electronics

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

The Industrial Recovery Act —and radio

♦

Resistance stabilized amplifiers

♦

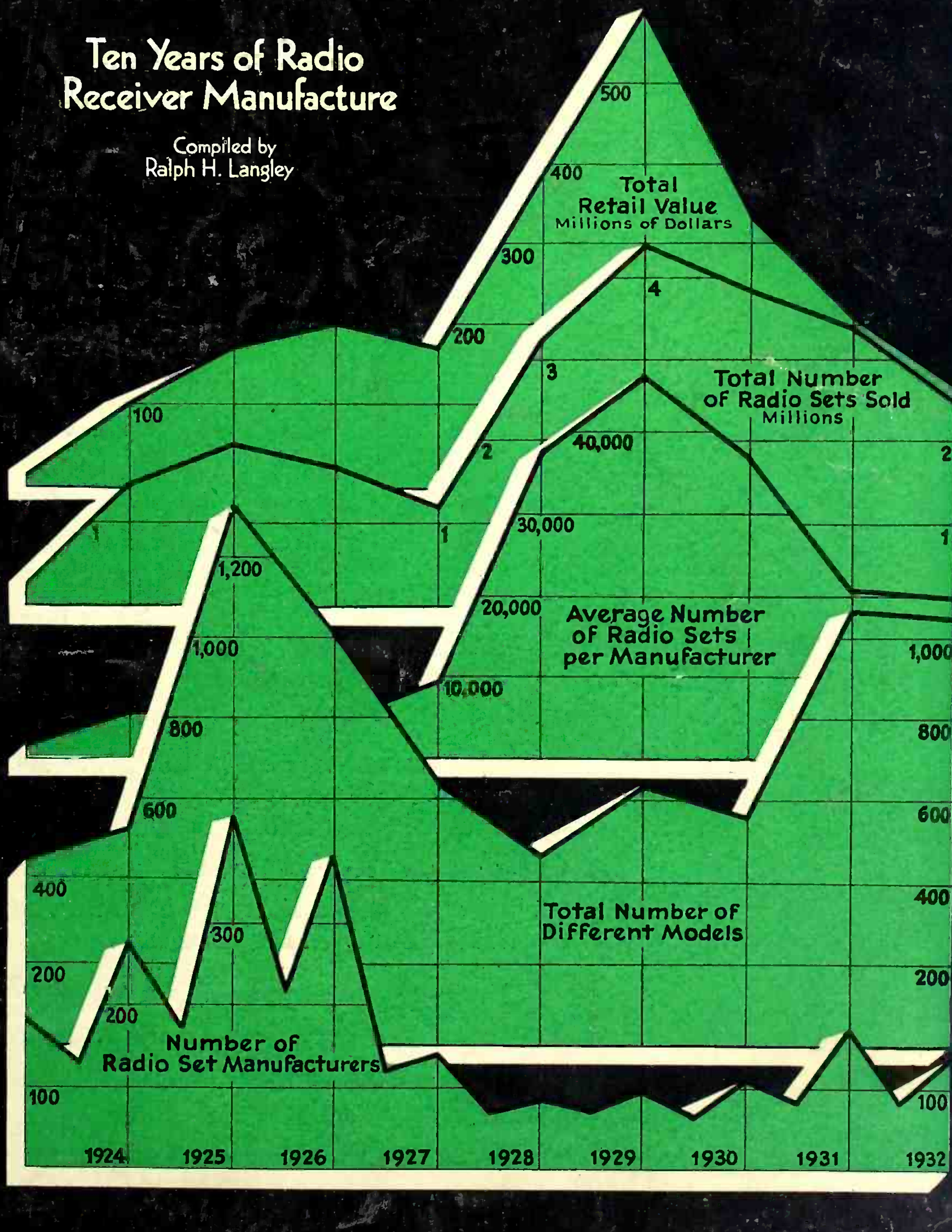
What's next in radio cabinet styles?

♦

Electron tube roles in a resistor plant

♦

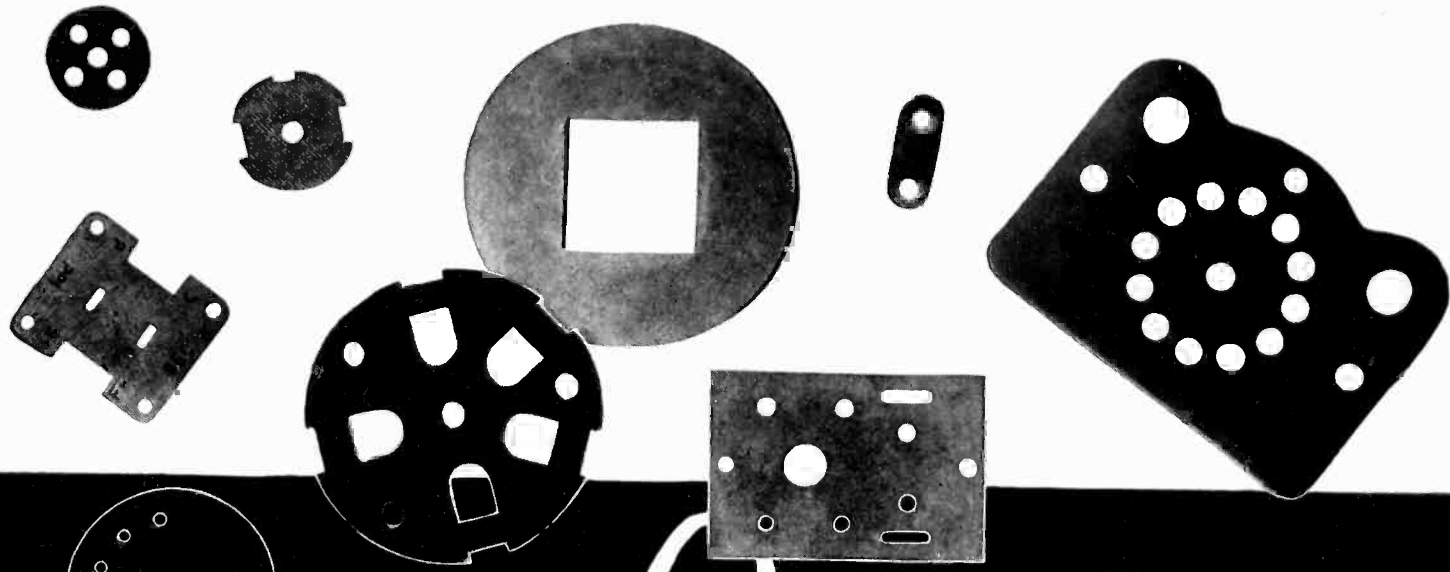
Sodium vapor lighting



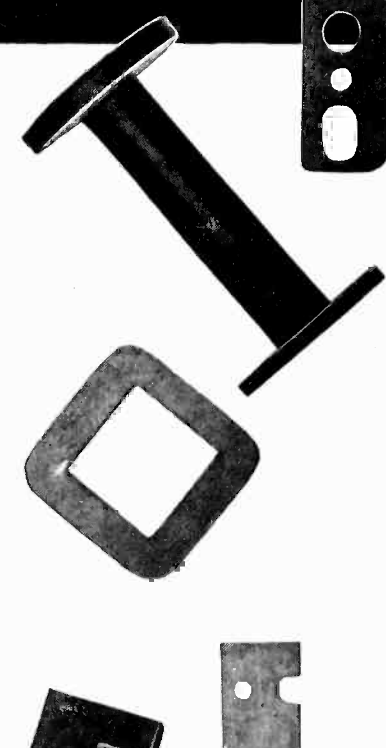
McGRAW-HILL PUBLISHING COMPANY, INC.

Price 35 Cents

JULY, 1933



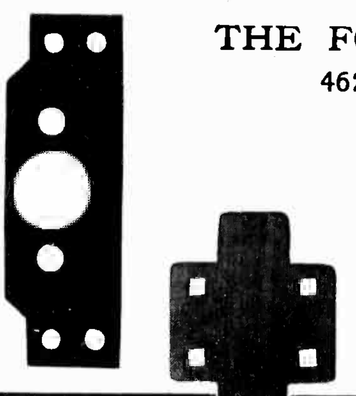
Lower Prices increase FORMICA'S use as Insulation



FOUR years of depression have brought down the price of Formica a great deal, and made it available for a lot of uses that from the commercial standpoint might not have been practical at higher levels.

Formica is economical insulation. It avoids tear down and replacement that are far more costly than small amounts saved on purchases of insulating material.

Formica can fabricate and ship promptly such parts as you need; as it is available in sheets, tubes and rods from which you can fabricate your own requirements.



THE FORMICA INSULATION COMPANY
4626 Spring Grove Avenue, Cincinnati, Ohio

FORMICA

Electronics, July, 1933. Vol. 6, No. 7. Published monthly. McGraw-Hill Publishing Company, Inc., 330 West 42d Street, New York, N. Y. $3.00 per year, 35 cents a copy. Foreign postage, $4 U. S. Currency or 20 shillings. Canada (including Canadian duty), $3.50. Entered as second-class matter April 4, 1930, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

O. H. CALDWELL
Editor
KEITH HENNEY
Associate Editor

electronics

McGRAW-HILL PUBLISHING COMPANY, INC.

Vol. 6, No. 7. New York, July, 1933

radio
sound pictures
telephony
broadcasting
telegraphy
counting
grading
carrier systems
beam transmission
photo cells
facsimile
electric recording
amplifiers
phonographs
measurements
receivers
therapeutics
traffic control
musical instruments
machine control
television
metering
analysis
aviation
metallurgy
beacons
compasses
automatic processing
crime detection
geophysics

To Speed Sales in September

RADIO production and the jobs of radio engineers depend on radio *sales*.

Radio engineers and radio technical men generally will therefore be deeply interested in the plans which the Radio Manufacturers Association has underway for a vigorous Radio Prosperity Campaign during September.

This month of active retail selling,—coupled with rehabilitation of existing radio sets,—will prepare the nation for a great series of special broadcast programs—Radio Progress Week, October 2 to 7.

NEARLY seven million homes have obsolete radio sets which should be replaced. Thirteen million other homes have no radios at all. And among the millions of homes with workable sets, a large proportion need overhauling of installation, tubes or parts. Then there are the opportunities to sell second or third "additional" sets, and automobile radios. And to put radios in offices, shops, stores and places of business.

The Radio Prosperity Campaign is a constructive, well-planned effort to stimulate radio sales and radio prosperity all along the line—among set manufacturers, parts makers, raw material suppliers, and broadcasters. It is a united drive to get, for radio, the dollars of the general public, for which the manufacturers of automobiles, refrigerators, clothes, and other personal commodities will be bidding.

The Radio Prosperity Campaign will put radio "back on the map," this Fall .

Radio Prosperity Campaign, ... **September 1 to 30**
retail sales, and set rehabilitation
in preparation for
Radio Progress Week, ... **October 2 to 7**
outstanding broadcasts on the air

THE "INDUSTRY RECOVERY

Employment and wage-scale proposals placed ahead of price-fixing and allotments by General Johnson

INDUSTRY'S "New Deal" is under way.

With the signing of the National Industrial Recovery Act and the appointment of General Hugh S. Johnson, as its administrator, President Roosevelt has put into action a revolutionary change in the industrial structure of America.

And now, like other businesses and industries, the radio industry is trying to find out just how it fits into the new industrial picture under the National Recovery Act, and what its responsibilities and benefits will be under the new plan as administered by General Johnson and his deputies.

Many business leaders and radio men had assumed, from their first readings of the Act, while it was before Congress, that here was a piece of legislation that primarily offered a convenient basis for entering upon price agreements between business competitors and the raising of price levels to consumers.

Undoubtedly these results will be among the eventual consequences of the economic forces set into motion by the National Recovery Act. But advices from Washington representatives of *Electronics,* who have been in close touch with the Administrator's office, now make it very clear that not price-fixing but EMPLOYMENT is the subject around which the Recovery Act revolves.

Employment and wage-scales first

Putting men back into jobs, rising wage scales, and the *spread of existing employment,*—these are paramount factors in which the Administrator is interested. In fact, he is not disposed even to consider codes unless these provisions for employment are prominent and effective. Industry groups who travel down to Washington with elaborate codes and agreements on price-fixing, are likely to be waved aside and asked to present, instead, their plans for *putting men back to work!*

General Johnson, center, and his labor advisors. Seated, Secretary of Labor Perkins and Dr. Leo Wollman, labor economist. Standing, John Frey, American Federation of Labor, and Edward F. McGrady, labor assistant to General Johnson

This National Industry Recovery Act was passed to give employment to men now out of jobs, and for no other purpose, is the theme that will be heard time and again around the Administration's offices. Everything else is secondary. The test is—

"What does your industry need *in order to put men to work.* Tell us how many people you can put to work, what wages you will pay them, and how work can be spread in order to get as many as possible on the payroll —so that the country's buying power may be restored as rapidly as possible.

"Those are things the Industrial Recovery Administration wants of industry, even roughly outlined, but at the very first. Then later come back with your price plans and trade agreements and let us see what you think is necessary in the way of price determination to keep such an employment schedule going.

"And let's see that we have wage increases before we have price increases. Wage increases will stimulate the country's buying power and get things going of their own momentum. But premature price-increases may stifle the very prosperity we are seeking to kindle and fan into flame!"

Industry groups who have gone to Washington have been told clearly that General Johnson's office considers it inadvisable for business groups to attempt to fix prices or to allocate production at this time. Back of this position, it appears, is the fear that Senators and Congressmen will find the new Industry Act guilty of "gouging" the public or promoting monopoly or wiping out small manufacturers.

If an industry's Code should go too far on this matter of fixing prices and allocating production, such a rumpus might be kicked up in the public mind that when the next Congress meets, industry is likely to have new additional severe restrictions put on it that are likely to hold it back or pull it down.

Sale below cost, is unfair competition

Furthermore in the actual administration of the Act, as so far carried out, business men who have discussed the situation with the powers-that-be in the Commerce Building, are told without quibbling that while the Government naturally wants business men to make a profit on the business they do, yet the Government cannot agree to a price which has a profit in it,—that is, cannot be put in the position where it is even impliedly guaranteeing to a manufacturer, a profit.

On the other hand, General Johnson's office has stated to callers that the code of an industry, like radio, may provide that any sale which is made below the cost of production, shall be deemed unfair competition. Such a provision in industry codes would seem to go about 90 per cent of the way toward a reasonable price level, so undoubtedly industry codes will be shaped up based on

ACT" — AND RADIO

Administrator will not guarantee a profit, but declares sales below cost to be "unfair competition"

the cost of production. Incidentally, such a provision, it should be noted, involves the setting up of a uniform system of accounting for the industry asking to operate under such a cost-of-production Code.

But as already pointed out, labor and employment are the main points on which the Administrator will judge any Code submitted to him. How basic is this kind of thinking in the Administration offices, is revealed by the classification of industries, not in terms of what they produce, but in terms of the *kind of labor which they employ*. Thus shoes, belting, and leather goods would be grouped together; as would glassware, incandescent lamps, window glass, etc. So, also, jobbers employing warehousemen, packers and shippers would be classed together, regardless of what they dealt in.

And as emphasizing this labor aspect, now it even appears that President Roosevelt's famous dictum about "ten per cent of an industry" destroying the business soundness of the whole, referred not to gyps and price-chiselers as radio men supposed at the time, but was directed particularly at recent sweatshop *labor* practices, and was not intended to have the wide application with which business men clothed the remark.

Seven points for industry co-operation

But with careful planning of the codes for individual industries, and with the general improved conditions, there is no doubt that benefits will result to the radio industry and other business groups, growing out of the National Industry Recovery Act.

Here are some of the conditions which can underlie improvement in the radio and other industries:

1. Employment and purchasing power rising
2. Uniform hours and uniform wages as a foundation
3. Uniform cost accounting on production
4. Cost of production as the minimum selling price (affording a substantial brake on overproduction)
5. Publication by each manufacturer of his list prices and discounts
6. Secret rebates and unfair advertising made "unfair competition"
7. Retail price maintenance.

Millions of men at work by snowfall—that is the goal of the Administration. And not merely three million men, as had at first been supposed was the President's aim, but six to seven million more people in jobs and earning satisfactory livings under "the American standard," before the first chilly nights of winter roll 'round.

So important does President Roosevelt consider the administration of the National Industrial Recovery Act, that he is keeping in close touch with the progress of the Administrator's office personally, and it is understood that the first principal industry codes will not be approved without his personal study and sanction.

General Johnson is the Administrator who heads up the office.

As Deputy Administrators contacting the industry groups and holding hearings, there have so far been appointed W. L. Allen, former chairman Sheffield Steel Company; Earl D. Howard, former vice-president Hart, Schaffner & Marx; Arthur D. Whiteside, president of Dun & Bradstreet; Gen. C. C. Williams, former chief of ordnance U. S. A.; K. M. Simpson, president International Chromium Process Company; Nelson Slater, president S. Slater & Sons, cotton goods, and Malcolm Muir, president McGraw-Hill Publishing Company.

Members of the Industrial Advisory Board, charged with long-term planning, appointed by Secretary of Commerce Roper, are Austin Finch, president Thomasville (Ga.) Chair Company; Edward N. Hurley, chairman Hurley Machine Company, Chicago; Louis Kirstein, vice-president William Filene's Sons, Boston; Alfred P. Sloan, president General Motors Company; Walter C. Teagle, chairman Standard Oil Company, Gerard Swope, president Genreal Electric Company; William J. Vereen, Georgia cotton manufacturer.

The Labor Advisory Board, named by Secretary Perkins, is headed by Dr. Leo Wolman. The Consumers Advisory Board, intended to represent the interests of the general public, is headed by Mrs. Mary Rumsey.

General Johnson will have as his administrative assistant for industry, Dudley Cates, of Chicago, and as his assistant for labor, Edward F. McGrady.

RMA committee drafting radio Code

The Radio Manufacturers Association has been active in seizing the opportunity to formulate a code for the radio industry. President Fred Williams has appointed a committee on Industrial Recovery to draw up the code, survey the industry, and contact Washington, with the assistance of Executive Vice-President Bond Geddes. This Industrial Recovery Committee of the R.M.A. comprises:

Chairman, W. Roy McCanne, president Stromberg-Carlson Telephone Manufacturing Company; members, Paul Klugh, Zenith, Chicago; S. W. Muldowny of National Union, New York; Leslie Muter, The Muter Company, Chicago, and Arthur Murray of United American Bosch, Springfield, Mass.

The R.M.A. Code, when drafted, will presumably first go to the board of directors and to the membership for approval, before being submitted to General Johnson's office. It is understood that the hope is to get the radio-industry Code into operation by the end of July, in order that the radio business may get the benefit of Code cooperation through the coming radio season. Incidentally that will provide a severe test of the unity of mind of the industry, if such speed is to be accomplished. But there seems no doubt that a Code can be developed that will bring beneficial results to radio and the radio industry.

Electronics in resistor manufacturing

By LEON PODOLSKY
Wirt Company
Philadelphia, Pa.

THE rapid growth of the radio industry set an all-time mark for the development of manufacturing enterprises. Many have been the companies which have sprung up and flourished as manufacturers of the component parts of these receivers.

When one realizes that eight or ten composition resistors are used in each receiver it can be seen that a resistor manufacturer with several large receiver customers must have a large production capacity and the ability to produce with speed, uniformity and accuracy of resistance value, by the hundred thousand resistances of the order of several megohms.

The task of gearing up plants to handle large volumes with accuracy naturally falls to the engineering department. New methods of control for the intricate and critical processes of resistor manufacturing must be devised. The remarkable results which have been produced have been due largely to electronic principles.

Each of the millions of resistors made must be tested for resistance tolerance. Manual and visual inspection methods are outmoded. Two electronic devices for the automatic testing of composition resistors are shown in Figs. 1 and 2. These methods employ a mechanical system of conveyors and ejectors to bring the resistors from a storage magazine to the testing station.

In Fig. 1 is a schematic diagram of a bridge circuit, two arms of which are vacuum tubes, the other two arms being a standard resistor and the unit to be tested, respectively. A standard resistance of the nominal value desired is placed in the plate circuit of tube A in the position marked "Standard," and another resistance of the same value in the "X" position in the plate circuit of tube B. The grid biases are then adjusted by means of the potentiometers R, so that the plate currents of the tubes are equal. Then the voltage difference between the plates of the tubes is zero and the galvanometer relay, G, is the neutral position. Now, if the standard placed in position X is removed and the resistors to be tested are brought successively to this position, the plate current of tube B will be dependent upon the resistance value of X, and consequently a voltage difference will appear across the plates of the tubes if X varies from the value of the standard, the magnitude of which will be dependent on the degree of this variation. The polarity of this voltage difference will be dependent upon whether X is higher or lower in value than the standard and consequently governs the direction in which the galvanometer relay closes. The contacts of the relay are connected to suitable circuits for operation of the mechanical ejecting mechanism which separates the resistances into three groups, inside limits, higher-than-limits and lower-than-limits. The amount by which X may vary from the standard without being ejected, is controlled by the shunt S across the relay, this shunt being adjusted to allow a proper current to close the relay. Several such circuits are usually mounted in conjunction with a single conveyor system. As many as twenty stations, each set to select a different resistance value have been employed. This method is independent of variations in tube characteristics since the grid biases can be adjusted to have the tubes draw the same plate current if it becomes necessary to change tubes or if recalibration is necessary.

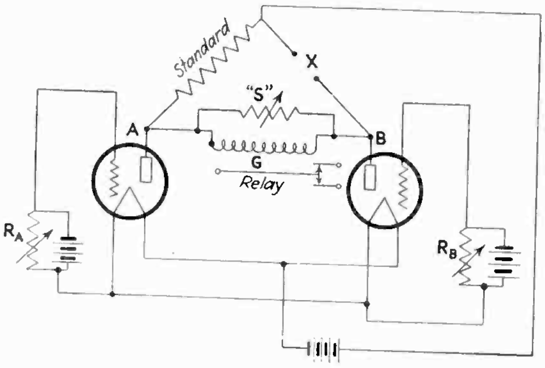


Fig. 1—Bridge for testing resistors

Another method for automatic testing of resistors is shown in Fig. 2. This shows a standard bridge circuit with the positions of the battery and galvanometer reversed from their usual positions, to allow higher voltages to be applied to the bridge to increase its sensitivity at high resistance values.

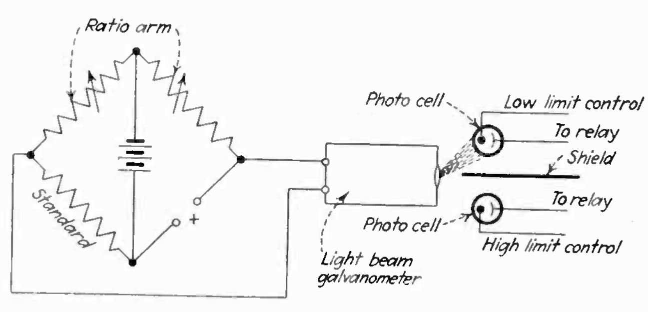


Fig. 2—Phototube automatic sorter

The indicating device used is the familiar light beam type of galvanometer of the Leeds & Northrup Company, developed especially for resistor measurements. The deflection of the light beam is, of course, dependent on the degree of variation of X from the standard resistance of the bridge. Consequently the two photocells are spaced a distance apart which corresponds to the deflection of the light beam galvanometer at the high and low resistance limits. The conveyor brings the units to be tested successively from a hopper to the testing station where contact is made to them. If the resistance value of the unit being tested differs from the standard, the bridge will be unbalanced and the light galvanometer will deflect right or left, according to whether the X unit is higher or lower than the standard. If this deflection corresponds to the limit of variation of resistance, or is greater than this limit, the light beam will sweep across one of the photocells and operate the associated relay and ejection mechanism and the resistor is eliminated.

Volume control inspection

Testing variable resistances, such as volume controls and tone controls, has always presented a problem since they are usually tapered in resistance value corresponding to certain degrees of angular rotation. The diagram shown in Fig. 3A is the circuit diagram of a cathode-ray tube device to test the resistance taper of variable resistances. A jig, in which the control to be tested is placed, is arranged so that a standard variable resistance of the correct taper can be rotated at the same time as the unit to be tested. The cathode-ray tube has two sets of deflection plates and the circuit is so arranged that the voltage picked off the control under test is applied across the other set of plates. Thus, the electron beam of the tube can be made to move in any desired direction proportional to the resistance values of the standard control and the control under test. The desired resistance curve can be drawn on the face of the tube, together with the limits of resistance variation. The operator in production has only to place controls to be tested in a test jig associated with the properly calibrated and marked cathode-ray tube and to follow the spot on the tube as the control is rotated. If the spot remains between the limit curves throughout the rotation of the control, the control is satisfactory. If the spot moves outside the limit curves it is rejected. Thus a continuous check on the resistance taper of any control can be had rather than the usual tolerance check at only two or three points.

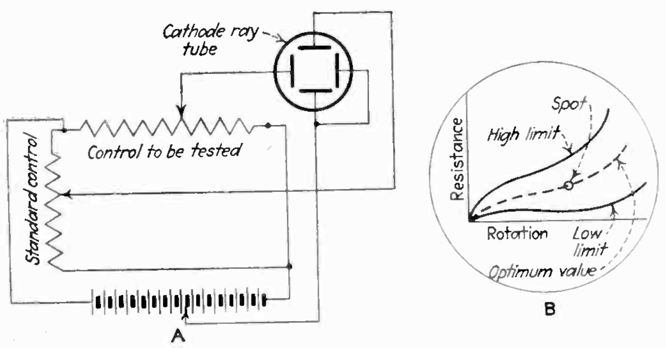


Fig. 3—Volume control inspection method

The use of medium temperature furnaces in resistance manufacturing is quite common and the requirements as to the allowable temperature variation are usually quite severe. A system used to control the temperature of a furnace, which employs a thyratron tube is shown in Fig. 4. A special resistance thermometer, R_2, placed in the furnace is made the 4th and variable arm of an a.c. Wheatstone Bridge. The temperature is adjusted to any desired value by variation of the resistance of one of the fixed arms of the bridge. At normal temperature no voltage is present across the input to the insulating transformer in the indicator position of the bridge. An increase in temperature of the furnace from the normal value changes the resistance of the thermometer arm and unbalances the bridge. A voltage is consequently applied to the transformer and then applied to the grid of the thyratron so that the grid is made negative during the half cycle when the anode of the tube is positive. This application of negative voltage to the thyratron grid stops the flow of current through the tube and allows the relay to open and interrupt the heater current. Likewise when the temperature of the furnace falls below its normal value the opposite phase is unbalanced and the thyratron closes the relay. One furnace using this type of control maintained easily a temperature of 500° C. within 5°.

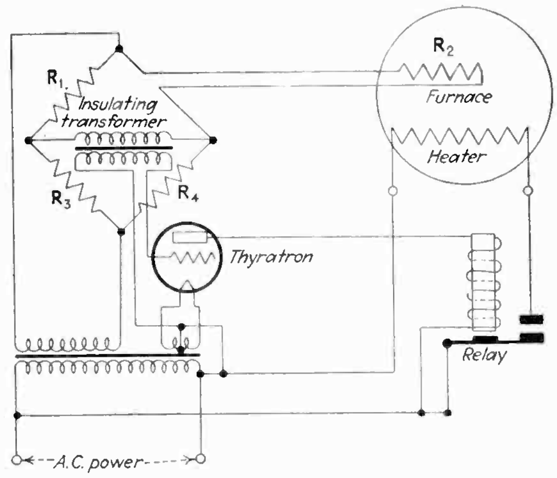


Fig. 4—Temperature control by electron tube

Many heavy viscous liquids are used in resistor manufacturing and it is important that the viscosity of these be the same every time they are used to maintain the uniformity of the finished product. A simple method of checking the viscosity of such heavy fluids is shown in Fig. 5. A quantity of the liquid to be tested is placed in the inclined glass tube which is inserted between two spaced coils in the grid circuit of a vacuum tube. A heavy steel ball is then rolled through the liquid in the glass tube and when this ball passes through the two coils two successive clicks are heard in the headphones or two flickers of the plate millimeter are seen. The time required for the ball to roll the distance D through the liquid in the tube at a given angle and at a certain temperature is a measure of the viscosity of the liquid. For direct comparison of different samples of the same liquid it is only necessary to note with a stop watch the time between the two flickers of the plate meter, or the two clicks in the phones, for a standard liquid of the proper viscosity, at a given temperature, and to compare this time with that obtained for other samples, a longer time indicating high viscosity and vice versa.

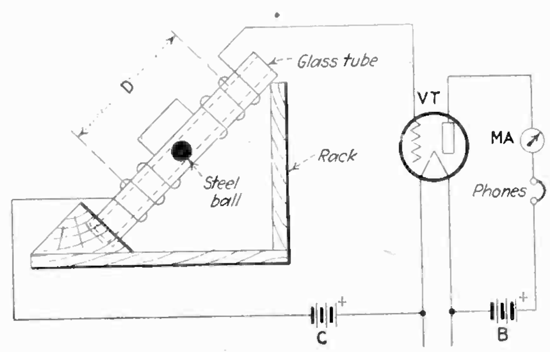
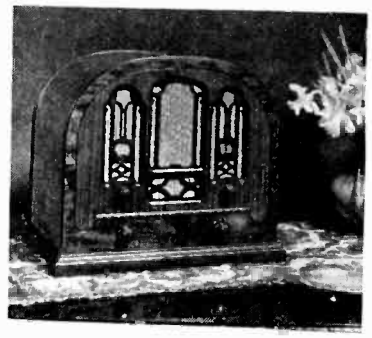


Fig. 5—Viscosity test device

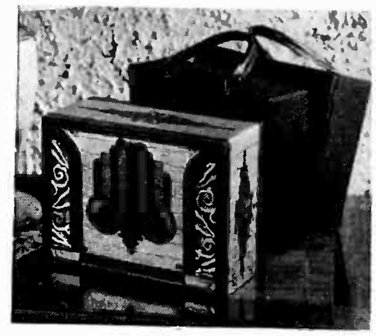
THE CABINET - DESIGNER'S

Radio cabinet design

Where do we go from here?



ATWATER KENT



BALKEIT

By RUTH KOCH GERTH*
Designer, New York City

IT is quite possible that the next couple of years will be an important period in the history of radio design. We shall witness the casting aside of old ideas and the introduction and promotion of new types of radios. The new era will give us radios original and legitimate in conception. We shall go further in the present direction of new materials, new forms, new colors, new finishes.

We laymen had our first unalloyed pleasure in radios when the results of the mechanism were our main desire, when radios were merely boards which held innumerable and intricate technical contraptions which, if manipulated carefully, brought forth music. We were tremendously pleased with the wonder of it. But the ardor of our first thrill was soon dampened (soaked would be a better word) by the lack of good taste and the atrocious design of the coverings or cabinets which were made to protect the contraptions.

When the engineering problems were solved and the mechanical features of radio became more or less standardized, attention was directed to the design of a case to house this mechanism. With this step radio lost its identity. All the dignity, the romantic and intriguing qualities of radio receiving were ignored.

A radio became a box, a camouflage, a disguise. It was secreted between false book covers, concealed in lamp bases, and masked by clocks. Knobs and dials were made in queer shapes with uneven markings and placed so inconspicuously that it became a problem to tune in a station.

Radio a byword for bad taste

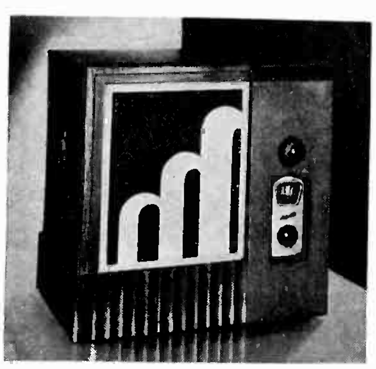
Sets were sold, but the buyers were not pleased. The more discriminating of them removed the "works" from their boxes, rather than inject the bad taste of the cabinets into their homes. Others allowed the sets to take up space in their living rooms but apologized for them when guests arrived. The sets were so bad in design that radio became the byword for bad taste.

But all signs now point to a new era in radio design. The near future should witness a revival of our first pleasure, and should stimulate a new interest in radio, for manufacturers seem determined to see that radios shall receive their rightful position in the scheme of modern living.

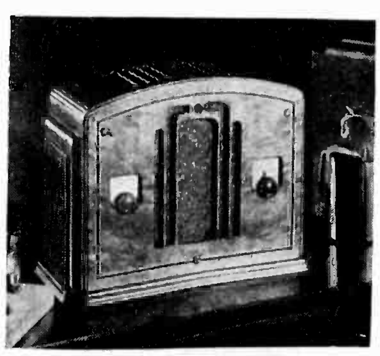
If the buyers' instincts and wishes are taken into consideration the new sets will be, and will appear to be, fine musical instruments. They will look like radios and not like writing desks or treasure chests. Dials and knobs will be important details of design. Dials will be easily read (no tricky square ones), and knobs will be large enough to handle comfortably. These features which function and are peculiar to radios should receive special attention. Clever designing of them would not only be honest and legitimate, but would add "swank" and smartness to the set, just as smartness is added to automobile body design by the accentuation of the design of radiator and fenders.

The new instruments should be far removed from the present box-like appearance of radios. Music spells

SOME OF THE RADICAL NEW DESIGNS IN RADIO CABINETS—

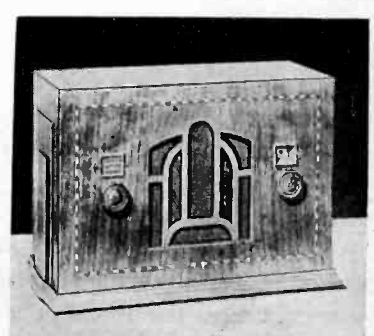


MAJESTIC



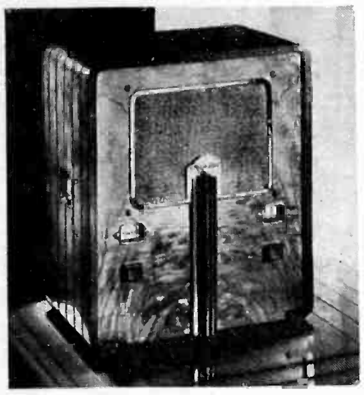
PHILCO

GENERAL ELECTRIC

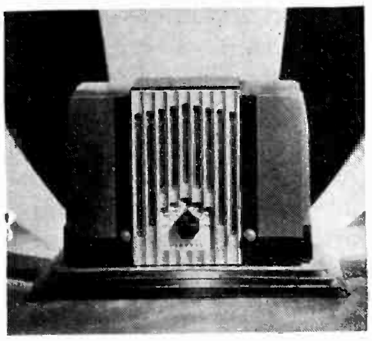


AMERICAN BOSCH

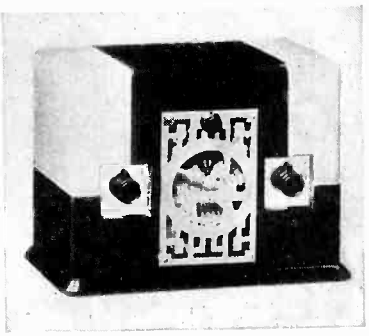
JOB IS TO GIVE NEW SALES APPEAL TO RADIO SETS



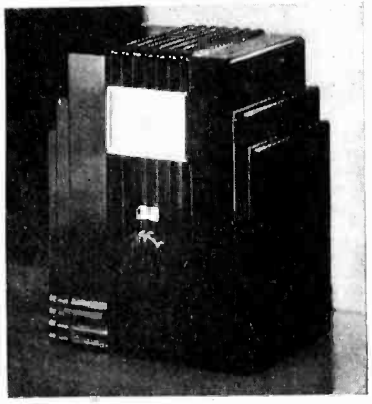
MAJESTIC



INTERNATIONAL



CLUB RADIO



AIR KING

something else to the average person. Music from the box-like upright piano never sounds as sweet as from a grand piano,—for the eye is not satisfied. The graceful curves of the grand piano follow the varying lengths of the strings and one sees the rhythm of music and feels it physically before a note is heard. Contrast this with the feeling derived from the boxed upright piano or the cramped midget set. In the midget set, not only is the shape lacking in grace and rhythm, but the relation of proportions is all wrong—there is too great a contrast between seeing and hearing. A concert received through a midget makes the set seem very unsatisfactory, picayune, and dinky in character.

Now that the introduction of the cheap, small set has made it possible for everyone to possess a radio, the mere desire for possession will not be sufficient to induce a purchase. Radio buyers will be interested in better quality in reception and design. Undoubtedly, this will lead to the introduction of two-unit receivers. The loudspeakers will be designed with accompanying adequate baffle-board area, and the tuning apparatus will be a smaller affair capable of being used in most any convenient spot. The most logical spot in the average living room is the space now occupied by the midget on the book-case shelf. If these remote control mechanisms become popular there should be one design, at least, which would fit a shelf. It should fit, not only in dimensions, but in character, so that it would not seem out of place in association with fine books. This does not mean that it should be camouflaged to look like books, but it might be leather covered and ornamented with tooling in keeping with book bindings.

Now that electronics has made possible finer music from records, the phonograph has become popular again. Aside from remote control possibilities here, as in radio, added impetus will be given to the use of the combination radio and phonograph outfits. Of necessity, such combination instruments will be large and hence the appearance will be of prime importance.

Women will control purchases

Women will have a great deal to say about the selection of these radio sets and combination units for the home, and women are interested not only in the performance but also in the design of the apparatus which makes the performance possible. They want to be as pleased when they look at the set, as when they listen to it.

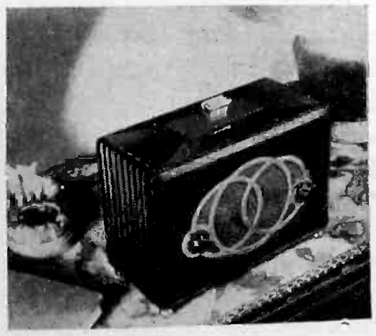
Wise manufacturers will keep an eye on the magazines which women read, and they will study the design of contemporary furnishings in order that they may make their product in character with these furnishings. Timeliness in design must also be considered. Such women's magazines promote the present mode of living and all things particularly applicable to this mode, and thus the woman reader becomes conscious of a definite contemporary feeling exemplified in all products worthy of mention. And she looks for it when purchasing any new article.

Manufacturers would do well to cater to the lady of the house. She considers radio a fine, important, necessary adjunct to modern life. But she insists that it be sane and honest in design and an expression of charm and good taste.

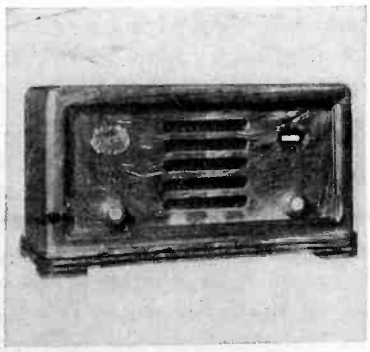
---

*Ruth Koch Gerth is a well-known free-lance designer of New York City. She is vice-president of the Artists Guild, Inc., a member of the American Union of Decorative Artists (Audak), and a member of the National Alliance of Art and Industry. She works with her husband under the partnership of Gerth & Gerth, 307 East 44th Street, New York.

EMPLOYING NEW MATERIALS, NEW FORMS AND NEW COLORS



COLONIAL



ZENITH

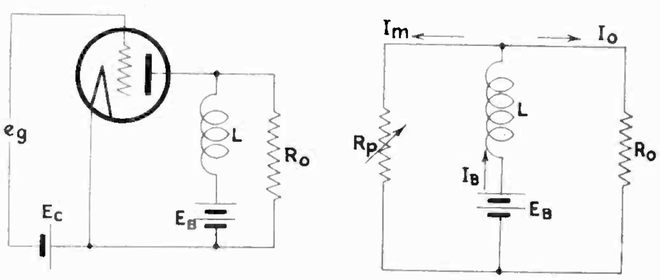
CROSLEY

RCA-VICTOR

A simplified method of modulator design

By E. A. LAPORT

IN everyday engineering practice one must frequently seek new methods of calculating designs that are less tedious than the conventional processes. This paper outlines a short-cut method for designing a modulator for a stated performance. Aside from its time saving merits, it provides a good physical picture of the mechanism of operation.



Typical modulator and equivalent circuits

The procedure is to obtain the characteristics of the load which is to be modulated; to compute the current and voltage conditions existing in the load when it is modulated in the desired degree; to compute the current in the modulation reactor circuit to give the modulating voltage; to determine the modulator characteristics to give these conditions; and to apply these computations to the static characteristics of the type of tube to be used to obtain the dynamics characteristics, the excitation required and associated information.

Modulation is usually applied to an r-f oscillator or amplifier. The oscillator or amplifier constitutes the load, and appears to the modulating circuits like a pure resistance of value

$$R_o = \frac{\text{Plate volts}}{\text{Plate current}} = \frac{E_b}{I_o}$$

It is desired to modulate the power delivered to this resistance by a given amount. By definition, the modulation factor is the ratio of the peak value of a-c applied (superimposed upon the plate voltage) to the value of the plate voltage E_b.

$$K = \frac{{}^mE_p}{E_b}$$

For a given factor of modulation, therefore, the plate voltage E_b has superimposed upon it an alternating component of voltage of peak value

$${}^mE_p = KE_b$$

Since the instantaneous values of both components are applied simultaneously across the resistance R_o, the instantaneous currents are in phase with the voltages, and of course the power dissipated in the load will vary as the square of the voltage.

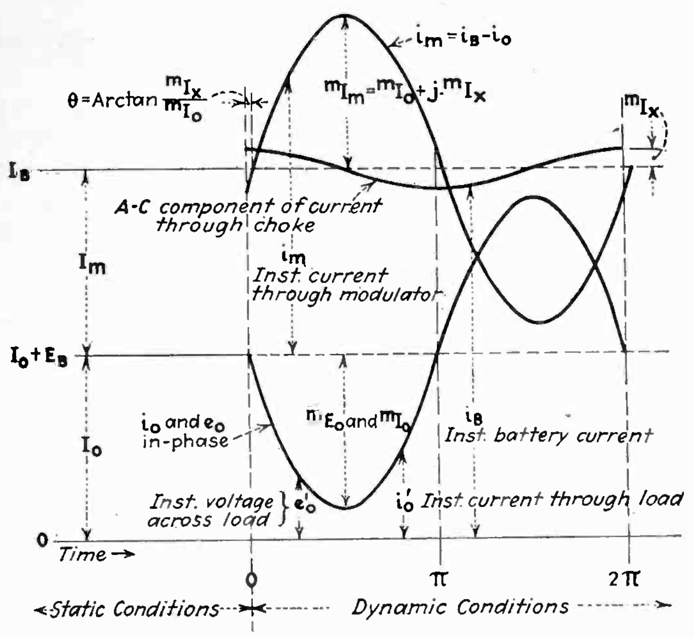
The work of the modulator is to produce this alternating voltage component known as the modulating voltage. To do this by the commonly used Heising system, the modulator circuits are connected in parallel with the load so that the modulator plate current is supplied by the same plate voltage supply as the load, through an inductance connected in series with the plate supply. The action of the modulator is to give rise to an alternating component of current through the inductance that will generate the required modulating voltage.

The current through the inductance must therefore have a peak value equal to the peak value of the modulating voltage divided by the reactance of the inductance at the lowest frequency to be reproduced. Ordinarily the reactance of the coil is much greater than the resistance of the load. The reason for this is apparent during the process of designing the modulator, for it becomes evident that the smaller the amplitude of the current through the inductance, to generate the desired modulating voltage, the more nearly the modulator plate current will approach the ideal 180° phase relation with the load current, and the more nearly does the modulator dynamic characteristic approach a single line.

Since the current through the inductance lags the voltage across it by 90°, and since the load current is in phase with this voltage, the load current must lead the current through the coil by the same interval. These currents can be plotted out in rectangular coordinates to scale.

The total current delivered by the generator is equal to the load current I_o plus the modulator current I_m when there is no modulation. The total current delivered by the plate generator E_b is equal to the sum of load and modulator currents at any instant, but during modulating the total plate current is equal to the steady load current, plus the steady modulator current, plus the alternating component (of average value zero) which builds up the modulating voltage. This latter component is the only change in total plate current that takes place when modulation is introduced into the system, assuming that the modulators give symmetrical output waveform. If the component is of negligibly small amplitude compared with the load a.c., the modulator plate current will be essentially equal and opposite to the a.c. of the load. But due to the fact that the modulator plate current cannot go to zero without encroaching on the lower bends of the static characteristics, with consequent distortion, the average modulator plate current must be somewhat more than equal to the peak value of the a.c. of the load. For an initial calculation add 10 per cent, and correct later when working out the dynamic characteristic of the modulator.

We now know the total plate current for the load and the modulator with the a-c component in its proper phase relation instant for instant, and we know the instantaneous current through the load and its phase relation. At any instant therefore, the modulator current will equal the total minus the load current, which is a matter of arithmetical subtraction instant for instant. Plot the modulator current curve out with the others and the



Current, voltage, and phase relations in a modulator tube

whole picture of the dynamic conditions are revealed.

Note that the modulator conditions thus obtained are for the entire modulator, which may require more than one tube. Select the type of modulator tube whose rating most nearly suits the operating voltages and currents. Divide the total power delivered to the modulator circuit by the plate dissipation capacity of the tube selected (or under consideration for selection) to obtain the number of modulator tubes required to give the desired performance. Then take a set of static characteristics for the type of tube selected and remark the current ordinates by multiplying each value shown for one tube by the number of tubes to be used. The static characteristics for one tube are now transformed into the static characteristic for the actual number of identical tubes to be used when they are connected in parallel. At the same time the curves for one tube are present by reference to only the original current ordinates.

Over the static characteristic curves for the complete modulator, locate the ordinate corresponding to the applied plate voltage, and run up this voltage ordinate to the point corresponding to the average modulator plate current as previously calculated. When there is no modulation, this will be the modulator plate current, and this point is called the operating point. This point will also fall on some value of grid voltage shown on the curves, which will become the bias voltage. Now to describe the dynamic characteristic, it is necessary to plot, point for point throughout a cycle, the instantaneous modulator plate current against instantaneous modulator plate voltage on the static characteristics. These values are already known from previous calculations. For a certain value of plate current occurring at the instant of a certain value of plate volts, a point is located on the tube curves. A succession of these points describes the dynamic characteristic curve, with corresponding grid voltages which is the required excitation to produce the conditions outlined.

Avoidance of distorting conditions

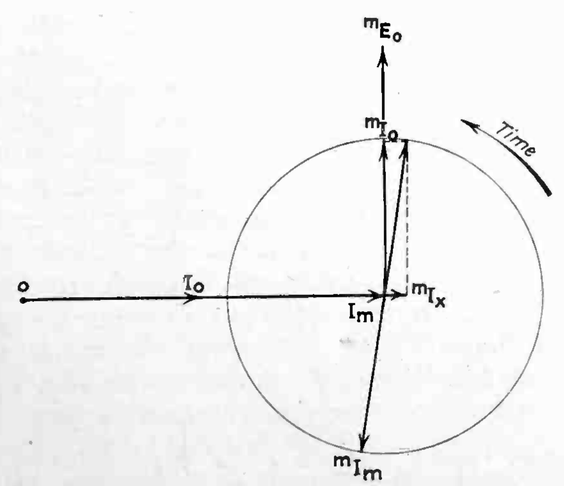
After the dynamic curve is obtained, refer to the single tube values to see what each tube must do. If there were points that could not be plotted on the curves because the points were non-existent, it means that the desired conditions cannot be realized, at least in the manner first chosen. If the inductance of the modulation was of low reactance the dynamic characteristic may appear as an ellipse, with time advancing with the points of the curve going counter-clockwise. Increasing the reactance of the modulation reactor will close this ellipse and the dynamic curve approaches a single line.

Next check the dynamic characteristic for symmetry by reading the grid voltage difference between the operating point and one extremity of the dynamic, and comparing it with the grid voltage difference from the operating point to the opposite extremity of the dynamic curve. If the voltage on one side of the operating point exceeds that on the other by more than 5 per cent, the allowable distortion limit tolerated in usual practice has been exceeded and the dis-symmetry must be reduced at least to the 5 per cent value. Examination of the static and dynamic curves will reveal immediately how much the operating point must be shifted to accomplish the correction, how much the inductance must be increased to bring about a given correction in phase angle or distortion of the dynamic curve. Correct the originally calculated values of currents in the various circuits to agree, replot the dynamic to their final values and the design of the modulator for a given performance is complete.

Typical general dynamic conditions are shown in the appended figures, one of which is in rectangular coordinates, the other in vector form.

Once the modulator dynamic characteristic has been calculated for the lowest modulation frequency, and the circuit constants for modulator and amplifier circuits are known, the designer can investigate the audio fidelity. In this work the actual physical characteristics of the modulation reactor, and the actual impedance of the load circuit, must be considered. The impedance of the modulation reactor will change with frequency and with the amount of d.c. passing through it. As its inductive reactance tends to rise with frequency, and the effect of distributed capacity is the opposite, so that actual measured values of impedance should be employed. While at low frequencies the oscillator or amplifier load, R_o, may be essentially pure resistance, there will be a departure from this condition at the higher frequencies because of the parallel capacitance in the r-f circuits. The values normally used for these condensers have low reactance, compared with R_o, at, say, 10,000 cycles. Hence this capacitive effect must be taken into account in accurate designing.

The audio characteristic is found by taking a given modulator exciting (grid) voltage, held constant at all frequencies, and calculating the dynamic characteristic for a number of frequencies.



Vector relations in modulator

Thyratron control of welding in tube manufacture

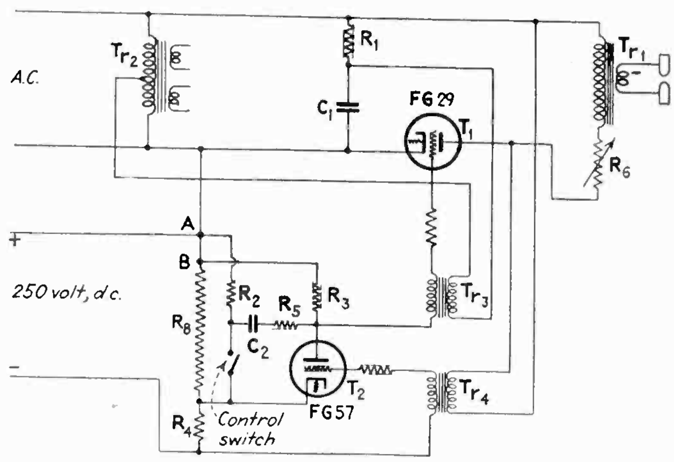


Fig. 2—Circuit used in the grid-controlled rectifier welding control

By H. W. LORD and O. W. LIVINGSTON
General Electric Company,
Schenectady, New York

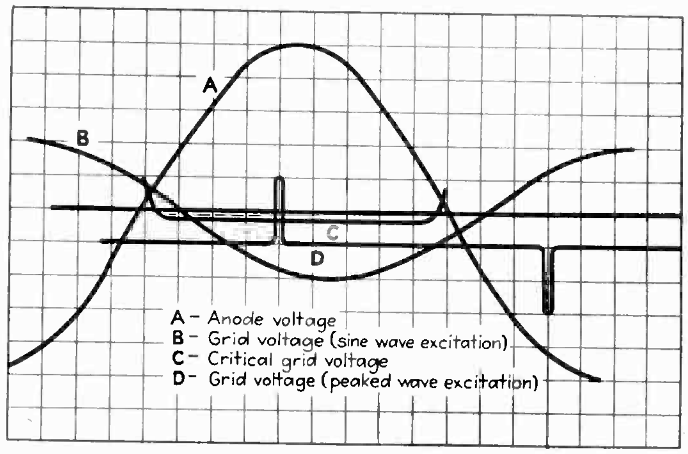


Fig. 3—Types of grid excitation for controlling thyratron

Vacuum tube manufacturers probably use spot (resistance) welding more than any other single industry. The welds required in assembling a vacuum tube are many and varied and the metals involved are often such as to make difficult the accomplishment of consistently strong welds.

Electronic tubes entered the field of resistance welding several years ago when the noisy and troublesome contactor necessary on high capacity welders was replaced by a series transformer with a pair of power Thyratrons shorting the secondary.[1] Further increase in control technique was obtained by the substitution of a Thyratron synchronous timer for the cam operated control switch.[2] These circuits, while applicable to the small welders, were developed primarily for high kva. capacity welders with a correspondingly high cost. This article will be limited to a new circuit for low capacity welders and the extent to which it fulfills the requirements of an ideal welder.

If we have an ideal welder it will consistently produce ideal welds of the following characteristics: The metal at the points of contact should be heated to the plastic state and the pressure made sufficiently great to press the two pieces together in a forging manner that binds them to each other with a bond at least as strong as the single pieces; no change in heat treatment or oxidation should take place except at the welded point.

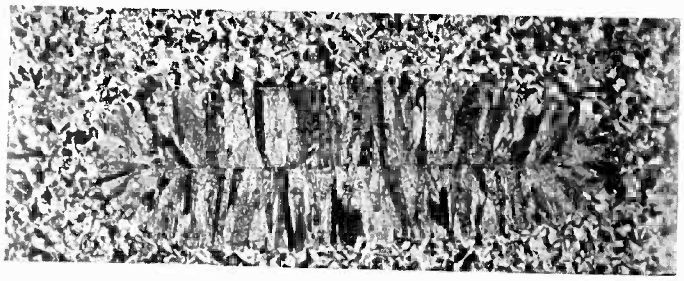
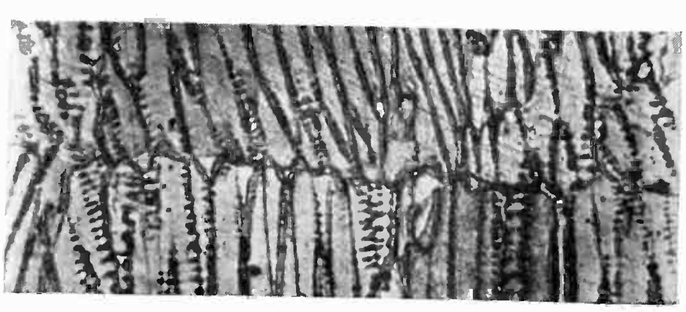


Fig. 1—Photomicrograph of welds on stainless steel. Upper figure, magnified 50; lower 1200 diameters



A photomicrograph of an ideal weld on .037 in. stainless steel is shown in Fig. 1. This shows a cross section magnified 50 diameters. The sharply defined line down the center leads one to believe that the weld is weak at this point, but in a section of this line magnified 1200 diameters crystals may be seen completely crossing the line, indicating a strong weld.

To prevent change in heat treatment or oxidation at other points the heat should be confined to the point of welding by applying the welding current for comparatively short times. At the short welding times accuracy is extremely important since a fraction of a cycle may be a large percentage of the total welding time.

The ordinary spot welder does not produce ideal welds for several reasons. With manual control the welding time is necessarily long and relies on the operator's judgment, taught only by experience. If the judgment factor be removed by controlling the welding time by time delay relays, the welds still must be made in comparatively long times owing to the non-synchronous action of the contactor destroying the accuracy when short times are attempted. Synchronous motor driven contacts have been used but, even with most careful

[1] Thyratron Control Equipment for High Speed Resistance Welding Equipment—G.E. Rev.—R. C. Griffith—Sept. 1930.
[2] Thyratron Control for Resistance Welding Machines—Welding—Samuel Martin, Jr.—May and June 1932.

adjustment, occasional sparks occur which are detrimental to the contacts as well as the accuracy.

Grid-controlled rectifiers substituted for contacts provide the synchronous feature by their inherent property of ceasing to conduct only when the current stops and may be made accurate by proper control of the starting time.

Thyratron welding control circuits

The simplest circuit is obtained when the contactor is replaced by a single tube, thus restricting the welding times to one-half cycle or less. The essentials of such a circuit are shown schematically in Fig. 2.

In the circuit tube T_1 replaces the contactor and T_2 controls the grid of T_1. In the "off" position T_2 is conducting and the d-c negative bias on T_1 is equal to the voltage drop across resistor R_3. An a-c bias, leading by approximately 160 degrees and supplied by transformer Tr_3 from the phase shifting circuit composed of capacitor C_1, resistor R_1, and the primary center-tap of transformer Tr_2, is also impressed on the grid of T_1. This bias has no function in the "off" position. With T_2 conducting and the control switch open, the capacitor C_2 is charged through resistors R_2, R_5, and T_2 to a voltage approximately equal to the voltage across R_3 and of a polarity such that the terminal connected to the anode of T_2 through resistor R_5 is negative. Closing the control switch to make a weld connects the positively charged terminal of capacitor C_2 to the cathode of T_2 and the anode of T_2 is drawn negative for a time long enough to commutate this tube. Capacitor C_2 then discharges through resistors R_5 and R_3 and recharges through these resistors to the reverse polarity. When C_2 has become very nearly charged to this new polarity the voltage drop across R_3 is low and thus T_1 has practically no d-c bias. As the d-c bias approaches zero, a condition is finally reached as shown on Fig. 3. Curve A represents the anode voltage of Thyratron T_1, curve B the a-c grid voltage, and curve C the critical grid voltage. With zero d-c bias the curves show that due to the a-c grid voltage leading the anode voltage by 160 degrees there is only a 24 degree firing angle. This means that if the d-c bias is sufficient to hold T_1 off for the first 24 degrees of the positive half-cycle, it will not "fire," even though the d-c bias drops to zero immediately afterward, until the beginning of the next positive half-cycle. Tube T_1 then carries current for practically the full half-cycle or not at all. (If it is desired to have the firing angle smaller, the a-c grid voltage may be increased and the phase of this voltage advanced until it is within a few degrees of 180 degrees leading.) The firing of T_1 excites the primary of the welder transformer and refires T_2 by the voltage impressed on the grid of T_2 through transformer Tr_4, biasing T_1 off before the start of the next positive half-cycle. Opening the control switch allows capacitor C_2 to recharge to the correct polarity for commutation of Thyratron T_2 upon closing this switch for making the next weld. The current flowing during the welding period may be set by variable resistor R_6.

If it is desired to weld in periods adjustable to one-half cycle or less, the circuit of Fig. 2 may be used by inserting a resistor (R_7) between points A and B which changes the method of controlling the grid of Thyratron

[*Continued on page 206*]

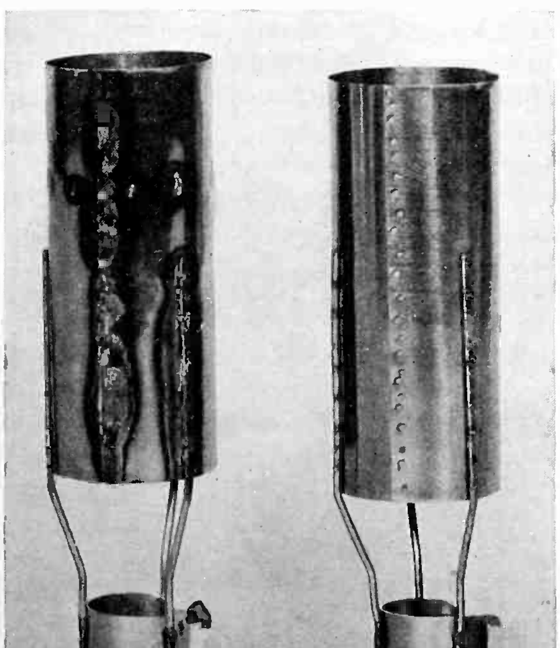


Fig. 4—Manual and tube controlled welding of thyraton grid assemblies

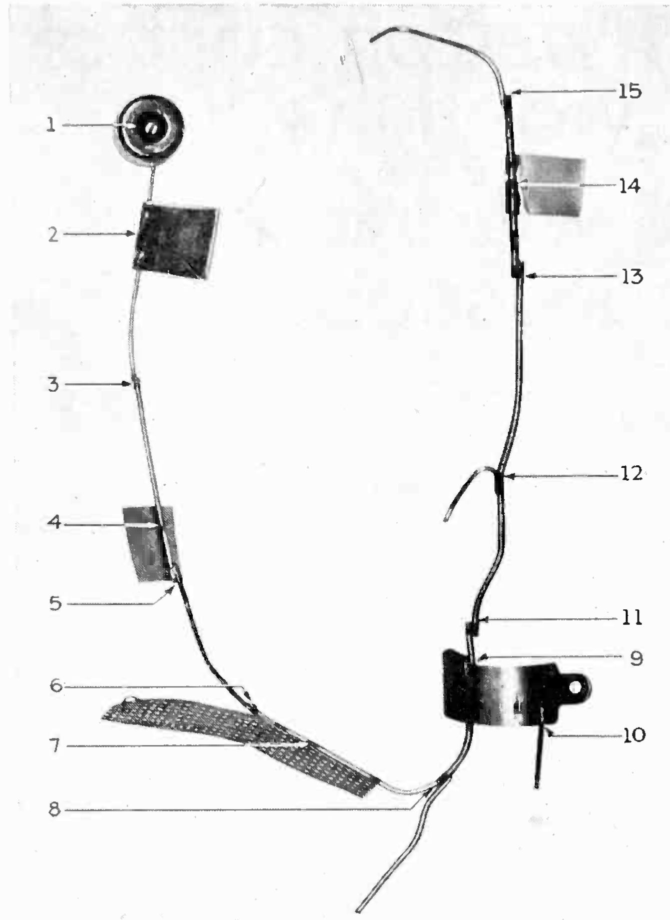


Fig. 5—Welds made with tube control

1—Copper wire and brass
2—Sheet nickel and soft nickel wire
3—Soft and hard nickel wires
4—Sheet nickel and hard nickel wire
5—Hard nickel and molybdenum wires
6—Molybdenum and invar wires
7—Perforated nichrome and invar wire
8—Hard nickel and invar wires
9—Invar wire and sheet monel
10—Sheet monel and molybdenum wire
11—Two invar wires
12—Soft nickel and invar wires
13—Invar and ascaloy wires
14—Ascaloy wire and nickel sheet
15—Ascaloy and hard nickel wires

Zworykin's iconoscope

Mosaic of 3,000,000 tiny photocells scanned by cathode-ray beam

DR. V. K. Zworykin presented before the Institute of Radio Engineers at Chicago, June 26, an account of his "iconoscope," a vacuum-tube photoelectric device which greatly improves television pick-up.

The iconoscope has several striking analogies to the human eye and the human retina of light-sensitive nerve cells, which in the Zworykin device is replaced by an "electronic mosaic" of several million little photoelectric cells, on which the image falls.

Dr. Zworykin has been working on his iconoscope (literally "image observer") for ten years, the first eight years in the Westinghouse laboratories at East Pittsburgh, Pa., and the last two years in the RCA-Victor television laboratories at Camden, N. J.

Zworykin's iconoscope seems a perfect adaptation of the several principles of electronics. It is a photoelectric tube and a cathode-ray tube at one and the same time. It employs an ingenious invention, the use of a roving beam of electrons to wipe the photoelectric slate clear of its electric charges set up by the picture to be transmitted. In this erasing process the point-by-point transmission takes place.

Imagine a 4-by-5-inch plate covered by some three million of small photoelectric cells, each connected to the electrical circuit through a small capacity. A lens, external to the iconoscope tube, focuses on this plate an image of the scene to be televised—in the same way that an ordinary camera lens focuses an image on the camera ground-glass or sensitive film.

Wherever the light of a bright part of the image falls on one of these minute photo-cells, current from the cell charges the small condenser associated with the cell. Thus one has a picture or image made up of electrically charged condensers.

Now imagine a cathode-ray beam sweeping back and forth across the 4 by 5-inch plate and spraying this plate with its electron bullets. Each time an electron from the cathode-ray beam hits a charged condenser, it discharges it. This discharge current is amplified and transmitted to the receiver.

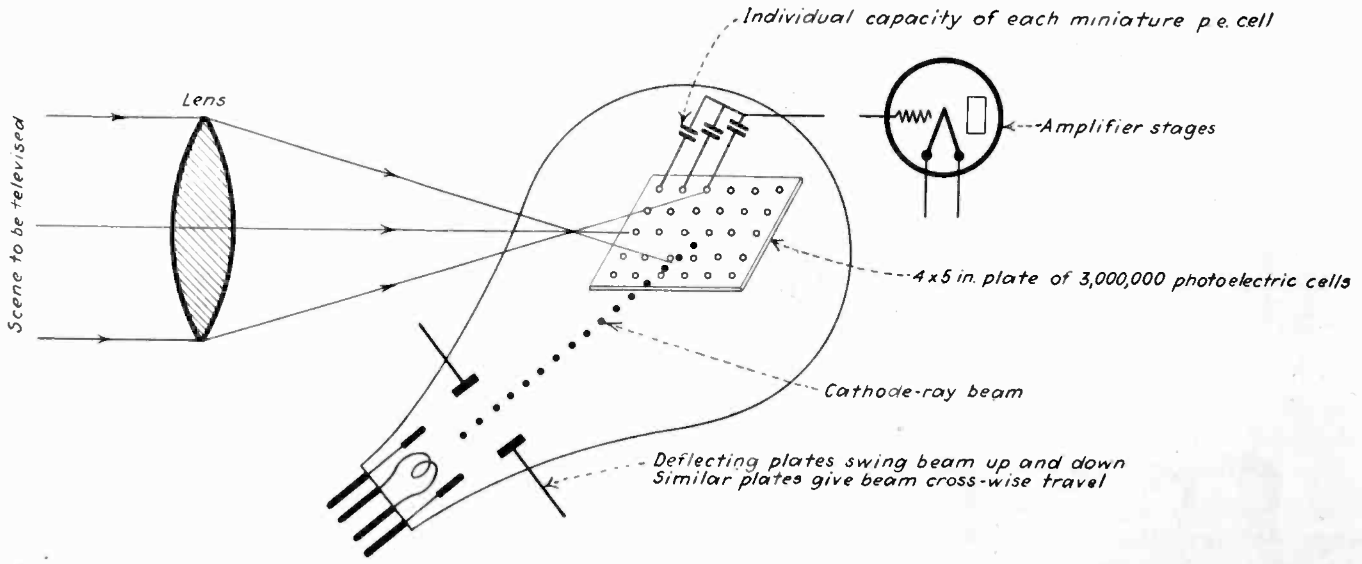
At the receiver end the incoming impulses are used to modulate another cathode-ray beam which, scanning a fluorescent screen, re-creates the original picture.

Since each photoelectric cell is extremely small (about 10,000 of them per square centimeter) the current from such an individual cell is small and the capacity of this surface to ground is very small. Therefore the time required for the "inertialess commutator" of the cathode-ray beam to charge and discharge the condenser is very small. Hence pictures with as many as 250 lines per square inch are possible.

The sensitivity of the iconoscope, at present, is approximately equal to that of photographic film operating at the speed of a motion picture camera. In its application to television the iconoscope replaces mechanical scanning equipment and several stages of amplification. The whole system is entirely electrical without a single mechanically moving part.

The iconoscope tubes measure about 16 inches long, with a bulb 8 inches in diameter, necessary to enclose the 4-by-5-inch mica sheet which carries the 3,000,000 independent photoelectric cell units.

The capacity action by which the individual photocells store up electrical impulses in the condensers, has been likened to a kind of "electronic memory," by which the images are being continuously gathered and reinforced, between the successive passages of the discharging cathode-ray beam.



The image of the scene to be televised is focussed on the 4-by-5-in. plate made up of 3,000,000 individual photo-sensitive cells. Each cell, when illuminated, stores its photoelectric charge in its associated condenser. The cathode-ray beam, sweeping the plate, discharges these condensers, producing impulses which are then amplified

Sodium-vapor lamps supplied from alternating-current circuit and used to light auditorium during industrial conference at Andover, N. J., addressed by Dr. J. W. Marden, Westinghouse research engineer

Sodium-vapor illuminants

New high-efficiency Philips, General Electric and Westinghouse lamps shown

LAST month "made history" in the introduction of new high-efficiency sodium-vapor illuminants into the United States. For a long time the high illuminative power of the sodium lamp has been known, but its commercial introduction waited on the development of a special glass that would resist the destructive action of the sodium at the high temperatures involved. Sodium-vapor lamps for outdoor highway lighting, for a year, however, have been installed on a large scale in European roads, particularly in Holland, Switzerland, Denmark, Sweden and England (see *Electronics*, August, 1932, page 253).

The first of the European sodium-vapor lamps to be shown in America was exhibited on June 14 before the New York Electrical Society. This lamp consumed about 80 watts and produced 500 cp. Its efficiency is about four times that of tungsten-filament lamps, but owing to its monochromatic light, the greater acuity makes four to five times as "good seeing," according to Dr. Holst of the Philips laboratories at Eindhoven, Holland, where the lamp was developed. Thus the gain in "seeing" power may reach 15 to 20 times that for the same energy applied through present street lamps.

Between Schenectady and Albany, the General Electric Company has installed half a mile of sodium-vapor lighting, employing 22 of its own new units. These lamps consume 80 to 90 watts, and produce 4000 lumens. The lamps measure 7 inches long, and 3 inches in diameter, and are enclosed in double-wall vacuum jackets, becoming literally "lamps in thermos bottles" to preserve the high internal temperature, 480 deg. Fahr. The lamps start with a neon glow, the familiar red color turning to the bright yellow of sodium as the lamp warms up. This yellow color is near the point of maximum sensitiveness of the eye, which accounts for the remarkable acuity of vision possible with the new lamps. The color is however objectionable for general lighting purposes, and it is likely that principal uses will be outdoors, for roadways, playing fields, tennis courts, etc.

In the Schenectady installation, the direct current 5-amp. series circuit is supplied by a thyratron tube, operating from a 700-volt alternating-current supply, stepped down from 2300 volts.

At Andover, N. J., the hall in which the New Jersey Industrial Conference met June 18, was lighted by Westinghouse sodium-vapor units as pictured on this page. Dr. Marden, associate director of research for the Westinghouse Lamp Company, also demonstrated a new cadmium-vapor lamp, the predominant red light of which restored the naturalness of flesh color, which was lost under the sodium illumination.

"The sodium-vapor lamp," said Dr. Marden, "is the most efficient source of illumination yet produced. It gives 40 to 60 lumens per watt as compared to perhaps 15 lumens per watt for ordinary tungsten. Any immediate practical use will probably occur where the color is no obstacle, but where the high visual acuity permits handling small objects and making close inspections in various branches of industry."

THE CHARTS ON THE FRONT COVER

"Ten Years of Radio Receiver Manufacture," the charts on the front cover, were compiled by Ralph H. Langley, radio consultant, 165 Broadway, New York City. The uppermost two graphs, total retail value and total number of sets sold annually, are from McGraw-Hill figures, collected annually by Radio Retailing and Electronics. For the total number of radio-set models each year, Mr. Langley drew on his own sources of information. The bottom curve, number of radio-set manufacturers, shows somewhat lower numbers than the corresponding McGraw-Hill records, but it is recognized that agreement here is a matter of definition. Certainly Mr. Langley's curve shows the general trend.

Resistance stabilized oscillators

By F. E. TERMAN
Stanford University

RESISTANCE stabilized oscillators are used in practically all of the beat-frequency and tuned circuit type of laboratory audio oscillators now on the market, and also are employed throughout the Bell System for generating carrier frequencies. They are characterized by a frequency that is virtually independent of tube voltages, and by an almost pure sinusoidal wave form. In spite of their usefulness, however, there is no published information available covering the design principles involved.

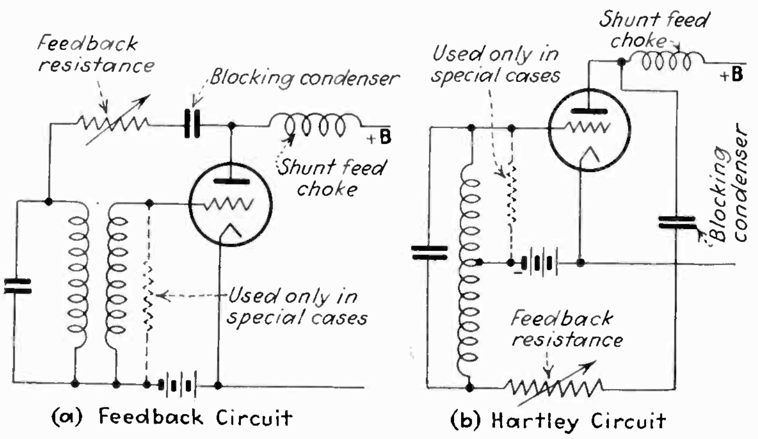


Fig. 1—Two typical oscillator circuits provided with resistance stabilization

Two typical resistance stabilized oscillators are shown in Fig. 1. It will be observed that these are ordinary oscillating circuits with the addition of a "feedback" resistance located between the plate of the oscillator tube and the tuned circuit. This feedback resistance should be as high as possible, and will commonly be in the order of 50,000 to 500,000 ohms. Its purposes are two-fold. It makes the resistance which the tuned circuit sees when looking toward the plate substantially independent of the electrode voltages because the plate resistance of the tube is only a small fraction of the total. Secondly, the feedback resistance limits the amplitude of oscillations to the straight line parts of the tube characteristic, so that practically no harmonics are generated.

The fundamental principles involved can be understood by the following consideration. If oscillations can exist at all they will begin with minute amplitude and will then build up until the grid draws current. This grid current introduces energy losses that increase rapidly as the oscillations become larger, and an equilibrium is finally established. If the feedback resistance is so high that oscillations are barely able to exist with no grid losses, then equilibrium will be reached at an oscillation amplitude which drives the grid only slightly positive. The crest a-c voltage which the oscillator applies to the grid under these conditions will be slightly (about 25 per cent) more than the grid bias.

The wave form is determined by the linearity of the tube's dynamic characteristic over the range of a-c voltages which the oscillations apply to the grid. It is apparent that if a good wave form is desired, the tube when considered as an amplifier must be adjusted so that it amplifies without distortion an a-c voltage on the grid having a crest value slightly greater than the grid bias. This means that the oscillator tube should be operated at a grid bias that is slightly less than the grid bias that would be used for Class A amplifier operation at the plate voltage employed.

While the feedback resistance is the most important single factor controlling the frequency stability of the oscillations, there are other factors that should be considered. In particular, the coupling between the grid and plate coils of the oscillating circuit should be as close as possible.[1] A good wave form also increases the frequency stability since harmonic currents will encounter reactive load impedances, and so consume reactive energy which must be supplied indirectly from the fundamental frequency of the oscillations.

The feedback resistance must be non-inductive and is commonly made of composition units. When the frequency is to be varied the feedback resistance should be tapped so arranged that each added step increases the total resistance 10 to 20 per cent. At audio frequencies resistances up to about 500,000 ohms are permissible, but at radio frequencies lower values, as 100,000 ohms, should be used to avoid trouble from stray shunting capacities. In the event that these maximum values of resistance are not able to limit the oscillation amplitude sufficiently, a high resistance should be shunted across the grid coil as shown dotted in Fig. 1. The blocking condenser in series with the feedback resistance should have a low impedance to the lowest generated frequency compared with the minimum feedback resistance.

The most satisfactory type of oscillator tube is one having an amplification factor of 6 to 10, combined with a low plate resistance. The 112-A tube is excellent, and the 27, 26, 37, etc., are also good. With such tubes the ratio of grid turns to plate turns is customarily near unity.

The shunt feed choke must have a high reactance compared with the plate resistance of the tube if phase shifts that impair the frequency stability are to be avoided. This means that the choke must be a good one and that the tube should have a low plate resistance. At radio frequencies the choke can be resonated with stray and tube capacities to advantage.

For frequencies up to several hundred cycles ordinary transformer iron cores are excellent. At higher frequencies it is possible to make satisfactoy coils with thin laminations, while iron or permalloy dust rings are even better. At radio frequencies air core coils must be used

[1]See F. B. Llewellyn, "Constant-frequency Oscillators," *Proc. I.R.E.*, vol. 19, p. 2063, Dec. 1931.

even though they do not permit as close coupling as do magnetic cores. Good paper condensers are satisfactory for tuning purposes. Excellent frequency stability will be obtained if the Q of the tuned circuit is in the order of 25 to 40, while values as low as 15 are usually permissible for the extremes of the frequency range.

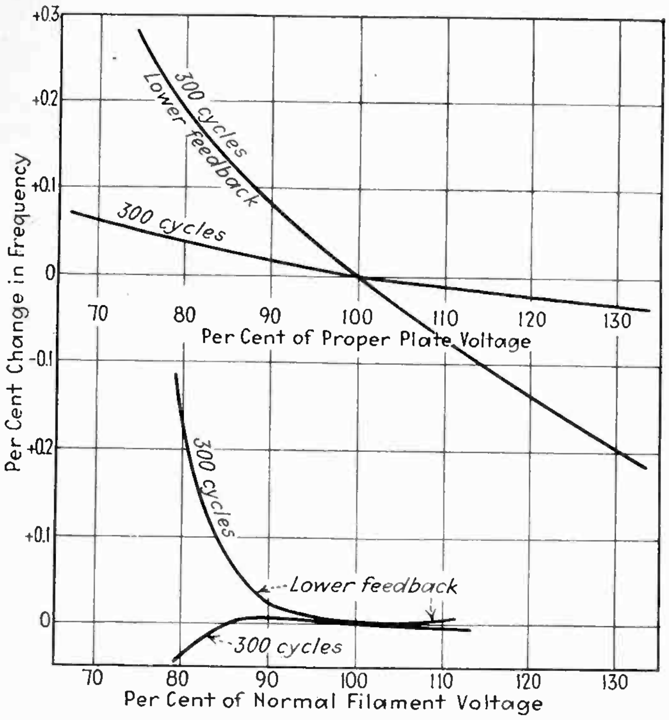


Fig. 2—Frequency stability of typical resistance stabilized oscillator

When the characteristics of the oscillating circuit are known it is possible to lay out a resistance stabilized oscillator on paper and predict accurately the amplitude of oscillations and the circuit conditions required for proper operation. For example, assume that it is desired to set up a feedback circuit such that at the frequency of operation the parallel impedance of the tuned circuit at resonance is 50,000 ohms. Assume further that the ratio between grid and plate coils is 1 to 1 and that a 112-A tube operated at a plate potential of 110 volts is to be employed. The first step is to select a grid bias slightly less than that normally used for amplifier operation at the same plate potential. A value of -5 is satisfactory; it must be obtained from a battery or a bias resistance, as grid leak bias is not allowable in the resistance stabilized oscillator. The amplitude of oscillations between the grid and cathode will be about 25 per cent greater than the bias, or roughly $6\frac{1}{4}$ volts crest.

The feedback resistance that will just barely enable oscillations to start has such a value that when 1 volt is applied to the grid of the tube, exactly 1 volt will be developed across the tuned circuit by amplifier operation. Assuming a good choke the feed-back resistance at which oscillations will just start is given by the formula

$$\begin{pmatrix}\text{Starting feedback}\\ \text{resistance}\end{pmatrix} = R_L\,(\mu-1)-R_p \qquad (1)$$

where R_p is the plate resistance of the tube, R_L the load resistance offered by the tuned circuit, and μ is the amplification factor of the tube. With $\mu=8.5$, $R_p=5000$, and $R_L=50{,}000$, the critical feedback resistance works out to be 370,000 ohms. The value actually employed should be about 10 to 15 per cent less than this or roughly 325,000 ohms. In the event that a resistance such as shown dotted at Fig. 1 had been placed between grid and cathode, this would have the effect of lowering the effective parallel impedance of the tuned circuit and would lower the proper feedback resistance accordingly. The feedback resistance is usually adjusted experimentally by setting it on the first tap below the one at which oscillations start, but calculations such as outlined above are of considerable aid in establishing the limiting values that will be needed.

It is also possible to predict the grid current with fair accuracy. Thus in the above case, when equilibrium is established with a feedback resistance of 325,000 ohms, the effective load resistance (including the effect of grid losses) is found from Eq. (1) to be 44,000 ohms, which means that the grid losses are equivalent to shunting 366,700 ohms across the grid coil. Since the grid current flows in impulses at the crest of the cycle when the a-c voltage is nearly $6\frac{1}{4}$ volts in amplitude, the average grid current is approximately $6\frac{1}{4}/366{,}700 = 16+$ microamperes.

The resistance stabilized oscillator may be coupled to an output tube by connecting the two grids together or by resistance coupling to the oscillator plate circuit. The grid connection is preferable from the point of view of wave form, since it makes use of the tuned circuit voltage, which is very nearly sinusoidal, but it has the disadvantage that the a-c output voltage available is small. Plate coupling makes use of the amplification factor of the tube to increase the output voltage, but has a slightly poorer wave form since all distortion generated in the plate circuit is passed on to the output without being discriminated against by a tuned circuit.

When such an oscillator is properly built, the generated frequency is practically independent of plate, filament and grid potentials within reasonable limits (such as 10 per cent variations). The stability is so excellent that the principal factor causing frequency changes is the temperature coefficient of the tuned circuit. The wave form also appears absolutely sinusoidal when viewed in an oscillograph after *distortionless* amplification. Finally, the amplitude of oscillations depends primarily on the grid bias, and so is largely independent of frequency and plate voltage. Altogether, the characteristics of the resistance stabilized oscillator make it almost ideal for laboratory use requiring generation of frequencies below 150 kc.

That these possibilities are actually realized in practice is shown by Fig. 2 which gives information on the performance of an oscillator built in the Communication Laboratory at Stanford University, covering the frequency range 15-15,000 cycles. It uses a 112-A oscillator tube at a bias of -5 and a plate potential of about 110 volts, with a 100,000 ohm resistance shunted across the grid coil. There are three sets of coils, each having midpoint taps to give a total of six inductance values with the grid-plate ratio approximately unity. Ordinary transformer laminations are employed in the lowest frequency coil (15 to 250 cycles) while the two smaller coils are wound on permalloy dust rings.

It is seen from Fig. 2 that at 300 cycles this oscillator does not vary its frequency by more than 0.015 per cent (about one twentieth of a cycle) when the plate or filament voltages are varied 10 per cent from normal. The curve marked "lower feedback" is for a feedback resistance of 108,000 ohms instead of the proper value of about 151,000 ohms, and shows the importance of using the highest possible feedback resistance. The Q of the tuned circuit at 300 cycles was between 20 and 25. At 1000 cycles where the Q was about 50 the frequency stability was increased to 0.01 per cent for 10 per cent changes in plate and filament potentials.

HIGH LIGHTS ON ELECTRONIC

Variable speed motor with vacuum tubes

A SYNCHRONOUS MOTOR operating efficiently at variable speeds by means of a new type vacuum-tube control was demonstrated in the General Electric test laboratories at Schenectady, to the 300 delegates attending the northeastern Spring meeting of the American Institute of Electrical Engineers. The new control, a development of Dr. E. F. W. Alexanderson, has many important uses in the electrical industry where it is desired to operate alternating current motors at various speeds with remote control.

An important field promises to be the electric ship. Steam turbines operate most efficiently at full speed. To slow down the propeller motors, it is necessary to slow down the turbines. With the new equipment the turbine operates at one speed at all times, and the speed of the propeller motors can be varied by changing the frequency of the current fed to them through the vacuum-tube control. Instead of the captain communicating orders to the engine room for a change in speed, the new apparatus makes it possible for him to regulate the speed of the driving motors directly from the bridge.

The equipment demonstrated consists of a 400-horsepower motor and 18 Thyratron tubes. Power is fed into the bank of tubes directly from a 4,000-volt line. The tubes convert this power into different frequencies before it is delivered to the motor. This varying frequency in the current results in varying speeds of the motor.

"The tubes, in changing the frequency of the current, perform the function of a commutator," Dr. Alexanderson explains. "The grid control makes it possible to start with full torque from standstill and to operate the motor at any desired speed without wasting power in resistance.

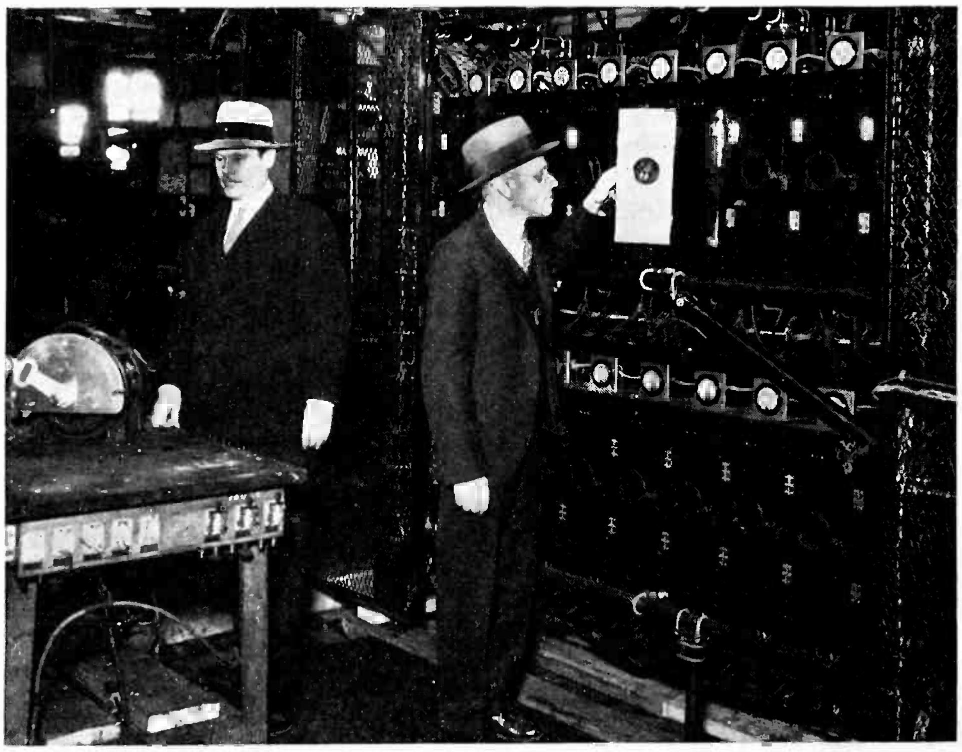
"Much engineering work is still ahead of us. However, I feel this development points the way to a new era in the electrical industry, in which many important functions and power transformations will be performed by vacuum tubes. With commutator motors, the efficiency between power lines and the motor shaft is now about 90 per cent; with the tube control this efficiency will be raised to about 98½ per cent."

✦

Tubes in rubber making

BY IMBEDDING the two grid condenser plates of an oscillator in a mass of rubber undergoing vulcanization, one rubber company has been able to follow closely the progress of the vulcanization reaction. As sulphur added to the rubber, the dielectric constant of the mass changed sufficiently to cause frequency variations in the oscillator circuits which could be interpreted in amounts of combined sulphur.

Oscillations of various frequencies are also found to have catalytic effects on many of the more common chemical reactions.



By means of eighteen thyratrons this 400-hp. synchronous motor fed directly from a 4,000-volt line gives ready adjustability in speed

Surgeon's approach opens operating-room door

RECOGNIZING THAT AFTER A surgeon has sterilized his hands and gloves preparatory to an operation, the touching of an operating-room door may transmit germs that negative all the precautions that have gone before, photo-cells are now being recommended for this important service of opening operating-room doors without touch or noise, at the mere approach of a surgeon or nurse.

A striking demonstration of this novel use of photo-cell control is contained in the model operating room at the Chicago World's Fair. A beam of light operates the door of the room, by merely stepping across it, so that the door is opened without even the touch of a sterilized glove.

Another electronic application in this model operating room is the system of microphones and loudspeakers by which every sound of the surgeon's voice is heard by the gallery of spectators above the operating table, although plate-glass shuts off the gallery and any possibility of infecting germs reaching the operating table.

✦

Photocell mine doors speed haulage, save power

AT THE CONVENTION OF the American Mining Congress held at Pittsburgh, Pa., in May, a model of the photo-electric mine-door control of the Nemacolin mines of the Buckeye Coal Company was demonstrated, based upon the action of the electronic control as used in the actual mine.

As the mine locomotive approaches the mine door, it intercepts a light beam initiating the control operation which opens the door. After the train has passed, another light-source on the opposite side casts its beam on a phototube motivating the controls for closing the door. The system is so interlocked that the operations cannot take place in any manner than their predetermined sequence. The light beams are projected at an angle from the track in such a way that the light will not shine between the cars.

With a photocell control of this kind, declares G. E. Stoltz of the Westinghouse mine-electrification department, coal transportation underground need no longer wait on the opening and closing of mine doors. The train does not have to slow down. Increased haulage speeds are maintained, and accelerating power is saved.

DEVICES IN INDUSTRY + +

Theaters use a photoelectric drinking fountain

PHOTOELECTRIC DRINKING FOUNTAINS have proved great attractions in several Chicago theaters. Using photoelectric equipment, such installations inject an element of mystery into the simple action of getting a drink. No handles are to be found at these fountains, but when patrons bend over to drink, the water flows automatically until the person straightens up.

The illustration appearing on page 79 of March *Electronics*, showed the photoelectric fountain at the Granada Theater, Chicago, employ G-M Laboratories apparatus. A second unit is at the Oriental Theater in the heart of Chicago, and the third is at the Southtown, the new Balaban-Katz wonder theater on the south side. In each of these photoelectric installations existing fountains were used with standard photoelectric control equipment.

The light beam is projected through an opening on one side of the fountain and is reflected onto the photoelectric cell behind the lower opening by means of a mirror mounted in the right hand pillar. Interruption of this light beam controls the flow of water.

✦

Multi-photocell counter checks up theater admissions

THE ELECTRO-SOUND PRODUCTS COMPANY, 317 Jackson Ave., Long Island City, N. Y., has developed a theater-attendance "checker" or counter which appears to be almost unbeatable in its accuracy in counting persons passing through its doorway, whatever their efforts to produce errors.

The doorway through which the entering traffic passes is spanned by some twenty or more beams of almost invisible blue light, focussed on photocells which operate interlocking relays. The counter is not operated by persons passing in the reverse direction. It counts correctly persons entering arm-in-arm, groups passing through in lockstep, persons carrying umbrellas or coats in front of them, and other situations which ordinarily cause false counts with ordinary single-beam counters.

Such a theater traffic checker is useful not only for preventing the double sale of tickets through collusion between the cashier and ticket-taker, but is also important in the case of percentage contract between film-owner and theater operator, where the film concern is entitled to a share of the door receipts. With such a checker a daily sealed record of attendance at the theater can be prepared.

Experience so far seems to show that the checker is "without error," even under the most severe door-traffic conditions. Test installations have been made so far at the Arcadia Theater, The Bronx, New York City; the Queensboro Stadium, Queens Plaza, Long Island City, and the Didsbury Theater, Walden, N. Y.

✦

Restaurant door opens when guest approaches

ONE OF THE LATEST installations of "Magic Doors" made by the Stanley Works of New Britain, Conn., is shown in this photograph of The Susan Palmer Oyster Bar and Restaurant at the corner of Fifth Ave. and 49th St., New York City.

As far as is known these are the first entrance doors in the world to be sold as a commercial article to a restaurant owner. The entering light ray shines from the vestibule wall to a photo-cell in the railing. The exit light ray shines from the left-hand post to a photo-cell in the right-hand post.

New problems were encountered over the familiar restaurant kitchen service door, such as wind pressure at the street intersection, heavy combination metal and plate glass doors, danger of a customer walking up to the wrong door and being hit, and proper housing of the operating mechanism for appearance and for operating under widely varying temperatures. While a kitchen service door may be hooked open in case of failure, these doors have to swing as freely by hand as any other door on account of fire and so as not to inconvenience the customers.

High-frequency waves kill pests in beans

J. H. DAVIS, chief engineer of electric traction for the Baltimore & Ohio Railroad Company, who is carrying on extensive tests with high-frequency radio waves (20-kw., 6 meters) for the extermination of insect pests in foodstuffs stored in warehouses at Baltimore, comments as follows on the success of his method as applied to beans, peas and other similar vegetables:

"From our experiments here in Baltimore, we believe infested beans respond nicely to this method of insect extermination. It appears to us, based upon our research work, that one great field of usefulness for this method of treating infested materials will be for beans, peas, and similar products. Indications are also, that this method of treatment, sufficient to exterminate insect life, will promote plant germination and growth.

"Some very eminent authorities on food values are now carrying on a series of tests for us, to determine the effect of this treatment upon the food value. We have already received reports concerning this phase of the matter indicating that in general the food value of the loaf made from wheat treated by us, was very satisfactory."

✦

Comparing "amount of ink" in printing book-forms

BOOK PRINTERS HAVE ALWAYS experienced difficulty in printing the various "forms" of a book to the same degree of weight of ink. Often one "form" will be printed light, another following form will be considerably darker, and still other forms darker yet. Except for the printer's eye, no scale of standards of depth of printing has heretofore been discovered, and if the practical pressman viewed his work under differing illuminations, he was likely to misjudge the intensity or depth of printing he was using.

To set up a positive standard for depth of printing, an American Photoelectric reflectometer has now been used with considerable experimental success. With this instrument a two-inch circle of the printed page is compared with the same paper unprinted or blank. Taking the blank paper as 100 per cent, a "dark" or heavy-inked page gives a reflecting factor of 85 per cent; medium gives 86½ per cent; and very light inking gives 88 per cent. Of course the sample included in the two-inch circle must in each case be of fairly solid and comparable type composition.

Night radio effects

Night radio effects have been reproduced on 4-cm. waves by P. Keck and J. Zenneck, of the Munich Institute of Technology. One of the main effects shown by broadcast waves is that the long path parallel to the earth's magnetic field which the skywaves follow at night produces a distinct rotation of the direction in which the electric oscillations take place. Neon or argon, at pressures below 1/1,000 mm. mercury, in a container of 20 cm. diameter and 25 cm. length with plane ends is ionized by means of an electrodeless discharge; a magnetic field is produced parallel to the length of the container, and damped electric waves from a spark gap are sent through it in the direction of the oscillations of the electric force taking place perpendicularly to the magnetic field. The free electrons in the discharge, at a concentration of 30,000 million electrons per cu.cm., are set in motion by the waves, and this, despite the small weight of the negative charges, causes partial absorption of the waves and a rotation of the direction of vibration (polarization) which is the more pronounced the longer the path. The value of the angle *(Annalen der Physik 15: 903–925, 1932, and Hochfr. u. El. Ak. 40: 153–158, 1932)* found (10 to 40 degrees) is in accordance with the ionic theory of the propagation of radio waves in the higher atmosphere.

✦

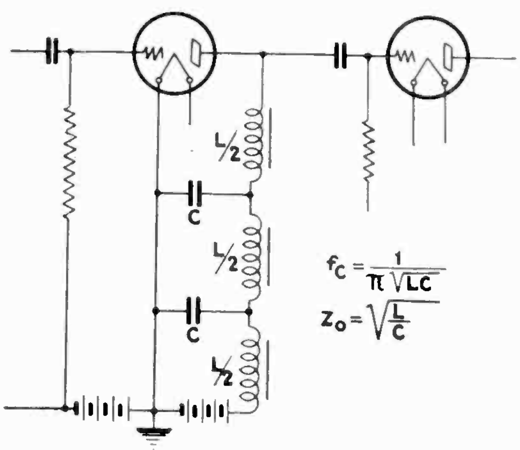
Filter-type interstage amplifier coupling

By Wallace G. Stone

The basic circuit of an amplifier[1] using a low-pass filter to couple the tubes together is shown in the figure. It will be seen to consist of a mid-series termination filter. Such a filter has the characteristic of reflecting all frequencies above a certain cut-off frequency without alteration of form. Its effective impedance is many times its characteristic impedance at any frequency appreciably above the cut-off frequency even if not more than one and one-half sections are used. Z_0 is the d-c resistance of the tube.

In a typical amplifier of this type consisting of three stages with one and one-half sections of filter in the plate circuit of each stage with a cut-off frequency of 20 cycles, the gain using old types of tubes was 66db, the maximum variation from 30 to 7,500 cycles was 1 db and up to 15,000 cycles the maximum variation was 5 db. The input impedance was 100,000 ohms, the output impedance was 4,000 ohms.

In an amplifier for a public address system with an output of 10 watts the largest choke was a 530 henry, 5 ma. winding, the others being smaller in inductance but carrying somewhat more current. It is an error to assume, as some have done, that if values of inductance of this order are used it is unnecessary to bother with making a filter. If a 92.5 henry choke is used without bothering to use it in the form of a filter the ratio of reflected energy to lost energy at 60 cycles when used in the plate circuit of two 45-type tubes in parallel is about 12 db. against 76.5 db. when used in the form of a filter.



Low-pass filter coupling

[1]U. S. Patent No. 1,869,715 to Winfield W. Salisbury.

✦

A new impedance measuring device

By Alfred W. Barber

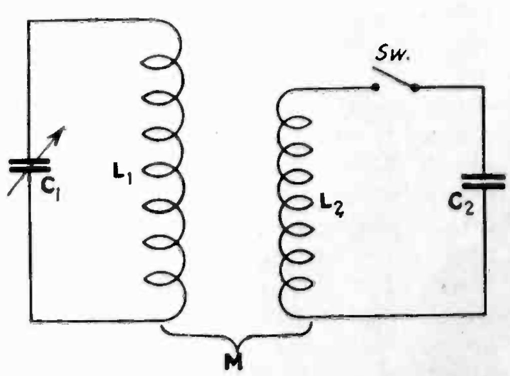
Bridge measurements of capacity and inductance are familiar to every engineer. Rough measurements by bridge methods are easily made but for precision, many precautions must be taken and often elaborate apparatus is required. To equip a laboratory with a number of special purpose bridges is expensive and bridges covering wide ranges are not highly accurate or are unduly complicated and difficult to operate.

Beat frequency methods which have been used to compare two equal capacities are easy to operate and give accurate results but are limited to the range of the standard which is usually about 1000 $\mu\mu$f. By the introduction of a ratio coil and a novel method of zero beat indication, it is possible to extend the range of measurement while retaining the ease of operation and precision inherent in the best frequency method.

In a self-contained instrument, a reactance measuring device covering a range of 1 to 5,000,000 $\mu\mu$f. and 1 to 1,000,000 microhenries is possible. The only external connections are to the 110-volt line, a pair of telephones and the unknown reactance.

To compare an unknown capacity with a known change in capacity of a standard condenser by beat frequency methods, it is necessary to have two oscillators and a detector. One oscillator is maintained at a fixed frequency and the other oscillator is tuned to it by means of the standard condenser C_1. Zero beat may be detected by means of the telephones in the plate of the detector which receives voltage from both oscillators. The unknown capacity C_2 is then connected in parallel with the standard condenser and the latter reduced in value until zero beat is again obtained in the telephones. The difference in capacity of the standard between its initial and final values is then the capacity of the unknown. If the oscillating tubes do not change frequency due to line voltage variations or heating while a reading is being taken, the accuracy with which the unknown may be found is very high and is of the order of the accuray with which the standard condenser may be read.

The figure is the basis for a system in which the unknown reactance may be larger or smaller than the standard. L_1 represents the primary of an ideal transformer, L_2 represents the secondary and M the mutual inductance between primary and secondary. If variable condenser C_1 is across the primary and L_1 is in series with the plate of a dynatron, the frequency of oscillation with switch Sw. open will be closely $F_1 = \frac{1}{2\pi\sqrt{L_1C_1}}$. Now if the secondary



Circuit for measuring reactance

FROM THE LABORATORY ++

is coupled to the primary 100%, i.e., so that $M = L_1L_2$ and we close switch Sw., the frequency of oscillation will become $F_2 = \frac{1}{2\pi\sqrt{L_1C_1 + L_2C_2}}$. If we now restore the frequency of oscillation to F_1 by decreasing C_1 to a value C_3 we have $F_1 = \frac{1}{2\pi\sqrt{L_1C_3 + L_2C_2}}$. Equating the two expressions for F_1 we obtain as the value of C_2, $C_2 = \frac{L_1}{L_2}(C_1 - C_3)$, and if the inductances of the primary and secondary coils are proportional to the square of their respective number of turns, we have the relation, $C_2 = \frac{(\text{primary turns})^2}{(\text{secondary turns})^2}(C_1 - C_3) = n(C_1 - C_3)$. When the secondary is equal to the primary, $n = 1$; when the secondary is larger than the primary, $n < 1$; and when the secondary is smaller than the primary, $n > 1$.

Use of transformer

By using a tapped secondary and a multi-point selector switch, we make instantly available ratio factors equal to 0.1, 1.0, 10, 100, 1000, and 10,000 or whatever ratio points are convenient. Actually, the primary coil may be omitted and the tapped secondary alone used for the ratio coil in the form of an auto-transformer.

The detection of zero beat between two inaudible frequencies by means of telephones always presents a problem since the response of telephones and ear both fall off badly at very low frequencies. A simple and effective method which permits extremely close adjustment of the two beating oscillators, consists in the introduction of a third signal into the system upon which the very low audio beats are superimposed and which then become easily detectable in the telephones. The effectiveness of the system depends largely on the frequency and intensity of the third signal.

To measure inductances with the system, the unknown condenser is simply replaced by an unknown inductance and since this increases the resonant frequency, zero beat is restored by increasing the capacity of the standard condenser. By means of standard inductances, the standard condenser may be calibrated in terms of inductance.

Although many special purpose instruments based on the principles outlined above may be visualized the device described briefly here makes a universal reactance meter of high accuracy and great ease and spread of operation.

A high gain a.c.-d.c. amplifier

By Earl R. Meissner

While tubes with a very high amplification constant have been built it is in general impossible to realize but a small per cent of their gain at zero frequency. For instance if a voltage gain equal to one half the mu of the tube is desired we must use a plate resistor which matches the plate impedance of the tube. This means for a type 58 tube a resistance of 800,000 ohms, and a battery voltage of 6,810 volts. Such a high voltage is of course impractical.

One way out of this difficulty is to use a tube having a very high plate impedance as the coupling device. Figure 1 shows such a circuit where type 58 pentodes are used. While this circuit necessitates an isolated screen and grid bias as well as a separate filament supply it does accomplish the desired results.

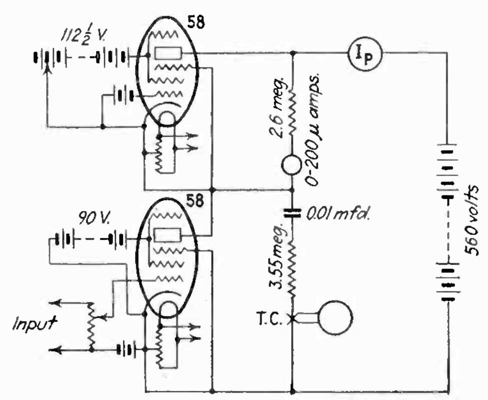


Fig. 1—Direct-coupled amplifier

The bias on the tubes is arranged so that they divide the plate voltage equally. Thus the plate voltage-plate current curves intersect at the point *a*. Now assume the bias on one tube to be increased so that its plate voltage plate current curve is represented by the curve O-E_{g_3}. Now the point where the two tubes draw equal current is shifted from point *a* to point *b*. Likewise the voltage across one tube increases to E_1 and the voltage across the other decreases to E_2. Thus for very small changes in grid voltage the plate voltage change may be very large.

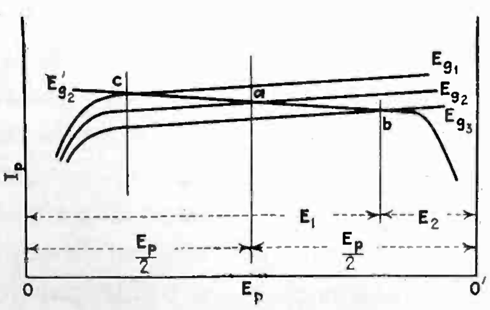


Fig. 2—Tube characteristics used

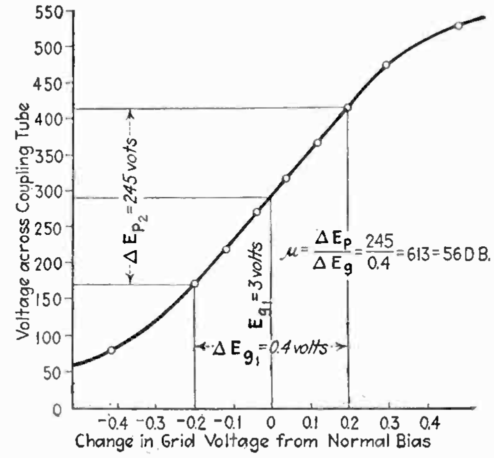


Fig. 3—Amplifier characteristic

Figure 3 shows the C_g-e_p relation. The slope of this curve represents the d-c amplification and is of the order of 610 for the tubes indicated. This is approximately half the amplification constant for a type 58, which is given as 1280.

This circuit may also be used as an a-c amplier. A frequency curve, when operating at a gain of 56 decibels, is shown in Fig. 4. Using a coupling resistor of 64,000 ohms for the a-c component, in place of the 3.55 megohm resistor, gives a gain of 41 decibels and 10,000 cycles is down 0.9 decibels. The loss at the low end depends only upon the size of the coupling capacity. If it is desired to extend the curve down to zero frequency the coupling capacity is removed. The bottom end of the resistor is returned to the mid point

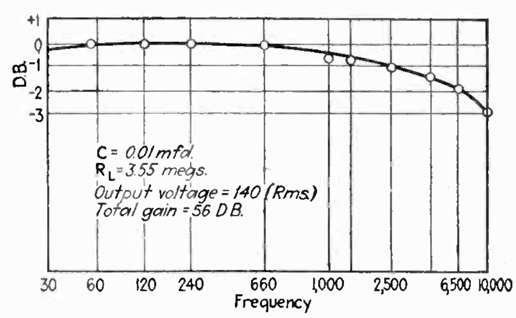


Fig. 4—Fidelity curve of amplifier

of the "B" battery so as to buck out the d-c drop across tube one.

When a triode is placed in series with a pentode, practically the full mu of the triode is realized. The pentode acts as a constant current device and regardless of the impedance of the triode maintains constant current through it. Testing several triodes in this manner the author found their amplification constants to check very closely with their rated values.

electronics

McGraw-Hill Publishing Company, Inc.
330 West 42d Street
New York City

O. H. CALDWELL, *Editor*

Volume VI —JULY, 1933— Number 7

Five per cent for research

CERTAINLY that was an admirable proposal by the I.R.E. to have a percentage set aside out of manufacturers' gross sales, to be applied to research and scientific study in the art. Five per cent has been suggested, and this would not be too much, although at the present economic juncture, it may be difficult to secure approval of such a figure. On the other hand, such an amount has not been far from that assigned by notably successful corporations for their research funds.

A five-per-cent fund for research, imposed on all manufacturers of radio and allied products, would have many interesting and beneficial effects. It would aid technical employment and advance the art. And it would kill off the gyp manufacturers or force them to contribute to the art which they now benefit from but do not support.

The foreign language market for short wave sets

THERE are thousands of foreign-born people in this country that would like to hear their native language from their native land. This is possible on a good short-wave set. It is now a common thing to hear Rome, London, Paris, Berlin, Madrid very well every day one listens. News, songs of the fatherland, all kinds of talks in their own language, await the owners of a good short-wave set. But to date such sets have been mere adjuncts to a broadcast set. There is a place for a good a.v.c. set selling at from $50 to $100 and sold to foreigners through their own language newspapers and dealers.

Patents are not "monopolies"

THE recent decision of the United States Supreme Court in the so-called Lowell and Dunmore case contradicts the commonly held belief that a patent is a monopoly. The decision reads, "Though often so characterized a patent is not, accurately speaking, a monopoly, for it is not created by the executive authority at the expense and to the prejudice of all the community except the grantee of the patent. The term monopoly connotes the giving of an exclusive privilege for buying, selling, working or using a thing which the public freely enjoyed prior to the grant. Thus a monopoly takes something from the people.

"An inventor deprives the public of nothing which it enjoyed before his discovery, but gives something of value to the community by adding to the sum of human knowledge."

Long-wave vs. short-wave broadcasting

MUCH discussion has been waged on the question of widening the broadcast band by adding a few channels on longer waves. It has been suggested that some philanthropic organization undertake the construction of a superpower station on 1,000 meters or thereabouts, to get the ball rolling. Undoubtedly it would be a noble experiment demonstrating the superior carrying powers of the lower frequencies—and the louder static.

But without spending much money the stage is all set for an experiment of broadcasting on the very short waves. For coverage to the horizon, waves in the vicinity of 5 to 8 meters have been proved useful. Why not persuade the NBC to turn its programs into the two high-frequency channels of the Empire State Building transmitter? Let the home radio-set builders make receivers for these transmissions and determine experimentally how they compare in service with the regular broadcast band.

Certainly this is also ready-made equipment for an experiment with binaural transmission; perhaps it is also the ideal equipment for local coverage on low power. The 5-meter region would provide politicians with plenty of room for new stations, at least.

The "cigar-box" receiver—its place in the home

THERE can be no doubt that the new sub-sub-midget, of cigar-box dimensions, has achieved marked popularity with the public by its sheer compactness. With its inadequate baffle-area, its tone quality will always be deficient, but it is bound to find increasing demand as an auxiliary set.

In every home there is need for one or more quality radio receivers which will bring in the fine music, the great symphonies and the world's best artists, with all the fidelity that the broadcasters secure in transmitting these rich tones. But there will also be secondary points for other sets, in upstairs bedrooms, in the children's room, in the old folk's sitting room, in the kitchen, and in the new cellar gameroom.

There was an old merchandising maxim: "Every room needs an electric clock." Within the next year or two, we may witness its radio counterpart: "Every room needs a personal radio set," and should shape our marketing plans accordingly.

Indirect contributions by the photo-cell

ALL of the photo-electric cell's contributions to industrial improvement are not direct applications of the cells to machines in factories. The light-sensitive cell and electronic tube render some of their most important services to industry through quite indirect means.

For example the goggles used by glass-blowers were formerly blue-green glasses which cut down the glare from the incandescent glass, but also reduced the visibility of all objects around so as to make them almost invisible. Then one day a piece of didymium glass was being analyzed in a photo-electric spectroscope, and revealed a surprising peak of absorption completely shielding the yellow flame color of sodium, which gives the color to molten glass. Using these new didymium goggles, therefore, the glass blower has the yellow glare of the sodium glass completely cut off, but can see clearly the objects around him in the shop, by light of all the other wavelengths.

NEWS NOTES

Radio set sales, first quarter—Sales of radio sets by RCA licensees are understood to have increased to 525,000 for the first quarter of 1933, as compared with the 500,000 figure for the same quarter of 1932. The average value, however, is said to have decreased from a $27 factory price in 1932, to $14 in 1933.

Airplane beacon sends voice simultaneously—A combined airplane-beacon station which will transmit voice and directional signals at the same time, is being placed in operation at Elizabeth, N. J. This will enable pilots whose planes are so equipped, to receive weather reports and other flying information, while being guided by the visual indications on the plane's instrument board. The transmitter will be remote-controlled from the Newark flying field.

Federal decision opens sound-picture servicing—Federal Justice John P. Nields, at Wilmington, Del., has rendered a decision supporting the plaintiffs in the suit of the Stanley Company, General Talking Pictures Corporation, and Duovac Radio Corporation, against Electrical Research Products, Inc., and associated companies, in the matter of exclusive motion-picture licenses and servicing fees, imposed by the Erpi group on theater-owners using its equipment, which number some 5,000 houses. The decision opens the field to independent organizations for apparatus and repair parts. No action regarding the taking of an appeal by Erpi is reported.

Parts makers reorganize—Under direction of Chairman Leslie F. Muter, the Parts, Cabinet and Accessory Division of the RMA was reorganized June 6, during the RMA convention. The various committees with their chairmen follow: Carbon Resistors, H. E. Osmun, chairman; Wire Wound Resistors, Leslie F. Muter, chairman; Variable Resistors, Arthur Moss, chairman; Fixed Condensers, Richard A. O'Connor, chairman; Variable Condensers, Lloyd Hammarlund, chairman; Cabinets, N. P. Bloom, chairman; Audio and Power Coils and Wire, Whipple Jacobs, chairman; Transformers and Chokes, C. H. Bunch, chairman; Sockets, H. H. Eby, chairman, and Instruments, Robert Williams, chairman.

HODOSCOPE SHOWS COSMIC-RAY PATHS

In this "hodoscope" built by Dr. Charles Johnson of Swarthmore, Pa.; the grouped Geiger counters operate corresponding neon lamps so that the angular direction of each high-speed cosmic-ray particle is clearly shown to World's Fair visitors

300-kw. transmitting tube

For the Hilversum broadcasting station, operating on a 296-meter wavelength, the Philips company of Eindhoven, Holland, has constructed a 300-kw. tube.

In this, as in all Philips' types of water-cooled transmitting valves, use has been made of the chrome-iron welding process (elaborated in the Philips laboratory) for joining the glass to the metal part of the valve-jacket a process that has given excellent results in practice; furthermore, the construction is such as to enable the cooling to be restricted to the anode, no cooling of other parts by water or air being required.

The filament voltage is about 34 volts, the filament current about 420 amperes. At an anode potential of about 20,000 volts the filament has an electronic emission of about 100 amperes. The valve, including its cooler, has an overall length of 140 cm. The consumption of water for anode cooling is 120 litres per minute.

✦

Penetration of different colors into the sea

[W. R. G. Atkins and H. H. Poole] To cover the range from the near ultraviolet to the deep red, the measurements in the English Channel on a steam drifter-trawler, were carried out, in the ultra-violet by means of a Burt sodium vacuum cell embedded in vaseline, in the blue end of the spectrum with a G. E. potassium cell (hydride, argon-filled and maintained in the sensitive condition by glow discharges) and for the rest of the spectrum by the use of a thin-film cesium vacuum cell CMV 6. In the ultra-violet, daylight is reduced to 1/100,000 at 30 meters below the surface, in the blue at 82 meters, in the green at 74 meters, in the orange at 26 meters.—*Phil. Trans. Roy. Soc.* London *222*:129-164. 1933.

✦

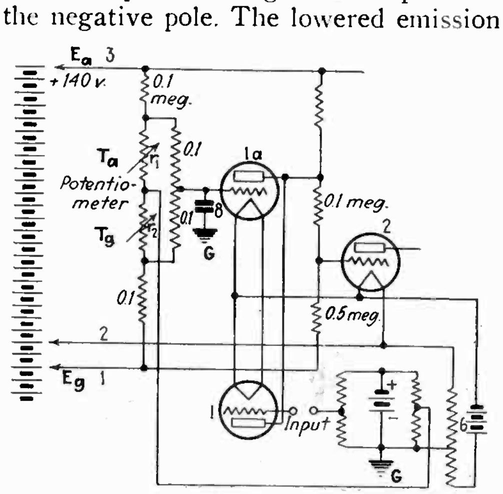
Narrow electronic beams at low gas pressure

[O. Scherzer, Research Lab. Algemeine Elek. Gesell., Berlin] It is now more or less accepted that the reduced cross-section of cathode ray beams obtained in the presence of a gas at low pressure is the result of the presence of the positive ions produced in the beam itself by the electrons. Their density in the steady state is such that the space charge which they represent drives the ions which are formed within a certain area through the area and out of the beam. On these assumptions the equation for the number of positive ions per unit volume, can be set up and solved in special cases, for instance the case where a cathode ray beam forms a succession of nodes along its path. Theoretically the outline of the beam between nodes ought to be a nearly sinusoidal curve, and the distance between nodes larger than $\frac{3.14\sqrt{m_-/m_+}}{e_p}$, where e_p is the probability of ionization.—*Zeits. f. Physik* 82:697-708. 1933.

✦

Three-stage direct-current amplifier

H. Konig, of the Swiss Bureau of Standards states that it is possible to render a three-stage d-c amplifier practically independent of the fluctuations of the several d-c sources used for its operation by applying to the grid, plate or filament of the preceding tube a fraction of the potential which is used for the grid, plate or filament of the following tube. The compensation of the fluctuations in anode and grid potential is obtained by means of a double potentiometer acting upon a first tube (1a) placed symmetrically in parallel with the input tube 1. The variable resistances r_1 and r_2 can be so adjusted that changing the anode or plate potential by two volts does not affect the output. A drop in the filament supply is counteracted through the use, in series with the A battery of a resistance one point of which is put to the ground in place of the negative pole. The lowered emission



due to decreased filament current is then compensated by the drop in grid bias. Oxide coated filaments are used, for instance REO84 tubes, with an internal resistance of 10,000, G_m 1.5 ma/v, μ of 15. Together the three stages amplify 900 times d-c or a-f voltages. With a perfect input tube they should be able to measure four electrons. The amplifier is described in *Helvetica Physica Acta* 6: 218-228. 1933.

✦

New cathode ray for decimeter waves

[K. Kreielsheimer, Heinrich-Hertz Institute] At very high frequencies the potential of the deflecting plates can no longer be considered as constant during the time which the electron takes to fly from one edge of the plate to the other; the length of the plate must be so chosen that the electron enters at the beginning of a period and emerges after one (or three) quarters of the period; this condition can be obtained by proper adjustment of the plate potential. Moreover, the electrons must enter the space between the second pair of deflecting plates in the same phase in which they entered the first pair; compensation can be obtained by adding a third pair of plates. With these changes the cathode-ray tube proved to be useful down to waves below one meter.—*Ferns. und Tonf.* 4: 13-15, 1933.

✦

The hexode

[W. Hasenberg] Two types of hexodes have been developed by Telefunken and are also produced by Radiorohren (Valvo tubes), one being intended to take the place of the first detector tube (RENS 1224), the other to serve as exponential tubes RENS 1234 (intermediate amplifier or input tube). In this latter tube the electrons slip through the first grid at — 1.5 volt, pass through the second grid (screen, 80 volts), are stopped between the second and third grid (—1.5 volt) so that they accumulate in this space and form a virtual second cathode which is easily influenced; they are finally drawn through grid 4 (80 volts) to the plate (200 volts). Grid 1 is so wound that it produces exponential variation of the current. The mutual conductance of the tube decreases when grid 3 becomes more negative, and the result of the combination is that the mutual conductance of the tube falls from 2 ma/v to 2/10,000 ma per volt when V_3 changes from 0 to —7 volts. The capacity between the first grid and the plate is below 0.01 uuf. The second tube is a mixing tube, allowing modulation in place of addition of the two frequencies so that no overtones of the original frequency are produced.—*Funkt. Monatsh.* 2:165-173. 1933.

The inductance of by-pass condensers

[P. Kotowsky and K. Kuehn, Res. Lab. Gen. El. Co., Berlin] The impedance of fixed condensers—consisting of two metal foils separated by waxed paper, the whole rolled into compact form—drops when the frequency is increased, but starts to increase above a certain frequency, owing to the magnetic field produced by the current in the lead-in wires and the displacement and the galvanic current in the whole roll. Older types of 2μf condensers may give resonance at 900 m. The measurements show that the largest part of the inductance is due to the lead-in wires and connections. By using closely spaced wires leading from the roll or pack to the outside, the resonance frequency of 2μf condensers as used in interference eliminators can be brought to 200 m.—*El. Nachr. Techn.* 10:105-108. 1933.

✦

Stability of two transformer-coupled tuned circuits

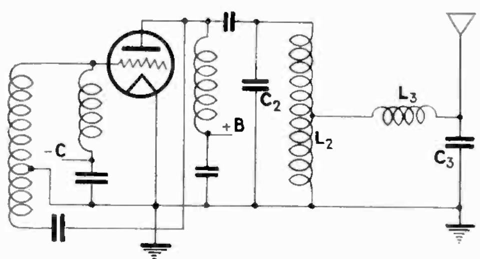
[J. Mercier, University of Bordeaux] The article deals with a much studied subject (see, for instance Pierce, Elec. Oscillations, McGraw-Hill). Starting with the characteristic equation of the period of the combination (see eq. 10 in Pierce, p. 96) and assuming an imaginary root as a solution (instead of a complex root in the general case), the damping coefficient ± R/2L in the first or generating circuit is eliminated and an equation of the third degree in f^2 is obtained which is studied in detail as a function of the period which the pick-up circuit would have in the absence of damping. Interesting conditions for the maintenance of oscillations occur when the separate circuits and their combination are nearly in tune. Theory and experiment illustrate how important it is to use loose coupling in measuring frequencies or in timing radio circuits as under certain conditions three frequencies are possible.—*Onde él.* 12: 93-112, 1933.

✦

Mr. Dietsch on harmonic suppression

Some confusion may result of the drawing in Mr. Dietsch's article in June *Electronics* on methods of eliminating harmonic radiation from broadcast stations. The radio field intensity survey gives values of fundamental and second harmonic radiation. It is not made clear (the draftsman's fault!) that the second harmonic field strength is in tenths of millivolts, not millivolts.

Mr. Dietsch suggests the drawing below be followed instead of Fig. 3 in



the original article. This represents a method of reducing harmonic radiation by proper design and termination of transmission line.

✦

The anti-fading antenna of Breslau

[F. Eppen and A. Gothe] The antenna is designed to shift the zone where interference occurs during the dark hours between the sky wave returned by the conducting layer and the ground wave away from the sender. Intensity variations may, of course, be reduced by automatic volume control but not so the distortion which is produced when the carrier wave is destroyed by interference and only portions of the side-bands remain. For the shorter broadcast waves and for soil of low conductivity, the near-fading zone moves close to the sender. For the Swiss station Beromunster (459 m.), for instance, it starts at 20 miles from the sender. The new Breslau sender (325 m.) uses a single cable of 140 m. length suspended in the center of a wooden tower as antenna. At its top the tower carries a horizontal metal ring of 10.8 m. diameter, insulated and serving as end capacity. Under these conditions a current node exists 19 m. above the ground, the antinode at 100 m. Such a structure emits less power under high angles than quarter-wave length antennas. By cutting the length down to the quarter wave, the distance where nearby fading occurred dropped from about 70 miles to 50 miles. Thanks to the use of the special half-wave antenna the area getting satisfactory reception is therefore nearly doubled.—*El. Nachr. Techn.* 10:173-181. 1933.

✦

Sensitivity of barrier-cells as a function of the frequency

[P. Goerlich, Zeiss-Ikon Labor. Dresden] Sinusoidal variations of light intensity obtained with the aid of a scanning disk were allowed to fall upon cuprous-oxide-copper back and front wall cells (reverse and obverse cells, see *Electronics,* October, 1932) and selenium barrier layer cells. The response of the front-wall cuprous oxide cell varies with frequency less than that of the other cells. Measurements with a vacuum tube voltmeter showed that from 100 at 100 cycles it dropped to 80 at 3,000 cycles and to 70 between 5,000 and 6,000 cycles. The sensitivity of the back wall cells increases slightly between 100 and 700 cycles. With the selenium barrier cell the response falls from 100 at 300 cycles to 90 at 1900, 80 at 3,400 and 70 at 4,600 cycles. (Selenium alone with its dark current shows a much larger effect, from 100 at 300 cycles, to 26 at 3,000 cycles).—*Zeits. techn. Physik,* 14:144-145. 1933.

✦ ✦ ✦

INCREASE IN TUBE TYPES SHOWN IN I.R.E. EXHIBITS, CHICAGO

The larger number of new radio tubes brought out each year were shown in these displays by RCA-Radiotron, Inc. and the Ken-Rad Corporation, during the Chicago convention of the Institute of Radio Engineers

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Sprayed suede finish

THE POPULARITY OF suede and suede-like materials has led to the development of a revolutionary new finish by The Zapon Company, Stamford, Conn., a subsidiary of Atlas Powder Company. It is known as Sprayed Izarine Finish. Formerly the covering of any article with suede or imitation suede meant cutting and pasting innumerable pieces and then laboriously mounting them. Now a suede-like finish can be given to any surface by merely spraying on an enamel and an Izarine powder with an air gun.

Manufacturers of a wide variety of articles, from compacts to caskets, and from toys to typewriters have shown interest in this new finish.—*Electronics, July, 1933.*

✦

Oscillator

VICTORY SPEAKERS, INC., 7131 East 14th St., Oakland, Calif., have introduced their Model K33 oscillator, designed by L. C. Rayment, which has direct calibration of the dial to all fundamental frequencies, thus eliminating the confusion of harmonic selection. A heavy cast-aluminum housing insures maintenance of calibration. The unit may also be used as a harmonic generator for locating short-wave bands. One scale is provided for broadcast frequencies and high intermediates, and a second scale for 150 to 350 kilocycles. The oscillator works wholly upon 60-cycle 110-volt alternating current. Price $16.80, less tube.—*Electronics, July, 1933.*

✦

Mercury switch, refractory protected

A NEW MERCURY SWITCH announced by the Westinghouse Lamp Company, Bloomfield, N. J., is refractory protected so as to confine the arc and to obtain long life with dependability. Made with nominal ratings from 3 amp. to 50 amp., it comprises a new line of single pole, single throw switches which may be operated in either a.c. or d.c. circuits.

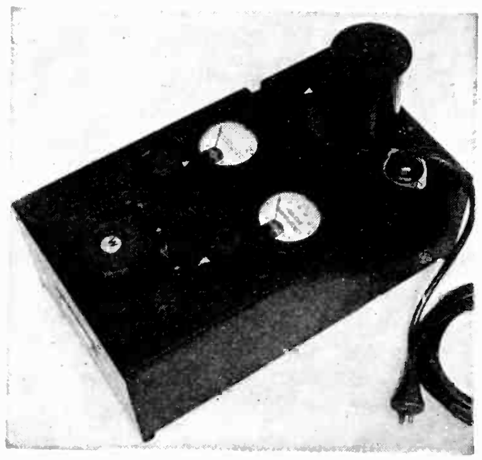
The contact in this switch is made by an impact between two pools of mercury within a refractory chamber encased in heavy glass walls. Instead of flowing slowly together, the mercury from one pool drops to meet the other with a sudden visible "jump." An atmophere of inert gas within the chamber keeps the mercury chemically pure and prevents the loss of fluidity that causes it to become gummy and slow flowing. The gas also dissipates the heat of the arc.

The 50- and 3-ampere switches are the largest and smallest in the new Westinghouse line of refractory protected switches which are single pole, single throw, and are designed for operation in either a.c. or d.c. circuits.—*Electronics, July, 1933.*

✦

Transparency meter

THE "TRANS-O-METER," a simple portable instrument for registering the transparency of flat materials directly on a dial is announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The unit is accurate, weighs only 8 pounds, operates from a 115-volt lamp socket, consumes but 200 watts, and is expected to find wide application in paper, textile, chemical, and similar industries.



In paper manufacturing, paper samples of any size or length can be used and if desired, a strip can be slowly drawn through the instrument, so that any variation in transparency can be noted. Only a few seconds time is required to determine the transparency with precision.

The density of film and plate emulsions, as well as negative contrast may be precisely evaluated. Elusive turbidity measurements can be made by using a special cup built to fit into the aperture.

The simple principle of the Trans-O-Meter consists in measuring the amount of light a 25-watt lamp will pass through the sample.—*Electronics, July, 1933.*

Photo-electric relay

IN AN IMPROVED MODEL of the DeVry "Electric Eye" the base provides space for a variable resistance unit. By merely turning the knob at the back of the base, it is easy to adjust the sensitivity for various degrees of light intensity.

The present model is made extremely sensitive to infra red rays, popularly known as "invisible rays", which makes it of special value where secrecy is required. The electric eye as described contains the transformer, photo cell, amplifier tube, and primary relay capable of carrying ½ ampere at 110 volts. A plug and 7 foot cord are included. The sockets in the base are for the relay operating contacts for closed or open circuit.

While any light source, such as flash lights, ordinary electric light bulbs, etc., may be used for operating the photo cells at short distances, operating practice utilizes a special light source with uniform illumination and lens system for making a parallel (pencil) beam of light, and the focusing mount for securing maximum illumination at varying distances.

The manufacturer is Herman A. DeVry, 1111 Center St., Chicago, Ill.—*Electronics, July, 1933.*

✦

"Make-your-own" adapters

WITH SO MANY NEW TUBES and circuits it is necessary to have many adapters for analyzing, tube checking, testing and experimental purposes, especially for use with out-of-date equipment. Since there are five different prong arrangements on the modern tubes, the number of adapter circuit arrangements becomes very great. To simplify the situation, the Alden Products Company of 715 Center St., Brockton, Mass., has introduced its new "Make-Your-Own" adapter parts.

In assembling the adapter, the required circuits are soldered to the convenient solder terminals of the socket section and brought down through the hollow prongs of the plug section soldering the wires to the ends of the prongs. A 6-32 screw and nut supplied with the adapter holds the socket and plug sections securely together. An important feature is the small size, making it possible for the use of these adapters in closely shielded sockets. Twin adapters or adapters with leads brought out can also be conveniently made.—*Electronics, July, 1933.*

Ring-type rheostat

The Ward Leonard Electric Company, Mount Vernon, N. Y., has developed a new ring-type rheostat for applications requiring a compact, heavy-duty unit which provides a fine, continuous adjustment.

In its construction, the resistance wire is wound toroidally around a base of refractory material and coated with Vitrohm (vitreous enamel). This construction prevents the resistance wire from shifting with adjustment of the contact shoe.

The "dead" shaft, insulated from the contact lever, makes the rheostat adaptable for mounting back of a steel panel without the use of troublesome insulating bushings or washers.

The rheostat can be furnished in values of resistance from 1 to 10,000 ohms. It will dissipate in free air 100 watts continuously with a temperature rise not exceeding 250 deg. C.—*Electronics, July, 1933.*

✦

16-mm. sound-on-film projector

Victor Animatograph Corporation, Davenport, Ia., announces that actual production of the new sound-on-film animatophone is under way.

Threading and operation are no more complicated than with a silent projector. The sound head, comprised of exciter lamps, lens, sound gate, photo-electric cell and threading rolls, is side-mounted on the support base of the projector and occupies a space of only $2\frac{1}{2}$ in. by $4\frac{1}{4}$ in. by 6 in. The highly developed amplifier (5 tube) is mounted at the rear of the projector and occupies a space of only 6 in. by 7 in. by 8 in. Auditorium speaker and 50′ cord are housed in a removable side of the projector carrying case. The entire equipment in carrying case weighs only fifty pounds.—*Electronics, June, 1933.*

✦

Self-generating photo-cell

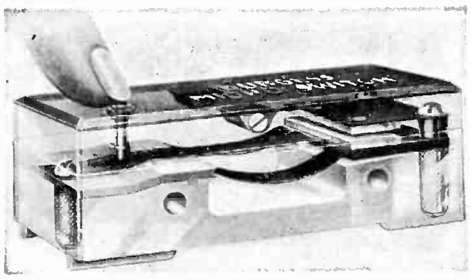
A new photoelectric cell which requires no battery or other source of voltage has recently been announced by G-M Laboratories Inc., 1735 Belmont Ave., Chicago. The new cell, designated as Visitron Type F2, is suitable for use with current indicating meters, for light-intensity measurements, or with sensitive electro-magnetic relays without vacuum-tube amplification.

The sensitive disc in the F2 cell is mounted in polished durable metal case $2\frac{1}{4}$ inches in diameter and $\frac{7}{16}$ inches thick, which is hermetically sealed. Terminal studs for electrical connections and mechanical mounting project from the rear of the cell to facilitate its use in manufactured assemblies, instruments or experimental work.

Micro switch

In Highly Compact Form, requiring only one thousandth of an inch movement and a few ounces' pressure for positive operation, there is now available a quick-acting switch capable of handling sufficient current for the majority of electrical control functions.

Contained in a neat, dust-proof, molded phenolic case, the Burgess micro switch measures $1\frac{15}{16}$ in. long, $\frac{11}{16}$ in.



wide and $\frac{37}{32}$ in. high. The body is black, while a colored top serves to identify the type of switch—red top, normally closed; green top, normally open; blue top, double-throw. All types are single-pole. A tiny plunger protrudes through the top and receives the slight energy required to operate the switch mechanism. The small motion required, combined with freedom from vibration difficulties, and again the fact that this switch can be used in any position, suggests its use in many industrial, laboratory, scientific and other instruments and appliances.

The use of beryllium copper for contact springs provides freedom from fatigue or crystallization despite millions of operations; extreme speed without sticking; and ability to withstand high temperature. The switch, supplied by C. F. Burgess Laboratories, Inc., 202 East 44th St., New York City, is rated at 10 amps., 110 v. or 5 amps., 220 v., alternating current.—*Electronics, July, 1933.*

✦

Oil-sediment meter

The Electronic Inspection Laboratories, 1624 Hayden Ave., Cleveland, Ohio, have developed an oil-sediment meter employing a photo-cell, for quickly measuring the capacity or density of the oil in the customer's crankcase, while the car is standing at the filling station.

The portable meter contains a lamp and a photocell, the output of which is read on a graduated meter. For comparison a sample of clean oil is first daubed onto a test slide, and the transmitted light measured by the cell. Next a few drops of oil from the customer's automobile crankcase are daubed on another slide and the reading again taken, with the result that the meter pointer usually falls to the position "Poor" or "Unsafe." Such a handy meter, making tests in the customer's presence, under actual trial has resulted in selling many changes of oil. The complete oil-tester retails for $75.—*Electronics, July, 1933.*

Microphone

Audio Research, Inc., 105 East 16th St., New York City, has developed a microphone unit intended for professional use, broadcast stations, recording studios and speech-amplifier systems. It is of the dynamic type and weighs $3\frac{1}{2}$ lb. Normal speech at a distance of 2 or 3 feet will give an output of approximately minus-65 decibels. With an output of plus-12 decibels, and an amplifier gain of 108 decibels, there is thus a margin of 31 decibels to take care of unusually weak signals.

This microphone has a resistance of only 50 ohms, and operates with a uniform response between 50 and 7,000 cycles. The enclosed space above the diaphragm being small, the cavity resonance experienced on condenser microphones between 3,000 and 4,000 cycles is absent. This eliminates the shrillness found in the best condenser microphones when talking directly into them. This microphone has negligible directional characteristics, thus obviating the necessity for skillful microphone placement.—*Electronics, June, 1933.*

✦

Manufacturers' bulletins and catalogs

Selenium, thorium, etc.—Special metals and ores of interest to researchers and manufacturers in the electronic field, are outlined in the current issue of "Foote-prints," the house-organ of the Foote Mineral Company, Sixteenth and Summer Sts., Philadelphia, Pa. Among the materials listed are selenium, tantalum, thorium ore (monazite), tungsten carbide, zirconium, and zirconium silicate.

Insulation testing — Bulletin 1355 of James G. Biddle & Company, 1211 Arch St., Philadelphia, Pa., describes briefly five different types and forty different ranges of the Biddle Company's well-known "Megger" insulation-testing instruments, under commercial and industrial conditions. The regular testing of insulation is recommended, during manufacture, before acceptance, after installation, and periodically while in service.

Nameplates and escutcheons—In a series of new bulletins, the Crowe Nameplate & Manufacturing Company, 1749 Grace St., Chicago, Ill., describes its new products: Bulletin No. 45, Miniature wedge-drive tuning units; No. 46, Steel cabinet for baby midget receivers; and No. 47, Etched dials and nameplates for miniature receivers.

Heat controls, vacuum switches—Bulletin VS-7 of Thomas A. Edison, Inc., Orange, N. J., contains specifications for the vacuum switches, heat controls relays and other circuit devices, which are marketed by the Burling Instrument Company, 185 Market St., Newark, N. J.

Mixer and volume controls — The new General Radio Type 653 volume control, an all-purpose mixer, is described and illustrated, with application circuits, in a new specification sheet just issued by the General Radio Company, 30 State St., Cambridge, Mass.

Radio alloys—Resistance alloys and wire products in use for radio purposes, are described and specified in full detail in a new bulletin just issued by the Driver-Harris Company, Harrison, N. J. Materials covered are Ohmax, Nichrome, Radiohm, Lohm, Midohm, Gridnic, and nickel.

Noise-meter — The E. E. Free Laboratories, 175 Fifth Ave., New York City, have issued a new descriptive circular of their Type 123 Noise-meter, covering also some of the accessories and other acoustic equipment. Dr. Free reports that despite the depression, many inquiries are being received regarding this noise-meter.

U. S. PATENTS

IN THE FIELD OF ELECTRONICS

Radio Circuits

Band-pass amplifier. A superheterodyne receiver with coupling between two circuits, adjustable so that the sensitivity of each stage is automatically reduced when the selectivity is decreased. W. V. B. Roberts, RCA. No. 1,907,669.

Interstage coupling device. In a tuned r-f receiver, coupling being so designed that the system has an approximately straight line selectivity characteristic, comprising a transformer with a primary whose natural frequency is low in comparison with the mid-range frequency of the system and a feed back for improving the response to high frequencies. G. L. Beers, W. E. & M. Co. No. 1,907,478.

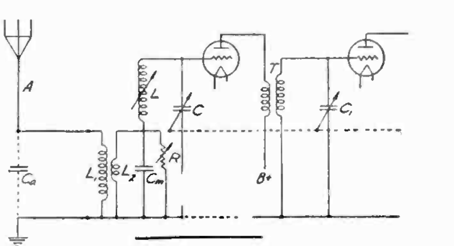
Switching system. Methods for changing a tube and circuit from a heterodyne to a radio-frequency amplifier. Lazarus Shapiro, assigned to RCA. No. 1,907,594.

Short-wave Receiver. A method of rendering the tuning of the input circuit of a short-wave receiver independent of antenna capacity changes by means of three resistances, two in series with the antenna and the high potential input coil lead, the third connected between ground and the mid point of these two resistances. The impedance of the resistors is 1,000 ohms. Herbert Muth, assigned to Telefunken. No. 1,907,653.

Detector circuit. A screen-grid detector, a method of deferring overloading in the anode circuit, comprising automatically decreasing the screen grid potential as the signal strength increases. P. O. Farnham and Raymond Asserson, assigned to RCA. No. 1,907,768.

Coupling system. A tunable high frequency coupling system. H. A. Wheeler, assigned to Hazeltine No. 1,907,916.

Input system. A series resonant circuit comprising a fixed and a variable condenser and an inductance. The input signal is impressed across the fixed condenser, and the voltage across the variable condenser is applied to the input terminals of the vacuum tube. H. A. Snow, assigned to RCA. No. 1,911,096.



Detector system. Method for deriving a steady grid biasing potential from the impressed energy comprising an impedance network solely in the input circuit, impedance common to the input and output circuit and means for preventing a-f variations of current traversing said impedance from affecting a-f variations of the potential of the grid of the tube. C. Travis, assigned to Atwater Kent. No. 1,908,381.

Cold cathode detector. Method of demodulation, using ionization in a cold cathode tube. August Hund, assigned to Wired Radio. No. 1,905,873.

Automatic volume control receiver. Combination of a carrier-wave amplifier and a screen-grid tube and means for developing direct current by diode rectifier action and for utilizing said voltage for gain control. P. O. Farnham, assigned to R. L. F. No. 1,910,099.

Piloting systems. A system for guiding mobile bodies, means for receiving energy on each side of a predetermined course with independent receiving circuits connected to each means. J. A. Willoughby, Cambridge, Mass. Filed Jan. 8, 1929. No. 1,903,846.

Crystal ejector circuit.. Method of using a quartz crystal between the intermediate frequency amplifier and the second detector in a superheterodyne to get rid of an undesired interfering carrier frequency differing slightly from the desired frequency. W. S. Barden, assigned to R.C.A. Filed Jan. 10, 1931. No. 1,904,605.

Antenna circuit. A tuned antenna circuit coupled to a receiver by a primary winding interposed between the input end of the aerial and the ground. H. A. Anderson, Brooklyn, N. Y. Filed March 10, 1930. No. 1,904,668.

Series circuit. Method of using indirectly heated cathode tubes with filaments in series, and for supplying anodes with rectified a.c. from a rectifier whose filament is in series with the amplifier tubes. A. F. P. Stenzy, Baltimore, Md. Filed Oct. 30, 1930. No. 1,904,839.

Automatic volume control. Means for rectifying a portion of the a-c energy amplified by a gain control tube and for controlling the gain of other tubes, by varying the effective anode load of the tubes according to the amplitude of the rectified current. T. A. Smith, assigned to R.C.A. Filed Oct. 29, 1929. No. 1,904,552.

Static eliminator. A resonant galvanometer with a pair of coils, one connected to an antenna through a radio-frequency amplifier and the other through a local oscillator. One of the coils is movable and carries a mirror from which light is reflected into a photoelectric cell. Variations in the collected signal energy rotates the movable coil. Joseph Bethenode, Paris, France. Filed Oct. 22, 1929. No. 1,904,607.

✦

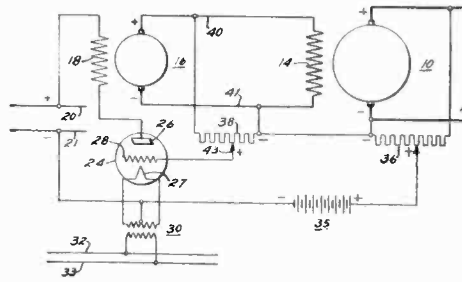
Electronic Tube Application

Inverter. System for converting d.c. to a.c., using two gaseous tubes, and a tunable oscillatory vacuum tube circuit, designed to drive the grid of the gaseous inverter tubes at the proper frequency. R. D. Fay. Assigned to Submarine Signal Corp. No. 1,906,558.

Electric piano. A musical instrument, comprising several sources of oscillation from the same fundamental frequency and of different harmonic composition; means for altering the relative phases of said oscillations; and for converting said oscillations into sound. C. T. Jacobs. Assigned to Meissner Inventions, Inc., No. 1,906,607.

Noise analysis. Apparatus for investigating noises and other mechanical vibrations associated with running machinery, comprising an amplifier and apparatus to give a visual indication of the oscillation. R. E. H. Carpenter and R. Fansteel, England, No. 1,907,415.

Generator control. Method of using an electron tube for controlling the excitation of a dynamo electric machine. F. H. Gulliksen, assigned to W. E. & M. Co. No. 1,909,104.

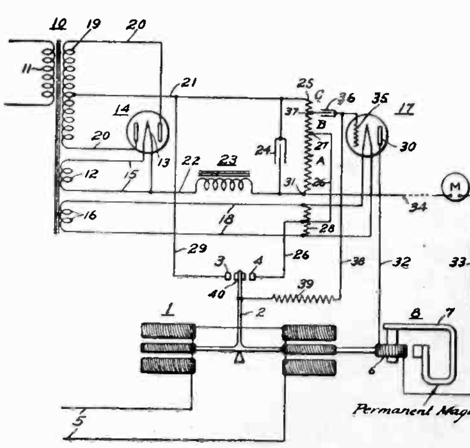


Polyphase generator. Method of producing a.c. by shining a light through holes in the periphery of a rotating disk onto a 3-cathode photo-sensitive surface. C. W. Hough, assigned to Wired Radio. No. 1,912,139.

Electrical musical instruments. Method of translating electric oscillations into audible tones. B. F. Miessner, assigned to Miessner Inventions, Inc. No. 1,912,293.

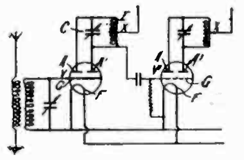
Stress measuring. Method of using piezo-electric apparatus for measuring stress of an object. A. M. Nicolson, assigned to Wired Radio, Inc. No. 1,912,213.

Remote indicating system. System for measuring a quantity, an energy storage device and a means using a vacuum tube for indicating the quantity of energy stored. B. E. Lenehan, assigned to W. E. & M. Co. No. 1,911,372.



Tube relay system. A maximum and minimum limit device employing vacuum tubes and their necessary relays. W. Van Benschoten, Fishkill, N. Y. No. 1,911,656.

Multi-element tube. A tube with a nickel filament, a control electrode, a plate electrode and several additional elements of similar physical character to the electrodes and disposed substantially outside the cathode field, the filament element being symmetrically disposed with the respect to the valve electrodes and the additional elements. James Robinson, London, England. No. 1,908.920.



Automatic steering device. Electron tube system for automatically steering sea-craft and aircraft. N. Minorsky, assigned to Pioneer Instrument Co., No. 1,912,489.

Altimeter. Method of determining the altitude of aircraft above the earth by radiating a high frequency wave from the craft; causing the frequency to vary cyclically as the craft varies in altitude. E. F. W. Alexanderson, assigned to G. E. Co. No. 1,913,148.

Modulating system. Method of modulating a photo-electric cell by means of a cathode ray tube. Fritz Schroeter, assigned to Telefunken. No. 1,912,732.

Electric organ. Vacuum tube organ containing means for producing notes which form harmonic or other notes, produced simultaneously, to change the timbre. E. E. Coupleux and J. A. M. Givelet, Paris, France. No. 1,905,996.

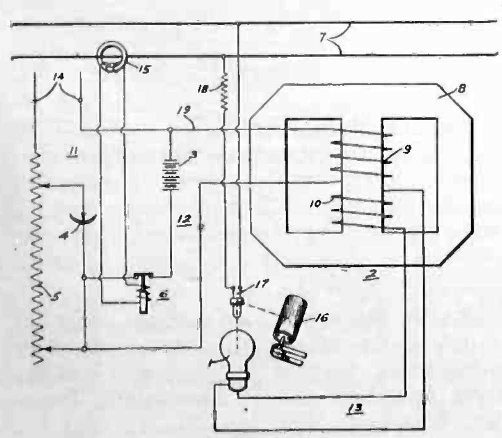
Signaling system. An amplifier system for communicating with trains. J. P. Barton, Westinghouse E. & M. Co. No. 1,905,260.

Co-planar tube. A pair of interlocked grid structures and spaced anode plates; the grid-plate capacities all being substantially equal to one another. E. H. Kurth, assigned to W. E. Co. No. 1,909,411.

Dynatron. Method of using a dynatron as an amplifier. P. O. Farnham, assigned to R.C.A. No. 1,909,940.

Antenna system. Directional system. E. Bruce, assigned to B. T. L., Inc. No. 1,910,147.

Light source control system. Method comprising a saturated core transformer with a lamp in the secondary winding and d. c. through the primary. J. W. Legg, assigned to W. E. & M. Co. No. 1,911,371.



Condenser tester. Means for repeatedly and rapidly charging a condenser and means for reading the charging current and the discharge current. C. J. Assigned to Joseph Weidenhoss, Inc., No. 1,906,466.

Timing arrangement. A condenser and resistance connected with a gaseous discharge device and a relay. K. H. Blomberg. Assigned to L. M. Ericsson, No. 1,907,279.

Photometric instrument. In combination with a light source a ratio indicating instrument having elements responsive to the quantity of light emitted by the source and the energy consumed thereby. F. C. Hoare. Assigned to G. E. Company, No. 1,906,597.

Light control system. Apparatus for detecting the variation in properties of fluid by measuring the variation of the optical properties, including a photo sensitive means. C. A. Styer, assigned Assigned to Westinghouse E. & M. Co. 1,905,251.

Tube voltmeter. A push-pull voltmeter with the indicating meter in the common plate lead and means for compensating differences in amplification constants of the two tubes. J. D. Booth. Assigned to Westinghouse S. & M. Co. No. 1,907,487.

Direct reading meter. Method of reading directly ohms and capacities by means of a vacuum tube oscillator. P. S. Edwards and C. D. Barbulesco. Nos. 1,905,348, 1,905,349 and 1,905,332.

System of control.—Method for controlling the motion of an object movable in a constrained path using vacuum tubes. R. B. Taylor, assigned to G. E. Co. No. 1,910,190.

Voltage regulator. Method of controlling the voltage of a d-c generator by means of vacuum tubes by impressing upon these tubes a potential determined by the difference in the generator voltage from a desired value. F. H. Gulliksen, assigned to W. E. & M. Co., No. 1,909,054.

Frequency meter calibration. A stroboscopic method of calibrating frequency meters using light sensitive cell. E. H. Greibach, assigned to W. E. & M. Co. No. 1,909,103.

A capacity controlled relay. Automatic control for photographing exposures. A light sensitive means for varying the light falling on a film in the printing process. L. A. Jones and C. M. Tuttle. Assigned to Eastman Kodak Co. No. 1,908,610.

Television system. Method for synchronizing the speed of a rotating armature with received signals by a circuit with an element which passes no current for less than a minimum applied voltage and a means for periodically reducing the voltage supplied below said minimum. H. C. Donle, assigned to Radio Inventions. Filed Sept. 17, 1928. No. 1,903,986.

Amplifier. Push-pull amplifier of four tubes, two on each side of the circuit with the grids and plates parallel but with the filaments in series. J. L. Reynolds, assigned to E.R.P.I. Filed Dec. 31, 1929. No. 1,904,533.

Lamp testing. Apparatus for testing incandescent lamps composed of an evacuated or gas-filled enclosure. A receptacle into which the device may be inserted and a high frequency electrical discharge circuit with current indicating means actuated by the current flowing in the circuit while the device is being subjected to the discharge. W. L. Kubach, assigned to G. E. Co. No. 1,904,059.

Stroboscope. A source of supply of d.c., a reactor and a capacitor in series, and connected with said source, a vapor electric discharge device to be energized from the capacitor and provided with a control grid and means for controlling the charge on the grid. W. D. Cockrell, assigned to G. E. Co. Filed Aug. 27, 1932. No. 1,904,124.

Control system. An a-c load circuit and control means for the circuit comprising electric valve apparatus provided with a control grid and a means for supplying a variable d-c control voltage to the grid. O. W. Livingston, assigned to G. E. Co. Filed Sept. 11, 1931. No. $1,904,485.

Amplifiers, Etc.

Push-pull amplifier. A two-stage cascade amplifier, a pair of transformers in the first stage having their primary winding connected in reverse parallel and a secondary winding in series. F. Thorington, Birmingham, Ala. Filed Nov. 15, 1929. No. 1,904,103.

Low frequency amplifier. Interstage coupling circuit composed of a transformer with a low ratio of transformation selected to approximately match the plate circuit impedance of the preceding tube with the grid circuit of a succeeding tube, when the grid thereof swings considerably positive whereby the introduction of distortion due to the flow of grid current in said amplifier is minimized. H. A. Wheeler, assigned to Hazeltine Corp. Filed Feb. 17, 1927. No. 1,904,185.

Interstage device. Circuit for connecting the output of a tube to the input of the following tube. K. Posthumus, assigned to R.C.A. No. 1,904,524.

Patent Suits

1,195,632, W. C. White, Circuit connections of electron discharge apparatus; 1,251,377, A. W. Hull, Method of and means for obtaining constant direct current potentials; 1,728,879, Rice & Kellogg; Amplifying system; Re. 18,579, Ballantine & Hull, Demodulator and method of demodulation; 1,811,095, H. J. Round, Thermionic amplifier and detector, filed Apr. 24, 1933, D. C., S. D. N. Y., Doc. E 75/346, Radio Corp, of America et al. v. Radio Syndicate, Inc.

1,231,764 (a), F. Lowenstein, Telephone relay; 1,618,017 same, Wireless telegraph apparatus; 1,465,332, H. D. Arnold, Vacuum tube amplifier; 1,573,374, P. A. Chamberlain. Radio condenser, filed Apr. 24, 1933, D. C., S. D. N. Y., Doc. E 75/345, Radio Corp. of America et al. v. Radio Syndicate, Inc.

1,231,764 (b), F. Lowenstein, Telephone relay; 1,618.017, same, Wireless telegraph apparatus; 1,403,475, H. D. Arnold, Vacuum tube circuit; 1,465,332, same, Vacuum tube amplifier, D. C., So. D. N. Y., Doc. E. 74/456, Radio Corp. of America et al. v. H. F. Lyman (Lyman Mfg. Co.) et al. Consent decree for plaintiff (notice Apr. 27, 1933).

BRITISH PATENTS
IN THE FIELD OF ELECTRONICS

Electronics Application

Deafness tester. Apparatus for testing and treating deafness comprising a valve generator having means to vary the frequency throughout a wide range without change of volume and means for widely varying the volume without changing the frequency. O. E. Marvel, Grand Rapids, Mich. No. 388,594.

Gaseous tube circuits. Vapor electric device rendered fully conducting by applying a high frequency potential to the grid circuit and non-conducting when a variable negative grid bias exceeds the amplitude of the high-frequency potential. The invention is applied in a system for alternately dimming and brightening simultaneously the lamps in two different circuits. B. D. Bedford, British Thomson-Houston Co. No. 388,809.

Constant frequency generator. Grid controlled rectifiers utilized to maintain the vibration of a tuning fork and arranged in push-pull so that starting the discharge in one tube stops the discharge in the other. G. E. Co., Ltd. No. 388,904.

Photo-electric engraving system. Process and apparatus for producing engraved surfaces with the aid of a mechanical cutter, the depth of cut regulated by coils energized by variations in the amount of light reflected in accordance with the variations in tone from the original onto the photo-electric cell. In this circuit, grid-controlled rectifiers are used to drive the cutting tool. J. W. Dalton, 16 Abbott Ave., Wimbledon, London. No. 389,102.

✦

Radio Circuits

Detection circuits. Method of overcoming the defect of a square law detector which accentuates the difference between loud and soft passages of the program. One method is by amplifying weak signals more strongly than loud signals. L. Pungs, Brunswick, Germany. No. 387,182.

Short-wave generator. Method of generating oscillations of the order of a few centimeters in length by a special structure tube. C. W. Rice, assigned to British Thomson-Houston Co. No. 387,697.

Low frequency amplifier. A resistance capacity coupled amplifier with an inductance in series with the coupling condenser to increase the relative amplification of the higher frequencies and a condenser in parallel with the inductance to tune it to the frequency at which a cut-off is desired, for example 9,000 cycles. Siemens & Halske, Berlin. No. 387,912.

Frequency changer. Method of adapting a receiving set for reception of wave lengths outside its tuning range by interposing between the antenna and the receiver a frequency changing device. I. Diaz, Neuilly, France. No. 388,235.

Frequency generator. A crystal control generator coupled to a second generator so as to maintain the frequency of the second at a figure which is an integral fraction of the former. The lower frequency modulates the higher frequency. F. J. Moles, assigned to British Thomson-Houston Co. No. 388,014.

Noise suppressor. Method of utilizing the r-f component in the AVC system to control the a-f amplifier so that this is inoperative in the absence of a signal. T. B. Morehouse, Marconi Co. No. 388,601.

Intermediate frequency coupling device. One coil, preferably the primary of an inter-stage transformer is tuned by a condenser to the intermediate frequency and the other coil so wound as to be resonant at a frequency higher than the intermediate frequency but lower than the lowest signal frequency to which a receiver can be tuned. The transformer as a whole resonates at the intermediate frequency. The secondary coil acts as capacity at all frequencies within the tuning range and attenuates signals which penetrate the first detector without change of frequency. W. A. MacDonald, Hazeltine Corp. No. 389,026.

Plate current reducer. The grid bias of a valve amplifier varies with the signal volume, the bias becoming so much more negative as the volume diminishes that the sum of the bias and the signal voltage is practically constant. In this way the consumption of plate current is reduced and the efficiency increased. Philips, Holland. No. 388,292.

FIG.1.

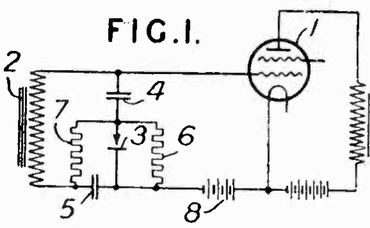
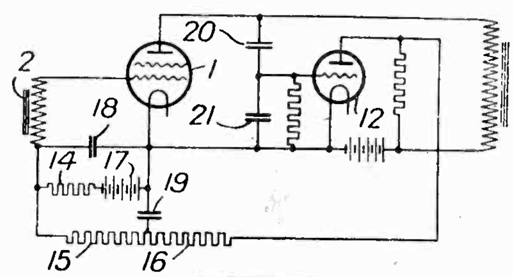


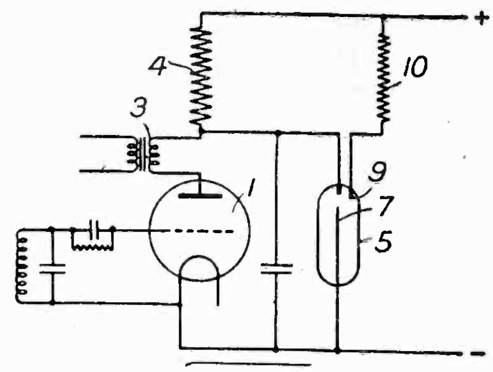
FIG.2.



Aircraft radio. Method of compensating for disturbances picked up by the aerial and due to the engine ignition system. To the input of the receiver components of correct amplitude and phase obtained from the disturbing source are applied by means of an auxiliary linear aerial. H. H. Beverage, Marconi Co. No. 384,470.

Battery eliminator. In a device to operate on d. c. or a. c., a choke is provided which functions as a smoothing choke during d. c. operation and as a transformer during a. c. operation. A. E. G., Berlin. No. 388,313.

Visual tuning device. Visual indication of the signal strength in a receiver is obtained from a glow discharge tube connected between the junctions of the detector anode impedance and the output transformer and the cathode circuit. G. E. Co., Ltd. No. 388,516.



Amplification, Generation, Etc.

Relaxation oscillators. Two generators, each comprising a neon tube in parallel with a condenser and supplied from a d.c. source through a resistance are interconnected by means of an electro-magnet, so that the ratio of frequency of the two circuits is maintained constant. Papeteries Navarre, Lyons, France. No. 386,327.

Distortion compensation. Frequency distortion in a photocell feeding an amplifier is counteracted by a frequency discriminating arrangement for television purposes. H. E. Ives assigned to ERPI. No. 386,296.

Modulation system. Use of a gaseous or vapor tube as a variable capacitance in a high-frequency signal transmission system in which a sheath of positive ions is attracted by a negative charge on an electrode. The thickness of the sheath, and so the capacitance, is controlled in accordance with the signals and varying the frequency of the oscillation transmitters. I. Langmuir assigned to British Thomson, Houston Co. No. 386,356.

Recording system. A gas-filled cell for use in reproducing photographic sound records has electrodes formed or arranged so that a highly non-uniform field of great density is produced at the anode together with an unstable ionization which raises the power of the cell and is completely controllable by variations of light with the highest potentials below the spark potential, without permitting a disturbing glow discharge. The cell may be used without a voltage amplifier. W. Barsties, Berlin. No. 386,369.

Code system. Single-current signals such as audio-frequency signals are converted into double-current signals by means of a tube so arranged that spacing the current is cut off as soon as marking current is received. Siemens Bros. & Co. No. 386,743.

Ac-Dc Receiver. An arrangement for radio set operation from either direct or alternating current by means of change over switches. C. P. Stanworth, Burnley, England. No. 386,776.

Measure C, R, L, and Power Factor on This New Bridge

Note These Wide Ranges!

Capacitance: 8μμf to 100μf
Resistance. 0.01Ω to 1MΩ
Inductance: 5μh to 100h

THIS new bridge furnishes a ready means for measuring the capacitance, resistance, and inductance of circuit elements and of determining in a single operation, the power factor of the condenser and the "Q" of inductors. Except for the necessary head telephone used for the a-c measurements, the instrument is entirely self-contained.

The extremely wide range of values that this bridge can cover makes it of tremendous importance to the experimental laboratory where the need for measuring anything that may come up with good accuracy is of importance. For the first time an all-purpose bridge is commercially available at a reasonable price.

The Type 650-A Impedance Bridge is priced at $175.00.

A new skeleton-type bridge is also available for laboratories where the wide range of the Type 650-A Impedance Bridge is unnecessary. The Type 625-A Bridge, with additional plug-in condensers and resistors, will be found useful for building up limit bridges and other special purpose instruments. *Price: $65.00 without accessories.*

Write for descriptive literature on these two new bridges. Ask for Bulletin EX-3304 and address the General Radio Company, 30 State Street, Cambridge, Massachusetts.

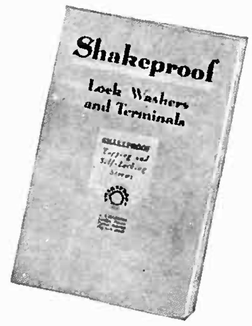
GENERAL RADIO COMPANY

SHAKEPROOF

YOUR PRODUCT IS GOING FOR A "RIDE"

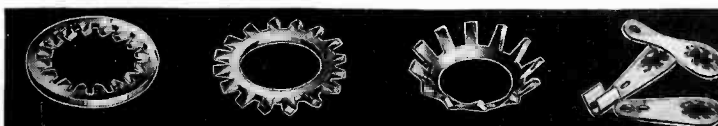
LOOK out! There's going to be a lot of rough treatment and bumpy rides that your product must be able to stand. If connections become loose and parts fall off, you can rest assured your customers will be far from happy. Don't take any chances—put Shakeproof Lock Washers under every nut and screw—then you'll know your product will go through in perfect condition. Let us send you complete information about our "Vibration Control" principle, and also be sure to request free testing samples for a thorough trial in your own shop. Write today!

It's the Twisted Teeth that LOCK!



Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

SHAKEPROOF
Lock Washer Company
(Division of Illinois Tool Works)
2539 N. Keeler Ave. Chicago, Ill.



Type 12. Internal	Type 11. External	Type 15. Countersunk	Type 20. Locking Terminals

U. S. Pat. 1,419,564—1,604,122—1,697,954—1,782,387—Other Pat. Pending—Foreign Pat.

BOOKS ON ELECTRONIC SUBJECTS

Einführung in die Elektronik

(Introduction to Electronics); Otto Klemperer; Verlag von Julius Springer, Berlin: 1933; Paper covers: 18.60 marks ($4.50); bound: 19.80 marks ($4.75)

DR. KLEMPERER HAS COMPILED in this comprehensive work an account of the experimental literature bearing upon the electron, its properties and behavior, with emphasis on the developments of the post-war period. The book is dated March, 1933, and covers the literature to the end of 1932.

The book is divided into three main headings: (1) The Free Electron; (2) Electron Emission; (3) Interaction between Free Electrons and Atoms.

The first section opens with methods of accelerating electrons, and the theory of the variation of mass with velocity. The mathematical expressions for the paths under the influence of electric or magnetic fields, or combinations of the same are given, and the experimental apparatus for velocity analysis outlined. Of especial interest are the so-called "electric lenses" and "magnetic lenses," which permit a tremendous concentration of the electron beam traversing them. The various methods for showing the action of free electrons are then taken up: viz., ionization chamber, anode heating, fog-tracks, B-ray scintillations, and traces on photographic plates. A section is devoted to the determination of the charge and mass of the electron. The fundamentals of the wave-mechanics theory are briefly stated, and application of the Fermi Statistics made to the electron gas in the interior of a metal.

The second main section deals with electron emission. Some criticism may be directed at the portion devoted to thermionic emission on account of its somewhat sketchy and non-critical character. The part dealing with photoelectric phenomena is more complete, although here also there is evidence that the author is relying upon other compendia. Professor DuBridge's large and excellent treatise fails to receive mention.

The final section deals with the interaction between electrons and atoms. The difficulties of applying the Schrödinger wave equation to any but the simplest cases is pointed out, and some of the results of approximate solutions of the problem of charge distribution in the atom are given. Scattering of electrons by the fields of the atoms and molecules they pass is described. Electron diffraction experiments receive considerable attention. The latter subdivisions deal with the experimental work on excitation and ionization voltages, electron absorpton, and the newer concepts of "free wavelegth" and "electron diffusion."

Dr. Klemperer is to be thanked for the lucid style and clear language used. The book is plentifully supplied with line drawings, and there are some beautiful experimental photographs.

An investigation of high-selectivity receiving circuits

By F. M. Colebrook. (Special Report No. 12, of the Radio Research Board) 69 p. with 22 diagrams. H. M. Stationery Office, London, Price 1s. 3d.

THE REPORT DISPOSES of the hope that the adoption of receivers with extremely selective tuning and tone-correction in the audiofrequency stages would permit the use of a larger number of stations within a given frequency band. It was found that the combination of high selectivity and tone correction merely reduces cross-talk, but is not insensitive to the interference between the wanted carrier and the carrier or side-waves of the interfering station (audible or inaudible beat). One half of the report is devoted to a theoretical, the other half to the experimental study of the problem (Transient conditions are not taken into account although the inventor of the circuits insisted at the time on the part they play, and the answer may therefore not be as definite as might be desired. The report attributes these effects to asymmetry in the resonance curve). The quartz crystal is found to have an inherently asymmetrical resonance curve even when a balanced bridge connection is used, resulting in harmonic distortion and non-uniform response to the modulation frequencies.

Thyratron control of welding in tube manufacture

[*Continued from page 187*]

T_1. The bias is reduced by commutation of T_2 to the voltage drop across resistor R_7 instead of to zero, and the peaked a-c grid voltage from peaking transformer Tr_3 is of sufficient magnitude to overcome the reduced bias and fire T_1. Curve D of Fig. 3 illustrates this type of grid excitation in the "firing" position. Shifting the phase of the grid transformer primary voltage by varying R_1 shifts the position of the peak, in this way controlling the length of the conducting period.

Examples of the performance are shown in Fig 4 and Fig. 5. Fig. 4 (left) shows an extreme case of the bad discoloration using manual control on an experimental assembly as compared to the same assembly (right) made with a half-cycle Thyratron control welder. Examples of various welds are given in Fig. 5. These welds were made with little difficulty, the only requirements being sufficient current for fusion and ample pressure to prevent sparking at the high current densities. The welding current ran as high as 6000 amperes peak for some of these welds.

A panel capable of delivering 75 amperes peak current to the primary of a welder transformer has been in operation at R.C.A. Radiotron Company. A panel of this current capacity operating from a 220 volt a-c source has sufficient kva capacity to meet most of the requirements of receiving tube manufacturers.

One of these panels, in conjunction with a suitable distributor, would supply up to ten one-half cycle spot welders and each welder have a maximum delay of only one-half second between closing the control switch and making the weld. Each welder would have a series resistor or taps on the transformer to regulate the current to the best value for the operation performed on that particular welder.

For many types of work the results obtained by the control described are so far superior to that obtainable with mechanical control that this system should have a wide field of application. The initial cost, although higher than most of the usual types of control, is warranted because of the superiority of the results obtained.