the half-wave circuit. The ripple frequency is twice that of the half-wave circuit.

Sweep circuit oscillator design

Investigation of many electrical wave forms by means of cathode ray tubes requires a sweep circuit to spread the electron beam and to supply a time axis for the variable under investigation. By such a circuit the pattern is given two dimensions, one representing time and the other the wave form to be studied. The deflection representing time must start at some predetermined point on the screen of the cathode ray tube, travel across the screen at a uniform rate, and return to begin a new cycle. Since the return period of the beam is not of special interest, is usually non-uniform, and superimposes a second and interfering wave-form on the screen, it should be made as small a proportion of the total sweep-cycle as possible. It is an additional convenience to have the sweep-cycle synchronized with the wave-form under observation. These requirements are adequately realized by the use of a relaxation-oscillator circuit which employs a grid-controlled gaseous-discharge tube for control of the timing voltage. In a tube of this type the plate to cathode voltage drop during discharge is practically constant and equal to approximately 15 volts. These tubes, of which the 885 is a good example, are often called grid-controlled rectifiers.

A simple sweep circuit oscillator is shown in Fig. 4. Current from the battery flows through the resistance into the condenser. The grid bias voltage, E_c, prevents current flow through the tube until the voltage across the condenser reaches the breakdown value, or point at which the grid loses control. The condenser now discharges through the tube, and the condenser voltage falls below the ionization potential of the gas.

The grid now regains control, the condenser recharges, and the cycle is repeated. The sweep circuit oscillator may be synchronized with another periodically varying voltage of approximately the same frequency or multiple of the sweep frequency by using a small part of the periodic voltage, usually less than one volt, in series with the grid of the 885.

A simple sweep circuit oscillator using a resistor to limit the current flow to the condenser does not give a linear time axis but follows an exponential law. To obtain a linear time axis, it is necessary to replace the resistor R of Fig. 4 by a device which will limit the current flow to a constant rate. This gives a linear increase of condenser voltage with time as $e = q/c = it/c$. Figure 5 illustrates the use of a pentode as a current limiting device. When the circuit is first closed there is no voltage across the condenser and the entire supply voltage is impressed between the plate and cathode of the pentode. The current flowing into the condenser increases the voltage across the condenser and decreases the voltage across the pentode until the condenser voltage is sufficiently large to cause breakdown and discharge the condenser through the gas triode. The pentode current is practically constant until the pentode plate voltage falls below about 20 volts. Thus, to obtain a linear rise of condenser voltage with time until the breakdown point is reached, the supply voltage should be at least 20 volts greater than the peak condenser voltage.

It is desirable to have the cathode of the 885 at ground potential and to avoid the use of a-c filament supply for the pentode. The type 34 is a convenient tube to meet this latter requirement, since the filament current is but 0.06 ampere. The resistance R_1 connected in series with the plate of the 885 is used to limit the peak current dur-

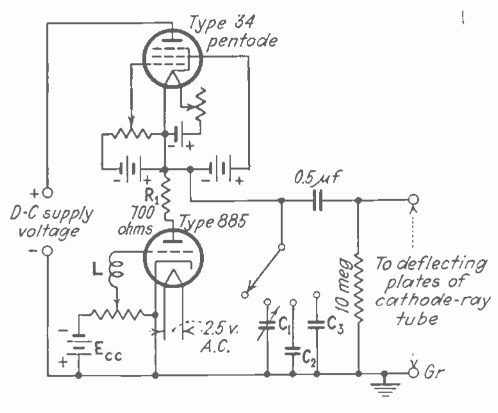


Fig. 5—Use of pentode as current limiter in typical sweep-circuit oscillator

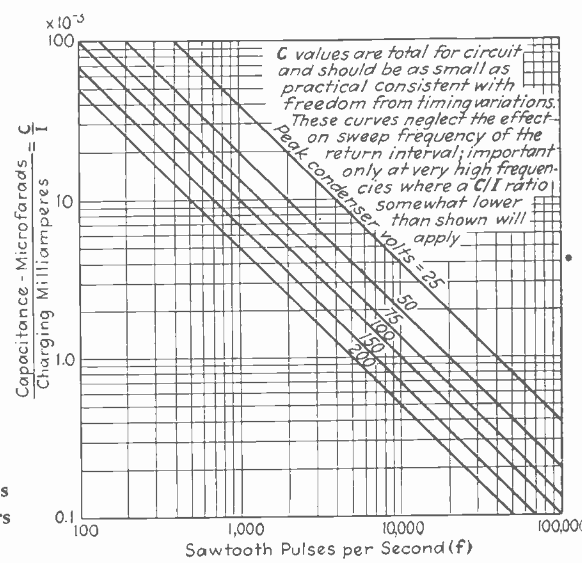
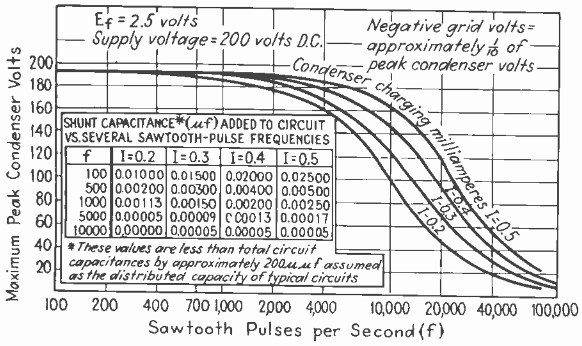


Fig. 6—Design considerations for sweep-circuit oscillators using gaseous triode



SHUNT CAPACITANCE* (μf) ADDED TO CIRCUIT VS. SEVERAL SAWTOOTH-PULSE FREQUENCIES

f	I=0.2	I=0.3	I=0.4	I=0.5
100	0.01000	0.01500	0.02000	0.02500
500	0.00200	0.00300	0.00400	0.00500
1000	0.00113	0.00150	0.00200	0.00250
5000	0.00005	0.00009	0.00013	0.00017
10000	0.00000	0.00005	0.00005	0.00005

* These values are less than total circuit capacitances by approximately 200 μμf assumed as the distributed capacity of typical circuits

Fig. 7—Operation characteristics of the gas triode, type 885

ing discharge to a safe value. This resistor does not appreciably increase the discharge period.

The time required to charge the condenser of Fig. 4 to any voltage V is: $t = Vc/i$ where i is the uniform charging current in amperes. The number of sweeps or sawtooth pulses per second is then $f = i/t = i/Vc$. A convenient plot of this relation for various values of peak condenser voltage is shown in Fig. 6. These curves are accurate only if $i = Vcf$ and then the condenser voltage wave form is a perfect sawtooth wave. The gas triode imposes limitations on this relation, however. Both the surge impedance of the tube and its de-ionization time are finite. During the time the condenser is discharging, current is flowing through the constant current tube and the 885. This current is not utilized in building up the sawtooth condenser voltage. Also, if de-ionization is not complete at the end of the discharge period when the condenser voltage is starting to build up, part of the constant current supplied by the pentode will be shunted through the 885, causing the condenser voltage to rise slowly until de-ionization is completed and destroying the linearity of a part of the sawtooth wave. Both these effects are of importance at the higher frequencies and increase the current supplied by the pentode over the value required for a perfect sawtooth wave of the same frequency and amplitude. This causes the curves shown in Fig. 6 to deviate from a straight line as the frequency is increased above 20,000 cycles. A measure of performance of a sweep circuit oscillator might be taken as the ratio of actual current to the theoretical current required for a perfect sawtooth wave. For the 885 and the circuit shown in Fig. 5 the ratio is practically 1 below 20,000 cycles and at 50,000 cycles is 1.1 to 1.25.

Figure 7 shows for the 885 the maximum peak sawtooth voltage obtainable at any frequency as a function of the condenser charging current. These data were taken with a circuit capacity of 200 μμf. Circuits can be designed which have a capacity between plate and cathode of the discharge tube of 50 to 100 μμf. Such circuits will give from 2 to 4 times the peak sawtooth voltage shown in Fig. 7 above 30,000 cycles.

For stable operation, the condenser must not be too small. This statement depends on the requirement that, for a definite frequency and peak sawtooth voltage, charging current decreases with condenser size. During the de-ionization time a small current can flow through the gaseous discharge tube. If this current is appreciable compared to the charging current of a small condenser the time axis will be non-linear and the charging period of the condenser non-uniform. Another effect which may occur when too small a condenser is used is "tailing" or the return of the cathode ray beam to a position ahead of its true starting point during the de-ionization period. This is caused by the comparatively large positive ion current to the grid which charges the condenser negatively.

Figure 8 is an unretouched photograph of the trace made on a type 905 cathode ray tube showing a 200,000 cycle per second sine wave as generated by a vacuum tube oscillator spread by a 50,000 cycle per second sweep. The return line is seen to be approximately one-fourth of a cycle or 1.3 microseconds. The picture was taken with a lens speed of F-6.3 and required a 2 minute exposure because only 500 volts was applied to the cathode-ray tube with 10.8 micro-amperes beam current. The stability of operation is shown by the exact coincidence of the individual cycles resulting in a clear picture.

Figure 9 is a photograph of a 50,000 cycle sweep spreading a 100,000 cycle sawtooth. This is interesting in that it shows the curvature of the time of the discharge period compared to the linear portion of the cycle.

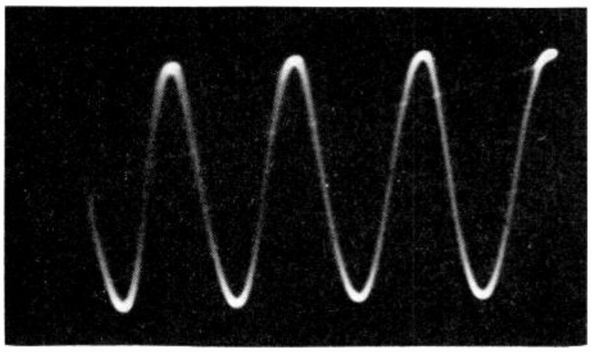


Fig. 8—Photograph of 200,000 cycle sine wave spread by a 50,000 cycle sweep

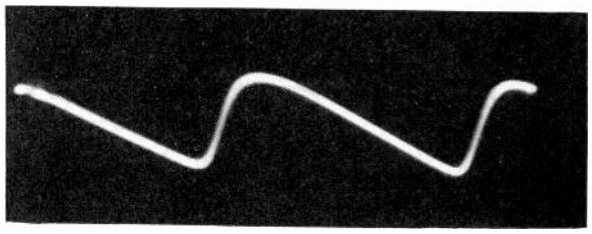


Fig. 9—A 50,000 cycle sweep spreading 100,000 cycle saw tooth wave

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NEW DESIGNS—NEW MATERIALS

NOW, as never before, industry is seeking new designs—and new designs dictate new forms and new materials.

—DONALD DESKEY

Annual tube replacement cost for broadcast stations

Of the total annual replacement expense born by broadcast stations, the greatest proportion goes into new tubes to replace those showing signs of failure, or which have lived out the life span allotted them by the station manager. Other items of expense involve new transformers, resistors, replacing of batteries, microphone repairs, etc. but in general these replacements do not bulk up so large as the tube costs.

In surveying the broadcast stations rather wide ranges of tube replacement costs were found. To a considerable measure these variations in cost are due to the different hours of operation, some stations remaining on the air for a considerable period and others, due to lack of paid programs or to the forced sharing of time, having lower annual replacement costs.

It is true too that some station operators feel that time off the air due to breakdown or to changing tubes is more costly than regularly replacing tubes. One station engineer states that he replaces tubes regularly at the end of 3000-hour periods regardless of the condition of tube. He points out that care in selection of tubes, particularly those which operate in parallel with other tubes will reduce the annual cost. One gathers that low priced tubes will not.

Another operator of several stations indicates that certain tubes have shown that they should be replaced at more frequent intervals; one particular tube, for example, is given a life of 86 days or 1500 hours. This amounts to three complete changes per year. Rectifiers on the other hand are replaced in this station only once a year.

And to show the opposite extreme, the chief engineer of a large station admitted that it was necessary to use the tubes to the limit. Naturally his figure for annual tube replacements costs was appreciably lower than those quoted above. The figures in the table, however, are good average figures made up of a number of stations in each power rating.

Reports from station operators indicate that the tube cost runs between 40 to 50 cents per hour of operation for a 1000-watt station with proportionate increases for stations of greater power. These figures have decreased somewhat in recent years due to several causes. In the first place competition for this market has forced tube manufacturers to extend themselves to lower prices and to increase the life of tubes. It is also true that many station operators have been forced by economy measures to extract the last hundred hours of operation from their tube equipment.

ANNUAL TUBE REPLACEMENT COSTS

Power	Costs
100 watts	$ 300
250 watts	600
500 watts	1,500
1000 watts	2,000
5000 watts	3,300
10 kw.	4,000
25 kw.	8,500
50 kw.	14,000

One station engineer states "it is possible to run up the hours on tubes much higher than 3000 hours, and I have observed that where such a routine is adhered to, the futility of trying to get the very last cycle out of a tube is quite conspicuous by the total number of hours the station is off the air due to a tube breakdown." In this particular station (5 kw.) burned out coils calls for an annual expenditure to replace of $100; another $100 goes for replacement of audio amplifier apparatus for an aggregate of 10 amplifiers of various types. Microphone repairs total to another $100 for 25 units used in the field and in studios; and finally, about $100 are spent each year for battery equipment for field work.

As proof that his ideas of station routine are correct, this engineer states that a station replacing tubes regularly at the end of 3000-hour periods was off the air a total of 51 minutes in one year for reasons of various sorts; another station trying to extract long life from the tubes was off the air for a total of 10 hours per year, the chief reason being tube trouble.

One engineer's statement in regard to the discrepancies between various cost figures is interesting: he states that the cost depends not so much upon the length of time the tubes are operated but upon the skill and care of the personnel. In other words some tubes can be run longer than others, and a routine schedule of throwing them away at the end of a certain number of hours is not economical. He describes the example of two 862 100 kw. amplifier tubes which operated for approximately one year and a half at 18 hours per day, or almost 10,000 hours. In this case the tubes were expensive, and additional hours of service represented a considerable saving.

The type of tube used for plate power rectification also influences the annual costs; if high vacuum tubes are used the power cost will be high; if mercury vapor tubes are used the tube cost will be higher. Gradual replacement of batteries by electron tube equipment increases the annual tube cost but decreases money laid out for batteries.

Other annual costs

Other items of expense involve personnel, power or fixed charges in addition to tubes and maintenance. Gradual tightening up of technical rules which govern the operation of the station under the Federal Radio Commission license has cost the station additional money each year; first for better frequency control equipment; then for higher modulation power. Recently the advent of receivers with compensated bass control brought to light the fact that many stations had considerable hum modulation; this had to be cleaned up. New monitoring equipment, and new measuring apparatus of various types add to the annual costs.

The smaller stations, particularly, must spend money for this type of modernization. As an example, a 100-watt station reports that its tube expenses for 1933 were approximately $300, while the cost of new equipment amounted to $800 involving a frequency monitor, new microphones, a class B modulator and repairs and replacement involving reconditioning of microphones, modernizing audio amplifier equipment, etc.

The power costs amount to approximately $1,500 per month for a 50 kw. station and about half this for a station of 10 kw. in power. Fixed charges and personnel vary with the station and the locality, of course.

The costs indicated by this survey are lower than figures assembled a few years ago by the National Advisory Council on Radio in Education and published in *Electronics*, June 1931. Since that time manufacturers of tubes have improved tube life to a considerable extent; and competition among the several companies supplying power tubes has lowered the prices. For example the figure in the table for $14,-000 for a 50 kw. station compares with 1931 estimate of $50,000 for a 12 hour day, while the 1933 figures are on an average day of 18 hours.

Shield grid Thyratrons

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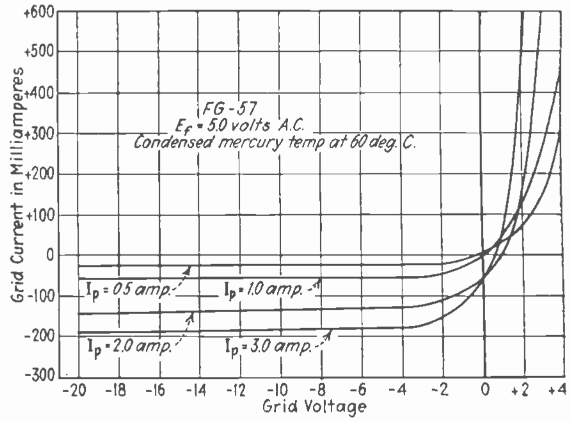


Fig. 2—Grid voltage-grid current curves for various anode currents

THE Thyratron, as originally developed, has three elements: a cathode, which furnishes electrons to carry the current; an anode, which collects these electrons under the proper conditions; and a grid, which exercises a limited control over the electrons. These elements are enclosed in a hermetically sealed envelope which contains an inert gas or vapor. If with a positive potential between the anode and cathode, the grid is held sufficiently negative, the electrons from the cathode will be unable to produce an ionized path to the anode and the tube remains nonconducting. If, however, the grid is permitted to assume a more positive potential a point is reached where cumulative ionization to the anode takes place and the tube starts and maintains an arc-like discharge which carries relatively heavy currents between the anode and cathode. Normally these currents are limited by the impedance of the external circuit. Under these conditions, unless large grid power is available, the grid exercises no appreciable control until the discharge has ceased and the ionization within the tube has been "cleaned up."

The grid power is, of course, dependent upon the grid voltage and current. A tube used in a circuit with sufficient bias to hold the grid voltage slightly more negative than the trigger point can be started with an extremely small signal voltage. Experience, however, has shown that biasing very close to the trigger point is in general not practical. Slight changes in applied voltage, surges, transients, slight changes in characteristic, etc. are likely to start the tube. In addition to this, in most installations it is desirable to be able to substitute a new tube at the end of life without the necessity of readjustment of the circuit and therefore the variation in characteristics from tube to tube must be taken into consideration. Thus, more or less additional bias is used depending upon the conditions encountered in the particular application so that no hard and fast rule on the necessary voltage swing can be given. The other factor involved in grid power is the grid current which can be more readily determined and its value may be taken as an indication of the magnitude of the grid power.

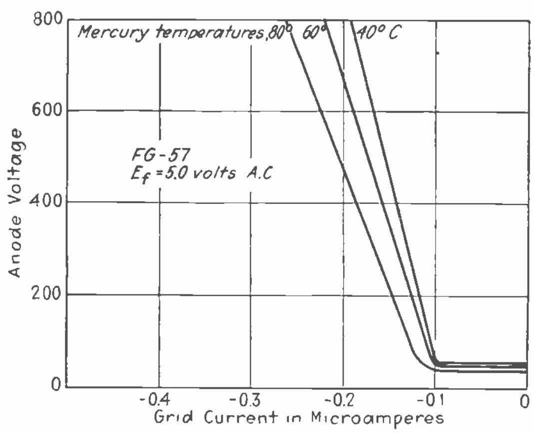


Fig. 1—Grid current at start of discharge for 3-element tube

Addition of a second, third, or fourth grid to high vacuum triodes revolutionized an art; made possible high-gain, compact, cheap receivers and stable, high-power transmitters. Now a second grid has been added to gaseous triodes, those new tools of industry. The advantages of such grid-controlled rectifiers over the older types are discussed here by engineers closely connected with electronics.

It will be seen in Figs. 1 and 2 that the grid current after discharge is many times the magnitude of that before discharge. This is not generally detrimental since the tube has already been controlled before the grid current after discharge occurs. Under certain conditions it may, however, upset a weak grid circuit causing incorrect firing of associated tubes or may result in a condition such as saturation of the grid transformer which may persist after the tube has ceased firing and the grid is again trying to exercise its control function, thus distorting the grid input voltage. The grid current before discharge, however, is a real limitation upon the tube when used with very high impedance grid circuits such as are frequently encountered in photoelectric or other control arrangements. This grid current invariably pro-

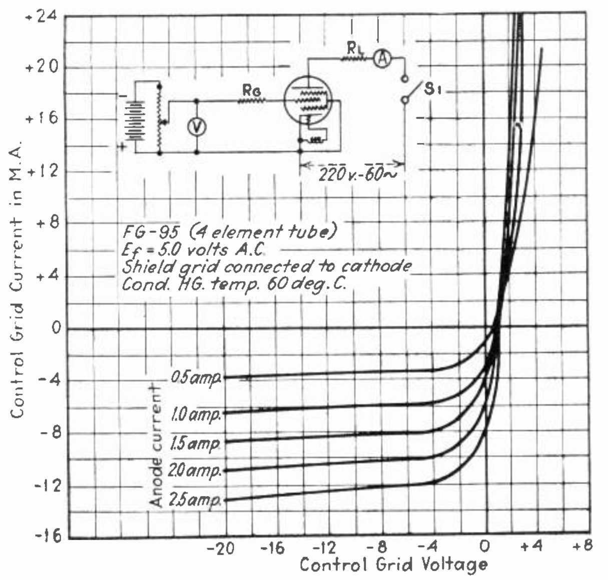


Fig. 3—Control grid current after start of discharge in 4-element tube

duces an impedance drop in these circuits which tends to reduce the actual grid voltage. In very high impedance circuits this drop tends to make the operation of the tube independent of the intended actuating voltage. In addition to this, the impedance drop may vary, for example, as the grid emission changes, due to the tube warming up under load, the grid current would vary and thus operation would be made unreliable.

To overcome some of these difficulties four element or shield tubes are now commercially available.

A number of factors tend to make the four element superior to the three element tube. The shielded tube is so constructed that under similar conditions it will pass much less grid current than the three element tube. In the latter construction it is desirable to have a large control grid, not only to control all possible paths between the cathode and anode, but also to protect the discharge path from extraneous charges which may accumulate on the walls of the tube. In the four element construction the shield grid protects the discharge from charges on the wall and closes all possible paths between anode and cathode except the opening in the grid baffles adjacent to which the control grid is situated. The small size of control grid results in small ion grid current both before and after discharge since the ion current is largely dependent upon the size of the grid.

The control grid is so situated that it is protected by the shield grid from cathode material sputtered or evaporated from the cathode. In the three element tube the grid is not so protected from the cathode material and during the activation process and tube operating life cathode material may be sputtered or evaporated onto the grid giving rise to grid emission. In addition, the shield grid also shields the control grid from heat radiated from both cathode and anode so that its temperature will be low tending toward less grid emission. The charging current of the control grid will be low not only due to its small size, resulting in low capacity, but also to the upper and lower baffles of the shield grid which shields it electrostatically from the anode and cathode.

The improvement of the FG-95 over the three element FG-57 is readily apparent from the illustrations.

The data taken on these curves do not, however, show the effect of charging current or of grid emission due to conduction. A simple test circuit shown in the figure gives a very good indication of the characteristics of a shield grid tube in these respects.

The tube under test is placed in position and the cathode allowed to come up to operating temperature. The switch S_1 is then closed allowing the tube to pass current provided the grid voltage is more positive than the "critical value."[1] The load resistance R_L is then adjusted to give full average current as indicated by the d-c ammeter in the anode circuit. With R_g shorted out the grid bias is made negative until the tube ceases to conduct. This is possible since we have alternating current on the anode and when the grid becomes more negative than the "critical value" the tube will not start during the positive half cycle. This reading we may designate as V_1. The tube is again made conducting and allowed to run with rated average current through the tube for some definite time such as 5 or 10 minutes to allow the elements in the tube to come up to full operating temperature. Then, with a known value of R_g in the grid circuit the negative grid bias is again increased until conduction ceases. This reading we may designate as V_2. If we use a large enough value of R_g these readings may differ by 30 or 40 volts. Since the tube characteristic generally changes only slightly due to the increased temperature, it is apparent that the difference in the two readings is voltage lost in drop through the grid resistor.

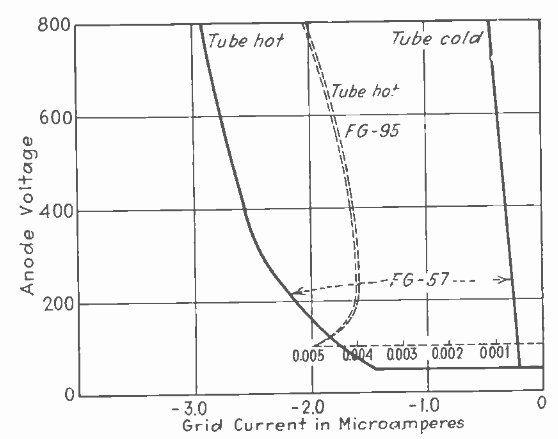


Fig. 4—Grid currents in 3- and 4-element tubes, hot and cold, at start of discharge

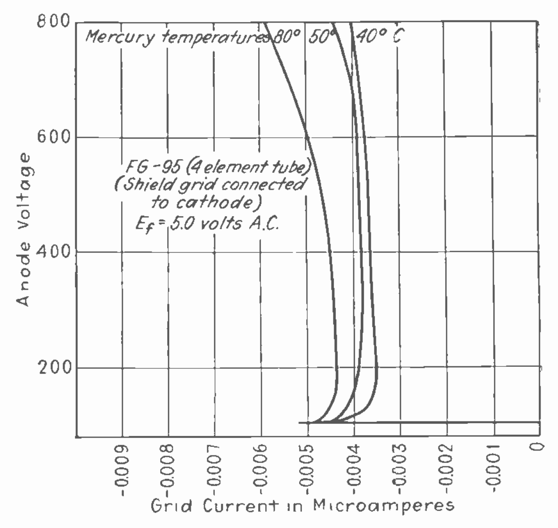


Fig. 5—Grid current in 4-element tube at start of discharge

With this test the FG-57 initially passes a test which requires it to cease conduction (after five minutes warming up operation at full load) with a resistance of 10 megohms and a negative voltage of not more than 50, whereas the FG-95 under the same conditions is capable of cuting off with a resistance of 100 megohms and a negative voltage of not more than 50.

Curves are given of anode voltage versus grid current at start of discharge for a three element tube when cool: that is, when it has been passing zero or a very small fraction of its rated current, and again when the tube is hot; that is, when it has been passing full average rated current for 5 minutes. A comparison of similar data for the four-element tube shows that while the three element tube shows a large change between the hot and cold condition, the change in the four element tube is very small, thus giving the latter tube the advantage of greater stability.

In addition to the small grid currents obtained in the four element tube it has another marked advantage and that is that the starting characteristic can be varied by varying the potential at which the shield grid is held. The starting characteristic of a four element tube when various d-c potentials are applied to the shield grid are shown making it possible to have a tube the starting characteristic of which can be made either "positive"[2] or "negative"[3] or by impressing a fluctuating voltage on the shield grid this tube can be made to have a negative control characteristic over some portion of the cycle and a positive control characteristic over other portions. By varying the phase relations of the two grid voltages many interesting control effects can be obtained.

As a further advantage, the shield grid construction tends to prevent transient conditions in the plate circuit from affecting the grid circuit and thus the operation of the tube. Such transients are more troublesome in gas discharge tubes than in high vacuum types as a surge of short duration in the anode circuit may, if reflected to the grid, affect the tube for an entire half cycle.

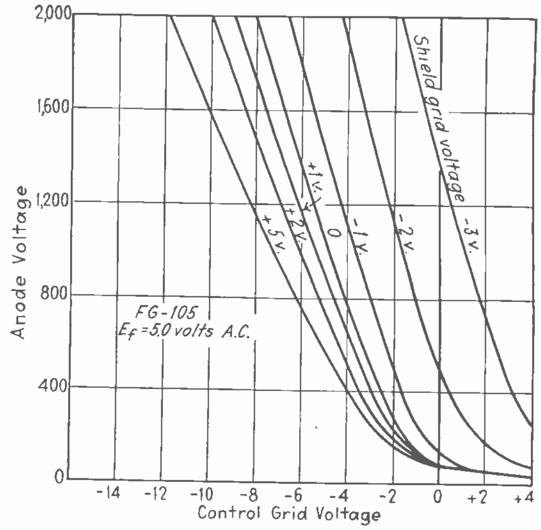


Fig. 6—Effect of varying shield grid voltage on relation between anode and control grid voltages at start of discharge

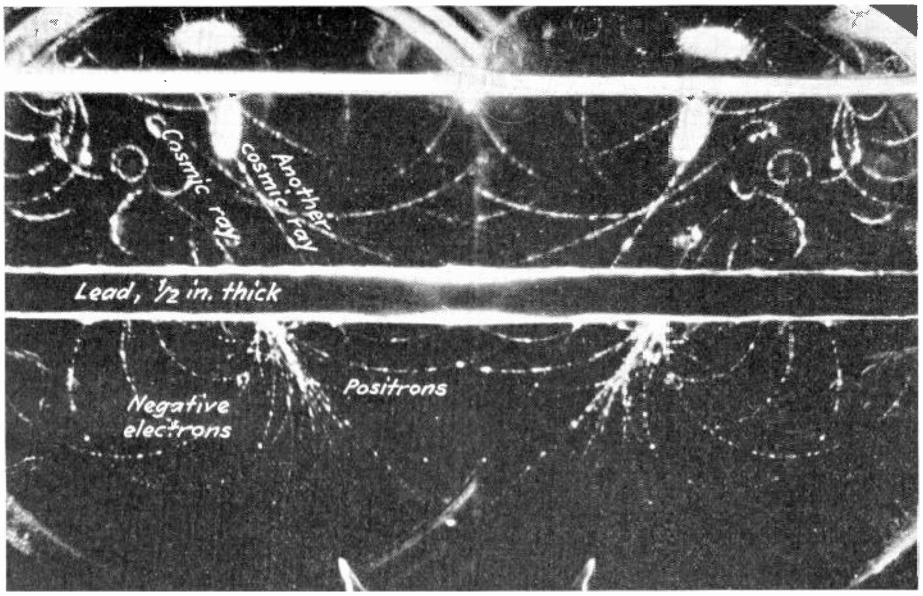
[1] "Critical value" of grid voltage is the grid potential that will just allow conduction to occur.

[2] A negative control tube is one which requires a negative voltage on the grid to prevent conduction over the majority of the operating range.

[3] A positive control tube is one which requires a positive voltage on the grid to start conduction over the majority of the operating range.

COMPARISON OF THREE AND FOUR-ELEMENT TUBES

Advantages of 4-Element Thyratron Over 3-Element Tube	Grid Emission	Temperature of Grid	Receives very little heat from anode, cathode or arc stream due to shielding effect of shield grid.
		Contamination of Grid	Grid is protected from sputtered or evaporated material from anode, or cathode coating, by shield grid.
		Photo-electric Current	Small Size Shielded from internal light.
	Ion Currents	Before Discharge	Small Size Low increase in gradient as anode potential increases causes only small increase in residual ionization.
		After Discharge	Small Size Grid removed from ion stream causing low density of ionization at the grid.
	Electron Currents	Negative Tubes	Small Size Shielded from electrons coming from cathode due to initial velocities.
		Positive Tubes	Small size collects smaller number of electrons.
	Capacity Effects		Small Grid Shielded from anode and cathode by shield grid.
	Leakage Currents	External	No base leakage as control grid lead is located on side of bulb.
		Internal	Leakage inside of tube reduced.
	Characteristic		Characteristic can be adjusted by varying voltage on shield grid.
Disadvantages of 4-Element Tube	Cost		Slight increase in cost.
	Mechanical		Extra connection is required for control grid.
			Slightly greater size.



Penetrating half an inch of lead, a billion-volt cosmic-ray electron smashes a lead atom, scattering electrons and positrons. The right-hand section is a mirror reflection.

ELECTRONS ON RAMPAGE

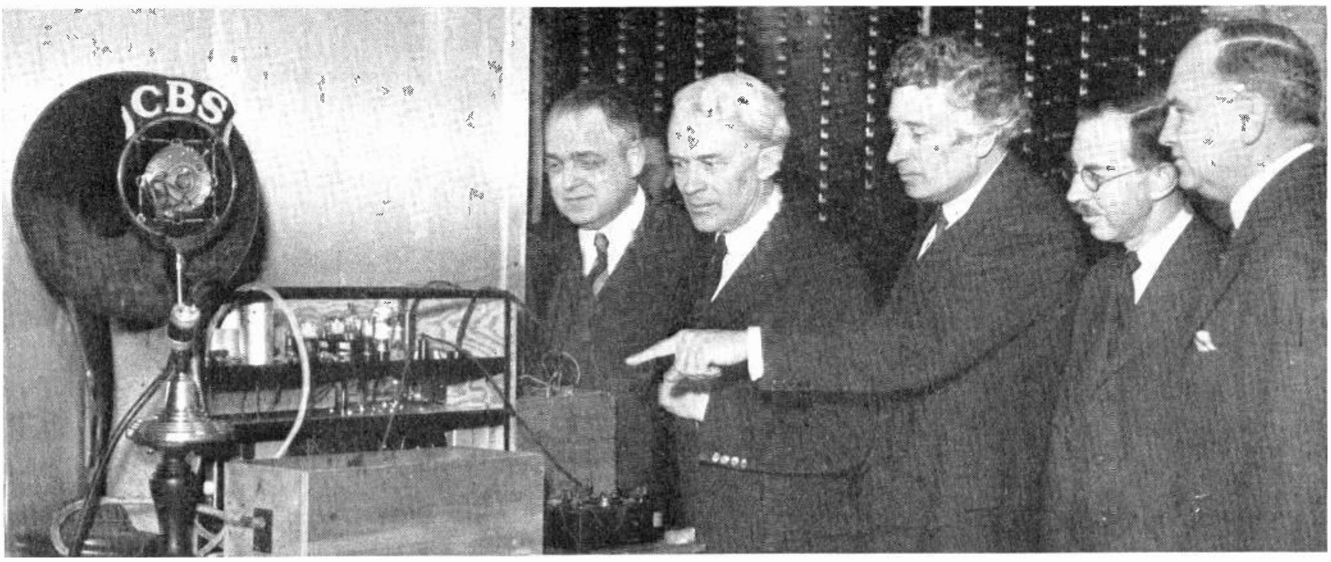
How cosmic rays smash atoms, penetrate steel and concrete

Recent cosmic-ray surveys have caused scientific opinion to veer around to the view that these rays are high-speed electrons reaching the earth from space, with velocities approaching the speed of light, and indicating energies of billions of volts. These projectiles apparently pass easily through steel and lead, which would effectively cut off any other rays known to science.

A cosmic ray passing through a half-inch plate of lead and then smashing a lead atom into its constituent electrons and positrons, is shown in the remarkable photograph above, just taken by Dr. Robert A. Millikan and his associates, at Norman Bridge Laboratory, California Institute of Technology, Pasadena.

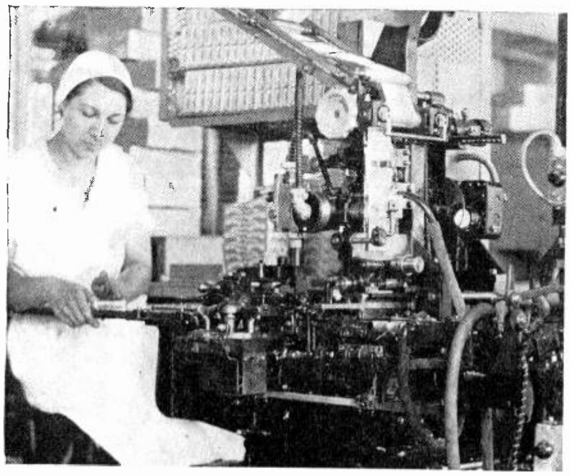
The photograph was made in a Wilson cloud chamber in the presence of an intense magnetic field of about 20,000 gauss, produced by a 2,000-amp. 500-volt coil. The principal actor in this cosmic-ray drama, passed clear through the lead plate, and just as it emerged from the lead, hit the ill-fated atom, sending a shower of electrons and positrons into the chamber. In the intense magnetic field, the fifteen or twenty negative electrons were deflected in spirals to the left (in main picture), while the half-dozen positrons, bearing positive charges, were swung to the right. Dr. Millikan estimates the energy of the initial cosmic-ray particle to be about a billion-and-a-half volts. The electrons and positrons of largest curvature had energies of two or three million volts, while those secondary particles which continued in almost straight lines had energies of over 400,000,000 volts. At the right is apparently the track of another cosmic-ray particle which went through the interstices of the lead sheet without incident except a change in velocity.

The mirror reflection is introduced in order to get stereoscopic vision. If the photograph is cut apart at the line of the mirror, and the right-hand side reversed, the two slightly-differing pictures can be viewed in a stereoscope, and the scene stands out in relief. Seen this way, the explosion of the lead atom appears as a beautiful shell-burst or fountain effect, in perspective, the electrons and positrons scattering in all directions.



Dr. W. F. G. Swann, director of Bartol Foundation, Franklin Institute, demonstrates that cosmic-ray electrons pass through 34 stories of steel and concrete of the Ruppert Building, New York, and then penetrate the armor plate steel of the vault 40 ft. below ground. The normal count of 60 rays per minute under the open sky, was reduced to 27 by the steel.

HIGH LIGHTS ON ELECTRONIC



One of the photocell-controlled wrapping machines of American Chicle Company

Wrapping speeded, complaints decreased

Sales of standard lines of the American Chicle Company, makers of candy gum, were increased because of new packaging made possible by photo-cell control installed on eight wrapping machines, according to L. C. Stone.

In addition, continuous rolls of labeling stock can now be used instead of single sheets.

Cell control on the counting machine has cut down complaints of shortages from the dealers by furnishing more accurate counts.

✦

Registering broadcast listeners' opinions

There is a very simple method by which a broadcast station can conduct listener votes, surveys, etc., using only facilities right at hand in every listener's home that has electric lights. This method involves having the listeners "telegraph" in their votes by each turning on an incandescent lamp for half a minute, when so requested. The total vote is thus registered by the *total additional electrical load* during this period, as measured by the electric light company at its distributing or generating station.

For example, supposing it desired to get the vote of persons listening in at a certain time, to determine the number of those who prefer Eddie Cantor, and those who demand Ed. Wynn.

First the announcer asks that all those who wish to take part in the vote will please turn on an ordinary incandescent lamp, preferably a 60-watt lamp, and keep it turned on while the announcer counts off say 30 seconds. During this period, the switchboard attendants of the electric light company note on their instruments the sudden increase in power taken by the system. Supposing this registers 600 kw. or 600,000 watts. At once this is an indication that 10,000 listeners have turned on their lamps momentarily and are ready to vote.

Then after a full minute's wait, to give each listener time to turn off his lamp, the announcer again calls out "Folks listening, all those who prefer Eddie Cantor, please turn on one lamp and leave it on, while I count thirty seconds." If the power house switchboard meter this time records 400 kw. or 400,000 watts, this is evidence that 6,666 sixty-watt ballots were cast by Cantor fans.

Next the announcer calls for votes for Ed. Wynn in the same way, and if this time the switchboard meter flips upwards by 200 kw., or 200,000 watts, it shows that 3,333 votes were cast for the Fire Chief.

Thus by comparing the sum of the two votes with the initial test ballot, the accuracy of any vote can be checked.

Electric light officials should be glad to assist in taking such electrical votes, although some preparation may be necessary to make sure that several different meters are read to get the total vote,—also that the balloting is attempted only when the regular electrical load is not changing rapidly, owing to motors coming on and off the line.

Of course, such balloting will include only listeners in electric lighted homes on the lines of the electric companies co-operating. As such lighting-company districts are usually far smaller than the area reached by even a small broadcasting station, this will have to be taken into account. But the actual number of listeners participating in the vote should be ascertained with fair accuracy.

The method is also open to the drawback that in a ballot like the above, some Ed. Wynn admirer might "stuff the ballot box" with a hundred extra votes for his idol by switching on and off an electric range (6 kw. or 6,000 watts!) instead of a 60-watt lamp. But such illicit voting is not likely to impair seriously the over-all dependability of the results of the method.

✦

Tube control of rubber extruder

In the plant of the Ohio Rubber Company, Willoughby, Ohio, solid rubber sections are produced as tires for children's vehicles, invalids' chairs, etc.

The rubber is extruded in round shapes from a tube mill; passed to a long endless take-off conveyor belt, operated with a variable-speed, direct-current motor; cut in sections of about 50 feet; cured, and cut into short sections for wheel tires.

Owing to different grades of mixture, temperature changes and varying feed into the mill, the speed of extruding varies considerably at times.

If the linear travel of the take-off belt is not just right to carry away the rubber as extruded, it will stretch and change the diameter of the tire stock, if too fast, or allow the tire stock to fall to the floor in loops and get tangled up, if too slow.

In order to eliminate the unsatisfactory manually operated speed control for the d.-c. conveyor belt motor, J. D. Crobaugh, electrical engineer of the rubber company, desired to install automatic control of some kind that would synchronize the speed of the take-off conveyor belt to the amount of rubber extruded at all times, under varying conditions.

The extruded tire stock is allowed to drop in a loop. A small roller, ¾ by 5 inches, suspended by a pivoted arm, rests on the upper side of the loop.

When the machine extrudes faster than the conveyor is operating, the loop drops a little, causing the roll arm lever to move the plunger of a small solenoid. This solenoid is used as a reactor and is connected in the grid circuit of a thyratron control for the field of the direct-current conveyor motor.

A slight increase in the loop causes the conveyor motor to increase its speed, while a decrease in the loop causes the motor to slow down. The regulation of the loop is so close that the roller on the loop does not move more than one-quarter inch up and down in order to obtain the proper speeds.

DEVICES IN INDUSTRY + +

Some possibilities in electronic exhibits

EXHIBITORS AT SHOWS, fairs, and expositions are often looking for novelties to install which will attract special attention to their booths. R. D. McDill, industrial electronic engineer, 1624 Hayden Avenue, Cleveland, Ohio, points out that electronic devices offer splendid opportunities for this kind of novel control, and offers the suggestions below, which can be built at costs of from $25 to $1,500, depending upon whether produced in some quantity or custom-built. Mr. McDill feels that there are many opportunities of this kind for electronic men to capitalize upon, while increasing the attractiveness of exhibits.

A 100-lb. iron bar follows the hand up for ten inches. The hand does not touch the bar. The hand is jerked away, the bar drops down. Magic? No. An electronic control does the trick.

A person approaches to drink from a flowing fountain. When his lips are in position to drink, the fountain stops. (This is of course the reverse of the standard photo-cell turn-on valve.)

A hand waved over a crystal ball causes mechanisms to operate, or music to play.

Approach an exhibit and the story of the exhibit is told, and, or pictures of the product's use or manufacture are shown. When the person walks away, the show stops.

A hand is held on the *outside* of a glass window or show case touching nothing but the glass, and the window lights up or mechanical exhibits are caused to operate inside.

A mechanical doll pushes objects off of a belt according to their color. Assume that several balls of the same size, but of different color, are rolling down a trough. The first doll will push off the white balls, the second doll the red balls, and the third doll the black ones, and so on.

An object when reached for is caused to jump from under the reacher's hand.

Toy trains and other objects are caused to operate by throwing light on the object.

Toy electric lamps are caused to light up without the aid of wires or batteries.

A hand gently waved over a crystal ball causes the lights on a picture or display to become gradually more intense the closer the hand comes to the ball.

A door opens if the proper number of words are said in the proper manner in front of the door.

Visitor walks up to a display. A light comes on in front of him. Sign says—"Blow me out." Visitor blows and the light goes out.

"If you want to see all of this display you will have to whistle." After each whistle (or word) a lamp lights in some different part of the display.

✦

Electric "ear" solves tire-design problem

ELECTRIC "EYES" HAVE FOUND a myriad of industrial applications, and have helped solve many a production problem. Now, it appears, electric "ears" are equally useful in their field of sound.

With improved engines, and engine mountings, new self-lubricating springs, and better built car bodies, the 1933 and 1934 automobiles have been quieted in operation to the point where the most noticeable remaining noise comes from the tires.

Tire noise analyses, commenced last March, and continued over a period of several months, by the B. F. Goodrich Rubber Company, have utilized noise-measuring equipment consisting of a Jenkins and Adair condenser microphone, a Burgess acoustimeter and a 1,000-cycle low-pass filter. The microphone, felt-padded in an iron box, was bolted to the test car floor in the position ordinarily occupied by the rear seat cushion, and was connected by a 4½ in. fiber tube with a hole in the car floor located directly over the rear axle.

Sound tests of many makes of tires were made. From hundreds of trial runs, at speeds from ten to sixty-five miles an hour, two treads are being made available on Goodrich's 1934 tires. One, having a broken or "button" tread is familiar to everyone. With refinements to decrease noise, it will be found on the majority of new cars. The other, with an unbroken, ribbed tread, to give a maximum of quietness in operation, becomes standard equipment on 1934 Auburns, Buicks and Chevrolets.

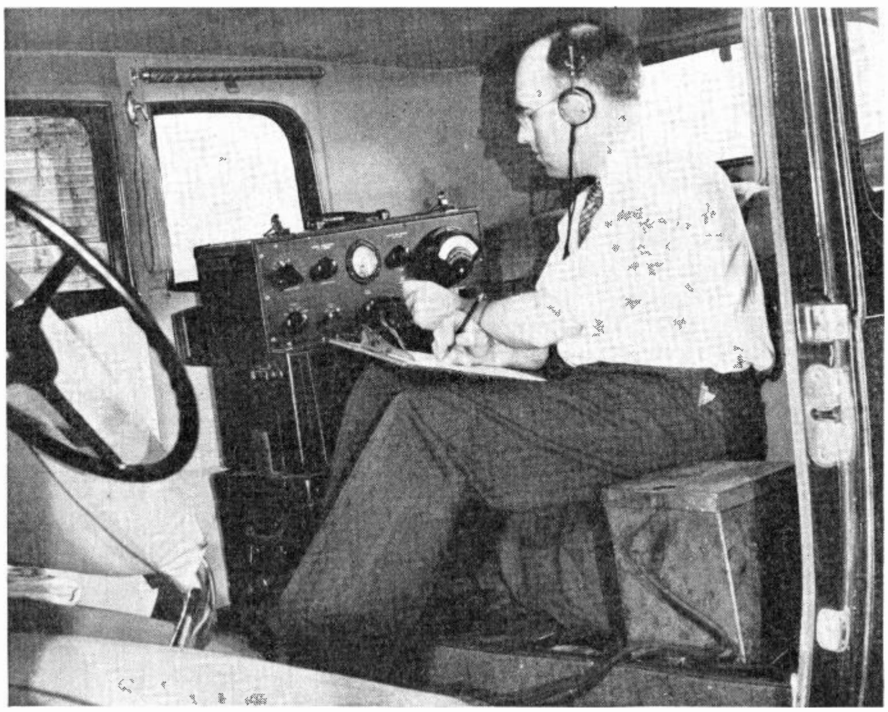
✦

Times "reaction-interval" of driver in emergency

AN ELECTRICAL INSTRUMENT which measures the speed of thought and muscular response of an automobile driver when he is called on to stop his car in an emergency, has been developed at the Massachusetts Institute of Technology.

Two cars are employed in the test. In the leading car operation of a stop light reproduces a highway emergency. The instant the foot of the driver under test touches his brake pedal a radio impulse flashes to the control car, and the difference in time between the two actions represents the reaction time of the driver.

This "delay timer" was invented by C. W. Frank, a Tech graduate of 1927.



Microphone and acoustimeter in use in test automobile, for comparing relative tire noises produced by different designs of tire treads.

A study of r-f choke coils

By REUBEN LEE

Engineering Department, Chicopee Falls Works, Westinghouse Electric & Manufacturing Company

IN CONTRAST with other components in the radio art, the radio-frequency choke coil seems to be an unknown factor; its design is still a matter of cut-and-try, or just plain guessing.

Recent work at Westinghouse Chicopee Falls laboratories is described here; it seems to throw much light on an hitherto dark subject.

IT is well known that the characteristics of r-f coils vary with frequency and that these variations affect the performance of apparatus employing these coils. The immediate question therefore in starting the investigation of chokes described here, was to determine what governs the frequency limits between which a choke coil may be operated, to determine the extent to which these limits affect circuit operation.

Existing literature gives rather scant information on this subject. In one prevalent idea, the choke is pictured as a pure inductance shunted by a capacity, the combination determining the coil natural frequency and the impedance at any frequency. Under this assumption it would be possible to predict coil performance, once the inductance and capacity were known. The validity of this assumption was tested during the course of the investigation.

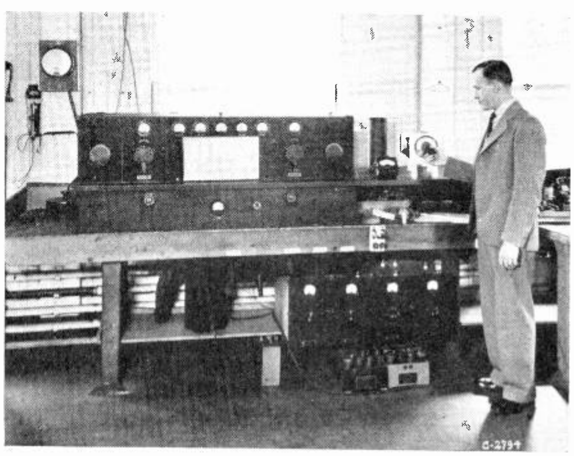
The source of r-f energy was the laboratory master oscillator and power amplifier, having a frequency range of 100 to 15,000 kc. and an output over this range of 200 watts. Terminals afforded direct connection of any apparatus to be measured across the power amplifier tank circuit; other terminals were arranged so as to allow inductive coupling between the tank coil and the coil to be measured. The whole set was well shielded.

One of the first things to be measured was the distributed capacity of a coil and the circuit used was that shown in Fig. 1. The method used was the well known one of plotting capacity against the wave length squared. That is readings were taken of the condenser setting required to cause a thermocouple type milliammeter to read a maximum, for various frequencies. Finally, the condenser was disconnected entirely, and the frequency changed until the current was a maximum. This occurred at what is known as the natural frequency, and the latter affords a check on the LC product of the coil as well as provides a point on the curve. This method yields a fairly accurate value of distributed capacity and resonant frequency.

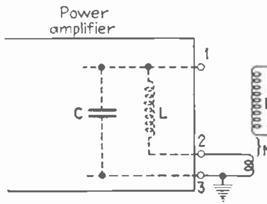
According to the assumption mentioned above, this resonant frequency should be that at which the impedance of the coil is a maximum. To check this point, the circuit of Fig. 2 was used, the measuring circuit being connected across the power amplifier tank through coupling condenser C_c. The current through L was measured with a milliammeter and the voltage across it was checked by means of the current through the calibrated variable condenser C_v. By using this condenser, it was possible to keep the r-f voltage across L nearly constant over a wide range of frequencies. The value of voltage as found by the condenser was checked by a static voltmeter and found to be accurate to within five per cent. The coil current divided into this voltage equals the coil impedance at any frequency.

By disconnecting L from the circuit, the reaction on the amplifier tuning may be noted, and from this whether the reactance of L is inductive or capacitive. The difference in watts input to the amplifier when the coil is removed, and the tank condenser is returned for a minimum plate current, is readily observable. This difference times the amplifier efficiency is the loss in the coil at a particular voltage and frequency.

The impedance of a typical coil, found as described above, is plotted in Fig. 3 (a) against frequency. At low frequencies, the curve follows the straight reactance line X_L ($= 2\pi fL$). At a frequency considerably below the natural frequency f_n, the slope starts to increase, and reaches a maximum point at a frequency f_m of 1.2 to 1.7 f_n. Above this frequency, the impedance decreases until a minimum value is reached at f_l, which is from 2.2 to 3.0 times f_n. At higher frequencies, the



Laboratory equipment for determining characteristics of radio-frequency coils



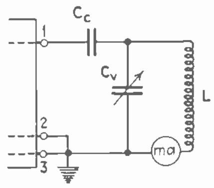


Fig. 1—(Left) Circuit for determining natural frequency of choke
Fig. 2—(Right) Circuit for impedance measurements

increase and decrease are repeated in a series of peaks and valleys at approximately equal frequency intervals. The second, fourth and sixth peaks are of lower value than the first, third, and fifth respectively. The seventh peak is followed by a flattened slope which suggests a submerged eight peak. The points of minimum impedance rise in value, so that at higher frequencies the valleys appear to be partly filled in, and the peaks levelled off.

The watts loss are high at points of low impedance, and rise sharply at the frequency f_l. At succeeding minimum points, the rise is less and less sharp; as the

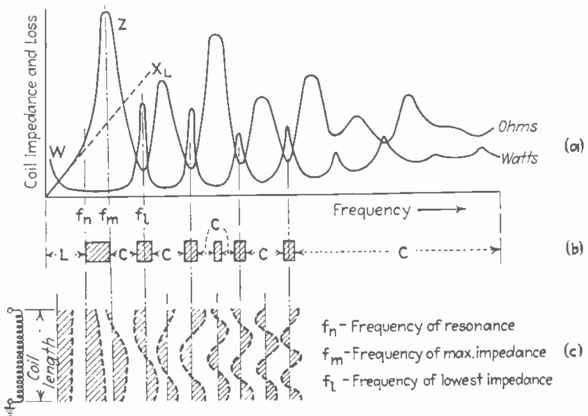


Fig. 3—Choke coil characteristics

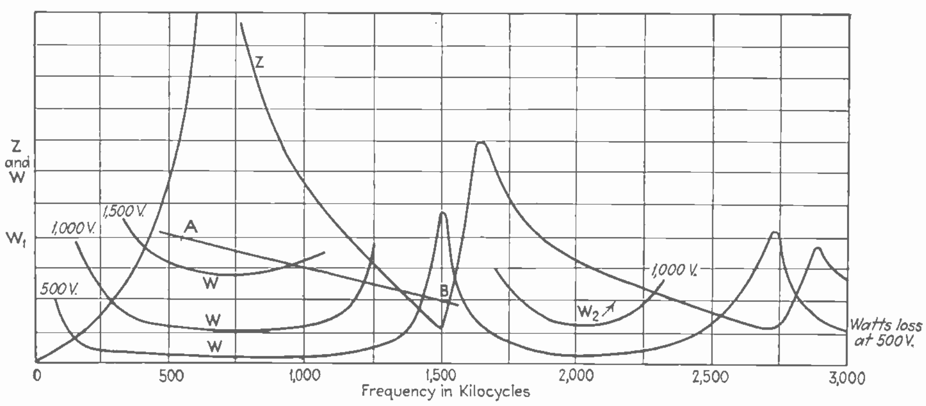


Fig. 5 — Determining operating voltage from choke characteristics

frequency rises, the valleys in the watts curve also become filled in to a greater degree.

The change in reactance is shown in 3(b). The coil is inductive up to the resonant frequency f_n. From f_n to f_m it has no noticeable effect on the tank tuning and hence is pure resistance, or nearly so. Above f_m, it is capacitive up to a frequency slightly below f_l, where it again becomes of indefinite reactance. Thereafter, it is capacitive, except for brief frequency intervals, where it is resistive, or only slightly inductive. At all higher than the fifth peak, the coil is capacitive.

The measurement of impedance was repeated for several different coils, and in each case the results were in general the same as those just described. These results do not bear out the assumption mentioned above, that the distributed capacity can be regarded as a single lumped capacity shunting the coil, because:

(a) The resonant frequency does not coincide with the frequency at which maximum impedance occurs.

(b) The series of peaks and valleys would not obtain in a circuit of L shunted by C.

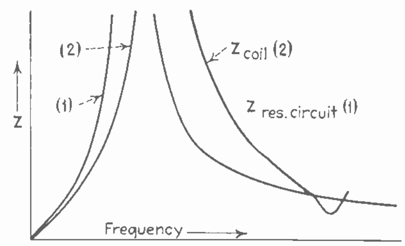
The difference in the impedance curves based on this assumption (1) and on an actual coil (2) is shown in Fig. 4 up to the first minimum impedance point. It will be seen that the assumption would yield wholly incorrect results. The difference can be attributed to the fact that the coil capacity is distributed between its turns, and the coil behaves like a circuit having distributed constants. As is well known, such a circuit has points of minimum and maximum impedance occurring at regular frequency intervals. However, the assumption of lumped capacity seems accurate enough in determining the resonant frequency.

How the choke affects circuit operation

Circuits having distributed constants are subject to standing waves at the higher frequencies. The character of these waves was found by tapping the coil at various points and inserting thermogalvanometers in series with the coil at these points. The current distribution as recorded from the meters inserted into the coil is plotted in Fig. 3(c) against coil length for over half of the frequency range. These diagrams show definitely the kind of standing waves as the frequency increases.

The curve of watts loss in Fig. 3(a) shows that there are definite zones of frequency, outside of which the coil will not operate at certain voltages without overheating. The question arises: will the operation of a

Fig. 4 — Comparison of choke with equivalent lumped circuit



vacuum tube be affected by the varying characteristics of the plate choke over its frequency range? To answer this question, the coil described above was used as a UX-860 master oscillator plate choke while the frequency was varied through a wide range. When the oscillator was tuned to frequencies corresponding to valleys in the choke impedance curve, it stopped oscillating. It likewise stopped at the low end of the frequency range where the watts are high, i.e., at the extreme left of Fig. 3(a). At other frequencies, operation was

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electronics

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Technical employees organize

FOR several years past, while the unemployment problem has been at its worst, thoughtful observers of the conservative course of the "regular" engineering societies have felt that the social and economic situation of technical men would have to be given more attention and help, or else new organizations of engineering employees, built on wage issues alone, would arise to claim the interest and membership of employed engineers and younger men.

Already such movements have come in several quarters. One trade union of "technicians" has obtained 2,000 members in New York, and has 3,000 more in Buffalo, Philadelphia, Pittsburgh, Baltimore, Chicago, and St. Louis. Wage proposals submitted by this group have demanded $30 a week for beginners, $45 for junior technicians, and $65 for senior technicians. At first the membership of the new "Federation" was drawn chiefly from the unemployed, but later accessions have come 75 per cent from among men with jobs, who seek to better their conditions.

FCC—Judge and prosecutor, too

THE proposed transfer of radio authority to a new Federal administrative body, the Communications Commission, is a mere switch from a group of five to a group of seven political gentlemen, chosen by law for their complete lack of radio knowledge. The increased number merely guarantees increased opportunity for disagreement, and hopelessness of constructive action. Even the suggested specialization into radio, telephone and telegraph divisions, with two commissioners in charge of each, proves a disappointment, for the text of the bills provides that radio will actually be administered by all three divisions, depending on whether the radio service is broadcasting, voice, or telegraphic record.

The most serious complaint against the Commission plan continues unchanged. A commission like the FCC is a combination of administrative and judicial functions. First, it issues its orders. Then, if it thinks it detects a violation, it hales the supposed offender into its own court, and sits in judgment on the case which it itself prosecutes! Such summary procedure is unsound, and contrary to the principles of American government.

Positron, neutron— can we put them to work?

EVER since the discovery of the positron and the neutron, there has been considerable question in the minds of practical electronic engineers as to the commercial applications which these new discoveries may lead to.

It is becoming increasingly evident that in these latest finds of pure science, we have new *entities* as fundamental in nature as the electron itself. That is, the world of matter is made up of electrons *and* positrons *and* neutrons.

Will these new entities then lend themselves to practical application along as wide a variety of possibilities, as has the electron itself? Shall we have a new and parallel "technique of the positron," as of the electron? Will "neutronics" be a coming art, the counterpart of electronics?

No one can yet give the answer to those questions. The future is rich with possibilities. Already the neutron is finding important uses as a projectile, without electrical charge of its own. The positron offers possibilities of separable cathode rays, electrically deflected. It will be surprising indeed if some new tube of 1935 or 1936 does not appear utilizing these latest tools, the neutron and the positron.

Price-cutting and consignment selling

THE radio-tube and radio receiver industries have had many examples of unrestrained competition in the past. Millions of receivers and millions of tubes have been sold without a profit.

Yet radio has not yet sunk to the levels which the dry-cleaning industry has achieved in recent price competition. With the NRA code setting up a 75-cent price for cleaning a man's suit, many cases of 20-cent offers have turned up, for the same service. In Chicago and Philadelphia the price of dry-cleaning even got down to 9 cents a suit, for a time. And one enterprising price-cutter in Winston-Salem, N. C., offered to clean six suits for a quarter!

It is to protect the radio tube industry against such practices and against itself that the new consignment plan has been introduced by important companies. This plan,—which has worked long and successfully in the incandescent-lamp business, which tubes have otherwise closely patterned after,—seems the only solution for the vindictive price-cutting practices that have infested the radio trade.

MENTAL COURAGE

Mental courage may not receive any acclaim because most frequently it isn't even observed.

This mental courage demands, however, certain assistance.

In the first place, it demands DETERMINATION *to face the situation at whatever cost.*

Then it demands a STUDY *of the situation, its conditions, its necessities, the means to meet it, the possible help to be obtained, the cooperation to be had, an analysis of what must be done, and planning along proper and essential lines.*

Usually it demands considerable SACRIFICES.

It demands a FIGHT *to put the right methods across.*

Finally it demands a FAITH *and belief in plans and people.*

But happily it MOST ALWAYS BRINGS SUCCESS *where failure might have ensued.*

There has not been for a long period such a time as now when such mental courage is needed, for the rich and the poor, the worker and the executive are in some distress.

NEWS NOTES

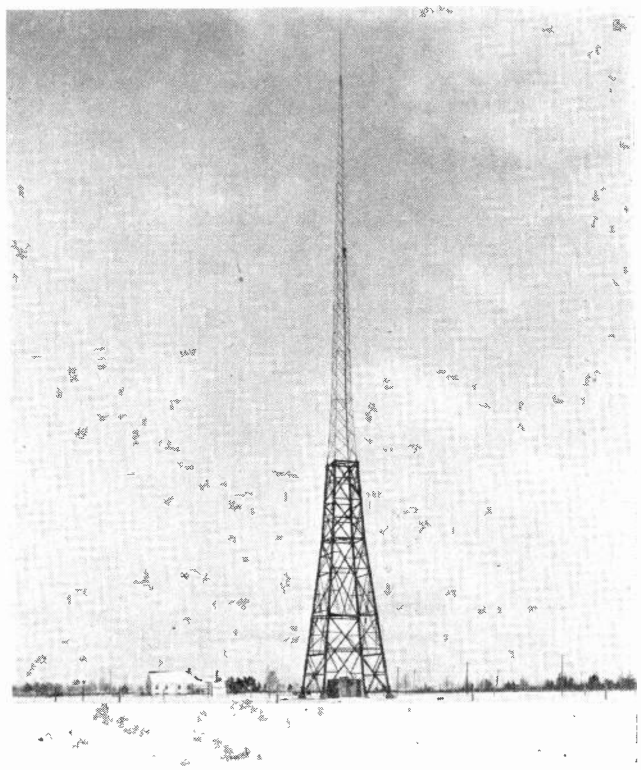
Sound-Picture Engineers at Atlantic City, April 23 to 26—The Society of Motion Picture Engineers will hold its Spring convention at Atlantic City, N. J., April 23 to 26. Dr. Alfred N. Goldsmith, president, has announced that NRA Administrator Sol. A. Rosenblatt will speak.

Electrochemical Society at Asheville, N. C., April 26 to 28—The Spring meeting of the Electrochemical Society will be held jointly with the American Ceramic Society at Grove Park Inn, Asheville, N. C., April 26, 27 and 28. Refractories, dielectrics, sodium-vapor lamps, indium and germanium, are among the topics to be discussed. Dr. Colin G. Fink, Columbia University, New York City, is secretary.

NEMA at Hot Springs, Va., May 20 to 24—The general Spring meeting of the National Electrical Manufacturers Association, which has several sections in the radio and electronics fields, will be held at the Homestead, Hot Springs, Va., May 20 to 24 inclusive. Arthur W. Berresford, 155 East 44th street, New York City, is managing director.

Passing of Gen. Squier and Maj. Hammer — Two pioneer workers in the field of electronics and radio passed away March 24, death in both cases being caused by pneumonia. Major-general George O. Squier, 69, retired head of the U. S. Army Signal Corps, was best known for his association with "wired wireless" or carrier conduction. He founded the Signal Corps school at Leavenworth, Kan. Major William J. Hammer, 77, was an associate of Thomas A. Edison in the development of the incandescent lamp and lighting. Major Hammer early turned his attention to radioactivity, fluorescence, radio, electronic control, etc., and had a large historical collection of vacuum tubes, gaseous tubes and photo-cells.

WEBC'S WOOD-STEEL TOWER

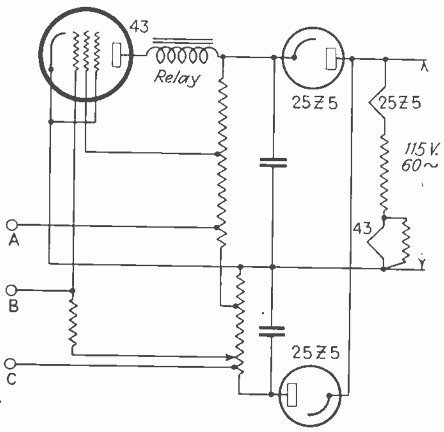


Modifying the practice of using all-wood radio towers developed in Europe (see front cover), WEBC, Duluth, Wis., has installed this combination structure, with 125-ft. wood pedestal, and total height 357 ft. A one-inch copper tube connects the tuning house with the steel radiator. Increases in signal strength have been reported.

+ + NOTES ON ELECTRON

Voltage doubler tube in novel use—a new light relay

Modern practice in biasing amplifiers is to use a cathode resistance through which plate current flows. The voltage drop along this resistance is applied to the grid circuit, and so biases the tube with respect to the cathode. Under certain conditions the plate current changes,



thereby changing the effective bias on the grid.

For example, in an over-biased amplifier (class AB) strong signals will drive the grid still further negative and cause distortion. As another example, a phototube may be used to increase the plate current in an amplifier upon illumination and thus operate a relay. In this case, as before, the grid is driven more negative by the increased d-c plate current and the photo current is partially counterbalanced.

R. C. Hitchcock of Westinghouse Meter Engineering Department, Newark, has developed a use for the 25Z5 which overcomes this difficulty. One half of the tube supplies plate voltage; the other half supplies grid voltage. The latter is independent of plate current variations. The circuit shows the use of a 43 tube which has sufficient plate power output to operate a 20-ampere relay directly. Leads are brought out so that the relay can open or close with illumination.

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Mass spectrograph for isotope research

As an aid to spectroscopic and radioactive experiments a new mass spectrograph has been put into service at the California Institute of Technology at Pasadena. The apparatus developed by Dr. W. R. Smythe and constructed by Dr. L. H. Rumbaugh, now of the Bartol Research Foundation, enables scientists to study the isotopes of such elements as lithium and potassium now obtainable in quantities of 1/1,000 gram. Potassium isotopes of this concentration are obtainable in 60 hours.

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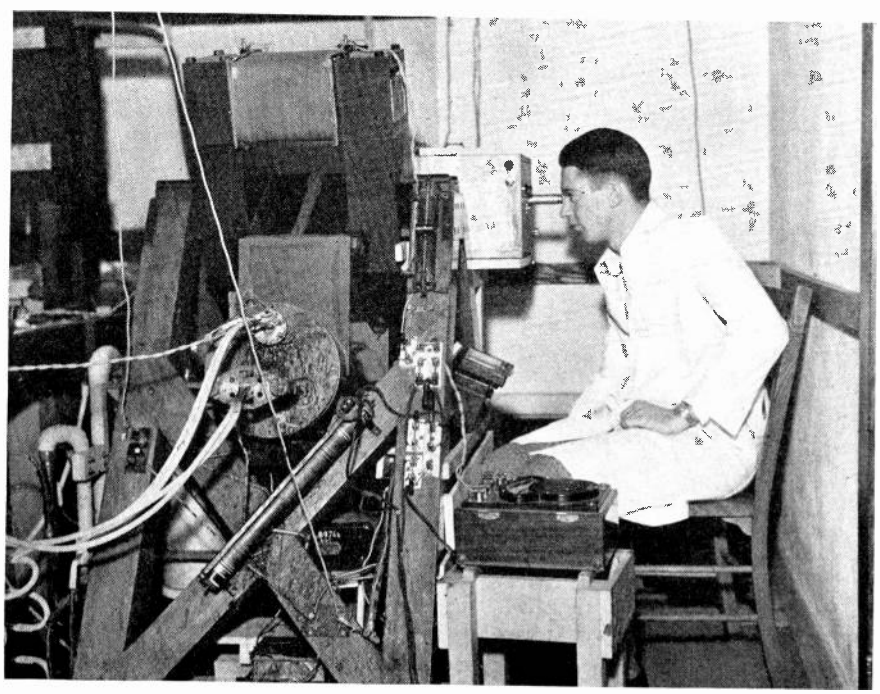
ISOTOPE DETECTOR



Dr. S. S. West, of Caltech, with the new mass spectrograph with which he has obtained rare isotopes of lithium and potassium in usable quantities.

Catechism on iron for radio tubes

Numerous notes have been published in *Electronics* on the experimentation by tube manufacturers in the use of high purity iron for plates and other tube parts now largely made from nickel. These notes have indicated that the economies possible by the use of iron are responsible for the growing use of the latter metal.

A tube designer has submitted several questions on the relative bearing of the chemical and metallurgical properties of iron and nickel. These questions have been answered by Dr. Paul Weiller, consultant to the Swedish Iron and Steel company, suppliers of SVEA metal.

1. *What is the vapor pressure of the sub-oxides of iron versus the similar of sub-oxides of nickel as a function of temperature?*

The vapor pressure of both the lowest oxides of iron and nickel is so low that it cannot affect the operation of a tube. The important item would be the dissociation pressure (oxygen pressure) over the oxides which is probably considerably higher than that of the oxides themselves. We have two facts which give some guidance as to the effect of the oxygen in either iron or nickel oxide in vacuum tubes. First: tubes with oxidized nickel plates have been made and are still being made on a commercial scale. Therefore, the oxygen pressure over nickel oxide must be low enough to be harmless. Second: iron oxides form alloys with iron very easily so that any trace of iron oxide present on the surface will diffuse into the metal during bombarding. The solid solutions formed must have a lower oxygen pressure than the oxide itself. Consequently iron offers a notable advantage over nickel, the latter having only a very slight tendency to absorb its oxides and thereby render them harmless.

2. *What is the temperature coefficient of the electrical conductivity of iron versus nickel from room temperature to yellow heat?*

Temperature coefficient and resistance of pure iron are higher than those of nickel at room temperature and also up to about yellow heat.

3. *What is the permeability of iron as function of temperature versus that of nickel and does the recalescent point in changing from the alpha to the beta state have any bearing on the tube design?*

The permeability of iron is of course much higher than that of nickel but I cannot see why this should have any bearing on the design of receiving tubes.

4. *Is there a beryllium iron alloy which is more suitable than pure iron on account of its superior characteristic*

of thermal conductivity, electrical conductivity, permeability, and so forth, which will render this material superior for high frequency treatment during the evacuating period?

No results as to beryllium iron alloy having any bearing on our problems are available as far as I know. There has never been any trouble in high frequency treating of SVEA parts. I can see no advantage in using any alloy solely for the purpose of changing its properties relating to induction treatment.

5. *Did the metallurgical problem of the production of OFHC copper help the manufacture of power tubes?*

A special grade of copper is being used in the manufacture of water cooled tubes but only to avoid porosity always present in ordinary copper.

6. *Is there room for progress in the production of a new alloy of the family iron-cobalt-nickel with the family beryllium-boron-magnesium and aluminum, which will have the advantages of pure nickel and be economically competitive in the cost of production?*

As pure iron SVEA metal is entirely satisfactory and in many cases superior to nickel, I cannot see any object in trying other alloys which would be more expensive but no better.

7. *Is it economical to cheapen the materials in a vacuum tube by 2% and increase the hazard of production by 10%?*

The saving by substituting SVEA metal for pure nickel in receiving tubes amounts to from 25% to 35% of the parts and to from 5% to 10% of the total cost of the tube including overhead, and not to only 2%.

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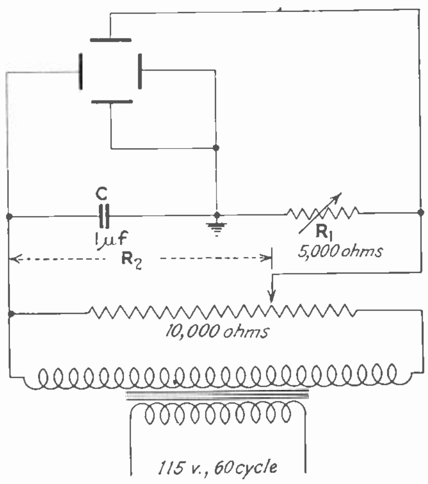
Photography of transients with a cathode-ray oscillograph

TAKING SATISFACTORY PHOTOGRAPHS of stationary recurrent patterns appearing on the fluorescent screen of a modern cathode-ray oscillograph is a fairly simple matter inasmuch as the exposure time need be limited only by the observer's ability to maintain a stable pattern. When, however, he must record transient phenomena in which the spot sweeps only once across the screen, the "speed" of both lens and sensitive emulsion must be suited to the brilliancy of the spot and to the speed with which it moves across the screen. There is a maximum spot velocity beyond which a given spot brilliancy and a given lens-emulsion combination will fail to produce a usable record. The experimental determination of this limiting velocity is a fundamental consideration.

The simple method of measuring the limiting velocity described here is believed to have been the original idea of Eduard Karplus, Engineer, of the General Radio Company. It depends for its operation on the fact that, when both pairs of deflecting plates are excited by equal a-c voltages of the same frequency but 90° out of phase, the circular (Lissajou) figure appears. This is traced out by the fluorescent spot



which sweeps around the circle once for each cycle of the applied a-c voltage. Obviously, the velocity of the spot is proportional to the diameter of the circle, so that if its diameter is progressively increased, there will be a point beyond which a single passage of the spot fails to make an impression on the emulsion. A record of this type is shown in which the diameter of the circle was rapidly widened during the exposure so that the spot executed a spiral.

A convenient circuit for making the test, using the 115-volt, 60-cycle line is shown. The two quadrature voltages are taken off across C and R_1, R_1 being adjustable so that the voltages can be made equal. R_2 is a voltage divider across the line. By adjusting it the diameter of the circular pattern can be changed at will.

The test exposure is made by increasing R_2 until the circle is a mere spot, then the camera shutter is opened and R_2 quickly reduces to zero. This produces a corresponding rapid increase in the diameter of the circle traced by the moving spot, which results in the spiral shown. The velocity at any point on the spiral is given by the relation $v = 2\pi rf$, where r is the distance from the center to the point in question, f is the frequency in cycles per second, and v is the velocity in linear units per second, the unit being the same as that chosen to measure r. The use of the 60-cycle line will usually give a sufficiently wide range of test velocities for cathode-ray oscillograph tubes now generally available, but greater velocities can, of course, be obtained by increasing the test frequency.

Because of the ease with which this test can be carried out, experimenters working with transients that approach the limiting velocity can easily test out each new package of emulsion stock in the same way that photographers who are trying for perfection often determine by trial the exposure required by a particular batch of printing paper used.

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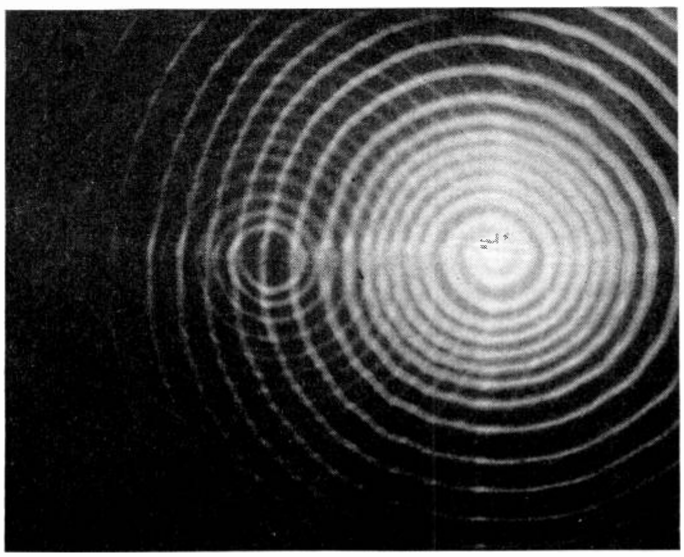
ELECTRONS IN A SPIDERWEB



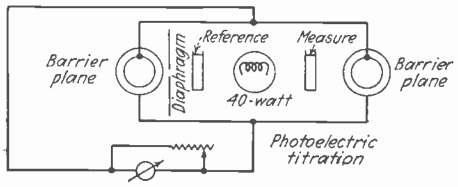
Spiral traces (60 cycles) to show the maximum photographable velocity for a single transit of the spot. The brighter trace is for a higher anode voltage.

REVIEW OF ELECTRONIC LITERATURE

HERE AND ABROAD

Automatic photoelectric titration

[F. MULLER, Laboratory of Phys. Chemistry, Dresden Institute of Technology.] When using a cesium oxide-silver photocell, with peaks at 0.3 and 0.75 micron, the change in color produced in the titration of 0.1 normal hydrochloric acid by 0.1 n. sodium hydroxide, and indicated by phenolphthalein generated a current of 1.5 μa. in a galvanometer giving one mm. deflection per 1/100 μa., the green line from a mercury arc being used as light source. The light from an incandescent lamp proved to be too weak. When a selenium-iron cell (front wall barrier plane cell) was used, its current being balanced against that of a second cell exposed to the light passing through a titrated reference



solution placed to one side of the 40-watt frosted lamp, it generated 180 μa. as the solution went from one side of the neutral point (20 cc. sodium hydroxide) to the other side (22 cc.). A microammeter giving about half a μa. per scale division and having an internal resistance of 50 ohms was used.—*Zeits. Elektroch.* 40: 46-51, Jan. 1934.

✦

Electrons in metals

[L. BRILLOUIN, Professor, College de France, Paris] The theory of free electrons inside metallic conductors as developed some thirty years ago gave a picture of thermoelectric and magnetic effects, the relation between thermal and electrical resistance, and so on, but the computed results were in poor agreement with the experimental values. While it became clear, before long, that one of the main mistakes made was to have assumed equipartition of energy, that is a regular increase of the velocity of the electrons with increase of temperature, the correct point of view was found only about seven years ago on applying to the electrons inside the metal the theory of extremely dense gases. (There are many times more free electrons per unit volume in a good conductor, sodium, for instance, [namely 2.7×10^{22}] than molecules in the same volume of air.) In this case the average velocity of the electron is given by 2.77 $(n)^{1/3}$, where n is the number of free electrons per cc. Their energy is practically independent of the temperature, up to 10,000 deg. C., and a function mainly of the density. All the electrons have about the same velocity excepting a very small group in which the kinetic energy increases slightly. The end of the group is influenced by temperature.

A second element entering into the picture is the fact that, in their motion inside the metal, the electrons may be replaced by waves (DeBroglie waves, see *Electronics,* March, 1932)

These waves, which determine the journey of the electrons through the metal, are more or less strongly influenced by the positively charged atoms forming obstacles in the form of the regular crystal lattice. If in their neighborhood the potential assumes very high values, the lattice acts nearly like a wave-filter with respect to the band of electron waves. Certain frequencies or velocities are completely blocked so that the energy distribution becomes discontinuous (so-called bound electrons).

The results computed on this basis are in striking agreement with the facts, and the theory has been able not only to account for the conductivity of a number of metals, but also to attack problems like that of the absorption of light by thin films of metals and tasks in the face of which the older methods were powerless.—*Revue Gen. Electricite* 17: 163—; 75. 202-208. 851-859. 1933.

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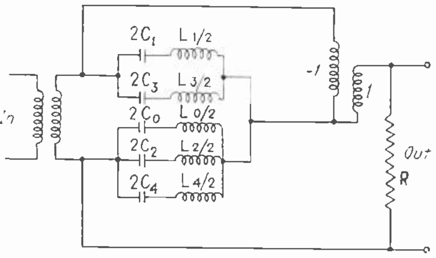
High quality band pass filters

[E. GLOWATZKI, University of Gottingen] Theoretical considerations show that when employing ganged condensers the filters to be used reduce to a certain number of series resonance circuits placed in parallel. Two such filters with negligible ohmic resistance are used, in series, and shunting the secondary of the input transformer, a 1:1 output transformer being placed across the first filter. The first filter consists of one or several resonant circuits in parallel, the second unit has as many or one more, but at least two series circuits in parallel (class 2). The load is applied to a resistance R. The properties of such circuits can readily be found from four small tables based on the theory of those filters. For instance, a combination of two series circuits in the first and three in the second filter (class 4) may be used. The total width of the band outside of which the amplitude is less than 1.8 per cent of that in the middle of the band is desired to be $p_s = 9{,}000$ cycles. Along the top of the band the attenuation shall not be more than two decibels and the resistance not vary by more than 50 per cent (or 20 or 10 per cent) from R. Under these conditions the width at the top is $kK\ p_s = kp$ (where $k = 0.9$, $K = 0.813$), and for a given frequency in the middle of the band, the necessary ten values for L and C are easy to calculate. We have



$L_o = L_4 = 1.268\ R/p$, and $L_1 = L_3 = 0.486\ R/p$

$L_2 = 0.37\ R/p$

while $C_o = 0.025/L_1 f^2_{-2}$

$C_o = 0.025/L_o f^2_{-2}$

$C_3 = 0.025/L_3 f^2_{+2}$

$C_2 = 0.025/L_2 f^2$

$C_4 = 0.025/L_4 f_1^2$

Hoch fr. Tech. El. Ak. 43 (2): 51-56, 1934.

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Selenium-iron barrier plane cells

[R. HIGGONNET, Le Material telephonique.] Curves are given showing that between 0 and 2,500 meter-candles the current (0 to 340 μ A) is proportional to the illumination when the external load is less than about three ohms. When the illumination fluctuates, the current assumes a value which is at most 3 to 4 per cent higher than the steady current which is reached to within 1 per cent inside one or two minutes, as is shown by graphs for 100; 1,000 and 2,500 meter-candles; another graph shows that for these three cases the temperature coefficient between —20 and +50° C. does not exceed 3 per cent in the most unfavorable case. The barrier plane cell makes a very handy foot-candle meter giving a reading which is 76 per cent of the correct value when placed in the center of a uniformly bright hemisphere. An important application has been found for the cell in the paper industry where it controls the hydrogen ion concentration, indicated by a colorimetric method, of the liquors which must be mixed with alkaline solutions before they can be used a second time. Automatic control within ± 0.15 pH is possible.—*Revue gen. El.* 35: 125-129. January 27, 1934.

Constant d-c voltages by means of discharge tubes

[K. LAEMMCHEN, Breslau Institute of Technology] The method is based on the slight linear increase in voltage drop with increasing current which is observed in discharge tubes working in the region of the abnormal cathode fall. By using a discharge tube having the resistance R_L and an ohmic resistance R_r as two arms of a Wheatstone bridge, two other resistances R and r as the other arms, and placing the load L in the bridge proper, the voltage applied to the load can be rendered independent of ordinary fluctuations in the supply voltage provided that after sufficient aging $R/r = R_r/R$, and it is equal to $(eR_r - R_LRL)/(R_r + R_L) - R_r/(R + r)$. Taking a lamp in which the voltage drop follows a linear law when the current varies between 15 and 35 ma., representing a resistance of 2,300 ohms, fluctuations of 10 per cent (that is $\pm$ 20 volts) in the supply are reduced to less than 0.008 per cent in the voltage across the load when the current is 24 ma. Harmonics, however, to the amount of 6 per cent of the d-c supply, with frequencies between 30 and 500 cycles, are reduced to not less than 0.4 per cent and 1.8 per cent, because the glow lamps present hysteresis.—*Hochfr. Techn.* El. Ak. 42: 119-126. 1933.

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Radio propagation in polar regions

[K. W. WAGNER, Heinrich-Hertz Institute, Berlin] In connection with the International Polar Year 1932-1933 a series of radio observations has been made at the Auroral Observatory at Tromso (lat. 69° 40′ N.; long. 19°E.) in Norway by an English and by a German party. The British party erected a sending station 20 km. north of Tromso; the power could be varied between 100 and 300 watts during each half-wave of the supply current it emitted a pulse of 1/10,000 to 1/3,000 sec. duration. For undisturbed conditions there are usually the two reflecting regions, the lower between 90 and 115 km. equivalent height, the upper above 220 km.

If the electric state of these layers is due to the sun's light, then the number of electrons is largest around noon. But in contrast with other regions the greatest ionization densities at the Auroral Observatory when the lower region is studied are encountered more often at night, from 8 o'clock on. The magnetic records show the same behavior, so that a small magnetic disturbance during the night is accompanied by an increase in ionization. During intense magnetic storms none of the wave-lengths between 20 and 500 m. are reflected, owing to increased absorption in and below the lower level. Only the ground wave is received. A period of 27 days due to the rotation of the sun is also apparent. Charged particles, electrons and ions, evidently play a part in the formation of conducting layers in high altitudes.—*Nature 132: 340-341, 1933 and Sitz. Ber. Ak. Wiss. 31/32, 1933.*

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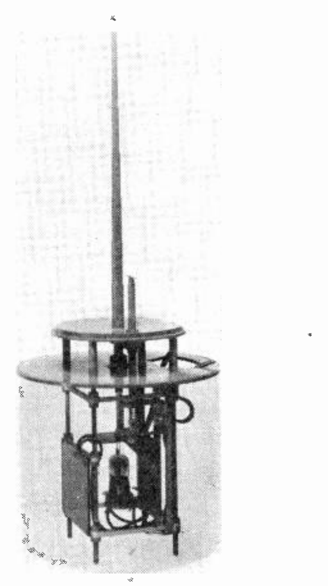
Ultra-short wave link between Lympne and Saint Inglevert —17.5 cm.; 1,724 Mc.

TESTS MADE OVER the 35 mile stretch (see *Electronics,* July, 1931) have led to the inauguration of permanent stations on January 26, 1934. Transmitter and receiver are placed 13 m. above ground at Lympne, and 20 m. at the other terminal, the wave lengths differing slightly. The antenna, 8 cm. long, is connected to the tube by means of a line of concentric conductors, spacers being placed at the voltage nodes. The two conductors are connected to the two ends of the grid. The filament is of pure tungsten and takes 12 amperes.



Ultra-short wave tube

Before the establishment of the ultra-short wave connection the airplanes had sometimes traversed the Channel before a message could be sent the port.—*Genie civil 104: 128-129, 157-158. Feb. 10 and 17, 1934.* See also *Electrical Communication,* January, 1934.

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Membrane material; condenser microphone sensitivity

[H. LUEDER and E. SPENKE, Siemens and Halske Laboratory] The reaction of the electric load upon the mechanical vibrating system tends to decrease the sensitivity of the electrodynamic microphone, and to increase the sensitivity in the case of the microphone built on the electrostatic principle. The factors limiting the sensitivity of the condenser microphone are the mechanical properties of the membrane material providing that the electrode is pierced by a sufficient number of vent holes. Highest sensitivity (that is, highest voltage across the load for a given pressure acting upon the moving membrane) is obtained when the value of $\sqrt{T/t}$ divided by d is large, where t is the thickness of the membrane, d the mass per unit volume, and T the tension.—*El. Nachr. Tech. 11: 20-32 (Jan.). 1934.*

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Specific losses of r-f coils

[H. GONNINGEN, Laboratories of the Lorenz A.G.] Coils used in transmitters are tested, cylindrical in shape, with the same ratio 1:1.7 of diameter to length, closely wound with litz wire made of six enameled wires of 0.07 mm. diameter, double cotton covered. When for a given diameter the number of layers is varied, and the wave length applied changed from 160 to 40,000 m., the lowest specific losses, that is the losses in watts per kva. reactive power, are independent of the number of turns or of the inductance of the coil. Each coil presents its lowest loss at a certain wave length which is longer the higher the number of layers. When a coil is found to heat up excessively in service the usual remedy of using heavier wire may make conditions worse. At the most favorable wave length the specific losses are inversely proportional to the diameter. For best results the depth of winding must be chosen small when the diameter is large.—*El. Tech. Zeits. 55 (8): 190-192. 1934.*

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The correct presentation of receiving circuits

[F. W. GUNDLACH] The usual method of drawing receiving circuits leads to a large number of lines which cross one another, owing to the fact that they refer to the path followed by the r-f signal rather than to the d-c voltages upon which, after all, the proper functioning of the receiver depends. If the d-c voltages are first laid out on the diagram with the line representing the highest positive voltage and the positive electrode at the top of the diagram above the tubes, and the line connecting the lowest points at the lowest level, the number of lines which intersect is greatly reduced. The rôle of the resistors used in determining the voltage steps clearly appears, and the only drawback is that coupled elements no longer necessarily appear side by side. The magazine publishing this article has decided to adopt this method for all its articles on receiving circuits.—*Funkt. Monatsh. (2): 51-53 (Feb.). 1934.*

Guiding electric beams in television reception

[M. von Ardenne, Berlin] The adoption of 40,000 elements per picture (180 lines) and 25 pictures per sec. makes it indispensable that the voltage curve causing the beam to sweep to the next line repeat itself at intervals which are equal to within one ten millionth second. To control with such a precision relaxation oscillations by using the principle of the suppression of the natural frequency (wrongly called pulling into step) by waves from the sender becomes very difficult, and the r-f circuits are fairly complicated, although being self sustained the oscillations prevent the beam from spoiling the screen in case the signal from the sender fails to arrive. To transmit the entire sweep voltage absorbs too wide a frequency band. The best solution is for the transmitter to send out a rectangular impulse at the end of the line, and a longer interval at the end of each picture, impulses which make the grid of a discharge tube momentarily positive so that the tube discharges across a condenser. In the present arrangement the impulses are obtained by suppressing the remaining carrier frequency amplitide. The light spot disappears during this time.—*Zeits. tech. Phys. 15 (2): 62-64. 1934.*

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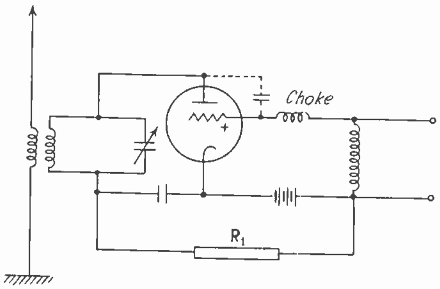
Electronic microscope with magnetic focusing

[E. Ruska, Berlin Institute of Technology] The total length of the microscope is 120 cm. It is entirely of metal and comprises the discharge tube at the top, the focusing or condenser coil, objective chamber, objective coil, tube in which the intermediate image is formed, ocular or projecting lens and camera. The windows are protected by leadglass 6 to 10 mm. thick. In the discharge tube electrons are produced at the flat surface, 1.8 cm. in diameter and readily exchanged for a new tip, of an aluminum or iron cathode, fitting into a cylinder of soapstone, 22 cm. long and entirely surrounded by the anode. The electrons pass through openings in the anode, then through narrow diaphragms, 0.1 mm. in diameter, and hit upon one of the right objects which can be placed one after the other across their path. The objects must be so thin as not to slow down the electrons, that is less than the equivalent of one micron of aluminum for 60,000 volt electrons. After having passed through the two magnetic lenses, the electrons form a sharp picture, for instance, of carbonized cotton threads only a 30-millionth cm. thick. Magnifications close to 12,000 are obtained and in the case of metallic fibers it will be possible to push it to 50,000, both values being far beyond that of the ordinary microscope.—*Zeits. f. Physik. 87. (1910): 508-602. 1934.*

The stopping-plate detector

[H. E. Hollmann, Heinrich-Hertz Institute] When the role of grid and plate is reversed, the plate repels the electrons having passed through the positive grid, until under the influence of an incoming signal it becomes a few volts positive; during these periods the plate current rises to a few ma. at the expense of the grid current. The change of grid potential to the change in plate potential is equal to the external resistance *R* in the grid or output circuit divided by the internal resistance *r* of the tube at the operating point, about 1,000 ohms for the tubes with tungsten filaments. The amplification cannot be brought to higher values by reducing *r*, as this would result in excessive damping in the tuned circuit of perhaps 10^6 ohm resistance in the plate circuit, unless the oscillating circuit is placed in the an-



tenna and the signal applied to the plate by transformer coupling. The best operating point on the lower bend is obtained by means of the high resistance R_1 by-passing the high voltage battery. Another improvement is to restitute the power absorbed by the plate (now control) circuit by regeneration, placing a condenser between grid and plate. A condenser of 250 μμf. increases the sensitivity seventy-fold in the broadcast range. The circuit is now capable of entering into oscillation.—*El. Nachr. Tech. 11: 3-15 (Jan., 1934).*

✦

The range of wired television

[F. Kirschstein and J. Laub, German Post Office Laboratory] With the use of ultra-short waves the quality of the pictures has improved, but the reception of television is now limited to the local emitter. To come back to real television, programs must be relayed over wires to different senders. The cables used must transmit the band between 0 and 500 kc. The higher frequencies travel 20 miles in about 0.1 millisec., the lower frequencies take about 1 msec. To prevent the dispersion of frequencies it is necessary to superimpose the whole band upon a carrier frequency of about 1,000 kc. Along cables the attenuation of r-f waves is proportional to the frequency, the amplitude being reduced to about 0.5 after 1,000 m. at 1,000 kc. Assuming that the use of high frequency cables allows an amplification at the end of the lines of 70 decibels, the useful range is about 20 miles; the range of overhead transmission lines about 70 miles (45 miles), providing that they allow the signal amplitude to be amplified 400 times (50 times) at the end of the line. Telephone lines are expected to give a range of three miles. —*Ferns. Tonf. 5: 1-4 (Feb.). 1934.*

✦

Distortion in photocell amplifying circuits

[P. Kotowski and H. Lichte, Telefunken Laboratory] When the plate resistor of the photocell circuit is placed in parallel with the grid resistance of the amplifying tube, then owing to the voltage drop in the resistors, the changes in the photocell current are no longer proportional to the changes in illumination, and the appearance of harmonics can only be prevented by using low resistances (as is the rule today), or by employing photocells with pronounced saturation currents, for instance, by placing a third electrode near the cathode of gas-filled cells. But the change in the photoelectric current depends also on the sign of the change so that a sine wave of illumination is reproduced as a different function. At audio frequencies, gas-filled alkali metal photocells give a distortion factor of about 1 per cent per 100 μa. per lumen sensitivity, selenium photo conductive cells about half this amount at the same sensitivity, at low frequencies, whereas vacuum cells are free from this distortion.—*El. Nachr. Tech. 11: 15-19, 1934.*

✦

Radio frequency megohm resistances

[P. Wenk and M. Wien, University of Jena] The resistances are prepared by sputtering a thin film of an alloy of platinum and silver upon a tube of Calan (talc containing less than ½% iron oxide, suitably kilned) 42 mm. long, 8 mm. in diameter, with a wall 0.1 mm. thick, by means of a discharge through nitrogen at 0.004 mm. pressure. The tube is kept rotating during cathode sputtering. The cathode consists of two parallel wires, one of silver, the other of platinum, the size of each being so chosen that the proper proportion is obtained in the desired alloy which must have a temperature coefficient of less than 1/10,000. For very high resistance a helicoidal band only is deposited. The ends of the magnesium silicate tube are provided with firmly adhering copper strips, so that the resistance of the tube can be measured during the sputtering. The units thus formed measuring between 100 and 100 million ohms are protected by slipping them into a second cylinder of Calan or by covering the metal with an acid resistant cement. They stand loads of the order of one watt for indefinite periods. —*Phys. Zeits. 35 (4): 145-147, 1934.*

A study of r-f choke coils

[*Continued from page 121*]

not affected. The conclusion is that the oscillator stops only at frequencies where the coil loss is high, and where danger of the coil overheating exists.

A further step was necessary to put such data into useful form. Figure 5 shows part of an impedance and watts loss curve for a choke coil, the loss being measured at 500 volts r-f across the coil. Multiplying these values by 4 and 9 gives the respective 1,000 and 1,500 volt loss curves. The dissipating ability W_1 of the coil is the loss per square inch for the allowable coil temperature rise, times the surface area of the coil. It is practically constant for frequencies below f_n, where the current is distributed evenly. From Fig. 3(c) it can be seen that at f_l the coil has over half of a standing wave of current. At f_l and at higher frequencies, the dissipation takes place over about half of the total coil surface, and here the loss W_2 may be permitted. Intermediate between f_n and f_l, the current distribution gradually changes from nearly constant to a half sine wave. Therefore, a straight line AB is drawn connecting W_1 and W_2 at their limiting frequency zones. The intersection of the loss curves at various voltages

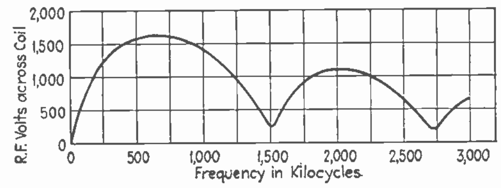


Fig. 6—Choke coil operating voltages

and the allowable loss lines W_1, AB, W_2, determine the allowable frequency ranges at these voltages. Thus the coil of Fig. 5 will safely stand 1,000 volts r-f from 150 to 1,200 kc. and from 1,800 to 2,250 kc. From these points, a plot can then be made of operating voltage versus frequency for this coil as shown in Fig. 6.

These curves insure correct coil voltages, but say nothing of circuit performance. Often the operating frequency range is further limited because the impedance must exceed a certain value throughout.

Data of this kind must be taken for any individual isolated coil. Engineers using such data are definitely assured of correct operation of the coil if it is used within the specified limits. Thus it would seem that the days of "peeling off a few turns" until a coil works properly are now over.

NEW BOOKS ON ELECTRON TUBES

Liquid dielectrics

By Dr. Andreas Gemant, Berlin Polytechnic Institute. English translation by Vladimir Karapetoff, 59 figures. John Wiley & Sons, Inc. 185 pages, price $3.00.

The electrical properties of glass

By J. T. Littleton, Chief, Physical Laboratory, Corning Glass Works, and G. W. Morey, Geophysical Laboratory, Carnegie Institute of Washington. John Wiley & Sons, Inc. 184 pages, price $3.00.

THE FIRST OF A SERIES of monographs, "The Nature of a Gas," by Professor L. B. Loeb, published in 1931, was reviewed in *Electronics*.

The volumes named above are now available. The second on "Liquid Dielectrics" is directed to the electrical engineer. The first chapter, dealing with conductivity, dielectric constant, and molecular structure, is followed by chapters on the mechanical, thermal, and physio-chemical properties of liquids with attention to those facts pertinent to the study of dielectrics. Then follow chapters which deal with electrical and optical behavior and finally with such practical matters as breakdown in cables, transformers, the Kerr cell.

The third volume on the dielectrics of a solid deals with glass and covers not only its manufacture and physical characteristics, but with the electrical phenomena associated with the use of glass as an insulator. Methods of measuring dielectric losses, the effects of temperature on resistance (or conductivity), the problems of dielectric strength, the effect of surrounding media, of voltage, and temperature on breakdown—all these matters are well handled.

Both books are well supplied with bibliographies and other reference material.

✦

The physics of electron tubes

By L. R. Koller, McGraw-Hill Book Company, 205 pages, 1934, price $3.00.

IN THE PREFACE, DR. KOLLER, of the General Electric Research Laboratories, states his aim to "present the fundamental physical phenomena involved in the operation of electron tubes" and to pay little attention to the external circuits used with such tubes. Thus the book is concerned with thermionic emission, various types of emitters and emitting surfaces, secondary emission, discharges in gas, the use of getters and cleanup agents, the effects of space charge, as well as the fundamental phenomena underlying the various light sensitive tubes.

The book forms one of the International Series in Physics already familiar to users of electron tubes from the volumes by Hund, *High-frequency Measurements;* Hughes and DuBridge, *Photoelectric Phenomena;* Williams, *Magnetic Phenomena*, as well as other, perhaps more theoretical, books.

Dr. Koller does not content himself with a mere recital of the facts underlying thermionic and photoelectric emission and the flow of electron and ion currents in high or low vacua. He shows, among other examples, how to calculate the emission "from a tungsten filament 10 cm. long and 0.025 cm. in diameter at a temperature of 2,200° K." and thus the book has much more than theoretical interest to those who use tubes of various types. Among other useful calculations are those relating to the determination of the radiation from cathodes coated on the inside compared to those used in high vacuum tubes where the coating is on the outside. The heat conserving ability of the inner-coated cathodes and the efficacy of using heat-reflecting vanes is quantitatively demonstrated and the calculations are carefully shown in the proper chapter.

In spite of Dr. Koller's statement that his text is primarily concerned with the tubes themselves and not with the external circuits, he does not neglect the latter completely. Methods of controlling the gaseous discharge tubes are given, as well as consideration of the dynatron as a current amplifier.

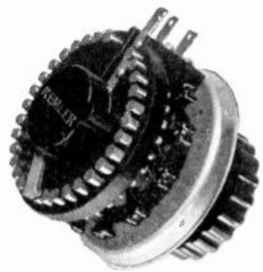
The book is a most useful and important addition to the bookshelf of electronic engineers, i.e., all who use, design, or build tubes of the amplifier, rectifier, high vacuum or gaseous or light sensitive types.

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Ladder-type attenuators

DESIGNED TO MEET exacting voice circuit requirements for broadcast transmission, recording and projection and high-class public address installations, the new Remler ladder-type attenuators increase attenuation in 53 steps of $\frac{3}{4}$ db. each, to 45 decibels. A rising attenuation characteristic serves to completely fade the program from 45 decibels to infinity. The frequency characteristic is flat from 20 to 20,000 cycles per



second, with extremely low noise level. The improved unifilar winding employs high quality silk-covered resistance wire.

The unit is enclosed in an aluminum shield $2\frac{5}{16}$ inches deep, and mounts either by means of a $2\frac{3}{8}$ inch hole, or by means of three screws through the panel.

Standard impedances are 50, 200 or 500 ohms, with special values available on order. Remler Company, Ltd., San Francisco, Cal.—*Electronics.*

✦

Continuous-reading vacuum gauge

THE CONTINENTAL ELECTRIC COMPANY, St. Charles, Ill., announces an improved model of its No. 6 Tru-Vac vacuum gauge.

This gauge, which has been developed by Continental engineers for use in their own plant, has a number of advantages over the mercury type of gauge where a dependable, accurate knowledge of vacuum conditions must be had. The Tru-Vac gauge gives instantaneous and continuous reading. Any changes in vacuum are indicated at the instant they occur. A continuous day-by-day record of vacuum conditions may be had by connecting up a recording device.

One of the outstanding advantages of the new gauge is that it will indicate the presence of water and other vapors, something which mercury type gauges will not do.

The gauge is adaptable to any vacuum pump or system and can be quickly installed in rubber or sealed to glass in any position in the vacuum system. In addition to reading the vacuum, it can also be used for filling, inasmuch as it will indicate the exact pressure of gas-filled devices.

The dials are calibrated in microns and readings of extremely small fractions of a micron may be obtained. It has no moving parts.—*Electronics.*

✦

Fixed resistors

THE WIRT COMPANY, 5221 Greene Street, Germantown, Philadelphia, Pa., is offering a new line of Wirthy fixed resistors which can be furnished in a wide range of resistance values, and covered with protective coatings of vitreous enamel, baked enamel, or a new material called Phenocote which is said to be the highest quality substitute for vitreous enamel that has yet been produced. This Phenocote, developed in the Wirt laboratories, is baked on the units at a high temperature, insuring resistance to moisture and heat. Tin-dipped tab terminals are carried in stock ready for immediate shipment; monel-metal pigtail leads can be supplied at a week or ten days' notice. These Wirt fixed resistors measure three-eights by one and three-quarter inches, and are rated to dissipate 10 watts in the open air. Stock resistance values range from one ohm to 25,000 ohms.—*Electronics.*

✦

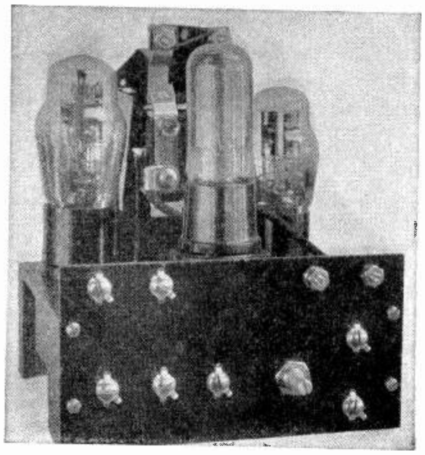
Dry electric condensers

THE CONDENSER CORPORATION OF AMERICA, 259 Corneilson Ave., Jersey City, New Jersey, manufacturers of Acracon condensers, have reduced their dry electrolytic units in size. Besides a greatly increased safety factor from a surge voltage standpoint, it is now possible to produce units in regular production having a power-factor loss as low as $1\frac{1}{2}$% and a leakage current of less than 8 to 20 microamperes per Mfd, at rated voltages of from 25 to 500, DC.

An exclusive complex impervious aluminum oxide film, developed during the past year, greatly improves their initial leakage characteristics after they have been unused for extended periods and also accounts for their superior filtering qualities during initial periods of operation.—*Electronics.*

High-current capacity light relay

A NEW MEMBER of the Westinghouse photo-relay family is a 20-ampere device using two of the most recent vacuum tubes, the 25Z5 and the 43. This device, known as the Type LE, is available for operation on either a.c. or d.c.



and utilizes a unique circuit. In this unit one-half of the 25Z5 furnishes plate voltage and the other half furnishes fixed bias for the grid of the amplifier. In this manner the bias on the tube is independent of changes in plate current produced when the illumination on the phototube changes.

The only moving part is the armature of the heavy-duty contactor; no telephone or delicate microampere relays are employed. The device may be operated in either an ON or an OFF arrangement, i.e., the contacts closing when the phototube is illuminated or when it is eclipsed.

It consumes 40 watts at 115 volts d.c. or a.c.; its contacts will handle 20 amperes 115 volts non-inductive; and 3 amperes, 115 volts on d.c. Its speed is such that from 100 to 300 operations per minute. The phototube may be placed as far as 25 feet from the amplifier; price from $35 to $46 depending upon equipment.—*Electronics.*

✦

Cathode-ray recording oscillograph

RALPH R. BATCHER, 113-35 198th Street, Hollis, N. Y., has developed for the market a new recording oscillograph using a cathode-ray tube. A steel lens tube houses the focussing lens. A slide door permits the spot to become focussed on the sensitive paper, a bromide preparation 6 centimeters wide and obtainable in 175-ft. rolls. A slow-speed motor is arranged to drive the paper past the opening at a rate from one to six inches per second. Exposed film passes into a magazine mounted so as to overhang the edge of the table. A cut-off is provided to chop off exposed sections from the roll.

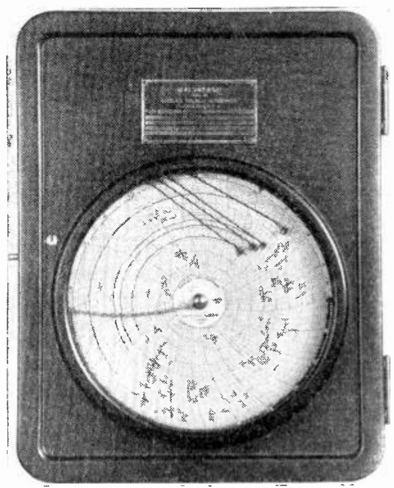
The various sections are readily demountable, so that the tube can be used in visual demonstrations without the camera. The screen of the tube is also visible to the operator during the recording interval, so that the movements of the spot can be watched at all times. When records are being made, only one set of deflection plates is used.—*Electronics.*

✦

Potentiometer pyrometer with electronic relay

The Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio, has developed a new potentiometer pyrometer which has been named "Galvatron" after the galvanometer-electronic relay circuit which it employs to operate slide-wire resistances and recording pens.

One Galvatron may include as many as four potentiometer circuits, the contact making galvanometer being automatically switched from one circuit to the next by relays actuated from contacts made by a synchronous motor-driven time device. One powerful synchronous motor drives these timing

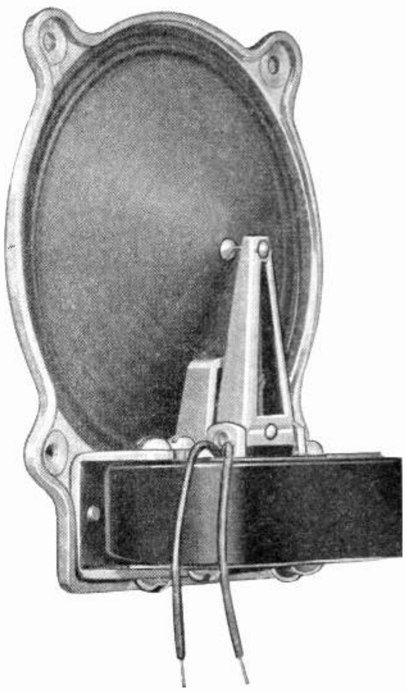


contacts for the relay as well as the galvanometer contacting mechanism, the recording chart, and the automatic standardizing relay contacts.

The Galvatron mechanism consists of a galvanometer of short period arranged to make contacts of a duration proportional to the deflection of the galvanometer needle from neutral. These contacts which close the circuit to the electronic relay carry only a few micro-amperes of current, and are connected to the grids of pliotron tubes.—*Electronics.*

Permanent-magnet speaker

The Best Manufacturing Company, Inc., 1200 Grove Street, Irvington, N. J., has developed a new Model PM3 permanent-magnet speaker, declared to be the first truly midget speaker for pocket-size radios to give results comparable to those of larger speakers. The unit is sturdy, dependable, and proof against abuse. It has



a double magnet and new armature design and suspension. A novel mechanical transformer transmits the power from armature to cone apex with a high degree of efficiency. The corrugated cone is moisture-proof, and black and aluminum finish protects all parts from rust. Maximum width, 3$\frac{15}{16}$ths inches; depth 1$\frac{31}{32}$nds inches, height 4$\frac{13}{32}$nds inches. Net weight, one-half pound.—*Electronics.*

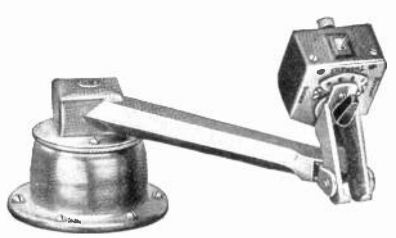
✦

Electrical pickup

Thorens, Inc., 450 Fourth Avenue, New York City, is introducing to the American market the Omnix electrical pickup, manufactured by Hermann Thorens S.A., Ste-Croix, Switzerland.

The needle-holder of this pickup is balanced in such a way that it can swing only at right-angles to the grooves of the record, eliminating distorting noises.

In comparing the tone quality produced by the Omnix pickup with that of other pickups, a marked difference in the mellowness and softness of tone is claimed. The pickup head is completely enclosed, thereby preventing dust from entering into the delicate mechanism. The arm of the pickup has a tangential movement which, in addition to the advantages of clear reproduction, considerably reduces wear of the record.—*Electronics.*



✦

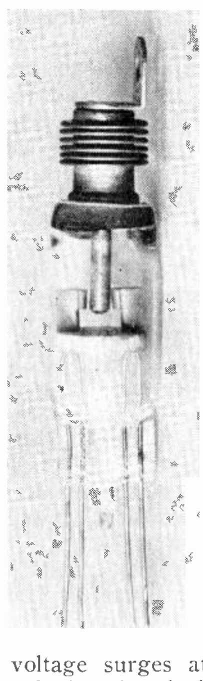
Space control relay

The Lumenite Electric Company, maker of electronic control apparatus, Old Colony Building, Chicago, Ill., affiliated with the Webster Electric Company, Racine, Wis., has placed on the market a new compact space-control relay which it calls the "Faratron invisible control."

Employing no light beam, mere approach of a person or object can be arranged to open doors, set off alarms, stop or start machines, turn on fountain, indicate liquid levels, control humidity, etc. Power relays carrying up to 30 amp. are provided. Double outlets are furnished for normally on or off loads. The Faratron is housed in a black steel case, measuring approximately 7 by 6 by 6 inches, and operates from 110 volts, a.c. or d.c.—*Electronics.*

✦

Vacuum contact device

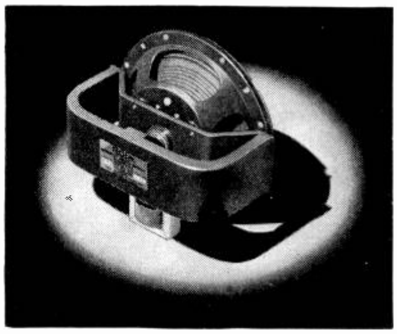


For use in atmospheres containing explosive gases, the General Electric Company, Schenectady, N. Y., has introduced the type HBA vacuum-contact device for auxiliary potential control service. It is a single-pole, double-throw contactor inclosed in an evacuated heavy glass tube, one end of which is sealed to a metal bellows which permits movement of one contact between and to either of two stationary contacts supported in the tube. Excessive voltage surges at interruption of circuit by the device are controlled by special contacts and the use of external condensers across the load terminals. The unit is inclosed in a steel container. The rating is 15 amp., 250 volts, with 10 amp. interrupting capacity at 115 and 230 volts, 60 cycles, and 125 and 250 volts d.c.—*Electronics.*

Permanent magnet dynamic speakers

The Rola Company, 2530 Superior Avenue, Cleveland, Ohio, has a new dynamic loudspeaker of the permanent magnet type, in which the magnetic air-gap and voice coil are effectively shielded against the entrance of metallic particles and dust that are attracted to these vital parts and cause troubles. Sensitivity, tone fidelity and power handling ability of these new PM-8 loud speakers are comparable to that secured in the finest of electro-magnet energized types.

A domed center shield, placed in the apex of the cone, effectively shields the magnetic air-gap, the vital part of the loud speaker, against the entrance of metallic particles and dust. The new particle-proof acoustic filter and corrugated diaphragm-type centering member protect the voice coil. Its amplitude is unrestricted. Elaborate precautions are taken at the factory during assembly to produce a unit that is absolutely clean when the air-gap is sealed. A radically new and highly efficient type of magnet core construction and other exclusive features of assembly give greatly increased flux density. Arc welded construction assures the retention of full magnetic strength and permanence of all parts.—*Electronics.*



✦

Electronic products

Amplex Electronic Products, Inc., 501 Madison Ave., New York City, is an organization of executives and engineers until recently the operating personnel of the Duovac Radio Tube Corporation, and now engaged in the production of tubes for motion-picture, sound systems, radio transmission and receiving, and industrial uses.

Prominent among its new products are Amplex 264-A non-microphonic amplifier tube; 205-D amplifier tube for sound-picture equipment; caesium-argon gas-filled photo-cell, 3-A; photo-cell 868: output amplifier 242, and exciter lamps and charger bulbs.

Particular attention is called to Amplex 205D, in which electrical leakage between filament and grid have been reduced to a minimum by a special construction which permits a very wide spacing between electrode leads at the stem. The filament used is a special development, an alloy of several metals, and designed to maintain its full electron emission at high efficiency over a long period of time.—*Electronics.*

✦

Photo-cell kit

The Automatic Music Instrument Company, Grand Rapids, Mich., is putting a new photo-cell kit on the market. This Argus photo-relay comes in a knocked-down arrangement with everything supplied, including wire, solder, screws, nuts, a caesium-argon photo-cell, a type 56 amplifier tube, and a relay capable of handling non-inductive loads up to 100 watts.

With the set are instructions for hooking the photo-cell up to operate small motors, counters, bells, alarms, signal devices, time-recording instruments, window displays, and a variety of other uses. A light-source with a focussing lens system, an infra-red filter with a 50-ft. light range, and a beam reflector are included. Price $39.50—*Electronics.*

✦

Distributor suppressor

The Erie Resistor Corporation has recently added to its line of moulded carbon resistors and suppressors, a new type distributor suppressor. This unit has a snap fitting on one end which fits firmly into the distributor cap. It is so designed that there are no exposed metal parts, once the suppressor has been snapped into the distributor head, making it impossible for arcing to take place between it and the spark-plug leads. The high-tension lead from the spark coil is connected to the suppressor by a screw recessed in the bakelite socket.

The unit is extremely compact and ruggedly constructed. A resistance pin ¾" in length, similar to those used in the other styles of Erie suppressors, is used in this new design. In spite of its smallness of size, repeated tests are said to show that this suppressor changes less than 5% in resistance value in 50,000 miles of use.—*Electronics.*

✦

All-wave antenna

All-wave Receivers for best results require an antenna of special design. After many tests, the Lynch "all-wave" antenna kit has been introduced by the Lynch Manufacturing Company, 51 Vesey Street, New York City. Better signal strength, less noise, from vacuum cleaners, oil burners, etc., can now be obtained. The "all-wave" kit comprises the following parts: 15 transposition blocks, 8 commercial type insulators, 1 universal coupler, 200 ft. "Hi-Mho" (special high-conductivity) wire. List price, $6.50.—*Electronics.*

Remote controls for auto-radio

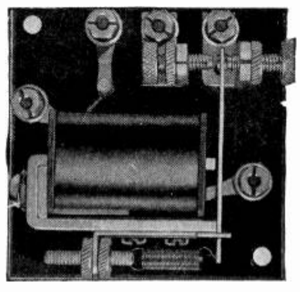
The F. W. Stewart Manufacturing Corporation, makers of speedometer parts, have put on the market a line of remote-control units for automobile radio sets. These are complete with case, dial, clamp, light assembly and bulb, key knob, and extra key. The dials may be supplied with black or white cards carrying white or black lettering, and with number arrangements "550 to 1,500" or "0 to 100," reading either to the left or to the right. Special names and distinctive marks on the dials can be employed to make the equipment most individual.—*Electronics.*

✦

Sensitive relay

The Ward Leonard Electric Company, Mount Vernon, N. Y., announces a new senstive relay. These relays are especially suited to photoelectric and similar applications where operation of the relay is dependent upon extremely low values of current.

The design and construction of the magnetic circuit provides a high degree of sensitivity at low induction, good contact torque at pull-up, and a crisp constant drop-out that can be adjusted to 85% of the pull-up value.



These relays will operate on approximately 14 milliwatts. Where smaller gaps between contacts are permissible, the relay can be adjusted to give positive operation on 4 milliwatts.

Detailed information on these relays is given in Ward Leonard Bullein 251. —*Electronics.*

✦

Replacement socket

The American Phenolic Corporation, 549 West Randolph Street, Chicago, Ill., has developed a new all-purpose replacement socket, the Amphenol molded-Bakelite Cliptite socket.

This can be mounted to replace any socket without drilling holes in chassis. It can be positioned for most convenient location of leads. The shield can be added to any tube without riveting or drilling base. The naturally high insulation value of the bakelite moulding, plus a construction that prevents accumulation of soldering flux, eliminates radio-frequency socket losses.—*Electronics.*

U. S. PATENTS

IN THE FIELD OF ELECTRONICS

Sound Reproduction, Television, Etc.

Loud speakers. Two patents, No. 1,941,476 and 1,941.477 on methods of making magnetic sound reproducers. P. L. Jensen, assigned to Jensen Radio Mfg. Co.

Sound picture recording system. Picture and sound recording methods consisting in fixing a distance from a sound pick-up device to a scene including a sound source as a percentage of the distance from the camera to the scene and in setting said percentage according to the focal length of lens. J. P. Maxfield, assigned to E.R.P.I. No. 1,939,074.

Multiple scanning system. Method of synchronously operating a pick-up and a recording system. B. W. Woodward, assigned to Walter Howey, New York, N. Y. No. 1,938,990.

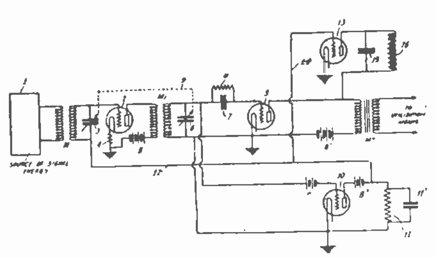
Television system. A scanning system involving rotating mirrors. H. M. Dowsett, assigned to R.C.A. No. 1,939,805.

Synchronizing system. For television use. F. Klaiber, Berlin, assigned to Telefunken. No. 1,945,355.

Picture transmission. Transmitting shaded pictures by radio subject to fading by producing a carrier wave of constant frequency and amplitude. producing an a-c of varying amplitude in accordance with the shade of the unit areas of the picture, rectifying said a-c, and keying transmitter wave in accordance with the amplitude of the rectified current. P. C. Gardiner, assigned to G. E. Co. No. 1,950,171.

Amplifiers, Generators, Etc.

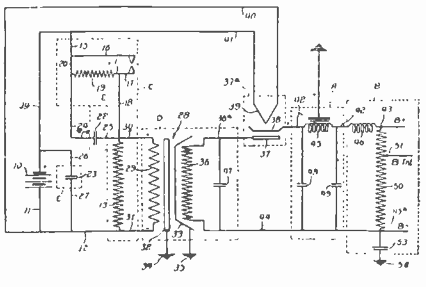
Automatic tone control. Circuit for automatically shunting audio frequencies at low signal levels. W. S. Barden, R.C.A. No. 1,947,822.



Harmonic neutralizing amplifier. A full wave amplifier comprising two symmetrical series of three or more direct connected triode amplifiers. T. H. Nakken, assigned to Nakken Patents. No. 1,949,217.

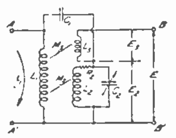
Automatic regeneration. Circuit for giving constant regeneration regardless of frequency change in an amplifier circuit. D. W. Norwood, U. S. A. No. 1,946,499.

D-c a-c system. A low voltage battery, a vibrator, a transformer, a rectifier filter system for transforming d-c of low potential to d-c of high potential. E. L. Barrett, assigned to Utah Radio Products Co. No. 1,946,563. Application June 6, 1932.



Cold tube amplifier. A multi-stage amplifier with several glow discharge devices having cold electrodes. August Hund, Wired Radio, Inc. No. 1,950,003.

Band pass circuit. Means for effecting a maximum suppression of alternating currents of a frequency away from the resonance frequency. P. O. Farnham, assigned to R.F.L. No. 1,950,358.

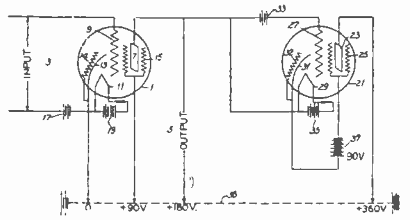


Frequency divider. A regenerative audio frequency circuit. W. F. Curtis, Washington, D. C. No. 1,950,400.

Variable reactance circuit. Operating a triode as a variable impedance element in a circuit including a reactive coupling between the grid and anode, and a resistance between the cathode and anode by varying the resistance to produce consonant variations of the effective anode-grid reactance. F. E. Terman, Stanford University. No. 1,950,759.

Frequency control. A long line in the form of a coil having an increased number of turns at its ends per unit of length to maintain uniform inductance at the ends of the coil, connected between anode and control electrode, the line being several wave lengths long. J. W. Conklin. No. 1,945,544. R.C.A.

Direct coupled amplifier. Method of effecting a substantial increase in linearity of amplification, using a tube with a non-linear resistance with a given ratio of dynamic to static resistance. Otto H. A. Schmitt, St. Louis, Mo. No. 1,950,365.



Modulating system. An absorption modulation circuit. Norman Wells, R.C.A. No. 1,950,464.

Radio Circuits

Aircraft landing marker. Method of marking at least two sides of an area by transmitting waves from a point on first one of said sides with signals of zero intensity, and directionally transmitting waves of a slightly different frequency from a point on a second side whereby a beat note results. Ross Gunn, Washington, D. C. No. 1,947,469.

Automatic channel selection. An automatic method of shifting from a main receiver to a relief receiver when a receiving system is subject to fading. R. S. Ohl, assigned to B.T.L. No. 1,950,123.

A-c d-c system. Method of switching the power supply of a receiver in accordance with whether it is operated from direct or alternating current. W. J. A. Raffel, Dayton, Ohio. No. 1,947,660.

Superheterodyne receiver. Means for determining when a receiver of the frequency changing type is in tune. C. G. Kemp and L. G. Kemp, R.C.A. No. 1,950,731.

Oscillating circuit. Two tubes connected in phase opposition are driven from the third tube, the output going into a fourth tetrode type tube. P. F. Scofield, assigned to Heintz & Kaufman. No. 1,950,752.

Tuning indicator. Method of using a cathode ray oscillograph tube for indicating when a superheterodyne receiver is properly in tune. H. W. Parker, Rogers Radio Tubes, Ltd. No. 1,951.036.

Tuning indicator. An electric gaseous discharge device containing three elements in which the cathode glow depends upon the voltage gradient. T. E. Foulke, General Electric Vapor Lamp Co. No. 1,951,143.

Non-communication Applications

Temperature-measuring device. A means for modulating the high frequency at audible frequency by a temperature controlled device. P. S. Edwards and C. D. Barbulesco, Dayton, Ohio. No. 1,951,276.

Measuring gravitational forces. Changes of acceleration due to gravity are observed by obtaining a harmonic of a gravitational periodic system, and comparing the frequency of this harmonic with the frequency of a standard periodic system. P. I. Wold, Schenectady, N. Y. No. 1,951,226.

Determining light intensity. Determining and correlating light intensity with respect to the sensitivity of various photosensitive materials. C. A. Watrous, New Haven, Conn. No. 1,951,180.

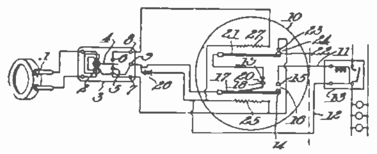
Photographic printing apparatus. Automatic exposure control using light sensitive means. R. N. Carter, Eastman Kodak Co. No. 1,946,612.

Musical instrument. A photoelectric system using rotating disks. P. M. G. Toulon, Puteaux, France. No. 1,948,996.

Timing system. Method of measuring the time of travel of a body over a certain path by means of a timing device which responds to a certain form of atmospheric wave energy for starting the device at the beginning and stopping it at the end of travel of the body. E. A. Speakman, Narberth, Pa. No. 1,950,273.

Control system. A demand control device in an energy-consuming system having a demand meter controlled by light sensitive apparatus. H. L. Miller, Philadelphia, Pa. No. 1,950,256.

Relay system. A time delay circuit for use with light sensitive cell of the dry disk type. A. H. Lamb, assigned to Weston. No. 1,949,689.

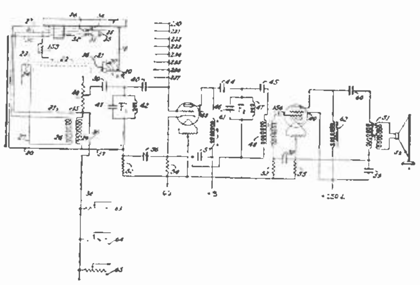


Synchronizing system. A photo-electric method of synchronizing apparatus for television purposes. F. von Okolicsanvi and Gustav Wilkenhauser, Berlin. No. 1,950,831.

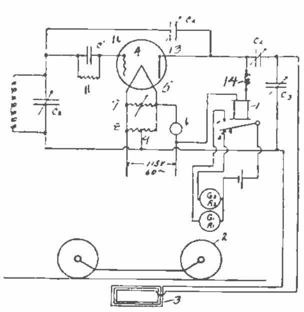
Elevator control system. Electron tube method involving a variable mutual inductance for controlling the variable voltage generator supplying power for a motor on an elevator. R. J. Stevens, New Malden, England. No. 1,948,685.

Temperature control system. An alternating current relay and phase shifting means comprising inductance and capacity. Waldemar Ilberg, assigned to Telefunken. No. 1,949,254.

Electrical music sytem. Several generators of complex tones equal in number to the notes of the system, tone filtering devices, etc. R. H. Ranger, Newark, N. J. No. 1,947,020.



Traffic signal. Traffic varies the oscillatory character of a vacuum tube circuit. W. C. Nein and T. W. Varley, New York. No. 1,950,741.



Tubes and Tube Apparatus

Tube tester. Circuit including a meter and a resistor in the plate circuit of a tube so connected that the resistor, which is variable, can be calibrated as a measure of the tube characteristics. J. R. Barnhart, assigned to W. M. Scott and R. E. Tresise. No. 1,946,466.

Vacuum tube tester. An oscillating circuit connected across grid and plate of the tube under test, a neon indicator, etc. C. E. Urban, assigned to C. J. Kauffman. No. 1,949,341.

Cathode production. Method of producing highly emissive cathodes by purifying the surface of a tungsten wire, heating it in an oxidizing atmosphere to produce a coating comprising the higher tungsten oxides and reducing the coating in water-steam and hydrogen to pure tungsten dioxide. Vaporizing an alkaline metal on the coating of pure tungsten dioxide. Ernst Waldschmidt, Berlin. No. 1,949,094.

High voltage rectifier. Gaseous discharge tube comprising cathode, anode and two grids. G. Holst, assigned to Philips. No. 1,949,048.

Railway control. A train control system of the coded alternating current track circuit type in which current flows through at least one rail of the track, the current containing harmonics of its fundamental frequency. G. W. Baughman and F. H. Nicholson, assigned to Union Switch & Signal Co. No. 1,948,197.

Power control circuit. Patents of the following numbers granted to G. E. Co., involving thermionic tubes for controlling power circuits: No. 1,948,372; 1,947,189; 1,947,197; 1,947,242; 1,947,255, a telemetric system; 1,947,268 and 1,947,292.

Patent Suits

1,251,377, A. W. Hull, Method of and means for obtaining constant direct current potentials; 1,297,188, I. Langmuir, System for amplifying variable currents; 1,707,617, 1,795,214, E. W. Kellogg, Sound reproducing apparatus; Re. 18,579, Ballantine & Hull, Demodulator and method of demodulation; 1,811,095, H. J. Round, Thermionic amplifier and detector, filed Oct. 30, 1933, D. C., S. D. N. Y., Doc. E 76/361, Radio Corp. of America et al. v. Traveltone Radio Corp.

1,862,914, W. E. Wagner, Propellant powder and process of making same, filed Oct. 30, 1933, D. C., S. D. Ohio, W. Div., Doc. E 873, Western Cartridge Co. v. The King Powder Co. et al.

1,231,764, F. Lowenstein, 1,618,017, same; 1,239,852, Vreeland; 1,544,081, same; 1,103,475, Arnold; 1,465,332, same; 1,403,932, Wilson; 1,573,374, Chamberlain; 1,702,833, Lemmon; 1,811,095, Round; Re. 18,579, Ballantine & Hull; Re. 18,916, Aceves; filed Dec. 13, 1933, D.C., E.D.N.Y., Doc. E 7142, Radio Corp. of America, et al. v. Powrad, Inc.

1,239,852, Vreeland, 1,544,081, same; 1,573,374, Chamberlain; 1,702,833, Lemmon; 1,811,095, Round; Re. 18,916, Aceves; Re. 18,579, Ballantine & Hull; 1,618,017, Lowenstein; 1,231,764, same; 1,403,932, Wilson; 1,465,332, Arnold; 1,896,780, Llewellyn; 1,507,016, De Forest; 1,507,017, same; filed Dec. 12, 1933, D.C., E.D. Mich. (Detroit) Doc. 6182, Radio Corp. of America et al. v. Detrola Radio Corp. et al.

1,251,377 (a) Hull, 1,297,188, Langmuir; filed Dec. 12, 1933, D.C., E.D. Mich. (Detroit), Doc. 6181, General Electric Co. v. Detrola Radio Corp. et al.

1,251,377 (b) Hull; 1,297,188, Langmuir; 1,728,879, Rice & Kellogg; 1,820,-809, Kellogg; filed Dec. 13, 1933, D.C., E.D. N.Y. Doc. E 7141, General Electric Co. v. Powrad, Inc.

1,128,292, Colpitts; 1,231,764, Lowenstein, 1,426,754, Mathes; 1,432,022, Heising; 1,448,550, Arnold; 1,504,537, same; 1,483,273, Blattner; 1,493,595, same; D. C. Del., Doc. E 734, Western Electric Co., Inc., et al. v. The Stanley Co. of America. Claims 1, 2, 4, 5, 6, and 7 of 1,231,764 held valid and infringed; bill dismissed with prejudice as to claim 25 of 1,426,754, claims 1 and 5 of 1,128,292, claims 17, 19, 20, 33, 34, 35, and 36 of 1,504,537, claims 6 and 8 of 1,483,273, and dismissed without prejudice as to 1,432,-022, 1,448,550, and 1,493,595 Dec. 11, 1933.

1,141,402, R. D. Mershon, Electrolytic apparatus employing filmed electrodes; 1,784,674, same, Film formation and operation of electrolytic condensers and other apparatus, appeal filed Dec. 8, 1933, C. C. A., 1st Cir., Doc. 2880, Sprague Specialties Co. v. R. D. Mershon et al.

1,251,377, Hull; 1,297,188, Langmuir; 1,477,898, Rice, filed Dec. 21, 1933, D.C., S.D. N.Y., Doc. E77/82, General Electric Co. v. J. D. Mendelson (Metro Mfg. Co.).

1,465,332, Arnold; 1,573,374, Chamberlain; 1,618,017, Lowenstein; 1,231,764, same; 1,702,833, Lemmon; 1,811,095, Round; Re. 18,579, Ballantine & Hull; 1,403,932, R. H. Wilson, Electron discharge device, filed Dec. 21, 1933, D.C., S.D. N.Y., Doc. E77/83, Radio Corp. of America et al. v. J. D. Mendelson (Metro Mfg. Co.).

1,573,374, Chamberlain; 1,618,017, Lowenstein; 1,231,764, same; 1,702,833, Lemmon; 1,811,095, Round; Re. 18,579, Ballantine & Hull; 1,403,475, Arnold; 1,-465,332, same; 1,403,932, Wilton, filed Dec. 30, 1933, D.C., S.D. N.Y., Doc. E77/98, Radio Corp. of America et al. v. Royal Radio of New York, Inc., et al.

1,251,377, Hull; 1,297,188, Langmuir; 1,477,898, Rice, filed Dec. 30, 1933, D.C., S.D. N.Y., Doc. E77/97, General Electric Co. v. Royal Radio of New York, Inc., et al.

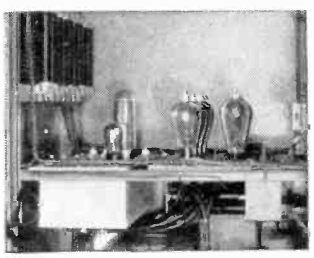
1,855,168, C. L. Farrand, Loud speaker, appeal filed Dec. 9, 1933, C. C. A., 1st Cir., Doc. 2826, Utah Radio Products Co. et al. v. R. T. Boudette et al. (Boudette & Co.).

1,901,735, A. Crossley, Piezo electric crystal system; 1,572,773, same, Piezo electric crystal apparatus; 1,831,151, G. P. Walker, Temperature control system for frequency determining elements; 1,649,828, A. Hund, Method of preparing piezo electric plates, filed Dec. 26, 1933, D.C., S.D. Ohio, W. Div., Doc. E 358, Wired Radio, Inc., v. Radio Station WSMK, Inc.

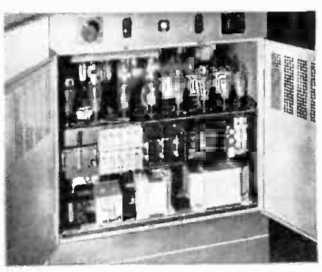
Characteristics of the 249B

Filament Potential, Volts	2.5
Filament Current, Amperes	7.0
Approximate Anode Cathode Drop, Volts	15.
Maximum Peak Plate Current, Amperes	1.5
Maximum Peak Inverse Potential, Volts	7500.
Safe Operating Ambient Temperature Range	0 to 50° C.
Maximum Overall Length	8¾″
Diameter of Bulb	2 11/16″
Base—Standard Four Prong Thrust Type	

It helps you to give them a good send-off!



Typical mounting of 249B Tubes in Western Electric 9A Rectifier.



Mercury Vapor Rectifier Tubes supplying plate power for 305A Western Electric Transmitter used by New York City police.

Users of the Western Electric 249B mercury vapor tube report uniformly long life and freedom from sudden failure. This tube is used widely in rectifiers, to supply anode voltage for power tubes in broadcast, police and aircraft transmitters. Its low arc drop—practically independent of load current—increases efficiency, improves regulation and quality.

In the 249B, the cathode is mounted in a metal housing which conserves heat, insures uniform cathode temperature and full electron emission from the entire cathode area. These features provide an electron supply much greater than the maximum peak current rating.

The oxide-coated cathode is constructed of a special mesh which eliminates peeling of active coating. Anode mounting and terminal design prevents failure from arc-backs. After a thorough vacuum exhaust, an exact amount of mercury is introduced into the envelope by flashing of a "mercury pill container."

For full details about the 249B, write to Graybar Electric Co., Graybar Building, New York, N. Y., or telephone the nearest Graybar branch.

Western Electric

RADIO TELEPHONE BROADCASTING EQUIPMENT

Distributed by* GRAYBAR *Electric Company

WESTON MODEL 705
Contact-making Indicator
Size, 3¼" diameter, made for either flush or surface mounting, single or double contact. Scale may be calibrated for current, voltage, temperature, etc.

THE WESTON *Supersensitive* CONTACT-MAKING INDICATOR

low operating values · high contact capacity contacts made and held magnetically

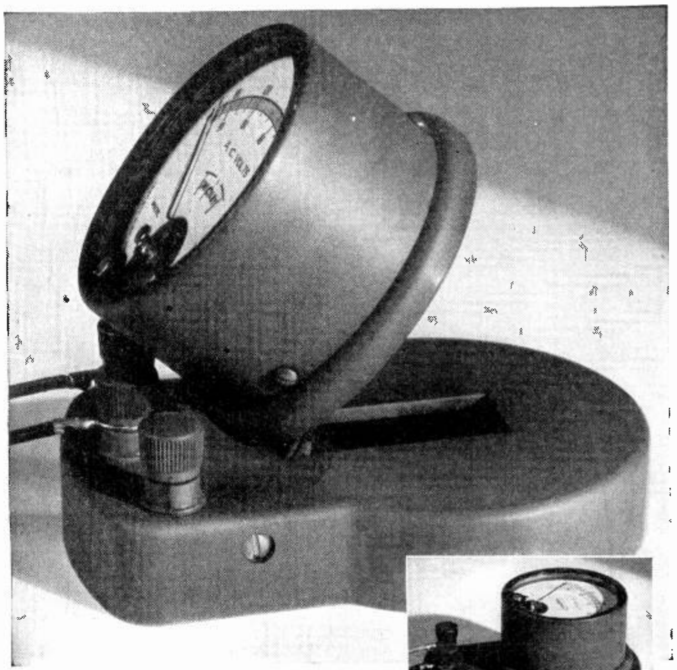
Here is a sensitive relay that will make contact on values down to three microamperes or one millivolt, with contacts capable of handling five watts at 110 volts, non-inductive load. It's the new Weston Model 705 . . . the first relay of such sensitivity ever produced capable of handling this amount of energy on its contacts.

And Model 705 employs a radically new principle of contact-making. A few microamperes swing the moving contact into the field of the permanent magnet stationary contact which pulls the moving contact in positively and holds it tight until contact is broken manually or automatically.

Model 705 greatly broadens the fields of application for sensitive relays and simplifies many existing problems. It permits of control by means of small electrical quantities such as are generated by photo-electric cells, thermocouples, etc. It has been found ideal for alarm and protective systems, smoke-detection devices, paper-break detectors, etc., as well as for temperature control.

Complete information on Weston Model 705 Contact-making Indicator and other Weston relays is available and will gladly be sent on request . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

WESTON *Instruments*



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The exacting engineer prefers a Triplett Portable Instrument because it serves a double purpose. It can be used either as a regular portable instrument, or, as the new adjustable type. Before starting a chart, he can adjust the meter until he can readily see the dial . . . regardless of where he places it! A single glance at the upraised easy-to-read dial gives him the information he desires . . . and enables him to continue with his experiment without moving from his position and without loss of time.

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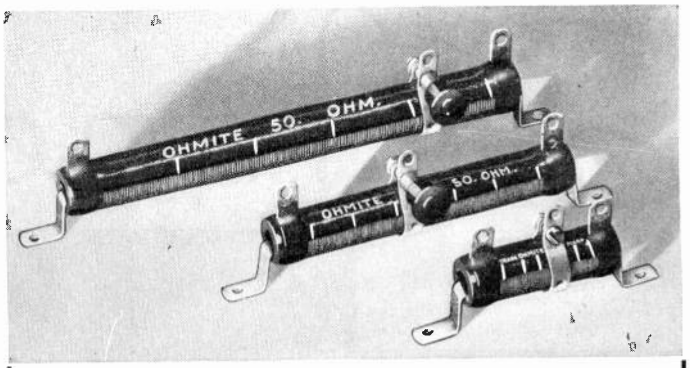

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(Stranded and Solid—Bare or Enameled)

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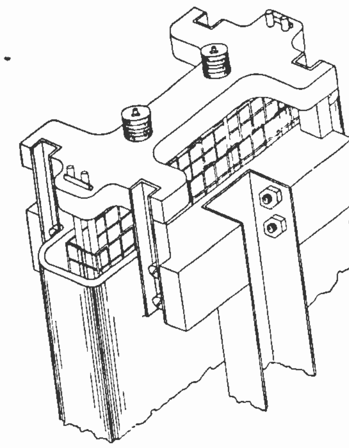

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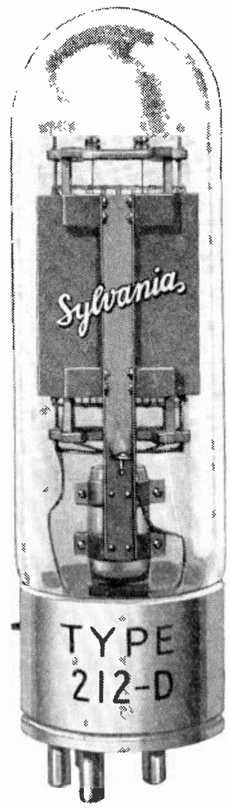

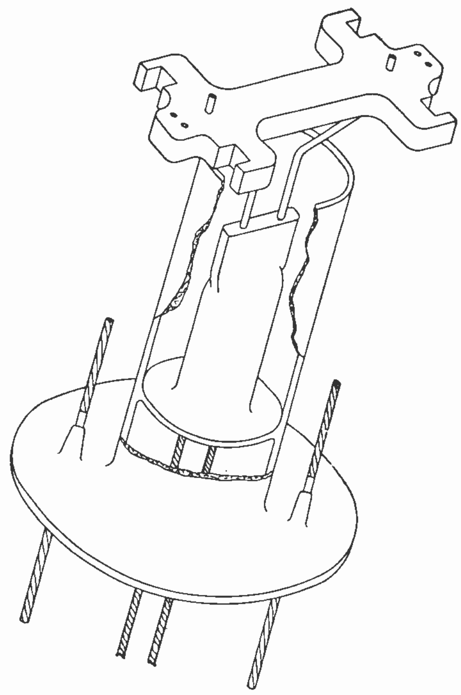

Ring Seal Stem

THE REASONS WHY!

NEW

1. Graphite Anode
2. Thoriated tungsten filament
3. Mesh grid (uniform surface)
4. Channel beam (molybdenum) element supports
5. Ring seal (grid and plate leads bead-sealed through flare—external to the press)

OLD

1. Nickle Anode
2. Oxide coated filament
3. Wound wire grid
4. Flat metal supports
5. Less adequate insulation between high and low voltage elements.

NET RESULTS = LONGER LIFE EXPECTANCY - GREATER STABILITY

This tube is superior for R. F. as well as for modulator service

● Like the many other types of SYLVANIA GRAPHITE ANODE tubes, this greatly improved 212D is receiving a hearty welcome. It is Sylvania's answer to a clamorous demand for a modern tube of this type to cope with present-day broadcast quality standards.

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Lower Cost Per Hour Price

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Where

Bakelite Insulation Protects

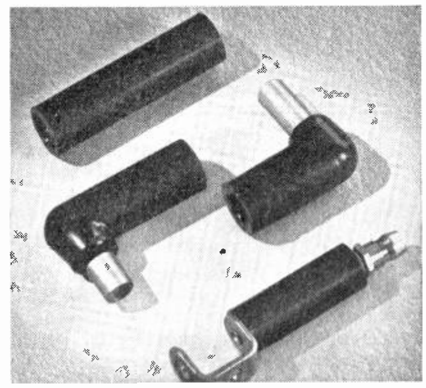
Automobile Receiver performance

FEW REALIZE the extent to which Bakelite Insulation is relied upon to protect Automobile Radio Receiver performance. In the well known Emerson receiver more than 50 separate parts formed of Bakelite Materials are used.

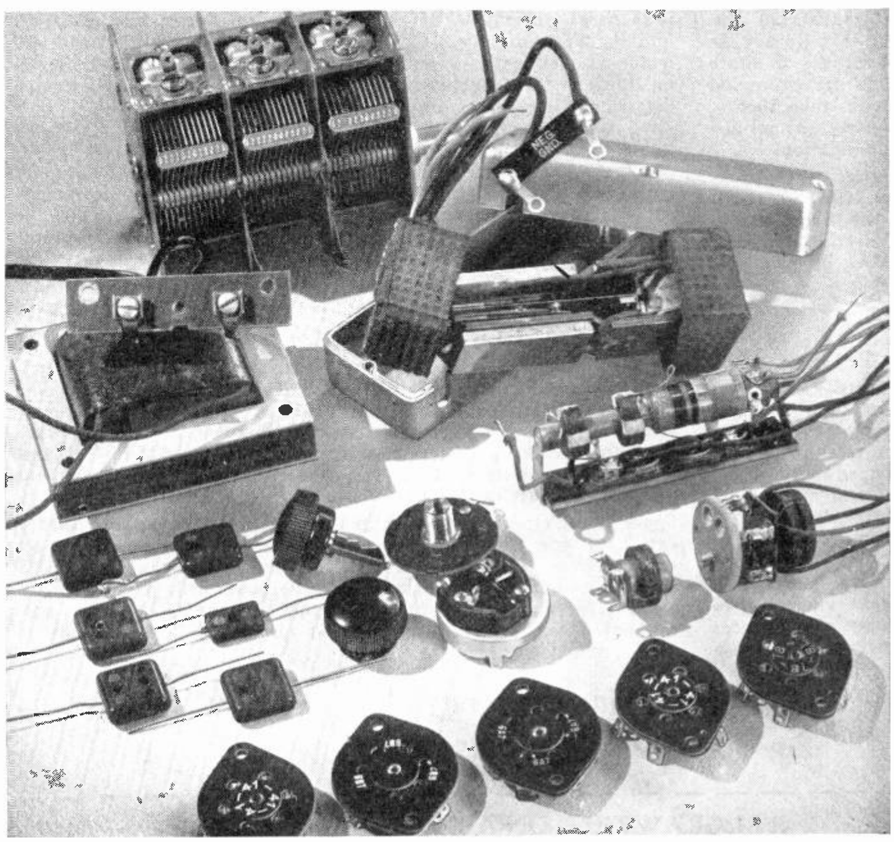
Bakelite Laminated tube sockets account for 15, coils for 10, variable condenser for 9, vibrator for 7. The six mica condensers are housed in Bakelite Molded. The two control knobs are also made of the same material. The transformer is insulated with Bakelite Varnish and has a terminal strip of Laminated. The tone control and switch has three Laminated parts and two Molded. In addition to this there are Bakelite Molded suppressors and tube bases.

There is, of course, a reason for this wide use of Bakelite Materials for radio receiver insulation. They combine many properties essential to superior receiver performance. They possess permanently high insulation value; are unaffected by climatic variations and perform equally well in moist air and dry, and engine heat does not harm them. They are adapted to economical and efficient production and assembly processes.

Each of the Bakelite Materials mentioned are described in illustrated booklets 13L and 13M. You will find them informative and helpful, and copies will be mailed promptly on receipt of your request.



(Above) Suppressors made of Bakelite Molded. Manufactured by Erie Resistor Corp., Erie, Pa.



(Left) Emerson Radio Receiver parts made from Bakelite Materials. Receiver by Emerson Radio and Phonograph Corp., New York.

BAKELITE CORPORATION, 247 Park Avenue, New York, N.Y. . . . . 43 East Ohio Street, Chicago, Ill.
BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

BAKELITE

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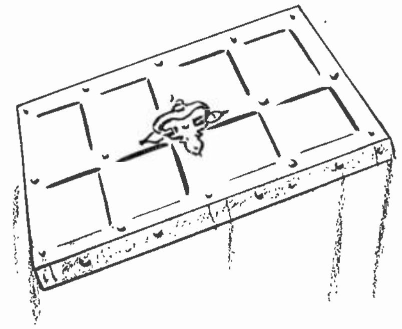
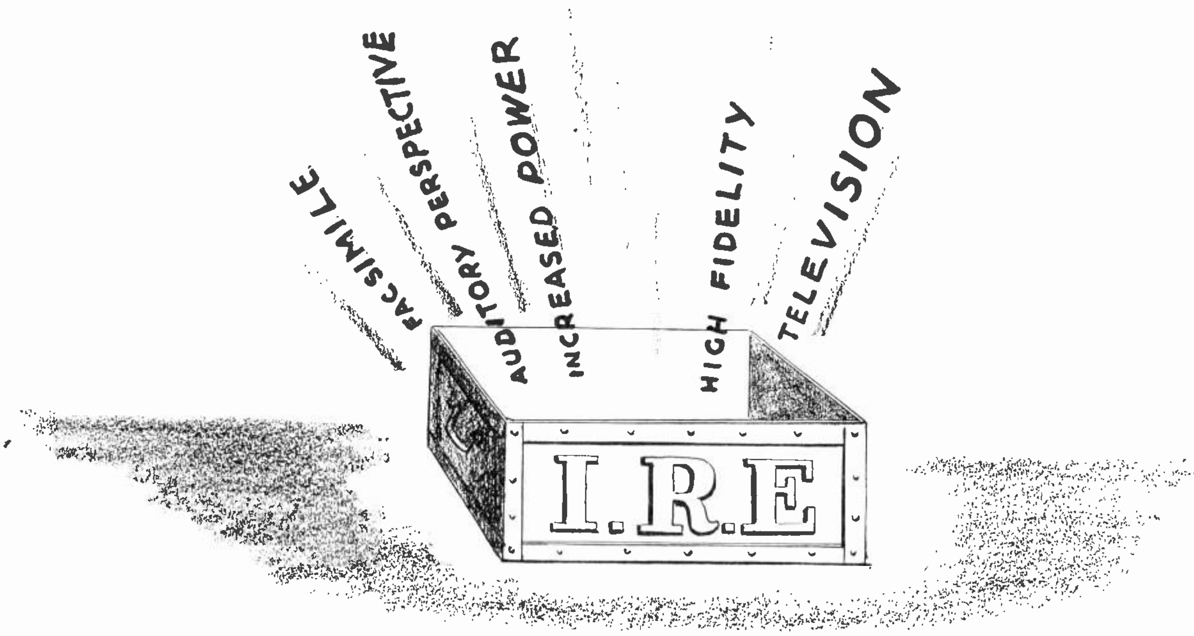


WE'RE MAKING A



WHAT do we mean by this? Just this: For four years inventive genius in our electronic industry has not been stifled, but it has been cramped. Engineers could develop and suggest newer and better things and they did. Many of their developments reached the market. But engineers always realized that above them were business executives and financial men who okayed some expenditures only when driven to the step. This took some of the kick out of initiative—some of the sparkle out of life.

Things will be different at the Institute of Radio Engineers Convention in the Benjamin Franklin Hotel, Philadelphia, May 28th to 30th. Members will trek to the City of Brotherly Love with fire in their eyes and enthusiasm in their minds. Because business is better. Because money is available again. And money, like the sun, will make ideas flower again.

Everything in the electronic industry looks better—radio communications and broadcasting, sound engineering and industrial applications of photocells. The prospects are better because money is being spent.

We could amplify this theme for hours. We could talk about better radio sales and the better prospects for component parts. We could expound government and mu-

PREDICTION:

At no I. R. E. Convention in 4 years has the lid been off as it will be in May

nicipality buying of radio equipment. We could mention work going forward in broadcasting stations to increase power and fidelity of transmission. We could talk about the increasing installations of permanent and mobile sound systems, particularly in the public address field. We need only point to the references in Stuart Chase's new book to show that industrial applications of photocells have definitely arrived.

It all boils down to this: the coming May Convention of the I. R. E. will find both speakers and attendants in an enthusiastic, if not positively jubilant frame of mind—a frame of mind that will be translated into buying of the very things you have for sale.

So we say to suppliers of parts, materials and services used in the field of electronics: "Advertise in the May I. R. E. Convention Issue of *Electronics.* Your advertising will be productive, particularly since it will be supplemented by an exceptionally interesting editorial section in this I. R. E. Issue—an editorial section that will strike the keynote of the Convention for those who attend and those who stay home."

At I. R. E. time tell your story and sell your wares to the 7,500 engineers and executives who read *Electronics.* They read it because of their common interest in electron tubes and associated apparatus. They're a group that includes not only I. R. E. members but non-members as well, convention attenders and stay-at-homes.

For the man who works out advertising schedules: Advertising forms for the May I. R. E. Convention Issue of *Electronics* close on May 5th. Yes, there'll be color in the advertising pages for those who want it. . . . Yes, copies of the May issue will be distributed from *Electronics'* booth at the I. R. E. Exhibit.

electronics

A McGraw-Hill Publication
Member of the ABC and ABP
330 West 42nd Street, New York

YES even the advertisements help

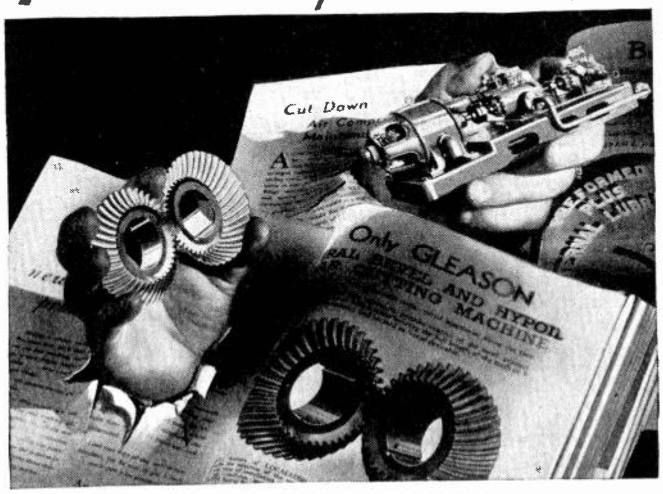
FOR several generations McGraw-Hill Publications have been helping men at their work—teaching them new methods—keeping them abreast of each new development in their industry or profession. Edited not merely to report news and reflect opinions, but rather to inform and improve, McGraw-Hill Publications have built up editorial standards which command universal respect.

Knowledge of how others are meeting new responsibilities and new conditions is *your* key to success in facing the future. The editorial pages of McGraw-Hill Publications furnish this knowledge. That is why more and more new subscriptions are coming in every day.

But there's another reason why thousands read McGraw-Hill Publications regularly. It is because they find the advertising pages equally helpful and informative. Each issue is a veritable "exposition"—a printed "exhibit" of up-to-date equipment, products or services, which cut costs, smooth out production difficulties, improve products, increase sales.

McGRAW-HILL PUBLISHING COMPANY, Inc.

you "keep alert"



Perhaps the very problem that's bothering you in your own job, has a solution in the advertising pages of your business paper. Perhaps your subordinate executives would be doing a better job, if they were regularly reading McGraw-Hill publications.

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Make sure that you see these new products and ideas at least as soon as your competitors. And make sure that your department heads keep up with the progress in their own fields. Do it now! Put yourself and your key men on a "Keep Alert" program such as this:

1. Follow the latest developments in your own profession, business or industry by reading regularly the leading paper in your field.
2. See that your department heads read regularly publications pertaining to their jobs, whether in management or operation, production or maintenance. (See list of Publications opposite.)
3. Ask to have a McGraw-Hill representative explain the various editorial features and services of the publications.
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McGRAW-HILL PUBLICATIONS

American Machinist . . . for machinery and metal product manufacturers . . . business and technical magazine of the metal-working industries.

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Bus Transportation . . . for executives of transportation companies operating and maintaining buses in common carrier service.

Business Week . . . gives the busy executive all important and significant business news in one publication . . . quickly . . . accurately . . . tersely.

Chemical and Metallurgical Engineering . . . for the chemical engineer . . . covers production, technology, marketing, finance, economics, and management.

Coal Age . . . devoted to the operating, technical and business problems of mining and marketing coal.

Construction Methods . . . an illustrated review of current field practice and equipment used in all general and special construction activities.

Electrical Merchandising . . . serves the electrical appliance trade . . . electrical retailers and wholesalers . . . helps them become better merchants.

Electrical West . . . serves the specific interests both of engineering and of selling in the electrical industry of the eleven Western States.

Electrical World . . . for electrical engineers . . . weekly business and technical coverage of electrical industry activities, including all phases of generation, distribution, and utilization of electricity.

Electronics . . . industrial design, engineering and manufacture of radio, sound, and communication equipment. Features new applications of electronic tubes.

Engineering and Mining Journal . . . complete and authoritative technical and market publication of mining, milling, smelting and metal refining industries.

Engineering News-Record . . . leading weekly publication of civil engineering and construction, covering news and technical performance.

Factory Management and Maintenance . . . all phases of plant operation . . . management, production and services including maintenance of electrical and mechanical equipment.

Food Industries . . . production, operation, engineering, and distribution in food manufacturing and processing plants of all kinds.

Power . . . every phase in the production and transmission of power in any form, including all prime movers, and auxiliary equipment.

Product Engineering . . . for engineers and executives who create, design, and develop machinery and "engineered" metal products.

Radio Retailing . . . home entertainment merchandising . . . for retailers and wholesalers of radios and allied products, and their service men.

Textile World . . . business and technical, edited generally for the textile industries, and specifically for cotton, wool, silk, rayon, knit goods, and processing.

Transit Journal . . . engineering and business magazine of local transportation, electric cars, rapid transit, buses, trolley buses, and taxicabs.

Mail the Coupon TODAY!

McGRAW-HILL PUBLISHING COMPANY, INC.
330 West 42nd Street, New York, N. Y.

Please enter my subscription to the following publications and bill me with the first issue

....

....

or please send me, without obligation, the material checked below.

☐ Sample copies of the following publications

....

....

☐ Descriptive folder of all McGraw-Hill Publications

☐ Catalog of McGraw-Hill Books

NAME..

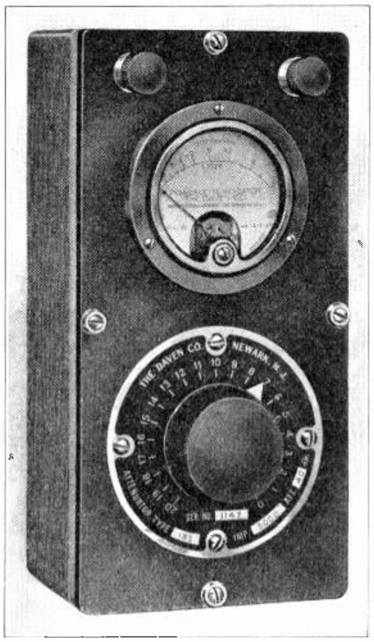
TITLE...

COMPANY...

ADDRESS...H

DAVEN *Speech Input Devices*

are Modern in Design and Reliable



. . . consider the Power Level Indicator

High in accuracy—plus or minus 0.1 db or better; high in sensitivity; flat frequency characteristic up to 50,000 cycles; twenty steps of attenuation.

Type A-185
—Cabinet Mounting
—10 db to + 46 db

Type B-185
—Panel Mounting
—10 db to + 46 db

Type C-185
—Cabinet Mounting
—20 db to +36 db

Type D-185
—Panel Mounting
—20 db to +36 db

Check items in which you are interested for literature.
Speech Input Control Apparatus ☐ Attenuators ☐ Potentiometers ☐ Faders ☐ Volume Indicators ☐ Output Meters ☐ Line Equalizers ☐ Attenuation Boxes ☐ Multipliers ☐ Decade Resistances ☐ Resistances ☐ Glastor ☐ Super Davohm Precision Resistors ☐

THE DAVEN COMPANY
158-160 SUMMIT STREET, NEWARK, NEW JERSEY

Quality C-D condensers

—at the Right Price

Wound on sturdy core for more constant capacity. Longer life than comparable units. Foils swaged under metal caps with leads soldered and firmly anchored.

Patented impregnating process insures long life and constant capacity.

Introduced four years ago, "Cub" units have become the most universally used condensers in radio set design. Used extensively by over 135 radio set manufacturers in United States and Canada.

●

Simplicity of design and construction permits manufacturing economies passed on to users in the form of very low prices for these rugged, reliable units capable of standing up under the most rigid operating conditions.

●

In a word, C-D "Cubs" strike that happy balance between high quality and low price, due to engineering achievement and tremendous production.

***Write* for new 1934 catalog No. 127 describing the large variety of "Cubs" as well as complete line of paper, mica, sulfinite, pyranol, oil and electrolytic types.**

CORNELL - DUBILIER CORPORATION
4380 Bronx Blvd., New York City

PROFESSIONAL SERVICES

Consulting—Design—Research—Testing
Measurement—Development—Acoustics—Patents

ELECTRICAL TESTING LABORATORIES

Characteristics and
Life Tests of Vacuum Tubes
Tests of photocells, glow lamps, crater lamps.
Tests of electronic and optical devices.
80th Street and East End Avenue
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Design
Electromagnets Solenoids
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JENKINS & ADAIR, INC.

Engineers

Designers, developers, and manufacturers of accessories and essentials for recording, broadcasting and testing at sound frequencies.
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Cable Address: Jenkadair *Telephone:* Keystone 2130

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Electronic Consulting Service

Special lamps, tubes and discharge apparatus designed and constructed according to specifications. Vacuum laboratory equipment and experimental glass construction.
Ridgefield, N. J.

The Real Value

of placing your unusual problem in the hands of a competent consultant eliminates the elements of chance and uncertainty from the problem and provides real facts upon which to base decisions.

SEARCHLIGHT SECTION

POSITION WANTED

ENGINEER-OPERATOR, age 26, with eight years' experience in construction, installation, maintenance and operation of transmitter and studio equipment. Will go anywhere. PW-60, Electronics, 520 No. Michigan Avenue, Chicago, Ill.

HIGH GRADE NEW AND USED

ELECTRON TUBE EQUIPMENT

Write for Bulletin Showing Savings From 20% to 80%
KAHLE ENGINEERING CORPORATION
Specialists in Equipment and Methods for the Manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
350 Manhattan Ave., Union City, N. J.

All types of High Grade New and Used Equipment for the manufacture of Electron Tubes.

Lowest prices on the market.
AMERICAN ELECTRICAL SALES CO.
65 East 8th St., New York, N. Y.

"Opportunity" Advertising:

Think *"Searchlight"* First

TEXTOLITE Laminated

SHEETS RODS TUBES

... one piece or a truck load ...
Ready for immediate delivery

General Laminated Products, Inc., 233 Spring Street, New York City, is the exclusive distributor of G-E Textolite non-gear laminated materials. Its fabricating plant is the largest and most complete in the industry.

Satisfaction with the high quality of its fabricated parts is assured by the long experience and ingenuity of this corporation in making the most intricate parts.

With a special department for handling all small orders in 24 hours or less, and with complete stocks of every specification of laminated material available, its facilities for quick delivery are unsurpassed.

For detailed information on the properties and uses of Textolite, mail the coupon below.

SEND FOR USEFUL BOOKLET

Plastics Dept., General Electric, West Lynn, Mass.

Please send me a free copy of your new PLASTICS PRODUCTS PRICE LIST, GEA-937C.

Name..

Company..

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942-15

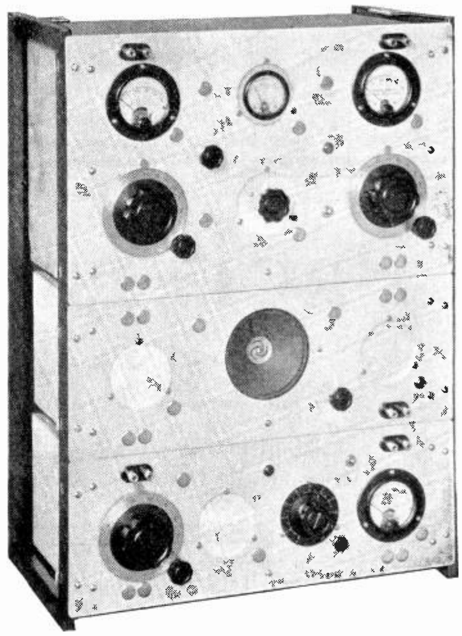
GENERAL ELECTRIC

Work in Three Dimensions

General Radio bench-racks and drilled panels are great savers of bench space. Panels are drilled for meters, jacks and commonly used parts.

Temporary or permanent laboratory or test assemblies go together quickly on the drilled sections and make a workmanlike assembly.

Experimental models can be quickly put together in a form which approximates that of production models. Test data taken on such models will more accurately forecast performance of finished models than does that obtained from the customary bread-board assembly.



Type 661-A Unit Panel 12 x 19 in., Price $6.00
Type 661-B Unit Panel 7 x 19 in., Price 4.00
Type 661-C Unit Panel 7 x 19 in., Price 8.00 (with speaker)
Type 660-A Universal Rack 26½ in. high, Price 5.00

Prices include buttons and blank disks for unused holes.

Described in Bulletin 935-E.

GENERAL RADIO COMPANY

CAMBRIDGE—MASSACHUSETTS

INDEX TO ADVERTISERS

This index is published as a convenience to the reader. Every care is taken to make it accurate but *Electronics* assumes no responsibility for errors or omissions.

SEARCHLIGHT SECTION

Classified Advertising

CONTENTS *for* APRIL, 1934

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42d STREET, NEW YORK, N. Y.

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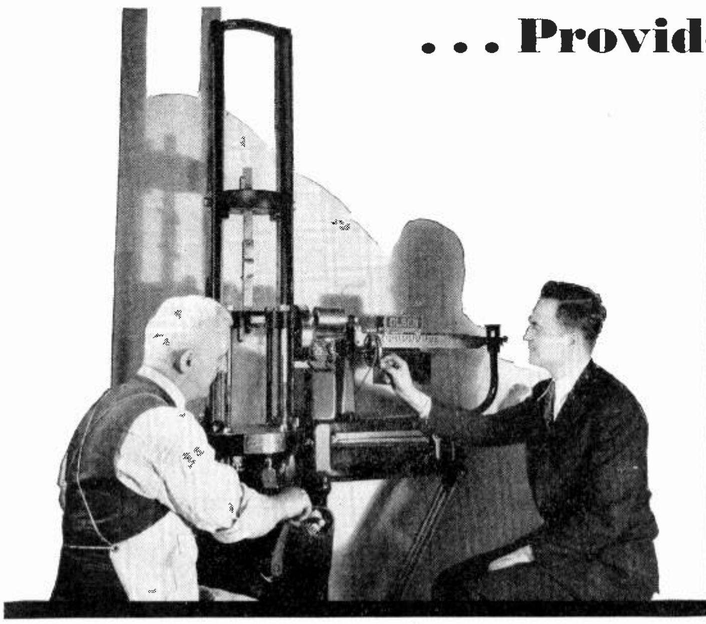
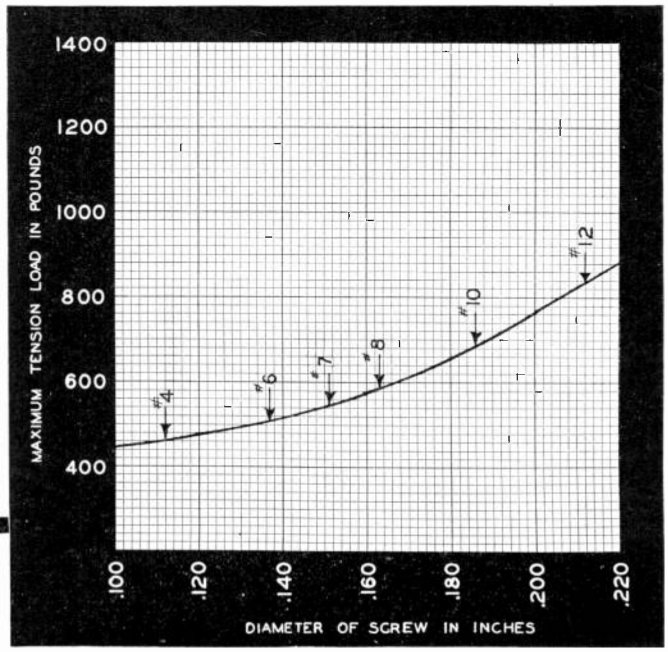
Save in Fastening to Plastics

Self-tapping Screws eliminate inserts, tapping, scrapped parts

. . . Provide Greater Security, too





Great Strength of Fastenings Proved by Unbiased N. Y. U. Tests

How much holding power do you require for your fastenings to Bakelite, Durez and other plastic materials? Check it against the holding power of Self-tapping Screws, as shown in the graph, which gives the values obtained from unbiased tests made at the laboratory of New York University. It is probable that Self-tapping Screws will actually give you better, stronger fastenings.

Where and How to use them

Type "Z" Hardened Self-tapping Sheet Metal Screws

For joining and making fastenings to molded, cast and laminated plastics; die castings and sheet metal. Just turn Screws into drilled or molded hole. Can be removed and replaced without impairing holding power.

Tyqe "U" Hardened Metallic Drive Screws

This type of Self-tapping Screw is for making permanent fastenings to molded, cast and laminated plastics, also steel and metal castings. Just hammer the Screw into a molded or drilled hole.

And economy is the big reason why so many manufacturers who assemble and make fastenings to molded, cast and laminated plastic parts are using Self-tapping Screws extensively. Elimination of troublesome and costly molded inserts, tapping, stripped threads and marred parts results in large savings and faster production.

Read what two users say:

"Self-tapping Screws save us about 25 per cent on assemblies formerly made with rivets, wood screws and machine screws in tapped holes. They have speeded-up production, smoothed out assembly troubles and reduced repairs on returned merchandise".

"By eliminating all inserts we not only saved the cost of inserts which alone are more costly than Self-tapping Screws—but we were able to speed up production in our molding department over 30 per cent, and we increased production in our assembly department by 100 per cent".

We would like to send you an interesting article by an outside engineer on the advantages of Self-tapping Screws for making fastenings to plastic materials. Use the coupon to get it. If you would like free samples for tests just attach a brief description of your fastening job.

PARKER-KALON
HARDENED
Self-tapping Screws
PAT. IN U.S. AND FOREIGN COUNTRIES

PARKER-KALON CORPORATION, 198 Varick Street, New York, N. Y.

Please send detailed article on use of Self-tapping Screws for making fastenings to plastics.

Name, Title ....

Company ....

Address ....

"A CINCH PLUG THE SIZE OF A QUARTER?"

—"and getting it so quickly—that's service." This engineer found himself with a standard size plug and no place to fit it. Then he thought of Cinch. "Let me have a plug," he said, "about the size of a quarter." Cinch radio engineers ever mindful of the policy "your problems are our problems" went to work. The result is another satisfied user of Cinch facilities. The needs of this manufacturer has helped us to serve the immediate needs of others. With this request for a new size was created the midget radio plug. Alert personnel, schooled in the supreme value of quick action and good service, a wide range of equipment, under skilled supervision! That is the reason for an outstanding service, *individual of Cinch.*

A CINCH FOR CINCH

Here is a new metal shielded midget plug designed and constructed to fill the immediate need of one manufacturer, it is already finding a market in a long felt need of numbers of others. Perhaps there is something other than standard plugs that you may want? Whatever the need, ask us. It is probable that we have something in stock. Cinch Manufacturing Corp., 2335 W. Van Buren Street, Chicago, Illinois. *Subsidiary of* United-Carr Fastener Corp., Cambridge, Mass.

Cinch radio sockets are licensed under H. H. Eby socket patents.