electronics

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

Progress in Industry Code

·

Cost versus quality in loudspeakers

·

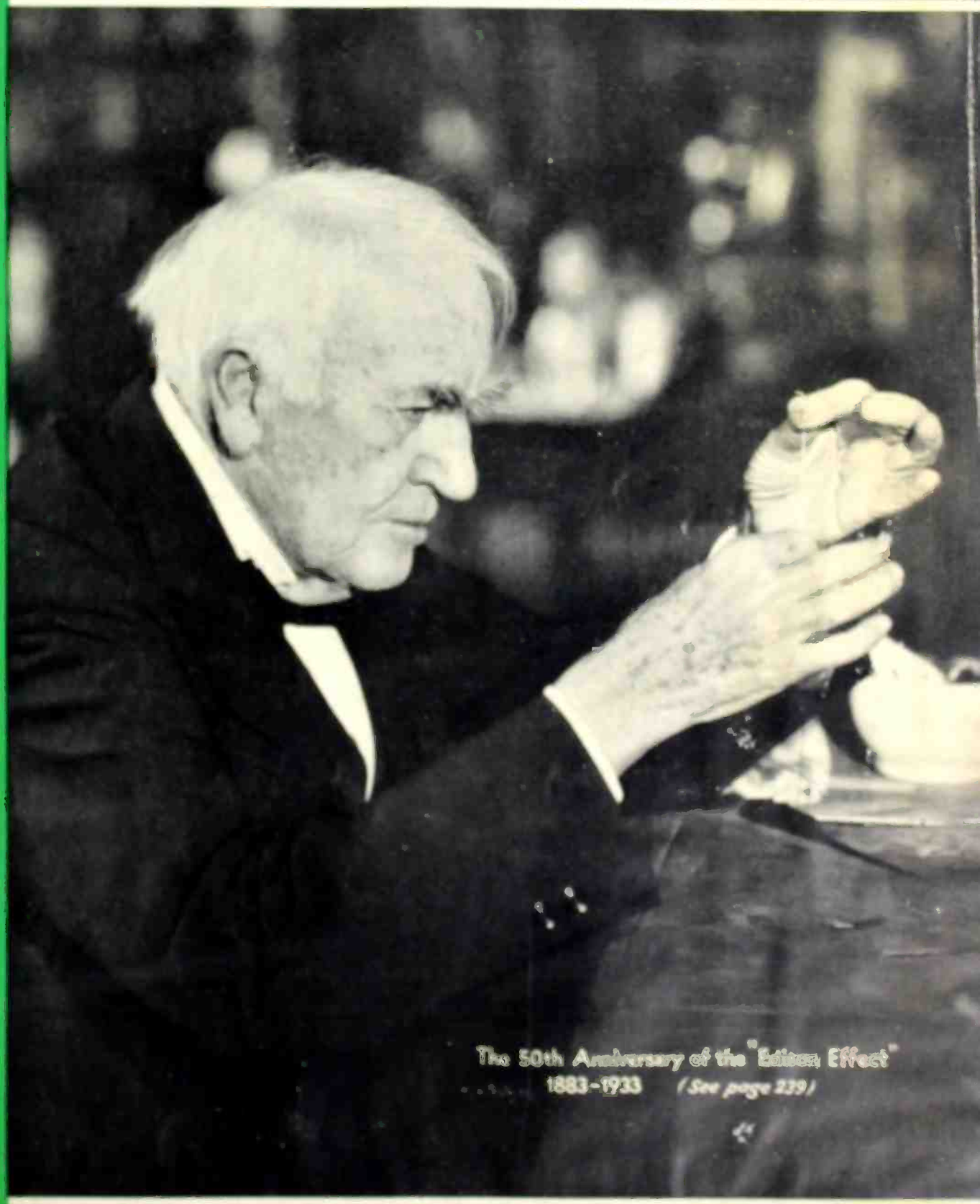
Testing mercury-vapor tubes

·

An electron microscope

·

Electron tube emitters



The 50th Anniversary of the "Edison Effect" 1883–1933 (See page 229)

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SEPTEMBER, 1933

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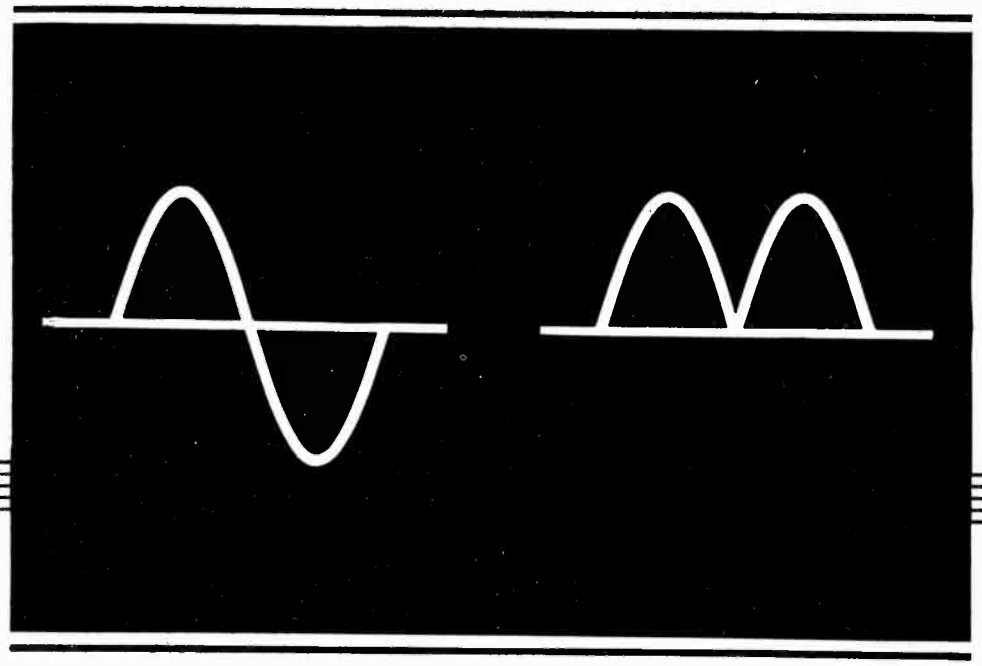

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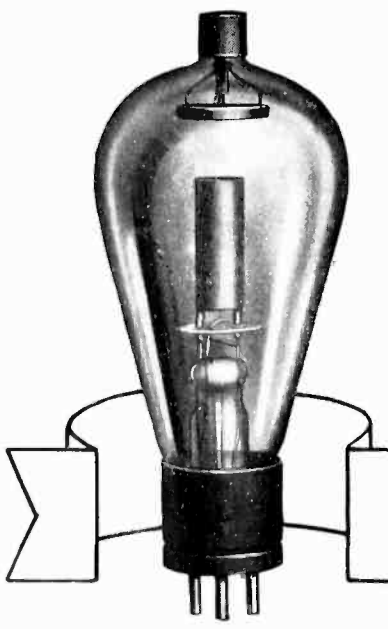

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301-139

GENERAL ELECTRIC

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SPEAKER AND CAPACITOR HEADQUARTERS

The Magnavox Company

FORT WAYNE, INDIANA

NRA MEMBER U.S. WE DO OUR PART

SUMMERILL ADDS MORE EMPLOYEES TO PAY ROLL

SMALL TUBE DEPARTMENT NOW RUNNING 24 HOURS

Radio Industry Takes Increased Output of Pure Nickel Tubing

INCREASING demands of the radio industry for nickel tubing have made it necessary for the Summerill Tubing Company to increase further the output of the small tube department at their Bridgeport plant.

Beginning with Monday, August 21st, this department operated 24-hours per day, with three 8-hour shifts.

This activity is due to the fact that precision tubing of pure nickel is ideally suited for use in electronic tubes and other radio purposes, and also because of the low present cost of this material.

The Summerill Company during 1930, 31 and 32, revamped and modernized its equipment and manufacturing processes so that radio tubing today is sold at one sixth the price which prevailed in 1929.

The Summerill Tubing Company located in Bridgeport 23 years ago. It was founded in Philadelphia in 1899. The first plant was a single room, 20′ x 30′, and the first product was precision steel tubing. In a short time only, however, other metals, brass, copper, aluminum, nickel silver, etc., were being manufactured.

Practically all of the materials manufactured by the company were taken by concerns that even, at that time, wanted to escape the necessity of machining the tubes which were used in their processes, and the business from the beginning was a success.

In 1910 the company moved to its present location and spread out into larger sizes and heavier wall tubing.

In 1914 the company succeeded in obtaining practically the entire hypodermic needle tubing market in this country, and ever since it has dominated that field.

Because of their experience in producing very small tubes, the radio industry turned to the company when pure nickel was found to be the most suitable metal in connection with the production of radio tubes. The company was prepared to produce large quantities, and in 1928 set about taking care of this additional demand upon its facilities. This business grew to such an extent that in 1929, even though its other lines were being produced by the company at a higher rate than ever before, the radio tube manufacturers took the largest percentage of the company's total output for that year.

Now, as in 1929, the radio industry takes a larger percentage of the company's output than any other line of business the company serves.

SUMMERILL TUBING CO.

(RADIO TUBE DIVISION)

Bridgeport (Phila. Dist.) Pa.

AGAIN OBSOLESCENCE TAKES IT ON THE CHIN!

Announcing

A *New* Weston TUBE CHECKER

NO LONGER is there any need for worrying about tube checker obsolescence. Again Weston has supplied the solution; providing a design with 18 sockets, 11 of which are wired to test all of the present tubes, some 90 in number. The remaining 7 sockets are spares, and can be quickly wired in to test some fifty-odd additional tubes, when and if these tubes appear on the market.

Weston Model 674 Tube Checker is an "English Reading" tester—and is outstanding in its simplicity of operation. All reference to or knowledge of tube characteristics is avoided. The operator simply follows the few concise steps indicated on the tube limit chart and correct indication is obtained in minimum time.

Moreover, by means of the cathode leakage button the testing of all cathode type tubes for leakage between cathode and heater is readily accomplished—and in the same socket used for regular tests on the tube. Independent checking of the second plate in all double plate tubes also is accomplished simply by throwing a toggle switch.

And there are many more outstanding features—a few of them listed on the right. They will explain why Weston Model 674 is the outstanding value in tube checkers today. The coupon will bring descriptive circular RA. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

OUTSTANDING FEATURES:

1. *Attractive appearance—harmoniously finished in three tones of brown.*
2. *"English Reading". Excellent readability.*
3. *Simplicity of operation—no calculations necessary.*
4. *Lowest obsolescence factor.*
5. *Tests second plates, all tubes—diodes, duplex and rectifier.*
6. *Tests cathode leakage by simply pushing a button.*
7. *Individual standard replaceable sockets.*
8. *Line voltage adjustment.*
9. *No adapters required.*

Also, the new Weston Model 673 Tube Checker. Combines attractive appearance, good testing ability, and low price. . . . Send coupon for descriptive bulletin.

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WESTON *Radio Instruments*

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Please send circular RA containing full information on Model 674 Tube Checker and other radio instruments.

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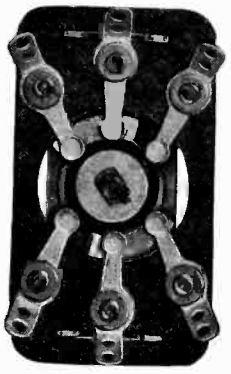

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ACHIEVEMENT

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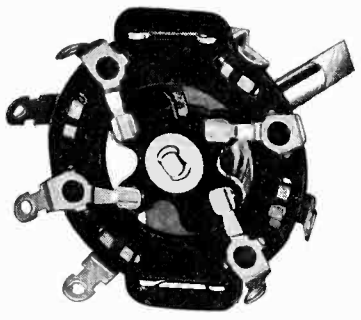
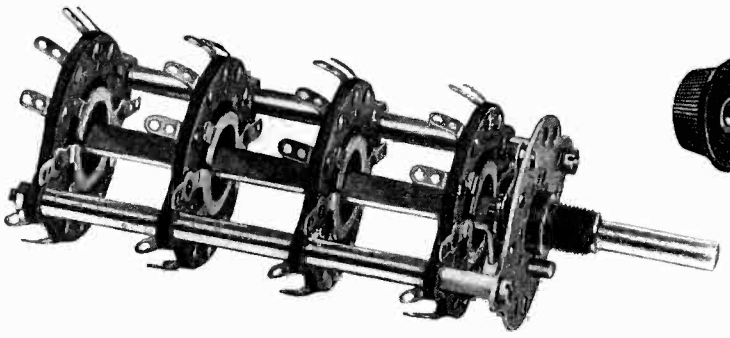
Yaxley switches simplify complex switching problems in radio receivers, instruments, meter circuits, testing devices and other radio and electrical applications.

Many types of switches are included in the complete Yaxley line. Switches in the single section types are provided with as many as six pole single throw operations. Combinations, incorporating groups of sections (each section providing several circuits assembled in a minimum space) are also available.

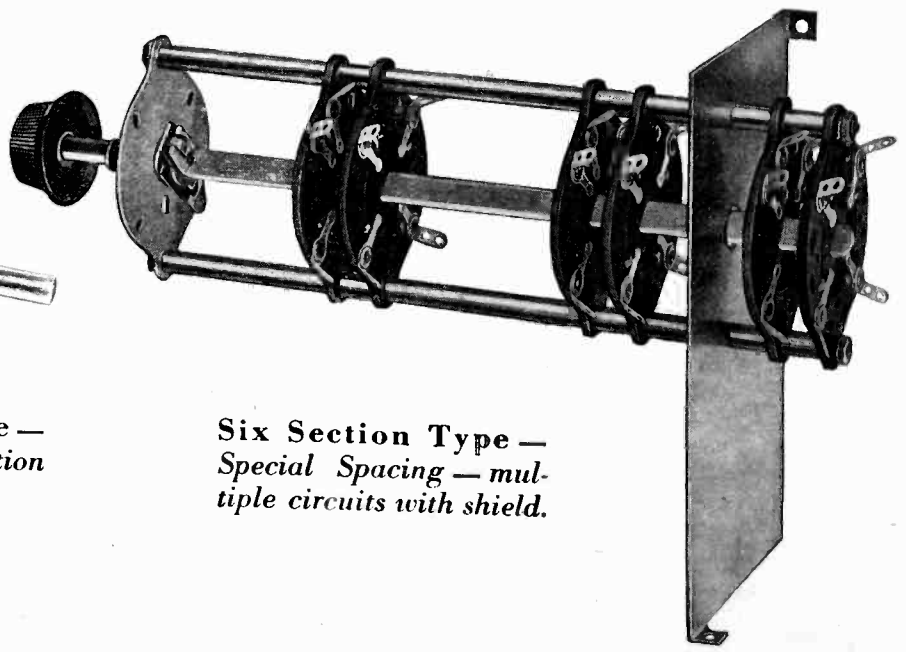
Send us your circuits — or a sketch of your switch showing circuits, contact points and spacing between sections — and we'll gladly mail a sample of the Yaxley switch that will best meet your requirements.



No. 2141 — *Range Switch, four circuit, single throw.*



Four Section Type — *Two circuits, each section Standard Spacing.*



Six Section Type — *Special Spacing — multiple circuits with shield.*

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electronics

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McGRAW-HILL PUBLISHING COMPANY, INC.

New York, September, 1933

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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

The New Leisure—

and the electronic arts

THE New Deal has restricted the hours of labor and thereby has introduced a tremendous amount of New Leisure. A current estimate places this sudden new recreation time at *thirteen million hours per week.*

Sooner or later this "Niagara of leisure" will have to be absorbed in part by amusements, sports and other recreations. A large part will be devoted to such electronic entertainment as radio, sound-pictures, home talkies, phonograph reproduction, synthetic musical instruments, and eventually, television.

Thus, suddenly our products are called upon to help shoulder the burden of the New Leisure. New markets are opened up for our entertainment carriers, multiplying their importance far beyond their former relationship in a world that worked long hours with little time for recreation. Now all forms of electrical entertainment find themselves in a new and rising market.

WHATEVER the restrictions placed on production and expansion in other industrial fields, under the new order of things, it is clear that a new boon and a new boom have been handed to the electronic industries of radio, sound pictures, and associated fields. The far-reaching influences of these will be more apparent as the months of NRA roll on.

Make no mistake about it. The New Leisure is a new deal for the electrical entertainment industries—an *expanding* opportunity for the electronic arts.

RADIO CAMPAIGN ON—

September sales drive to culminate in Radio Progress Week, Oct. 2 to 7

JUST fifty years ago, in 1883, Thomas A. Edison discovered the flow of electrons across the vacuum of his early incandescent lamp, laying the foundation for the whole electronic industry, radio, and other applications of thermionic amplification.

And this month, appropriately enough, the radio industry starts its sales campaign, leading to Radio Progress Week, which will be celebrated Oct. 2 to 7. Radio Progress Week thus marks fifty years of the electronic arts, beginning with the first faint phenomena detected by Edison, which thereafter lay unused for almost a generation, but now expanded into services that span the earth and entertain its peoples of every land.

Radio Prosperity Campaign

The Radio Prosperity Campaign is being conducted under the auspices of the Radio Manufacturers Association which has organized a special staff to issue campaign posters, placards, booklets and circulars to promote radio receiving set sales during September. Campaign headquarters are at 330 W. 42nd St., New York City.

Local committees have been set up in the retail and wholesale radio trade in a hundred or more cities, and the development of local radio campaigns is being pushed by these local groups. A number of radio shows are being held during the month, and newspapers are giving the subject of radio special attention, some papers even issuing radio supplements in connection with local shows and local observations. Service men's organizations are also making special drives to put all listeners' sets into best operating condition.

The September Campaign is designed to get the homes of the United States equipped with improved radio reception in order to hear the special features which will be on the air during Radio Progress Week, October 2 to 7. For this week, both the great national chains and the independent broadcasting stations are co-operating with special programs, designed to attract the attention of listeners, and to demonstrate the great advances that have been made in radio transmission and reception as a means of delivering improved realism, tone quality and musical values.

Thus during September and October a well-planned drive is underway to create more radio sales and more radio volume, which should be felt throughout the whole industry, all the way back to the set and parts manufacturers and engineers.

NRA puts radio under NEMA code

Meanwhile the radio industry has been having its code worries under the National Recovery Administration. At the time the last issue of *Electronics* appeared, it was the plan of the Radio Manufacturers Association to draft and operate under its own special Radio Code, and a committee headed by W. Roy McCanne of the Stromberg-Carlson company, worked long hours and many days in New York and Washington to shape up a code that would meet the agreement of the many interests in radio, as well as have the approval of the NRA administrator at Washington. This special radio code, as submitted, was outlined in the last issue of *Electronics*.

On August 24, however, Deputy Administrator Allen informed the RMA committee that the special Radio Code would be unacceptable to the NRA, pointing out that he considered especially objectionable (1) the provisions for setting up "average costs" of manufacture as the cost figure to be adopted by all manufacturers, and (2) the uniform sales agreements between manufacturer, wholesaler and retailer, which were a part of the code. Administrator Allen advised that the radio manufacturers withdraw their code and apply to come in under the Electrical Manufacturers Code, submitted by the National Electrical Manufacturers Association (NEMA), which had already been approved by the President on August 5, and which went into effect August 16. The radio men were told that, while they were free to submit a revised radio code, there was grave danger that at a hearing objection would be raised and that there was little likelihood that any future code could be gotten through with wage provisions as favorable to the employers as those embodied in the NEMA code. Thereupon the RMA code committee withdrew its own code, and the RMA board of directors at a special meeting approved the application of the radio manufacturers to be included under the NEMA Electrical Code.

NEMA will administer code

The NEMA code fixes 36 hours as the maximum week's work in processing departments, and prohibits employment of any one under 16 years of age. For all other employees, except executives and traveling and commission sales people, a 40-hour week is prescribed. Minimum wages are fixed at 40 cents per hour, except in cases where the 1929 rate was less, but in no case shall the rate be under 32 cents per hour. Learners must be paid at least 80 per cent of the minimum, and the number of learners must not exceed 5 per cent. The minimum wage outside of processing employees must not be under $15 a week.

Administration of the code upon all radio manufacturers will be in the hands of an organization set up by the National Electrical Manufacturers Association, and the cost of such administration will be prorated among the radio manufacturers whether members

The portrait of Mr. Edison on the front cover has been declared the best photograph ever made of the great inventor, intent on a problem. It was taken at Dearborn, Mich., by the photographers of the Ford Motor Company.

RMA ACCEPTS NEMA CODE

NRA administrator turns down radio code. Radio manufacturers put under electrical body

or non-members. It also seems likely that a Radio Section of NEMA will be formed, similar to the many other sections already set up among groups of manufacturers of various electrical specialties and supplies. If such a Radio Section is formed, its members will have the opportunity to draft a Radio Supplemental Code to the NEMA code, into which can be introduced special considerations bearing on fair practice and trade relations in the radio industry. The objections made by the NRA administrator to the RMA code will, however, apply to such future supplementary radio code.

An RMA committee to work out methods for the administration of the new Electrical Code under NEMA, has been holding conferences with the NEMA organization at the latter's headquarters, Commerce Building, 155 East 44th St., New York City. This committee comprises Arthur T. Murray, United American Bosch Company, James M. Skinner, Philco Radio & Television Company, and David T. Schultz, Raytheon Production Company.

After a plan of administration has been developed, it is expected that a meeting of the RMA board of directors and members will be called, to ratify the plan determined upon. Already a number of radio manufacturers who are also electric-refrigerator makers, are members of the NEMA, and it is expected that the others will also join. The future of the RMA organization itself was in some doubt as this issue goes to press. One group of members insisted on the importance of radio maintaining its separate identity; another group objected to paying dues to two associations, and recommended the dissolution of the RMA and the division of its assets among the members.

Following are some of the significant provisions of the NEMA Code:

"V. With a view to keeping the President of the United States and the administrator informed as to the observance or non-observance of this code and as to whether the electrical manufacturing industry is taking appropriate steps to effectuate in all respects the declared policy of the National Industrial Recovery Act, each employer shall, no less than once in each year, prepare and file with the board of governors or the executive committee of National Electrical Manufacturers Association an earnings statement and balance sheet in a form approved by said boards of governors or said executive committee or in a form acceptable to any recognized stock exchange. Each employer shall likewise prepare and file with such person or organization as the board of governors or the executive committee of National Electrical Manufacturers Association may designate and at such times and in such manner as may be prescribed, statistics of plant capacity, volume of production, volume of sales in units and dollars, orders received, unfilled orders, stocks on hand, inventory, both raw and finished, number of employees, wage rates, employee earnings, hours of work, and such other data or information as the board of governors or the executive committee of National Electrical Manufacturers Association may from time to time require."

No sales below cost

"IX. No employer shall sell or exchange any product of his manufacture at a price or upon such terms or conditions that will result in the customer paying for the goods received less than the cost to the seller, determined in accordance with the uniform and standard method of costing hereinabove prescribed, provided, however, that dropped lines, seconds, or inventories which must be converted into cash to meet emergency needs may be disposed of in such manner and on such terms and conditions as the supervisory agency may approve and as are necessary to move such product into buyers' hands, and provided further that selling below cost in order to meet existing competition on products of equivalent design, character, quality or specification shall not be deemed a violation of this article if provision therefor is made in supplemental codes for any branch or subdivision of the industry, which may be hereafter prepared and duly approved by the administration."

▼

The basic thermionic discovery, as described by Mr. Edison in his patent application of Nov. 15, 1883.

"I HAVE discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candle-power of the lamp."

▲

Loudspeaker cost vs. quality

By HUGH S. KNOWLES

Chief Engineer,
Jensen Radio Mfg. Company

A SURVEY of the speakers now manufactured shows that emphasis has been placed on small size as well as on low price. A practical discussion of the influence of cost on performance, therefore, becomes a consideration of the influence of size on performance. For the sake of brevity and concreteness, the average performance of a number of 5-inch ($3\frac{3}{4}$ in. piston) and 12-inch ($9\frac{3}{4}$ in. piston) speakers will be compared.

The principal criteria of loudspeaker performance are loudness efficiency[1], type of response and power handling capacity. The term "type of response" rather than "fidelity" is used because it appears that fidelity or exact reproduction of the original is seldom wanted. The emphasis is usually on bass response even though "synthetic" and on other characteristics which make the combined speaker and set sound like a radio and have consumer acceptance.

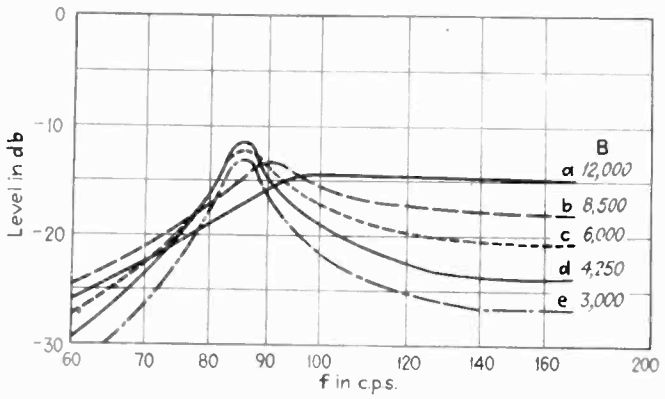


Fig. 1—Variation of output near resonance of good 12-inch speaker. Curve a represents fully excited field; curve d critical value of B for maximum output at resonance

Special emphasis is placed on loudness efficiency in inexpensive speakers because they are usually used with sets having limited electrical output. Of almost equal importance is bass response or an illusion of it. Here the small speaker is asked not only to overcome its own handicap as a sound radiator at low frequencies but to do it in a cabinet which affords very little effective baffle.

Loudness efficiency in small speakers is closely allied with fidelity. Many design considerations are common to both and to simplify the discussion, these will be treated jointly and only a few of the most important considerations discussed.

In considering loudness efficiency and fidelity, it is convenient to divide the response of the speaker into three ranges. These are:

(1) The resonant range from the lower cutoff to from 100 to 300 cycles depending upon the natural period of the system. (2) The piston range extending from (1) up to 600 to 1,000 cycles in the speakers here considered and (3) the high end or top extending from the first center moving mode to the upper cutoff frequency.

Calculations of speaker efficiency are most commonly made in the piston range because the assumptions which are made regarding radiation resistance, mechanical impedance, etc. hold closely and the performance can be accurately predicted. Unfortunately, the calculated efficiencies of two speakers in the piston range do not give an accurate index of their relative loudness efficiency. It gives values which are too low particularly in the case of inefficient speakers. This is due to the fact that the sound pressure in the piston range, measured on the speaker axis, is less than it is at the low and high ends. That is, inefficient speakers usually have a swayback characteristic as shown, for example, in Curve B, Fig. 7, where the dotted curve shows the low end measured in a large baffle.

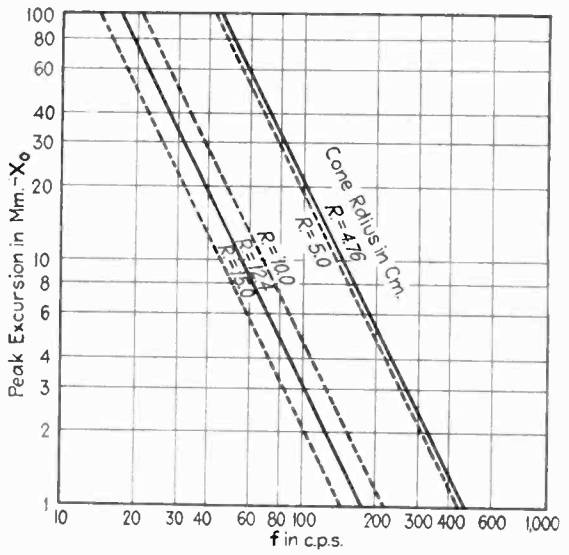


Fig. 2—Peak cone excursion as function of cone radius and frequency for 1 watt of sound output. The 5-inch speaker is curve R 4.76; the twelve inch is curve R 12.4

Hereafter we will use the terms "small, inexpensive and inefficient" interchangeably with the understanding that the terms apply to the present type of 5-inch speakers and to a lesser degree to slightly larger speakers. It is obvious, of course, that small speakers could be made much more efficient although at greater expense.

In an inefficient speaker the loudness efficiency is primarily controlled by the response in the resonant and high ends. In other words, the ear does not give much weight to the frequencies which lie in the limited piston range.

The factor BL (where B is the instantaneous average flux density the coil embraces in gauss and L is the length of conductor in centimeters if the c.g.s. system is used. L is, of course, a constant in any particular design) is the coupling factor between the electrical and mechanical circuits in a dynamic speaker. This factor

has an optimum value just as it has in the analogous electrical case.

Figure 1 shows a family of curves of an efficient 12-inch speaker covering the resonant range for different values of B. The output at resonance actually increases as the flux density is decreased until the maximum is reached with a density of 4,250 gauss corresponding to curve *d*. This occurs after the efficiency in the piston range is dropped about 9 db. From this we can see that the optimum output at resonance is secured in relatively inefficient speakers. This accounts for the large rise in output at resonance in small speakers.

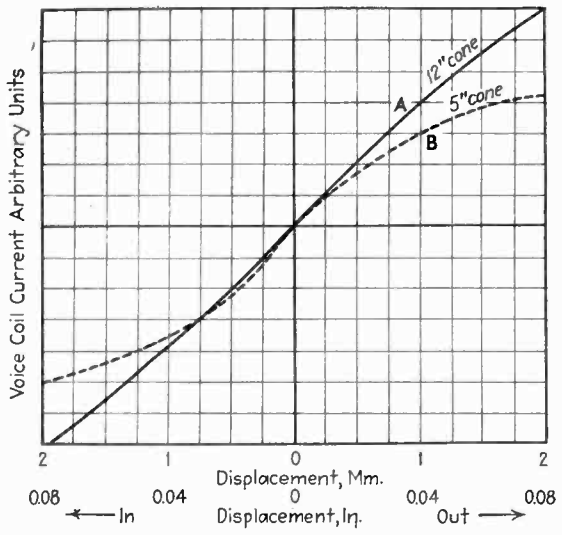


Fig. 3—Voice coil displacement curves. Note lack of symmetry due to difference in fringe flux and accounting for some even harmonic distortion

As the excitation is dropped, the high end is dropped fairly uniformly along with the piston range so that the speaker operating under conditions corresponding to curve *d* Fig. 1 has relatively more bass response than curve *a*. In curve *d* due to the small amount of damping, there is a large transient term so that there is considerably more response at and near resonance even though resemblance to the original wave form is entirely lost. This is especially true when the high amplitude low frequency signal is of short duration as is nearly always the case.

If the input to the speaker of curve *a* were attenuated 9 db below the input to that of curve *d* so that they had substantially the same output in the piston range and at the top, we would expect curve *d* to be louder because of the exaggerated bass response.

Curve *a* is for an ideal speaker in which the steady state and transient response do not vary with efficiency. In this case, if the efficiency in the piston range were lowered by say 6 db and the power input raised 6 db, the speaker would sound just as loud as it did originally. Curve *b* shows what occurs when the field excitation and piston efficiency are lowered. When the piston efficiency corresponds to curve *d* (down 12 db) for example, the input has to be raised 9.3 db to make it sound as loud as curve *a*. That is, the loudness efficiency has dropped only 9.3 db. These were run by listening 60 deg. off the speaker axis in a room with average absorption so the difference in highs did not mask the difference at the low end.

In getting the maximum loudness efficiency out of small speakers, designers have found empirically that the greatest loudness efficiency is obtained with thin top

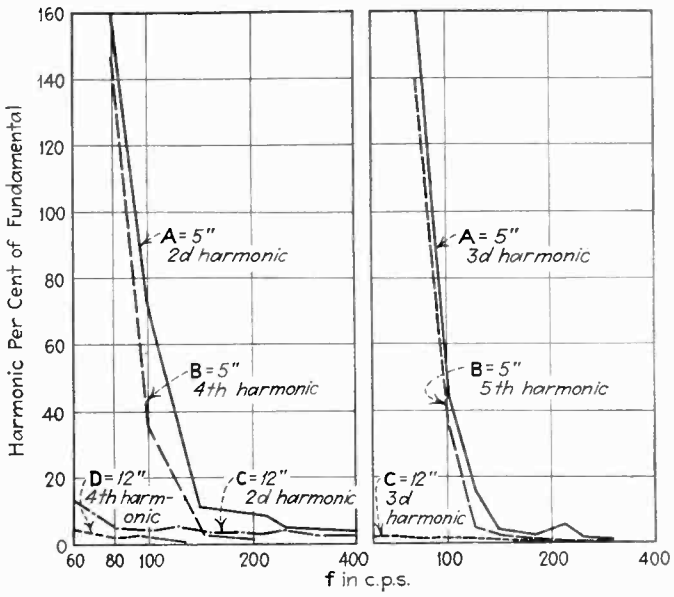


Fig. 4 and 5—Steady state distortion of several speakers (averaged). All curves were made with same sound output. Fifth harmonic of 12-inch speaker is negligible

plates and voice coils only slightly longer than this thickness. We realize intuitively that the average flux density embraced by the voice coil cannot be constant when the cone moves appreciably in such speakers. This is verified by Fig. 3. These curves give the static relationship between voice coil current and cone displacement.

These curves are composite curves which show the combination of the effect of the decrease in flux density, and hence force on the coil for constant voice coil current as the voice coil moves out, and the force displacement curve of the mechanical system. This shows that for the thin top plates commonly used considerable steady state distortion is to be expected if the excursion is large. The solid curve is for a 12-inch speaker with $\frac{3}{8}$ in. top plate and the dotted curve for a 5-inch speaker with $\frac{3}{16}$ in. top plate. The current is given in arbitrary units so that the slope at the origin could be made the same to simplify comparison.

An idea of the contribution of this factor to the steady state distortion may be gained by determining the peak displacement required at low frequencies. The power radiated from a speaker in an infinite baffle is[2]

$$W = \frac{4\pi^5 \rho R^4 f^4 X_0^2}{10^7 c}$$

where W is the sound output in watts, ρ is the density of air, R is the cone radius in cm., f is the frequency in cycles per second, c is the propagation velocity and X_0 is the peak excursion. Solving for X_0 we obtain

$$X_0 = \frac{4.78 \times 10^5}{f^2 R^2}$$

From this we see that the excursion for constant output varies inversely with the square of the radius and, therefore, increases rapidly as the size of the diaphragm decreases. For the same sound output, the excursion of the 5-inch speaker cone ($R = 4.76$ cm.) is 6.8 times that of the 12-inch speaker cone ($R = 12.4$ cm.). Therefore considerable steady state distortion can be expected at low frequencies in a small speaker with narrow top plate and voice coil.

In practice, no attempt is made to reproduce very low

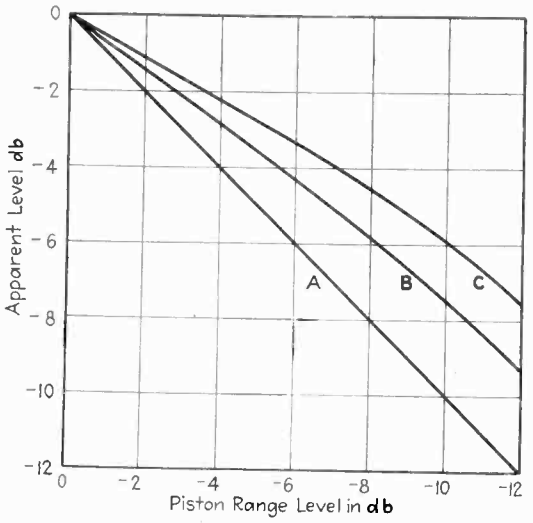


Fig. 6—Loudness efficiency as a function of field excitation and voice coil mass

frequencies with a small cone because of the large excursion requirements and because the speaker is used in a small cabinet where the radiation would be very small. The natural period is, therefore, usually put near the frequency for which the loss in pressure due to the small baffle is just about offset by the increase in pressure due to resonance. This tends to hold up the overall curve and still permits appreciable power to be radiated at resonance so that the transient distortion increases the apparent bass response.

Near critical values of BL the efficiency of a speaker may be high enough so that 1 watt or more is radiated at maximum input. The excursion is proportional to the square root of the power output so that for $\frac{1}{4}$ watt output these excursion values are halved.

The combination of all steady state distortion factors is shown in Figs. 4 and 5. These curves were both run in 3 foot baffles with large input transformers which gave little frequency discrimination and wave form distortion. The large baffle gives lower values of distortion for the small speaker because the fundamental is radiated better than it would be in a small cabinet. On the other hand, distortion curves show that when the small speaker is run with the usual "toy" input transformer, in spite of the transformer distortion, the total distortion below 100 cycles falls rapidly because there is practically no transmission and the cone excursion decreases.

Loudness efficiency criteria

Input was supplied from a distortionless triode amplifier at exactly the same level obtained at different frequencies when running the speaker out of a 43 type tube just below maximum output. The 12-inch speaker was then adjusted to give the same sound pressure and the distortion measured.

The effect of increasing the high frequency output of a speaker is to increase its loudness efficiency. The high frequency output is, in combination with other factors, increased by reducing the mass of the voice coil. In general, less efficient speaker designs require smaller voice coil conductor masses for optimum output. In inefficient speakers, the high frequency end can, therefore, be made better in proportion to the response in the piston range. If, therefore, the speaker efficiency is lowered by a change in design including a reduction in voice coil mass, the output may be relatively greater at the high end. In Fig. 6 curve C the efficiency of the speaker in the piston range has been lowered by altering the design in this manner. Here we note that due to the increased high frequency output the loudness efficiency drops less rapidly than it did in curve B. In fact, if the piston efficiency is lowered by 12 db, the loudness efficiency drops only 7.6 db. These figures are not, of course, exactly applicable to all designs. The exact difference will depend on the type of input (whether music or speech) and the frequency and power distribution of the input.

The amount of decrease in loudness efficiency is also complicated by such factors as the location of the natural period. For example, in a 5-inch speaker where the natural period is usually placed between 180 and 250 cycles, the loudness efficiency on *speech* will be much better than if this were dropped to say 80 cycles even though the baffle were large enough to permit radiation at this lower frequency.

The effect of the steady state distortion is to increase the apparent bass and loudness efficiency because the fundamentals of the lower frequencies are radiated poorly and the ear is more sensitive to the upper harmonics particularly at low levels.

In the case of sine wave excitation, the transient may be very large. In the case of the 5-inch speaker with a high natural period the amplitude of the transient due to a suddenly applied low frequency signal may be several

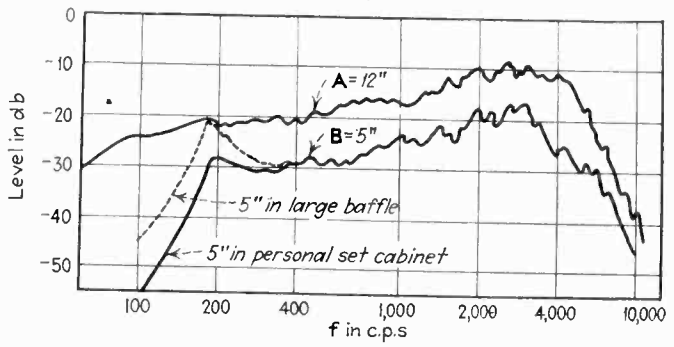


Fig. 7—Response of 5- and 12-inch speakers. Full curve B is small speaker in small baffle

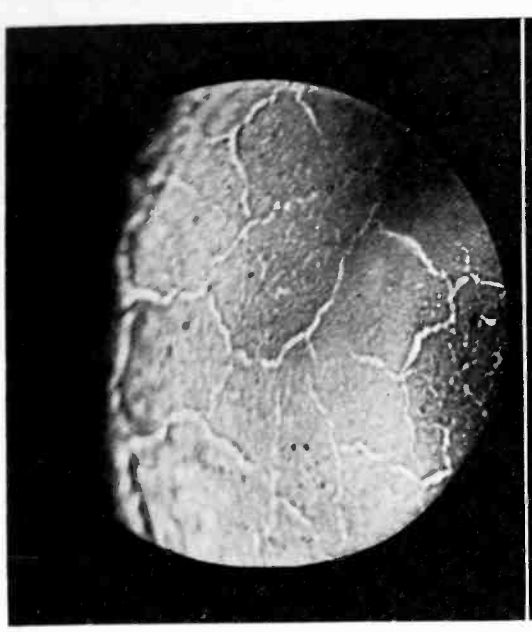
times the amplitude under steady state conditions at this frequency. This transient further creates the illusion of bass response from small speakers.

Representative steady state frequency curves of 5-inch and 12-inch speakers are shown in Fig. 7. Advantage is taken of the small voice coil mass (in 5-inch speakers) to get considerable rise in the middle high range from 1,500 to 3,000 cycles. This gives fairly good articulation and some semblance of highs. The higher frequencies above 3,000 cycles are deliberately sacrificed partly to increase the peak at 3,000 cycles but principally because set distortion is less objectionable when this upper end is suppressed.

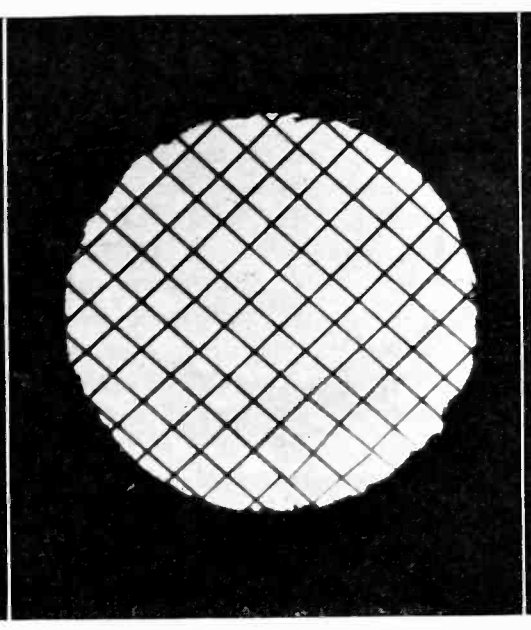
Power handling capacity

This leads us to the third important criterion of loudspeaker performance, namely, power handling capacity. This is improved by avoiding any sharp peaks in the high end which are accompanied by objectionable transient distortion and by lowering the high frequency cut off. When a set designer asks for a speaker which will "take it," that is, show minimum distress with the gain control wide open, he invites a speaker of this type. Many tests have shown that lowering the high frequency

[*Please turn to page 256*]



High emitting cracks of thick oxide coated cathode in gas discharge magnified 100 times



Molybdenum wire grating taken on a gilded glass screen. Velocity of electrons, 70,000 volts, spacing 0.3 mm.

Bright spot in cathode obscured by space charge in front

The electronic microscope

By M. KNOLL

AS LONG ago as 1927 theoretical studies indicated that the deflecting coil in a cathode ray tube must be the equivalent of a lens acting on light rays, and accordingly the diameter of the electron focus, i.e., the smallest ray-diameter adjustable on the luminous screen (d_s) depends only upon the diameter of the electron source (d_k). Therefore the distance of an object a and the distance of the picture b from the coil must follow the well known optical law $d_s = d_k\ b/a$.

Starting with this assumption the thought immediately presents itself that by decreasing the object distance enlarged images of a small object might be projected on a luminous screen provided the object emits electrons or is illuminated with electrons. This would constitute an electronic microscope.

The above law was proved within a precision of 5 per cent over wide ranges of a and b. The quality of images on a fluorescent screen focussed by magnetic coils was equal to that of good glass lenses. Furthermore electronic images could be produced by electric fields symmetrical to the ray axis and with systems composed of magnetic condensing and electric dispersing lenses, etc. For example if two magnetic lenses with an intermediate image plane are used, the direction of rays is identical to that of the ordinary projecting microscope. It was found that chromatic aberration could produce considerable distortion in the images; if, however, the velocity of electrons is homogeneous enough these errors can be neglected. The spherical aberration was below the limit of observation in the apparatus constructed.

It was not difficult to construct a practical electronic microscope (see page 258 this issue) for the 10 to 80 kv. range. It is a gaseous discharge tube. The figures show the precision of the image to be comparable to that of an ordinary microscope of the same enlargement.

Studies of cathode surfaces

The method was also thought useful to study the emission and the change of surface of oxide-coated cathodes under variable conditions and to observe the burn-out of oxide-coated cathodes, or the electron space-charge in front of a hot cathode. A microscope of smaller dimensions was then constructed especially for research at lower voltages (200 to 2,000 volts). After initial difficulties, caused by the inhomogeneity of the electric field of the emitting surface, perfectly sharp and undisturbed images (up to 100 times enlarged) could be obtained.

The enlargement so far attained is about 1:400. In the present arrangement this is due to the sensitivity of the apparatus to the movement of the mercury in the vacuum-pump. For technological investigations enlargements on smaller scale are sufficient; for physical investigations we hope to make further progress to increase the intensity of electron rays and furthermore to enlarge the electronic image on the fluorescent screen by means of an ordinary microscope. The limit of dissolving power of any microscope depends theoretically on the wave-length of the used radiation; therefore the dissolving power of the electronic microscope depends on the De Broglie wavelength of the electrons which is for electrons of 2,000 volts about 10,000 times smaller than that of light waves. Thus, theoretically, microscopic structures can be dissolved which approach the diameter of molecules even using a much smaller aperture than in ordinary microscope. How far this extremely high dissolving power can be obtained practically cannot be decided at present. In any case the further development of the electronic microscope and its methods will be of great importance for the technique of vacuum-tubes and for the physics of the gaseous discharge.

Electron emitting alloys of nickel and barium

By D. W. RANDOLPH, O. S. DUFFENDACK and R. A. WOLFE

A C Spark Plug Company and University of Michigan

THE development of stable alloys of nickel and barium that have electron emitting properties is of interest because of their adaptability to use in vacuum tubes. The experimental work with these alloys for the severe service encountered in spark plug electrodes has been described[1]. The purpose of the present article is to give in more detail the characteristics of interest in vacuum tube work.

A curve showing the relation between the barium content of the alloy and the thermionic emission as measured under conditions standardized for the experiments is given in Fig. 1. The thermionic emission was used as an index of the work function of the extraction of electrons from the wire, and, as is shown by the curve, a very small percentage of barium greatly increases the thermionic emission. Experiments were made to determine to what extent the percentage of barium could be increased and what were the properties of the resulting alloys. The first developments resulted in the production of alloys containing small amounts of barium, from 0.02 per cent to 0.20 per cent. These are now produced on a commercial scale. Later work has resulted in alloys containing up to 10 per cent barium. The purpose of the present paper is to describe the properties of these alloys in the lower percentage range and modifications of the alloys that are of interest because of their adaptability to use in vacuum tubes, glow tubes, and the like.

The first series of alloys had a composition of approximately 98 per cent nickel, 0.5 to 2.0 per cent manganese, and .08 per cent to .25 per cent barium together with traces of carbon, iron, and silicon as impurities. The alloys are produced in a 35 kva. Northrup high frequency furnace in carbon-free crucibles. Close temperature control is maintained by a Leeds and Northrup optical pyrometer occasionally checked by a standardized platinum-platinum rhodium thermo-couple. The molten metal is thoroughly degassed before the addition of the barium and poured into heated steel molds provided with refractory "hot tops" to assist in the pouring and to provide an escape for gases driven from the ingot as the metal cools. The cast metal is clean and bright and sections cut from the ingot are not attacked by water, showing the absence of free barium. Whether these mixtures are true alloys or not is not yet known for the higher percentage range, but in the lower range, apparently true alloys are formed. The distribution of barium throughout the metal is very uniform and no measurable variation in the composition of samples cut at random from large coils of wire is found, nor is there any segregation detectable under the microscope. The alloys are resistant to corrosion at elevated temperatures both from atmospheric gases and sulphur dioxide. The barium used is produced by the process described by Guntz[2], and is carefully handled to avoid the formation of oxides and nitrides.

The samples with which these tests were made were hot rolled to one-fourth inch round rods at a rolling temperature of approximately 1900° F and wire was cold drawn from these rods to the finished sizes. The majority of laboratory tests were made on wire 0.072 inch in diameter, although samples of fine wire and of ribbon were also made for vacuum tube tests. The finished wire was analyzed chemically for important elements, and the barium content was checked by the spectroscopic methods developed by Duffendack and Wolfe[3] These spectroscopic determinations were especially useful in checking the finished alloys to make sure that no undue segregation of any of the elements had taken place.

Numerous specimens of the alloys have been tested for thermionic emission. The current recorded is the emission current from approximately one square centimeter of surface at a temperature of 1050° C. The alloys were found to give steady electron currents over long periods of time. provided a temperature of 1000° C. was not exceeded. If the filaments were operated at higher tem-

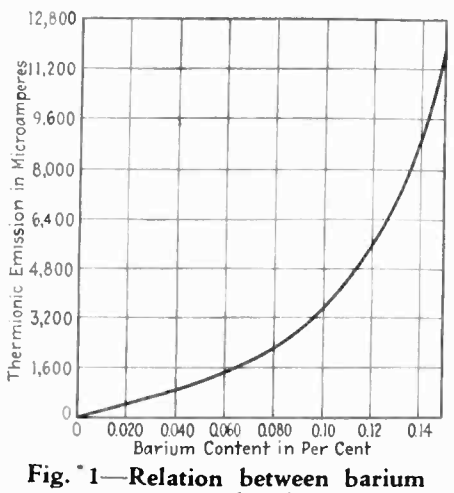


Fig. 1—Relation between barium content and emission

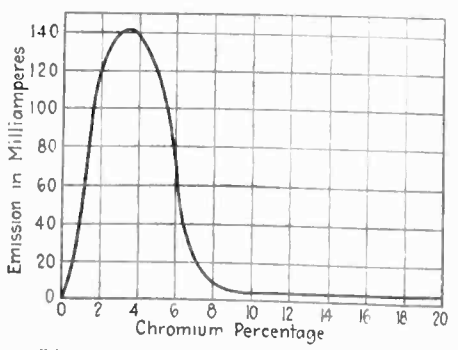


Fig. 2—Effect of chromium on electron emission

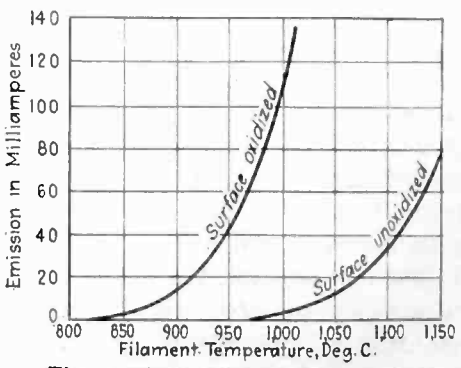


Fig. 3—Importance of oxidizing filament surface

TABLE I

Alloy No.	Ni	Mn	Ba	Cr	C	Impurities	Emission in Milliamperes	Remarks
518	96	2.03	.062	2.0	.164	.....	29. at 1050°C	Emission rapidly decreases with time
469	96	2	.072	...	...	2.0 Co	2.1 at 1150°C	Very heavy evaporation
263	95.5	2	.190	...	...	1.52 Fe	1.3 at 1150°C	Heavy evaporation—Compare emission with No. 420
420	94.0	2	.144	1.99	...	.....	180.0 at 1050°C	Very little evaporation
576	93.0	2	.09	4.0	...	1.0 Si	82.0 at 1150°C	Quite heavy evaporation

peratures, the alloy evaporated and the active surface was destroyed. The original emission could be restored by maintaining the filament at a lower temperature again for a time as the barium diffused to the surface from the interior of the wire.

The first measurements on the thermionic emission from barium-nickel-manganese alloys failed to show a regular variation of the electron current with the barium content. Detailed spectroscopic and chemical analyses revealed the presence of small amounts of impurities that had relatively large influences on the thermionic emission. Among the impurities invariably found to be present, though in varying amounts, are carbon, iron, and silicon. Titanium and additional amounts of the others were added to study the effects of their presence. Carbon, iron, and silicon when present in amounts more than mere traces increase the rate of evaporation of the alloys. Rapid evaporation is detrimental to the stability of the electron emitting surface of the filament, and, as a consequence, the alloys that evaporated rapidly were found to give decreasing thermionic electron currents. Iron and titanium apparently affect the work function of these alloys adversely, as those in which these elements were present gave lower thermionic currents for a given percentage of barium than alloys which did not contain them. To illustrate these effects, Table I gives the results of measurements on a number of specimens containing approximately the same amount of barium and varying amounts of some of the elements mentioned.

The rates of evaporation of the several alloys were determined qualitatively by observing the accumulation of metallic films on the walls of the vacuum chamber in which the filaments were mounted for measurements on thermionic emission. All of the alloys in this series evaporated somewhat at temperatures above 800° C. The films were examined spectroscopically and contained all of the elements of the alloy. The films were relatively richer in silicon and manganese than the alloy showing that these elements evaporated at a somewhat higher rate than the others. Especially is this true of silicon. The change in the composition of the alloy through evaporation was, however, very slow. The effect of small percentages of chromium on the rate of evaporation of these alloys is especially important and will be discussed later. When added in small amounts, it very materially decreased the rate of evaporation. Carbon in excess of approximately 0.05 per cent, iron in excess of .25 per cent and silicon in excess of .20 per cent markedly increase the rate of evaporation.

The maximum rate of thermionic emission from the nickel-barium-manganese alloys at temperatures that can be maintained over long periods of time without detriment to the alloy is not great enough to permit of their use for uncoated filaments in electron tubes. As a base metal for oxide coated emitters, however, these alloys have certain definite advantages. A series of experiments on the use of these alloys containing 0.15 per cent barium as a base for oxide coated filaments in commercial vacuum tubes was reported by Beese[4] who concluded that the small continuous supply of barium from the core metal produced a more active source of electrons than is the case where the coating alone furnished the barium. With thick oxide coatings, the barium alloy filaments attained an emission about 70 per cent larger than did those with pure nickel cores. With light coatings of oxides, the activity of the barium alloy filaments was comparable with that of pure nickel bearing a heavy coating and the life of the alloy filaments was normal.

A still more stable alloy than the nickel-barium-manganese alloy was desired for use for spark plug electrodes. It was found that the addition of chromium in certain percentages produced marked beneficial results, and the electron emitting characteristics of such alloys was investigated. The addition of chromium produced an appreciable effect on the thermionic emission from the alloy, the amount being dependent upon the percentage of chromium in the alloy. Figure 2 shows the emission

TABLE II

	Nickel	Ni-Mn-Ba	Ni-Mn-Cr-Ba
Barium content	0	.08–.15%	.08–.15
Electron emission per sq.cm. at 1150°C	....	7.5–20.0 m.a.	140.0 — space change limited
Electron emission per sq.cm. at 1050°C	....	.....	18.0–180.0 m.a.
Resistivity — ohms/Cm³	10–12	12–14	40–42
Temp. coef. of resistance ave. 20°C–900°C	.0040	.0046	.00063
Strength of .072 in. dia. wire			
At 20°C — lbs/sq.in	60,000	70,000	70,000
At 800°C — lbs./sq.in	8,000	8,800	12,000
Melting point	1454°C	1430°C	1420°C
Evaporation temp.(*)	....	850°C	1050°C

* This is the temperature at which the rate of evaporation becomes serious enough to affect the electron emission of the heated filament. Below this temperature the rate of evaporation is so slight that the walls of a glass container are not perceptibly darkened in 100 hours.

observed from a series of alloys with the same amount of barium and with varying percentages of chromium. It will be observed that the electron emission increases with the amount of chromium to a maximum at 3.5 per cent chromium and then decreases again.

The addition of chromium was found to be beneficial in other ways as well as in increasing the thermionic emission. The alloys containing chromium are more resistant to corrosion and have greater tensile strength, especially at temperatures of 800-900° C. The electrical resistivity of the chromium alloys is greater than that of those not containing chromium which makes it necessary to increase the cross section of filament wires in order to give them the same voltage rating. Whether this is an advantage or not depends upon the design of the tube, but in some cases it is an advantage because of the increased area of the emitting surface. The rate of evaporation of the alloys containing from 1 per cent to 7 per cent of chromium was found to be markedly less than that of alloys without chromium and less than pure nickel. This low rate of evaporation permits the maintenance of a very stable emitting surface for a long period of time, and this is a decidedly advantageous feature in many electronic tubes.

TABLE III

Barium content	0.44 per cent
Electron emission per sq.cm. at 810°C	100 m.a.
Resistivity	24 microhms/Cm³
Melting Point	1420°C
Evaporation temperature (*)	850°C

*Temperature at which the rate of evaporation becomes large enough to effect the electron emission of the heated filament.

It was found that a very stable emitting surface with a higher rate of electron emission could be formed on the chromium alloys by producing a light surface oxidation. A very thin film of oxide was formed by the heating of the filaments in air or other oxidizing atmosphere for a few seconds to a temperature of about 850° C. A slight discoloration of the surface is observed when the oxidation has proceeded to the right point. The emission from an alloy containing 4 per cent chromium and 0.10 per cent barium was found to be increased 50 fold at a temperature of 1000° C. by this treatment. The active surface is very stable at temperatures up to 1100° C. and the electron emission rate is remarkably constant over long periods of time. Figure 3 shows a comparison of the thermionic currents from an oxidized chromium alloy and the same alloy unoxidized.

As a base metal for oxide coated emitters, the chromium alloys have proved to be very satisfactory. When the surface of the alloy is oxidized slightly before the application of the oxides, the coating is found to adhere very tightly and uniformly, and the low evaporation rate insures the stability of this adherence. These alloys are especially free from gas and can be produced with great uniformity of composition.

The characteristics of the two alloys described in this paper that are now available on a commercial basis are given in Table II. The constants for pure nickel are given for comparison.

In addition to these alloys of relatively low barium content, a number of nickel-barium alloys are now under test containing considerably larger amounts of barium. Methods of alloying and working this metal are in process of development, and such tests as are in progress show the possibility of the production of a uniform alloy of high electron emitting properties. Certain specimens of that series have been drawn into sizes such that measurements on the thermionic emission could be conveniently made. Typical data on this alloy appear in Table III. It will be noted that the thermionic emission per sq. cm. is of the same order of magnitude as that from oxide coated emitters.

A filament of this alloy was used to maintain a low voltage arc in CO. An arc current of 15 m.a. at 180 volts was maintained for over 200 hours. This performance indicates that the emitting surface can withstand considerable positive ion bombardment.

[1]O. S. Duffendack, R. A. Wolfe, and D. W. Randolph Trans. Electrochem. Soc. LIX, 1931; 181-198.

[2]Guntz-Bull. Soc. Chim. 29, 1903.

[3]Duffendack and Wolfe, *Physical Review* 40, Po.1038/1932

[4]Thermionic Emission of Oxide Coated Cathodes Containing a Ni-Ba alloy core, N. C. Beese, *Physical Review* 36 Pa.1309, 1930.

The Code and the Engineer

By Dr. L. M. Hull, President, Institute of Radio Engineers

AMERICAN RADIO MANUFACTURERS are now operating under a "Code of Fair Competition for the Electrical Industry" which was approved by President Roosevelt on August 4. In the necessarily broad regulations thereby established for this highly ramified industry there is no formal recognition of that select class of professional laborers to whose creative effort the principal commodities of every radio manufacturer owe their origin. There exists, nevertheless, a vital connection between the corporate welfare of every radio manufacturer and the productivity of his engineering employees. Unless the teachings of industrial history are mockery, the radio industry will be distinguished for years to come by an essential dependence upon inventive thought, both technical and artistic. Periods in which this industry has provided large employment for labor and legitimate return on invested capital have always been preceded by exceptionally productive engineering activity. The recurrence of this sequence has been too consistent to suggest anything but a causal relation.

A choice is now presented squarely to all radio engineers and their employers: whether to revive conditions favorable to *inventive* engineering efforts or to continue with price-lowering as the main objective of engineering thought. Such a revival would provide sufficient centrifugal force to throw the industry out of the vicious competitive circle in which it is now spinning. Competition in ideas, rather than competition in prices, is still a sane and profitable activity. Furthermore, this revival of creative engineering is the most direct means of reconciling the Government's requirement of sustained highly-paid employment with that renewed effectiveness of invested capital which is vital to the industry. Recognition of this principle is an obligation to be shared alike by engineers and by their employers, in striving toward that rehabilitation of the industry which we all confidently anticipate.

Rectifier for modulation measurements

By J. L. POTTER
State University of Iowa

IN making modulation measurements by an oscillograph it is necessary to rectify the envelope of the carrier wave. If the oscillograph is to give an exact reproduction of what is happening in the transmitter, the rectifier must have a linear characteristic between the impressed voltage and the output current.

An attempt was made to find a tube which approached the linear characteristic very closely. Such tubes as the 280, 281, 866, 82, and some power amplifiers were tested. Of this group the 280 was found to be the most satisfactory. The two plates were connected together and the tube used as a half-wave rectifier. The distortion was found to be less than 2 per cent when used properly.

Figure 2 shows the curves of the 280 tube when various values of resistance R were placed in series with milliammeter I and the C battery voltage is zero. The more resistance added, the straighter the curve will be; but more power is necessary to obtain a given deflection of the meter or oscillograph, which fact is a disadvantage when making modulation measurements on a transmitter. Figure 2 also shows the relation between the distortion and the resistance R.

The per cent distortion was calculated by the same formula that is used in calculating the per cent distortion in power tubes. Per cent distortion =

$$\tfrac{1}{2}(I_{max} - I_{min}) - I_o/(I_{max} - I_{min})$$

When calculating the per cent distortion I_{min} must be the current when E is zero and I_{max} is the maximum current necessary to give good deflection on the oscillograph and I_o is the current value corresponding to E_o, where $E_o = E_{max}/2$

From Fig. 2 it is evident that most of the distortion occurs at the lower values of voltage. This distortion as far as modulation measurements are concerned may be eliminated to a certain extent by putting in a battery to supply a small voltage which will cause a small d.c. component of current to flow through the oscillograph element. The d.c. component of current will cause a constant shift of the oscillograph element, but this may be returned to zero by adjustment of the oscillograph.

Figure 3 shows the curves taken for three different values of battery voltage when R is 1000 ohms. Curve 3 of Fig. 2 is for zero C battery and R equals 1000 ohms. If the above precautions are taken, a rectifier can be had which has less than 2 per cent distortion.

When the modulation reaches 100 per cent the voltage must reduce to 0 and also increase to twice its normal value; hence, the total curve is put to use.

If the modulation is less than 70 per cent it will not be necessary to use the C battery.

Figure 4 shows the circuit diagram of the rectifier as used on an oscillograph for modulation measurements. Two 280 rectifier tubes with plates connected together are used to make a full wave rectifier. The purpose of connecting the plates together is to keep the a.c. plate resistance as low as possible. The filament battery is used for part of the bias voltage, the additional voltage being supplied by the 4,5-volt C battery. The pick-up coil is a bank-wound coil with 30 turns center-tapped, connected to the tubes by a three-wire flexible cable.

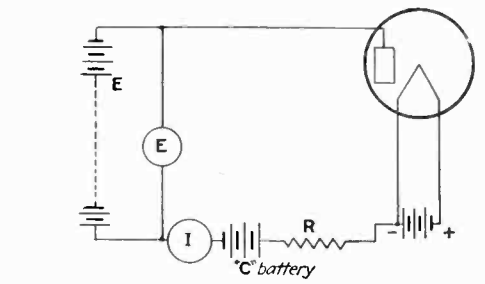


Fig. 1 — Circuit for determining rectifier characteristic

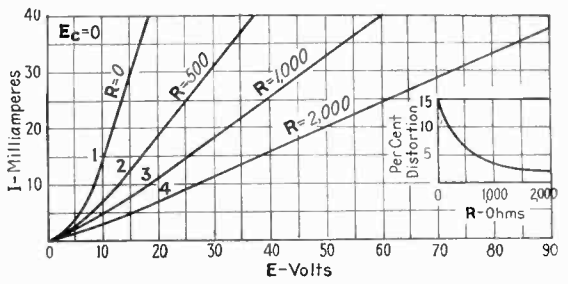


Fig. 2—Characteristic and distortion of rectifier for various loads

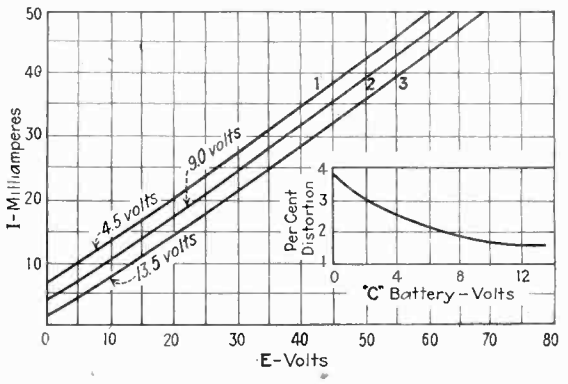


Fig. 3—Effect on distortion of using C batter on rectifier

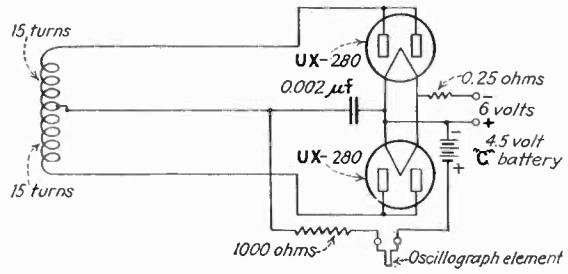


Fig. 4—Double-wave rectifier for oscillograph

The phantom tester

A method of testing high power mercury vapor tubes

By D. D. KNOWLES AND C. E. HALLER,

Westinghouse Elec. & Mfg. Company
East Pittsburgh, Pa.

THE development of high power mercury vapor rectifiers, Ignitrons and grid-controlled tubes has brought with it many problems in connection with the manufacturing and testing of the product. For example, to test the Westinghouse Grid-Glow Tube DKU-622 would require at least a transformer rated at 75 amperes and 30,000 volts, or 2250 kva. To control this voltage, an induction regulator or other control equipment would be needed. The energy would have to be dissipated in a huge resistor bank or else expensive converter equipment would be required to feed the energy back into the lines.

The latter is very difficult to do inasmuch as tests are often carried to destruction of the tube and the resulting surges and other disturbances necessitate very elaborate protective equipment. In event the energy is dissipated in a resistor, the cost for electricity alone may amount to something like $20 to $60 per hour, depending on the unit cost of power. At this rate, to season a tube for several hours, as is often desirable becomes almost prohibitive.

A solution to this problem has been sought by others.[1]

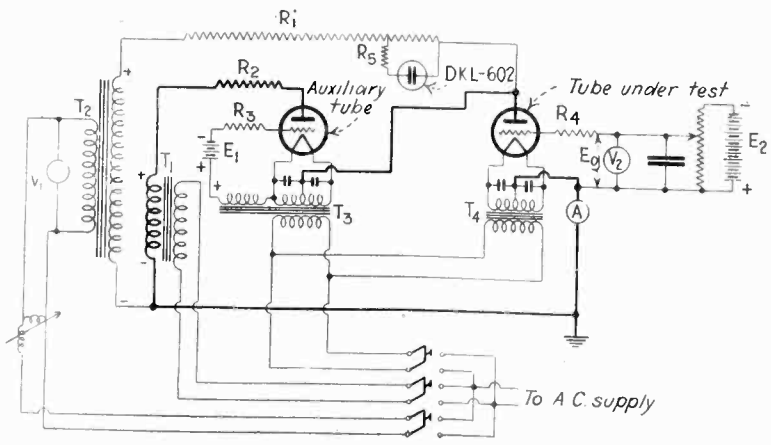


Fig. 1—Circuit of the "phantom tester" for determining the performance of large mercury vapor tubes

In general circuits fail to duplicate all the conditions of actual use, either by not applying rated inverse voltage following current conduction or by failing to apply rated forward voltage following the inverse half cycle. The authors, therefore, are not aware of any circuit that has been as effective as the one in use at the Westinghouse Research Laboratories for the last year or more. This circuit was designed primarily for the testing of Grid-Glow tubes and its operation is based on certain known characteristics of the tubes.

Theory of the circuit

Unlike a simple rectifier, a grid-controlled tube must be able to block a certain voltage in the *forward* direction as well as in the *inverse* direction. This requires the application of both halves of the high voltage wave to test the two conditions.

In either case, it is further recognized that only comparatively small currents can flow without forming an arc, which on the inverse half cycle constitutes what is called an arc-back and on the forward half cycle means loss of grid control. The significance of this fact is that, provided other conditions in the tube are normal, the high voltage transformer does not need to have a high current carrying capacity. For example, it may be rated at 1 ampere and 30,000 volts or 30 kva. instead of 2250 kva.

The tendency to arc back, and to a lesser extent, the tendency to lose grid control depends considerably on the amount of current passed on the previous conducting half cycle, both as it affects residual ionization and the temperature of the tube. It is, therefore, essential that the rated value of current be allowed to flow on each conducting half cycle.

Inasmuch as the drop across the tube, and hence the heating and ionization produced, depend only on current, it matters not whether the current comes from a high or a low voltage source. For economy then this current can be supplied from a low voltage transformer, say one rated at 75 amperes and 220 volts or 16½ kva. This results in a total power capacity of 46½ kva. instead of 2250 kva. as would be required under actual full load conditions.

Method of operation

The problem reduces then to one of applying rated forward and inverse voltages from a low current source and then, once the tube has started, allowing rated current to follow through from a low voltage source during the remainder of that half cycle.

The circuit shown in Fig. 1 contains two principal current paths:

1. *The high voltage path* starting from the secondary of transformer T_2 through resistance R_1 to the tube under test and from the cathode of this tube back to the opposite side of the secondary of T_2.

2. *The low voltage path* starting from the secondary of transformer T_1 through the resistor R_2 to the anode of the auxiliary tube; from the cathode of this tube to the anode of the tube under test and then from the cathode of the latter to the other side of the secondary of T_1. The transformers T_1, T_2 and T_3 are phased as indicated by the + signs on the secondary windings. During the conduction half cycle, the anodes of both the auxiliary tube and the tube under test are positive as is also the grid of the auxiliary tube. The latter, therefore, is biased to start at a low voltage and consequently

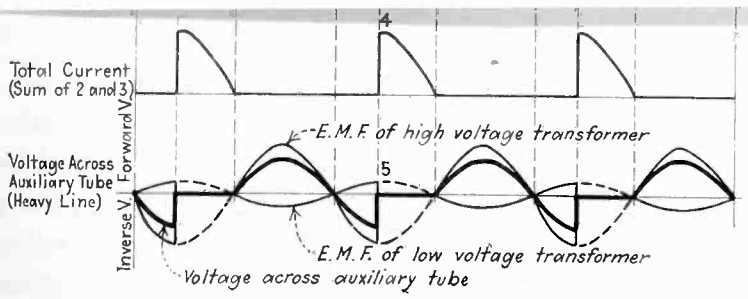


Fig. 3—Current and voltage relations in the high power tube testing circuit

to feed the desired current through the tube under test as soon as it starts.

If now the bias voltage E_g is reduced gradually from a high negative value, the tube under test will start first at the peak of the high voltage wave. This instantaneous value of voltage and the corresponding value of critical grid voltage gives us one point on the conventional control characteristic shown in Fig. 2. As the bias is still further reduced, the tube starts earlier in the cycle and in each case the desired current follows through from the low voltage path. The actual current through the tube is, of course, the sum of the currents from the two paths.

Fig. 3 shows graphically the current and voltage relations in the circuit.

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On the forward half cycle of test voltage, arc backs in the auxiliary tube might occur. If this happened, the forward voltage would be removed from the tube under test and it would be assumed erroneously that the grid of the latter was blocking the high voltage. To avoid this error, an arc back indicator can be placed also in the anode circuit of the auxiliary tube.

In conclusion the authors wish to point out that while the phantom tester has not been proven absolutely to be the equivalent of actual conditions, there has not been a single instance, out of several hundred tubes tested, to indicate otherwise. In other words, tubes that show a tendency to arc back on the tester at a given inverse voltage have actually always developed arc backs at that same voltage in a power circuit with similar characteristics. Obviously if the power circuit affords less time for deionization than the test circuit, it may arc back at a lower voltage. This, however, is another matter, concerning deionization, or rate of recovery of dielectric strength after current extinction and does not come within the scope of the present paper.

[1] *"Cheater Circuits"* by J. L. Zehner, *Electronics*, July, 1932, page 224.

The phan

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A method of power mercury

By D. D. KNOWLES
C. E. HALLER,

Westinghouse Elec. & Mfg. C
East Pittsburgh, Pa.

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NEW YORK,
N. Y.

THE development of rectifiers, Ignitrons brought with it many the manufacturing and tes ample, to test the Westingl 622 would require at leas amperes and 30,000 volts, voltage, an induction regu ment would be needed. dissipated in a huge resistc verter equipment would b back into the lines.

The latter is very difficult to do inasmuch as tests are often carried to destruction of the tube and the resulting surges and other disturbances necessitate very elaborate protective equipment. In event the energy is dissipated in a resistor, the cost for electricity alone may amount to something like $20 to $60 per hour, depending on the unit cost of power. At this rate, to season a tube for several hours, as is often desirable becomes almost prohibitive.

A solution to this problem has been sought by others.[1]

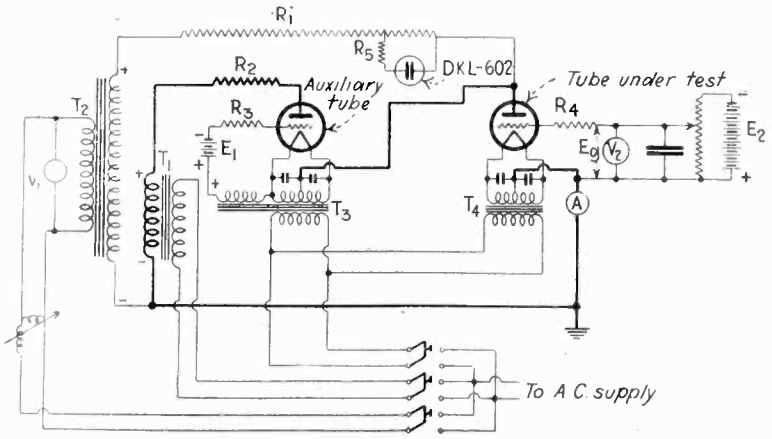

Fig. 1—Circuit of the "phantom tester" for determining the performance of large mercury vapor tubes

sults in a total power capacity of 46½ kva. instead of 2250 kva. as would be required under actual full load conditions.

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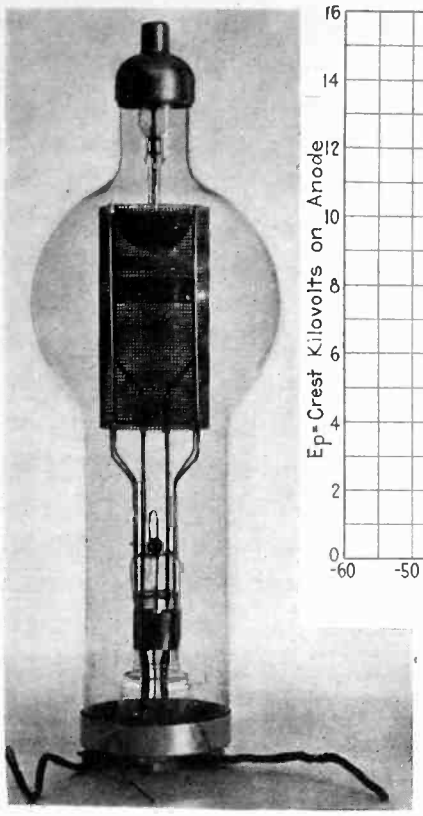

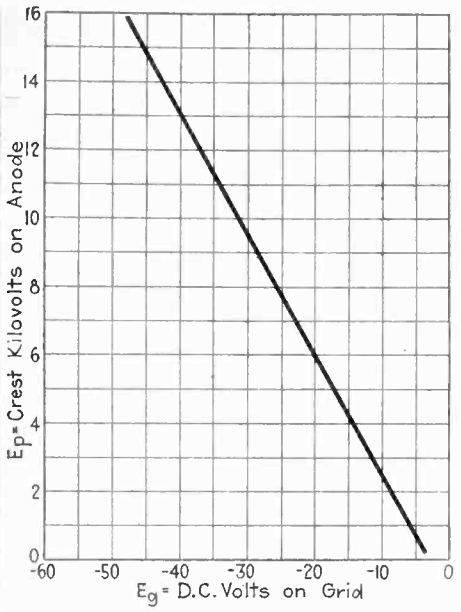

Fig. 2—Control characteristic of the DKU-623 rated at 25,000 volts, peak, and 25 amperes, average. It is a grid-controlled rectifier

Fig. 4—Grid-glow tube DKU-623, a high powered controlled rectifier

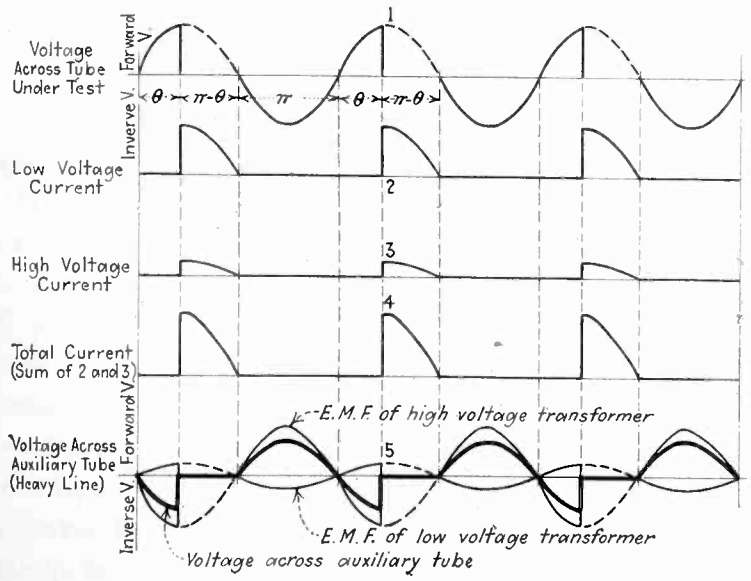

Fig. 3—Current and voltage relations in the high power tube testing circuit

to feed the desired current through the tube under test as soon as it starts.

If now the bias voltage E_g is reduced gradually from a high negative value, the tube under test will start first at the peak of the high voltage wave. This instantaneous value of voltage and the corresponding value of critical grid voltage gives us one point on the conventional control characteristic shown in Fig. 2. As the bias is still further reduced, the tube starts earlier in the cycle and in each case the desired current follows through from the low voltage path. The actual current through the tube is, of course, the sum of the currents from the two paths.

Fig. 3 shows graphically the current and voltage relations in the circuit.

Wave 1 shows the voltage across the tube under test for the condition when starting occurs at the peak of the cycle.

Wave 3 shows the current from the high voltage source and wave 2 that of the low voltage path.

Wave 5 shows the voltage across the auxiliary tube for both the forward and inverse potential conditions.

From this figure it will be noted that the auxiliary tube must have certain definite characteristics:

1. During the forward or normally conducting half cycle of the tube under test, the auxiliary tube must be able to withstand, in the *inverse direction,* the full peak of the high voltage minus the practically negligible peak of the low voltage.
2. It must, of course, be able to pass as much current as the tube under test.
3. During the inverse cycle the grid of the auxiliary tube must be able to block in the *forward direction* the peak of the high voltage wave minus the peak of the low voltage wave. This is accomplished automatically by the reversal of grid bias supplied by the secondary of T_3.

Interpretation of test results

To adequately analyze the various types of failure that may occur either in the tube under test or in the auxiliary tube, several special devices have been introduced.

During normal operation, any current flow through the resistor R_1 will always be from left to right in the diagram. Consequently a cold cathode neon glow lamp, such as the DKL-602, connected across a portion of the resistor R_1 will glow only on one electrode, the one on the right.

On the inverse cycle of test voltage either one of two failures may occur:

1. The tube under test may arc back.
2. The auxiliary tube may fail to block.

In either case current would pass through R_1 from right to left, thus giving a visible flash on the normally dark electrode of the glow lamp. A dependable arc back indicator in the circuit of the tube under test, for example at A, would indicate if this tube had arced back while a flash on the glow lamp without such an indication would mean a failure of the auxiliary tube to block. The latter must, of course, be guarded against because it removes the inverse potential from the tube under test.

On the forward half cycle of test voltage, arc backs in the auxiliary tube might occur. If this happened, the forward voltage would be removed from the tube under test and it would be assumed erroneously that the grid of the latter was blocking the high voltage. To avoid this error, an arc back indicator can be placed also in the anode circuit of the auxiliary tube.

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New York City

O. H. CALDWELL, *Editor*

Volume VI —SEPTEMBER, 1933— Number 9

Russia's high-power broadcast stations

DR. LOUIS COHEN, of Washington, D.C., consulting radio engineer, who returned recently from Russia, reports that the Soviet Government now has in operation one 500,000-watt broadcast transmitter and five 100,000-watt broadcast transmitters as well as 50 to 60 stations ranging from 2,000 to 25,000 watts. The advisability of building a 1,000-kw. station is also under consideration.

Three million radio receiving points are now available and it is expected to increase these to 20,000,000. Receiver production is now going on at the rate of 200,000 annually; with plans under way to increase set production to 1,500,000 annually.

Shoddy automobile radio sets

IT IS no secret that the editors of *Electronics* decry the manner in which shoddy radio sets have been sold to the depression-ridden public under the guise that the merchandise is merely low-priced and therefore in keeping with the times.

It is freely admitted that small sets, even cheap sets, may inoculate with the joys of radio reception a portion of the public otherwise deprived of receivers, or that in time this public will return for better merchandise.

But we view with alarm the mounting tide of shoddy automobile radio sets selling at such low prices they attract many buyers, many of whom are doomed to disappointment. Complaints received in a single week on one of the cheap sets bearing a well known name, involve lack of sensitivity, excessive vibrator trouble, speaker rattle, mounting difficulties, blown condensers, poor soldering, loose rivets in vibrator mounting, oscillation, instability, and critical operation as regards tubes. Of this particular set, widely advertised, an experienced dealer in the Northwest said, "we have had more trouble with this receiver than with any other model in our experience."

This indicates not only cheap merchandise but receivers shoddy in electrical and mechanical equipment and workmanship.

The fortunate failure at Mexico City

THE North American Radio Conference at Mexico City has broken up, after agreeing only on such obvious principles as 10-kilocycle separation, 5-cycle maximum deviation, interference elimination, and so on.

But on the vital topic of the allocation of broadcasting channels as between nations of the conference, no progress was made—or could be made. The demands of the other countries were excessive, out of reason, and based on no logical principle or premise, except national pride. The American delegation did well to move to adjourn, and close the sessions. Judge Sykes deserves the congratulations and admiration of every broadcaster and every listener for this prompt and patriotic action. Now for a while at least, the broadcasters can breathe easily, as the spectre of a new broadcast allocation recedes.

In their conferences at Mexico City the U. S. delegates were embarrassed by the anti-U. S. activity of several Americans. An American educational group actually distributed among the foreign delegations, propaganda injurious to the American position. And a former Vice-President of the United States attended the conference as "observer" for a high-power pirate station on Mexican soil!

A bed-side radio

THE admirable purpose of having "a radio set in every room" has now achieved such proportions in some homes, that when several members of the family are tuning in their different favorite programs, the resulting Babel is intolerable. A return to headphone or "pillow" radio on some of the sets in such a home would be a welcome relief.

Some smart manufacturer of cigar-box radios will probably shortly make this feature available by providing his little set with a cut-off jack, so that a head-phone unit can be plugged in, at the same time cutting out the loudspeaker. The little set will then become a true bedside radio, capable of operating a comfortable headphone or radio pillow. And the headphone people might find a renewed market for modern "cans" if redesigned for the wearer's real comfort—eliminating the old hair-pulling, head-pinching features of the standard article of commerce.

Such a radio could have "high quality" because of the close coupling to the ear; would need very little power output; could be small in size to the extreme.

Tied to the lamp's apron-strings

THROUGHOUT the short life of the electron-tube industry its progress has been hampered as well as aided, by its close affiliation with the incandescent-lamp manufacturing processes out of which it was born. The design of every tube carries unmistakable vestigial evidences of the lamp construction that preceded it. Because the incandescent lamp was already highly developed, and mass production had proceeded far, electronic tubes have been too often "modified lamps," instead of devices specifically designed for their electronic purposes. The bulky size of radio tubes, and the pear-shaped bulbs, bear striking testimony to the tube's lamp ancestry. The pinch-principle of element construction, and the re-entrant stem are both relics, without reason, of incandescent-lamp technique.

Now the tube designers are beginning to cut loose from the apron-strings of the lamp. The new dome-shaped tube, the smaller tube forms, the English "all metal" tube, are evidences of new independence of design.

NEWS NOTES

Is this the record amplification?—In carrying out tests of underground-cable transmission at the Bell Laboratories, New York City, A. B. Clark and B. W. Kendall recently set up the equivalent of a 7,650-mile circuit. To keep speech passing through this required a total amplification of 10^{1200} power, or ten raised to the 1200th power. Such a number, with 1200 ciphers, would alone occupy 20 lines in this column, or twice the length of this item. Bell engineers believe this to be the record amplification to date.

Short-wave radios at London show—Nine miles of exhibit spaces marked the giant radio exhibition held in London during August, with displays insured for $13,000,000. Short-wave sets were featured. Special attention was given to low current consumption with battery sets, made necessary by the multiplicity of lighting voltages in England. These Class B push-pull output circuits attracted wide attention. The Osram G-E Lamp Company displayed its new Catkin all-metal tubes.

Factory payroll increases—Hygrade Sylvania Corporation, with plants at Salem, Mass., Emporium, Pa., St. Mary's, Pa., and Clifton, N. J., increased its employees by 1,400 during August. Accompanying payroll increases were at the rate of $1,000,000 annually, or over 35 per cent. All plants of the company are working at capacity.

Armstrong sustained as inventor of regeneration—The United States Circuit Court of Appeals, Second District, has sustained Major Edwin H. Armstrong as the inventor of the regenerative circuit, in the suit brought by holders of the DeForest patent. The controversy as to who invented the feed-back or regenerative circuit has been in the courts for the past 18 years.

Sir Ambrose Fleming, 83, weds in England—Sir John Ambrose Fleming, who invented the Fleming thermionic rectifier valve in 1904, was married last month to Miss Olive May Franks, 34, an opera singer, according to a London report to the New York Times. Sir Ambrose is now 83 years of age and has been for many years a professor in University College, London.

Motion-picture engineers, Chicago, Oct. 16-18—The Fall meeting of the Society of Motion Picture Engineers will be held at the Edgewater Beach Hotel in Chicago, Oct. 16, 17 and 18. A feature of the meeting will be the announcement and inauguration of the newly elected officers. The semi-annual banquet will be held Tuesday evening, Oct. 17.

COURT RECORD REPORTED ELECTRICALLY

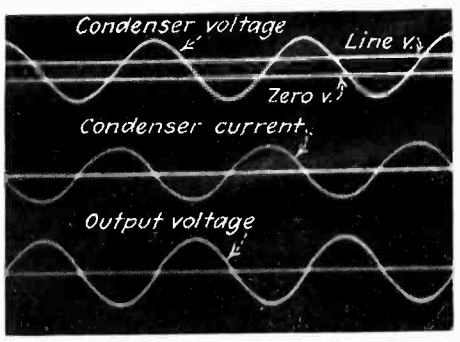
In this court at Hamburg, Germany, electrical recording has taken the place of court stenographers. Attorneys may demand its use at will

ELECTRONIC NOTES

A 75-watt commutator type inverter

By Herbert J. Reich*

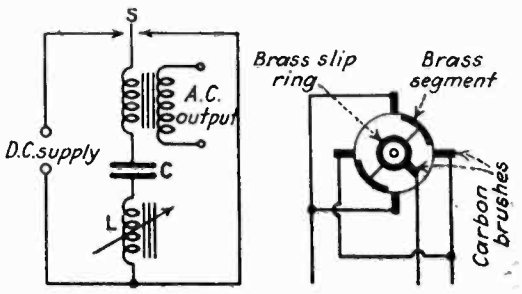
Occasionally the need arises, either in the laboratory or in commercial installations, for a simple device for converting small amounts of d.-c. power into a.-c. of good wave-form without the use of a motor-generator set. Tube inverters are available for this purpose,



but the wave-form is usually far from sinusoidal, and the tubes are expensive. The figure shows the circuit of a simple mechanical inverter which will readily furnish an a.-c. output of 75 watts or more at 60 cycles with excellent wave-form and fairly good efficiency when operated on 120 volts d.-c.

Use is made of the fact that in a series circuit containing L, R and C, with a high ratio of L to R, the charging and discharging currents are very nearly sinusoidal. If, therefore, the switch S is changed at the instants when the charging and discharging currents are zero, the condenser will charge practically sinusoidally from the d.-c. supply through the transformer primary and the inductance L, and discharge nearly sinusoidally directly through the transformer and inductance. The transformer primary current and the secondary voltage will be approximate sine waves. Since the current is zero at the instants of commutation little or no sparking occurs. In the practical circuit the double-throw switch is replaced by a commutator driven by a small d.-c. motor.

The correct values of C and L vary with the type of transformer and with large changes of load, but a 250-volt 40 μf. electrolytic condenser and a 50-millihenry low-resistance reactor form a good combination at 60 cycles with the average power transformer. A movable core in the choke makes it possible to tune the circuit to exactly the correct natural frequency, so that no sparking is visible at the commutator. Since the power output which can be obtained at a given frequency is determined by the size of the condenser and the d.-c. voltage, the voltage regulation is poor, and the transformer ratio must be chosen so



as to give the necessary terminal voltage at the desired value of load current.

The oscillograms here show condenser voltage, condenser current, and output voltage at 60 cycles with a 50 watt load. The circuit efficiency, neglecting power taken by the motor, was about 60 per cent. The maximum efficiency of about 74 per cent is obtained with an output of 24 watts. Both the maximum power output and the circuit efficiency increase considerably if the series reactor is omitted, but the wave-form becomes exponential, and some sparking is likely to occur at the commutator. The maximum power output is proportional to the condenser capacity and to the square of the d.-c. voltage. High voltage d.-c. may be obtained by rectifying the a.-c. output by means of a second commutator mounted on the same shaft as the first.

*University of Illinois.

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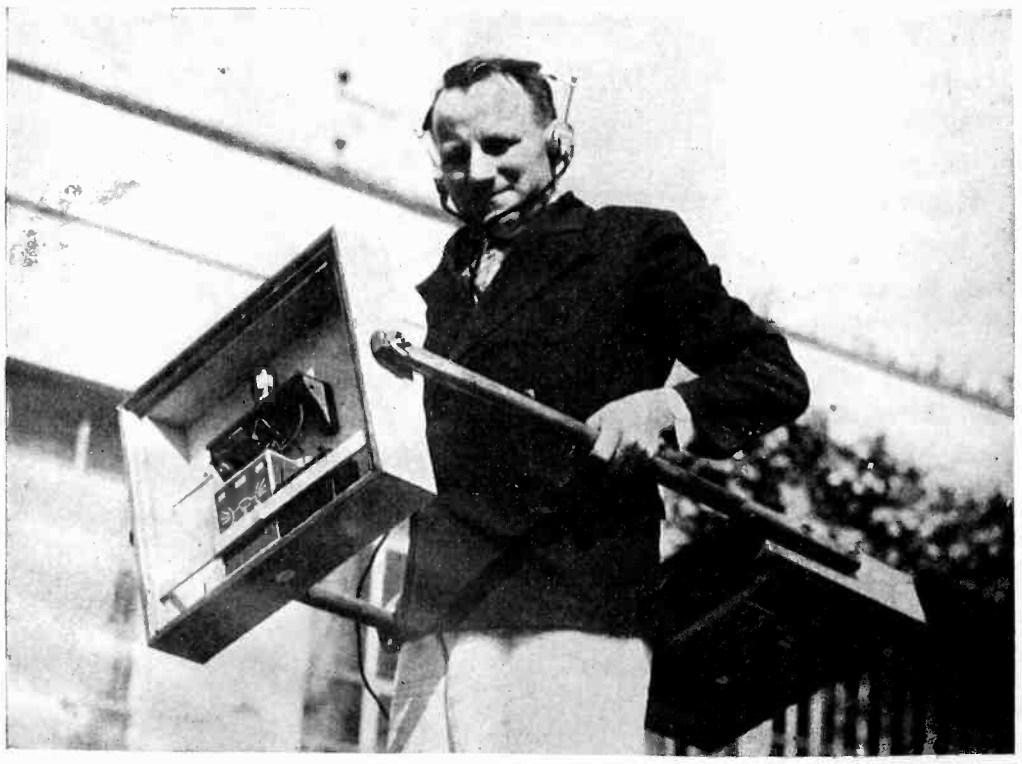
THE METALLASCOPE



Presence of metal bodies within a depth of 10 feet and a radius of 5 feet is made audible by this device perfected by Gerhard Fisher. It weighs 22 lbs.

Low range electrostatic voltmeter

By W. P. Koechel

There are many occasions when it is necessary to have available a voltmeter capable of measuring low values of potential without drawing any current from the circuit being measured. A low range electrostatic voltmeter is an ideal instrument for this purpose but such meters are expensive. By making use of a special vacuum tube circuit it is possible to make up a small and compact vacuum tube voltmeter capable of accurately reading voltages up to 25 volts and having an infinite input resistance. This vacuum tube voltmeter unit can be enclosed in a small portable case and *is in every way comparable to a low range electrostatic meter.* Furthermore it is surprisingly inexpensive and rugged.

Referring to the figure it will be noted that an inverted vacuum tube circuit is utilized. The entire voltage source is obtained from three small flashlight cells. Meter *M* is a 0-200 range micro-ammeter. Tube *T* is a type 30 and therefore the total drain on the flashlight cells does not exceed 61 ma. The voltage drop across resistor R_1 supplies the necessary plate voltage. Resistor R_2 serves as a means for ad-

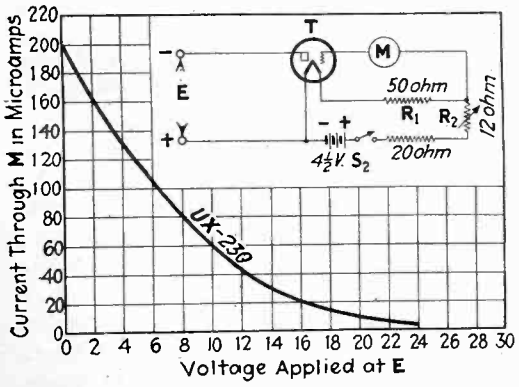
FROM THE LABORATORY ++

justing the circuit to the same plate voltage every time the instrument is used and is really an arbitrary zero setting control.

As the tube is used in an inverted manner, the grid really serves as anode. Being situated so close to the filament it takes only a very small potential to obtain 200 μa anode current. The plate is utilized as a grid and its control over the anode (grid) current is illustrated by the curve. In actual use M is calibrated directly in volts taken from the plotted curve.

The arbitrary zero setting is equivalent to the condition of full scale reading of meter M and this setting is adjusted by means of rheostat R_2. With rheostat R_2 adjusted to give the proper anode voltage, it is obvious that proper filament voltage will also be obtained. *All settings* are therefore taken care of by this one *single control*.

Even though the current drain is very small, it would be detrimental to the battery if left on for any considerable length of time. Therefore switch S_2 instead of being an ordinary toggle switch is combined into a small midget timer (supplied by the Walser Automatic Timer Company). This timer automatically turns off the circuit at the end of each 45 minute period, if the user of this instrument neglects to turn off the switch beforehand.



This meter has an infinite input impedance, but for certain applications it may be desirable to connect a grid leak resistor across the input. Furthermore, the use of a proper grid leak and a condenser in series with the meter permits the measurement of a-c voltage. A number of grid leaks of suitable value will also permit multiplying the scale range of the meter. If these grid leaks are of the order of ten megohms or higher, the input impedance of the meter unit will still be high enough for many applications. In setting for the arbitrary zero value, the input leads should always be shorted.

A few of the uses for which this meter has proven invaluable are:

1. Measuring grid voltages directly at the grid pin of the tubes on life test. (This is not possible with an ordinary meter due to the high protective resistance in series with the bias supply.)
2. Measurement of grid voltage values directly at the socket in radio sets, such as detectors and oscillators where a high resistance is always in series with the grid circuit.
3. Measurement of contact potential and back emission of individual floating elements in experimental tube tests.
4. Measurement of high resistance leakage path.
5. Electrostatic measurements of potentials across charged condensers.

The foregoing are only a few examples of the possible use of such a meter, but every laboratory will find many diversified uses for such an instrument.

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Selective fading

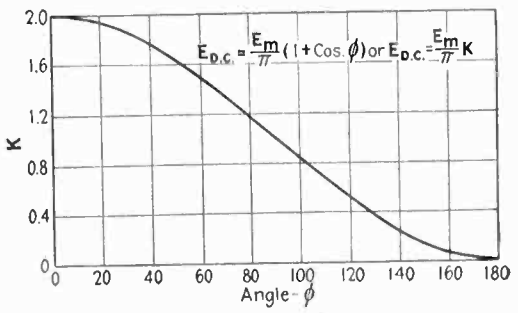
P. H. HANDEL AND H. PLENDL of the German Aeronautical Research Laboratory, Berlin, have explored an interesting phenomenon. Certain frequencies out of the 10 kc. band normally transmitted are found to suffer excessive attenuation when the distance between sender and receiver is 10 km. The frequency of a 51.4-m. wave emitted by a horizontal ¼-wave aerial oriented north-south was gradually increased until 750 cycles had been added in the course of a ¾ minute, then decreased to normal in another ¾ minute, maintained for about ⅓ sec., and the change repeated. The signals received on an antenna oriented north-south were nearly opposite in phase with respect to signals received on an east-west antenna. This can be accounted for by the rotation of the direction along which the electrical force vibrates, the amount of rotation depending upon the frequency (about ⅔ of a degree per cycle). There are considerable differences in the strength with which four frequencies f (=5.45 mc.) f+600, f+1,850 and f+2,500 are received at different times. The results of the experimental work may be found in *El. Nachr. Technik* 10:76-94. 1933.

✦

Grid-controlled rectifier current

ONE OF THE MOST IMPORTANT functions performed by grid-controlled rectifiers of the thyratron and grid-glow tube types is that of controlled rectification; i.e., current flows through the tube and the load for any desired fraction of the cycle which makes the anode positive with respect to the cathode. Thus the controlled rectifier differs from the two-element or classical rectifier where the current flows during the entire half cycle in which the plate is positive.

The average current flowing in a



two-tube full-wave rectifier of this type may be calculated from the following expression taken from *The Electric Journal*, April, 1932, page 192 from an article by Reuben Lee. The curve shows this equation graphically.

$$I_{ave} = I_{crest}\left(\frac{1+\cos\phi}{\pi}\right)$$

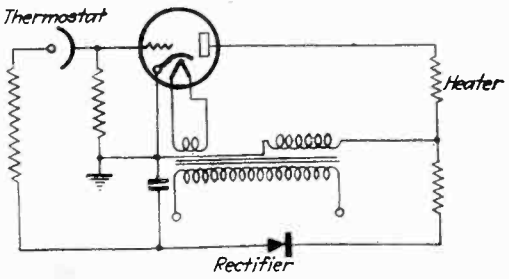
where ϕ=angle at which the tube starts to conduct current.

Curve furnished by Dr. Dayton Ulrey, Westinghouse Research Laboratories. The angle ϕ is the point in the cycle at which current flow starts.

✦

Tube control of temperature in crystal ovens

IN THE CRYSTAL OVEN ("incubator" to the British) used to maintain the frequency of G5SW at 11,750 kc. the constant temperature is maintained by a thermostat which through a grid-controlled rectifier of conventional type (1,000 volt, 0.25 ampere) switched on and off the a.c. to the heating coils. By use of a copper oxide rectifier the necessity of using a grid bias battery was obviated.



Ordinarily a fixed bias supplied by the battery maintained the grid at such a potential as to control the plate current. This battery required space, and of course had to be replaced. The circuit shown in the figure indicates how the rectifier replaced the battery. The grid bias was about 50 volts after supplying 210 volts a.c. through 50,000 ohms and 0.5 μf.

The frequency of this station, which was used for the early experiments on Empire broadcasting, was kept within 4 parts in a million of its assigned frequency for long periods of time.

HIGH LIGHTS ON ELECTRONIC

Smoke precipitation with electronic rectifiers

FOR YEARS MEN HAVE BEEN TAKING valuable products out of smoke and gas by electrically precipitating the materials they contain. The gases from smaller smoke stacks, the flues of cement kilns, natural gas and water gas with their fine mist of tar; from all these can be taken, if not gold dust, its equivalent. Sometimes it is not the dust that is valuable, but a gas which must be cleaned to be used, like furnace gas in a steel mill.

Electrical precipitation requires direct current of very high voltage. Hitherto it has been produced by mechanical rectifiers. Such rectifiers, troublesome to their operators and a source of radio interference, are no longer necessary. Their duty can be performed by two-element high-voltage vacuum-tube rectifiers which are quiet and positive, of fixed and unvarying polarity, with smooth and regular wave form. They do not burn themselves up with arcing, and radio sets find them silent. The tubes are shielded by glass cylinders from emitting possibly dangerous X-rays.

One set, built by Westinghouse engineers, delivers from a 25-cycle supply an average rectified current of 400 milliamperes, at a maximum pressure (r.m.s. value on transformer) of 100,000 volts a figure which can be reduced by an induction regulator to 47,000 volts. The filament transformers are inside the main tank. Filament voltage is kept practically constant, even if the line voltage varies 10 per cent, by a static regulating device.

✦

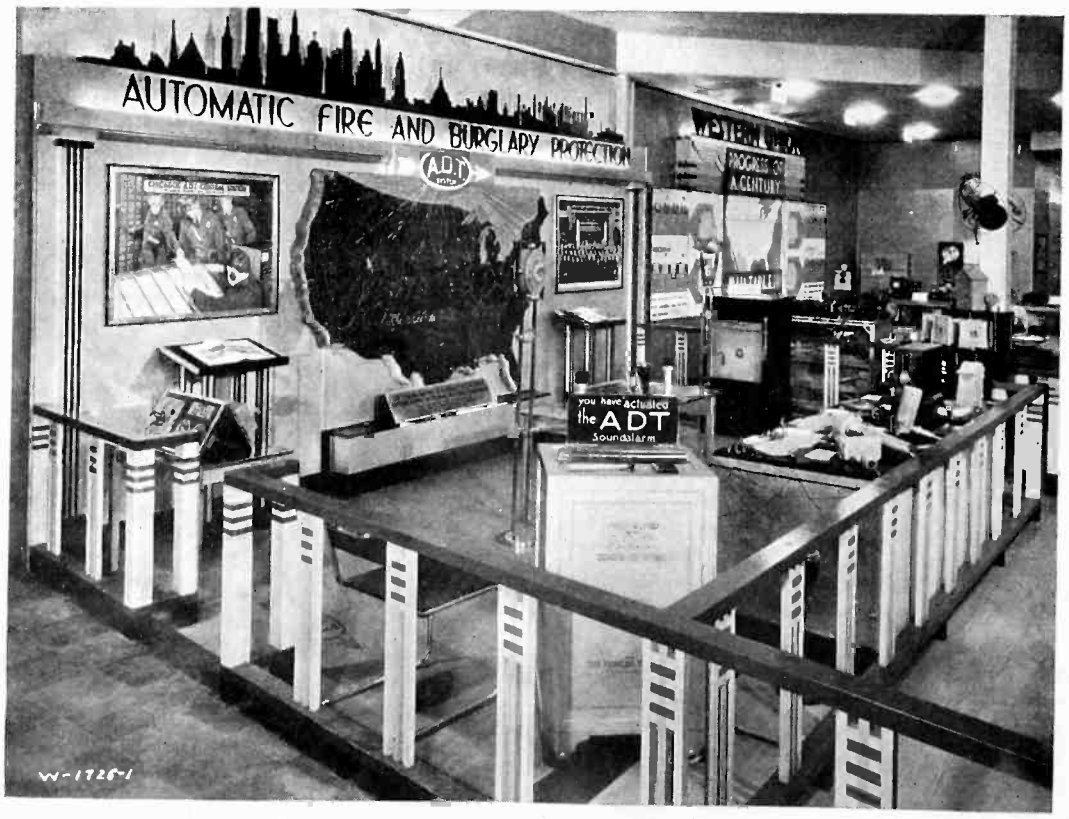
Microphones and loudspeakers in butcher shop

A BUTCHER'S SHOP, clean and germ-free like a hospital operating room, has been opened in Paris with the public blessings of several professors of the faculty of medicine and of representatives of the local authorities.

Dr. Kaplan, the author of this new venture in practical hygiene, has installed his salesmen in a huge glass chamber, the air of which is constantly being renewed and filtered, and kept at a temperature of 45 degrees Fahr. The salesmen wear rubber gloves and are dressed in white from top to toe. They cut up, weigh and pack the meat under the eyes of their customers with whom they communicate by means of microphones and loud speakers.

✦ ✦ ✦

APPROACH SAFE, ALARM RINGS



At Chicago, World's Fair crowds marvel at this A.D.T. Company exhibit of a safe with "space alarm." On merely approaching the safe, one's body sets a big bell ringing

Booth demonstrator reduces annoyance of booming low tones

HOW A DEMONSTRATOR'S WORDS may be understood by his audience without at the same time disturbing people outside the circle of listeners is interestingly shown in the Bell System exhibit at the Chicago Exposition.

Loud-speaking systems for such demonstrations have frequently been tried, but often with so much annoyance to unwilling listeners that they soon had to be discontinued. A principal cause of this is the carrying power of the low-pitched tones which emanate in large volume from most loud-speaking systems.

In designing the Chicago Fair installation, however, apparatus was produced which would favor the higher pitches, important to intelligibility, while discriminating against the merely noisy components which would boom out for hundreds of feet. At Chicago, this equipment is built into the demonstration booths, but it is commercially available in portable form as a single case which can be carried by one man and set up for use in a few minutes.

✦

Burglar alarm employs space principle

THE HOLMES ELECTRIC PROTECTION COMPANY of New York, which provides electrical alarms and supervision for business houses and banks, is now carrying on experiments with a space alarm, by which the mere approach of a marauder into the vicinity of a door, wall, table or safe can be detected.

As developed in the company's laboratory under the direction of L. H. Chase, electrical engineer, the outfit is compactly contained in a small carrying case which can be operated on either batteries or 110-volts alternating current. The output on a frequency between 4,000 and 5,000 kilocycles is accurately maintained by means of a crystal. The space alarm transmitter can be connected to any object or circuit it is desired to protect. In the case of a wall or doorway or furniture, adhesive metal foil is stuck onto the surface.

The new principle seems especially adaptable to the safeguarding of safes and strongboxes. Such a safe can be so arranged that anyone approaching it sets off the alarm, and under no conditions can the sensitivity of the system fall so low, even with the changes in conductivity due to damp weather, that the alarm is not sounded upon the slightest touch of the safe.

DEVICES IN INDUSTRY

Fewer failures under photocell-controlled school lighting

A 20 PER CENT REDUCTION in school failures has been the result of the two-year test in class room lighting conducted by the Tuscumbia (Ala.) City Schools in cooperation with Alabama Power and General Electric engineers.

Faced with the statements of educators that from 8 to 15 per cent of school children acquire defective vision within the few years of their school lives, F. C. Albert, a lighting engineer of the power company, sought the aid of the city schools in an experiment to prove his theory that poor lighting in the average school is robbing many of the nation's children of good vision.

Two school rooms were selected containing the same floor space and window area and with the same exposure to the sun. Each was already equipped with two 150-watt direct lighting fixtures controlled by a wall switch. In one this lighting equipment was permitted to remain unchanged, and in the other it was replaced with four Curtis 300 watt indirect fixtures controlled by a photoelectric relay, arranged to maintain a light intensity of 12 foot candles.

After standard "achievement" and Otis "intelligence tests," an equal number of pupils of the same rating were assigned to each room, and great pains were taken to balance the two groups as equally as possible in talents, intelligence and past achievements.

At the end of the first school year, it was found that it had been necessary for the lights controlled by the "electric eye" to operate 34.1 per cent. of the school hours to maintain 12 foot candles of light during school hours on the last three rows of desks farthest from the windows. At the end of the second year the lights had operated 32.6 per cent of the school hours to maintain the same intensity of light.

The first year's test developed 4 failures out of 36 pupils in the light-controlled room, as against 11 failures out of 34 pupils in the other room, an actual decrease of 20 per cent. The standing of the children in the photocell room was so astonishing as to grades, attentiveness and alertness that the experiment was continued a second year to check the methods of dividing the classes as well as the results. The second year's results duplicated those of the first, there being 8 less pupil failures in the photocell room than in the other, out of 42 pupils in each room.

Of equal importance, the teachers testified "The children in the photocell room were much more alert, cheerful and attentive, while those in the other room seemed restless and sleepy on dark days and were harder to teach."

The electric energy consumed in each room was metered and the cost of the additional electricity for the high-intensity lighting was $22.35 for the term. The annual cost of educating each pupil for the 1931-32 term was $28.

✦

Photocell smoke detector as "combustion-indicator"

C. C. SHEPPARD of the Ess Instrument Company, 30 Church St., New York City, has found it possible to employ some of his photocell smoke-detecting units as "combustion indicators," showing by means of a meter dial the exact condition at which combustion is proceeding most efficiently, such as the "haze-point" with oil-burning furnaces. With a meter calibrated at 100 for smoke, a reading of about 20 indicates a slight haze. Contacts introduced bracketing the needle above and below 20, can be arranged to light red and green lamps respectively, showing when the flue gases have too much air or too much unburned fuel.

Mr. Sheppard has installed a number of straight photocell smoke detectors in the New York area, in such prominent buildings as those of the Metropolitan Life Insurance Company, Standard Oil Company, Home for the Aged, New York Central power house, Port Morris, and Prudential Life Insurance Company, Newark, N. J. Photocell smoke detectors on ships offer another possibility, replacing the visual type of inspection tubes now installed at great expense.

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Sounds that cause chemical changes, cooking

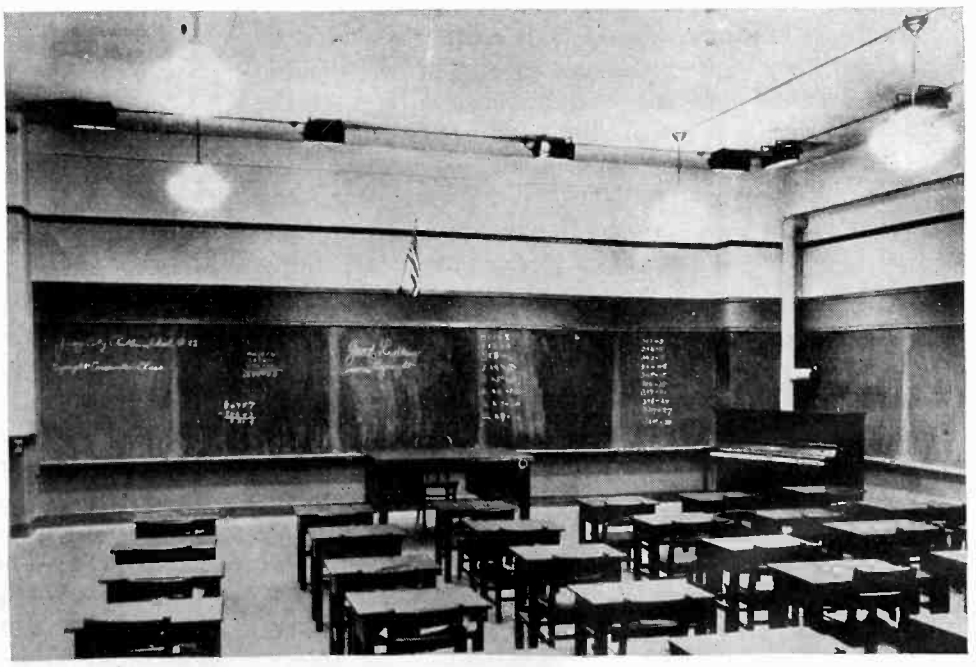
SOUNDS CAN CAUSE chemical changes of various kinds, if the sounds are only intense enough, according to a report presented to the Chicago meeting of the American Association for the Advancement of Science, by Dr. E. W. Flosdorf and Dr. L. A. Chambers of the University of Pennsylvania School of Medicine.

The sounds, projected into liquids, coagulated proteins, broke down ethyl acetate to produce acetic acid, "cracked" vegetable oils with the production of acetylene gas, and to a small extent decomposed starch to produce glucose.

A spectacular demonstration was the apparent soft-boiling of an egg subjected to the intense sound for a few minutes without any raising of the temperature.

The experimenters believe that these chemical actions are due to a momentary kinetic, or speeding-up, effect on the molecules involved, affecting them in much the same way as heating.

Most of the sounds used were very shrill, but one experiment employed tones only two octaves above middle C on the piano.



After two years' test of photo-cell controlled lighting in the Tuscumbia (Ala.) schools, brighter scholars, better grades, and fewer failures are reported

Loudspeaker cost vs. quality

[*Continued from page 242*]

cut off raises the permissible distortion. A 3,000 cycle peak produces what the average listener calls "highs."

For any given voice coil and cone there is a level at which the speaker gives maximum loudness efficiency. This is the point at which the cone just begins to break up. In small speakers the diaphragm is made so light that this critical level is reached with maximum input from the set. Therefore, when its loudness efficiency is compared with a large speaker which is intended to handle perhaps 6 or 8 times the power and, therefore, is a long way from its break up point the relative loudness efficiency of the latter suffers by comparison.

Cost versus quality

All of the factors discussed vary considerably in different speakers and it is, therefore, difficult to give concrete data which will help the set designer. To give some idea, however, of at least the general relationship between loudness efficiency and cost Figure 8 has been prepared. These data were obtained by measuring a

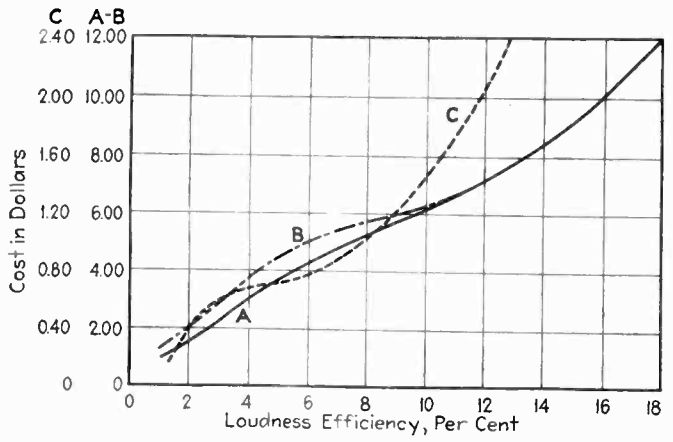


Fig. 8—Cost versus loudness efficiency showing operation of law of diminishing return

number of speakers in each price range and taking the unweighted average of the loudness efficiency with music and voice input. Curve A shows roughly the way in which loudness efficiency varies with cost. As would be expected, for very high efficiencies a point of diminishing returns is reached and the cost rises rapidly. At the low efficiency end a point of diminishing returns is also reached since the labor involved in making a very small speaker differs comparatively little from that of making a somewhat larger speaker and the reduction in the material cost is not enough to offset this. The curve, therefore, starts to flatten slightly.

Cost per decibel gain

If the small speaker is required to have as little steady state and transient distortion as the larger speaker, then the cost must be increased to maintain the same loudness efficiency. The estimated cost of producing small speakers with the same distortion now permitted in large speakers and with the same design factors (temperature, rise, etc.) is shown in curve B. It will be noted that in terms of percentage increase, there is considerable increase in cost in the cheapest speakers.

Curve C shows the cost of getting an additional db (approximately 26 per cent increase in efficiency at any point. For example, if the loudness efficiency is 4 per cent, the cost of obtaining an additional db of loudness efficiency is, roughtly, 68 cents.

In the design of a receiver, there are usually one or more points at which the cost of obtaining additional audio output increases sharply. This occurs, for example, when it is necessary to go from a single tube to two tubes in push pull when a transformer is added.

Because of the large variation in the cost of getting additional audio power in the case of different receivers made to sell at different prices, a curve corresponding to curve C, Fig. 8 for receivers must necessarily be made by each individual manufacturer with a particular series of designs in mind. Such a curve can then be used to determine the cost of various amounts of sound output. In the case considered above, for example, one db increase in the electrical output of the set might mean increasing the output from 1½ to approximately 1.9 watts. This might involve going from a single 43 to a pair of them in push pull if the plate voltage were limited. If the change would involve more than 68 cents, it would be more economical to increase the loudness efficiency of the speaker.

In general, this procedure cannot be justified if nothing but the loudness efficiency is considered. The power handling capacity of small speakers is, however, limited so that even if moderate distortion can be tolerated, it it frequently necessary to increase the size of the speaker to increase the total sound output that can be gotten even though additional audio power is available.

In more expensive receivers, fidelity is of greater importance and here the more efficient speaker justifies its additional cost by the lowered steady state and transient distortion as well as by the improvement in efficiency. The high efficiency speaker would be very common if the same distortion requirements were placed on the small speaker that obtain on the larger ones.

In spite of the high cost per db in large speakers, it is important to remember that the cost per db of set output also rises rapidly beyond a certain point because of the larger tubes involved and the higher voltages necessary. For this reason even in public address work where moderate distortion is usually tolerated, it frequently pays to use a more efficient speaker because the audio frequency output cost rises rapidly in an amplifier designed to supply more than about 20 watts.

The small speaker—pro and con

Summarizing, we see that as the efficiency of the loudspeaker is decreased in the piston range the loudness efficiency decreases more slowly. Small speakers, therefore, have relatively better loudness efficiency considering the amount of material used in their construction for all or most of the following reasons:

1. Greater output at resonance as critical coupling is approached between electrical and mechanical circuits.
2. Greater high frequency output because of the reduced voice coil mass.
3. Increased steady state distortion which also increases the apparent bass.
4. Operation nearer the critical cone "break up" point.
5. Common use of 400 circular mills per ampere in the field with very high field temperatures.
6. Use of "commercial" gap clearances which give greater voice coil alinement problems than would obtain in a conservative design.

The advantages of the small speaker are:

[*Please turn to page 260*]

Initial impulse indicator

By O. W. LIVINGSTON
and H. W. LORD
General Electric Company,
Schenectady, N. Y.

THIS article deals with a general method of determining which one of a series of rapidly occurring events happened first, together with a practical application of the principle.

It is first necessary to reduce the events which we wish to observe to voltage signals. In electrical circuit problems these voltages are often present or obtainable with little trouble but in other cases it may be necessary to translate sound, motion, or light to an electrical signal by the use of microphone, contact or phototube.

Figure 1 shows a circuit which may be used to determine which of three impulses occurs first. Let the source of the three impulses be connected between X_1-C, X_2-C, and X_3-C respectively and the switch S_1 closed. The voltage drop across the resistor R_1 is the anode potential applied to the three grid controlled rectifiers T_1, T_2, and T_3 and the voltage drop across R_2 supplies a bias normally sufficient to keep the tubes nonconducting. Let us assume now that an impulse is received at X_1-C which momentarily throws the grid of T_1 positive. The tube starts conducting within a few microseconds reducing the anode to cathode voltage to about 15 volts. This decreases the voltage across the resistor R_1 to this same value and the balance of the d-c voltage must appear across R_2. Thus, once tube T_1 starts to conduct the anode potential on all the other tubes is reduced and simultaneously their grid bias is increased making it impossible for them to conduct even if they receive subsequent impulses. Thus, the first tube to receive an impulse remains conducting until it is observed and the circuit reset by momentarily opening S_1. Of course this circuit may be extended to include any number of impulse sourses by adding an additional tube for each impulse source.

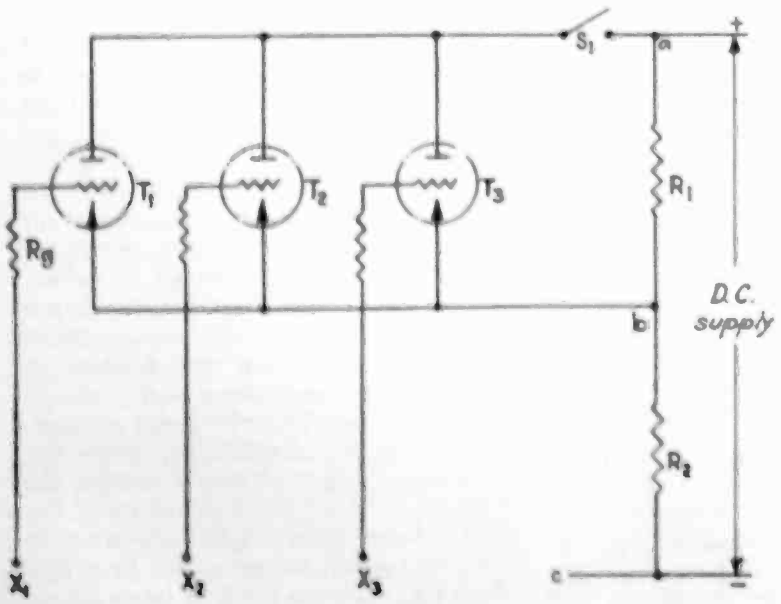


Fig. 1—Circuit for determining which of three impulses occurred first

Applications of the impulse indicator

One of the most useful of the applications of this circuit has been for arc-back indication in mercury vapor rectifier sets. If tube trouble is experienced in a multitube rectifier set it is often difficult, particularly with the modern trend toward metal tubes, to determine which tube is at fault. In the past simple magnetic reverse current relays have been used in the individual anode circuits but this is not very satisfactory since an arc-back in one tube generally produces a severe overloading of the other tubes, often causing them to arc back through no fault of their own. It is not uncommon to find all of these indicators open after a severe arc-back which, of course, does not help much in locating the trouble.

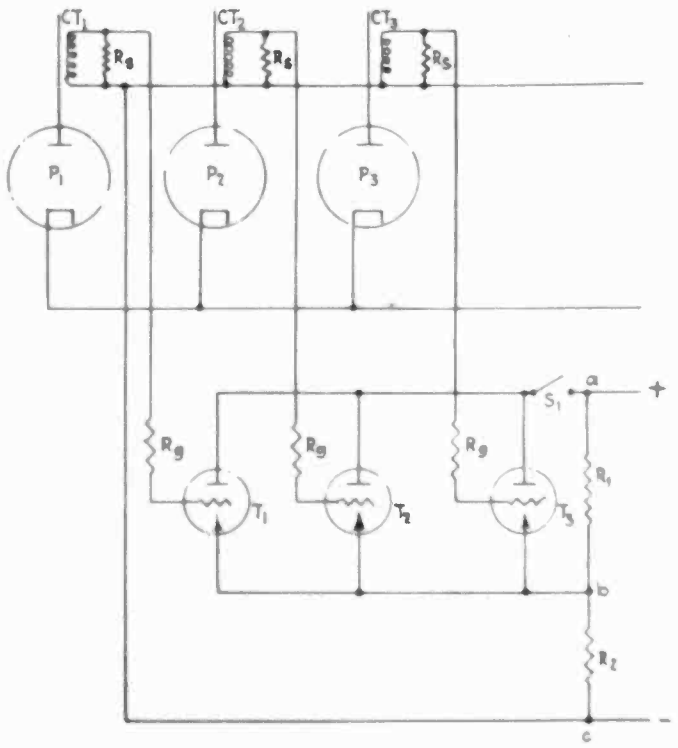


Fig. 2—Connections of impulse indicator to a three-phase rectifier

Figure 2 shows how the initial impulse indicator may be connected to indicate which tube in a three phase outfit is causing the initial trouble. Current transformers shunted by resistors are inserted in the anode leads of the power tubes as shown, so that as long as the current flows in the proper direction the current transformers are practically saturated and any small output voltage left tends to make the grids even more negative. As soon as a tube arcs back, however, a current of 10 or 20 times normal, depending upon the power transformer impedance, flows through the current transformer of the arcing back tube causing a positive signal on the grid of the associated tube. This tube then remains "on" re-

[*Please turn to page 260*]

REVIEW OF ELECTRONIC LITERATURE

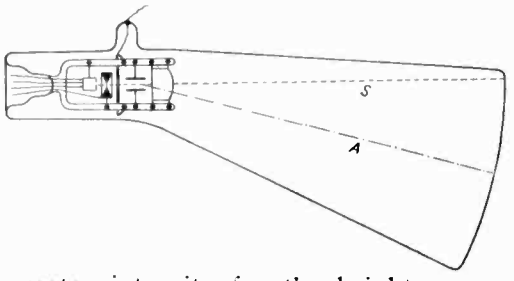
HERE AND ABROAD

Secondary electrons in screen-grid tubes

[J. HERWEG and G. ULBRICHT, Hannover Inst. of Technology.] While screen-grid tubes have to be operated with the plate at a much higher potential than the screen in order to get rid of the effect of secondary electrons, other portions of the characteristics may one day become useful. When in a screen-grid tube (H 4100 D), the screen is left at 100 volts, the control grid is made positive and the plate potential is increased from zero upward, the curve showing the plate current at a given grid voltage rises first, then drops with a slope which is steeper the more positive the grid, and starts to rise again at a potential which is higher the lower the grid voltage, but in any case only slightly above the point where the plate potential becomes higher than the screen voltage. The curves resemble in shape those obtained under normal operating conditions. The control grid exerts a strong influence upon the current, its value being 4, 12, and 21 ma. for zero, 4 and 8 volts on the grid (mutual conductance 0.005). Tubes with coaxial cylindrical electrodes do not show straight slopes, and some portions of the curves may vary from day to day. As the mutual conductance is given by the horizontal distance between the curves, it is very variable, starting with very high values at zero plate voltage, becoming negative in the falling portions and rising to a few hundred per cent.—*Hochfr. Techn. u. El. Ak.* 41: 189-194, 1933.

Distortion produced by space charges in cathode ray tubes

[E. HUDEC, German Central Post Office Laboratory.] The distortion occurs in tubes with incandescent cathodes when the plate potential is 2,000 volts and the normal discharge current of a few tenths ma. is exceeded so as to obtain



greater intensity for the brighter portions. The image appears distorted in the neighborhood of the horizontal, or vertical middle-line of the screen, or both, that is when the deflecting potential passes through zero. The effect is due to space charges formed by the positive ions in the neighborhood of the deflecting plates, and the electric forces they exert. It can be eliminated at the expense of brightness by reducing the pressure of the gas remaining in the tube. It is better and simpler to make the former center of the screen the edge of the screen, extending the screen to one side in order to give it its former size. The electron beam must be moved closer to one of the deflecting plates. These off-center screens, and tubes making an elbow between the screen and the deflecting electrodes give perfect reproduction.—*El. Nachr. T.* 10: 215-220, 1933.

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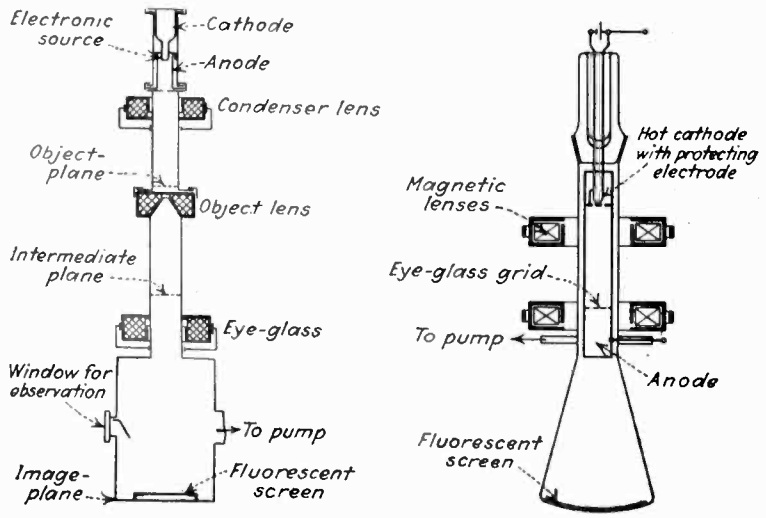
ELECTRONIC MICROSCOPE



Left, cold cathode; right, hot cathode microscopes of Knoll—see page 243 this issue of Electronics

Temperature of oxide coated filaments

[P. CLAUSING AND J. B. LUDWIG. Philips Research Laboratory.] Data on the electron emission of oxide-coated filaments as a function of their temperature vary a great deal owing to the difficulty of determining the temperature from the light radiated. An oxide-coated platinum filament gives a total radiation of about 8 watts per sq.cm. at 1,200 deg. abs. with a konel core 5 and with a nickel support 2 watts. The reason for the difference is that light from the core passes through the thin oxide layer, so that the radiation from strontium oxide on a nickel support increases first with the thickness of the layer (from 0 to 33 microns) and decreases beyond this value to become constant at about 0.1 mm.—*Physica 13;* 193-205, 1933.

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Secondary electrons in screen-grid tubes

[C. J. LUSSANET DE LA SABLONIERE, Philips' Research Laboratory, Eindhoven.] Knowledge of the part which secondary electrons play in screen grid tubes is useful because they limit the range over which the tube can be used. When the ratio a of the plate current I_p to the total current $I_s + I_p$ as depending upon the ratio V_p/V_s is plotted for a series of negative grid voltages, but constant ratios screen to grid voltage V_s/V_g, a family of similar curves is obtained which rise, fall and rise again to pass all through nearly the same point when V_p equals V_s. A simple curve following the first ascending portion of the curves and passing then through the common point $V_p/V_s = 1$ represents the ratio b of the number of primary electrons hitting the plate to the sum of screen and plate current $I_s + I_p$. It can be shown that any one of the b curves can be deduced from the a curves when only one point of it has been found by direct measurement or more simply by drawing a series of curves for various assumed b values, first in the range where V_s is larger than V_p and then in the region where V_s is smaller than V_p, and choosing as the correct b curve those two positions which most closely prolong one another. From these two families of curves the ratio of secondary electrons leaving the plate to primary electrons hitting the plate is found by a simple calculation, at any one point as equal to $(a-b)/(1-b)$. Various types of tubes examined did not show saturation.—*Hochfr. u. El. Ak.* 41: 195-207, 1933.

Positive-grid amplifying detector for 10 cm. waves

[H. E. HOLLMANN, Heinr. Hertz Institute, Berlin.] The new circuit is based upon the fact that when tubes with cylindrical electrodes and positive grid are worked near saturation and the electrodes are far apart (small mutual conductance) the grid current decreases from its saturation value at negative

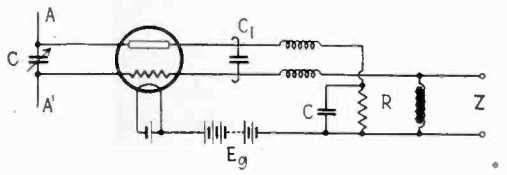


plate potential to a constant value as the plate becomes more and more positive, and the plate current increases from zero to a constant value. The sum of both currents is equal to the total emission. In the transition region, where the plate current starts to grow and just before it becomes constant, rectification is produced as the result of the non-linear characteristic, the characteristic being nearly independent of the grid potential when the mutual conductance is small. The modulated incoming wave is applied between plate and grid, the output transformer is placed in the grid circuit.—*Funkt. Monatsh.* 2: 249-253. 1933.

✦

The effect of metallic shields on tuning coils

[H. KADEN, Siemens and Halske Research Laboratory, Berlin.] To facilitate the correct design of shields for r-f coils the author develops practical formulas showing how much the inductance L_0 drops and the resistance increases when a tuning coil is placed in the center of a metal box and what is the ratio S of the field outside the screen to the field without shielding. For ordinary non-magnetic materials, such as aluminum or manganin of specific resistance r, radius R and with walls d cm. thick the formula holds that $1/S^2 = (\cosh 2p - \cos 2p)\ p^2R^2/9d^2$ where $p = 0.02\ d\sqrt{f/r}$. The resistance of the coil increases as the reciprocal of the fourth power of the radius R, the value $1 - L/L_0$ decreases with the reciprocal of the third power. For a shield of manganin of 4 cm. radius (r about 40 ohms per sq.cm. and cm. or $p = 0.6$ when $d = 0.5$ mm.) the ratio S comes out to be 1/20 at 150,000 cycles, the inductance L_0 is reduced to 0.88 of its initial value $L_{0'}$ and the phase angle caused by the shield is 0.007. For an aluminum shield ($R = 2.54$ cm. thickness $= R/100$), the outside field is reduced to about 1/100 at 100,000 cycles and to 5/10,000 at 1,000 kc. The formula for the outside field agrees with the theory given by Prof. L. V. King in *Phil. Mag.* 15: 201-223. 1933.—*El. Nachr. Techn.* 10: 277-285. 1933.

Shielded antenna leads

[E. SCHWANDT. O. NAIRZ.] Two types of shielded connections between antenna and receiver have been developed, one a shielded light cable which can be freely suspended from the antenna when the length does not exceed 100 feet. When longer leads are required it is necessary to use lead-clad cables mounted on the wall. Parts fitting any size of cable, parts for bridging gutters and special end pieces are available. It is important that shielding be continuous and extends to the lightning arrester, which enters into action at 350 volts, and the earthing switch prescribed by regulations.

The second author describes how he secured satisfactory reception with the aid of a shielded lead-in in a house on a street car line where it was at times impossible to receive a local station 15 miles away.—*Funkt. Monatsh.* 2: 255-257. 184-185. 1933.

✦

Filter-type interstage amplifier coupling

THROUGH ERROR THE CIRCUIT of Mr. Stone's interstage coupling device described on page 194, July *Electronics,* was not given correctly. As described, this interstage coupling system involves a mid-series termination low-pass filter. Of course the two end inductances in such a filter have one-half the inductance of the central inductance. Therefore the three inductances from the plate down should be $L/2$, L and $L/2$.

✦

The radiometer as field strength meter

[G. BEAUVAIS, French National Radio Laboratory.] To measure the field strength produced by tubes giving 10 to 20 cm. waves the author uses the rotation of a half wavelength radiometer vane placed in a small glass container in which the pressure has been reduced to 1/100 mm. mercury. A thin narrow foil of aluminum forms one long side of a small rectangular frame, a mica sheet of the same dimensions the other long side; a fine wire running midway between these two sides carries a light mirror, and suspension wires are attached to the cross-pieces between the wire and the aluminum foil. The frame is then bent around the central wire as an axis so as to place mica and aluminum face to face. At the resonance point the current induced by the field in the aluminum foil heats the foil and the impact of the gas molecules causes the whole frame to turn. The direction and strength of the field can thus be explored without the use of meters and connecting wires. The field strengths studied are of the order of 1/100 volt per m.—*Onde électrique* 12: 213-235. 1933.

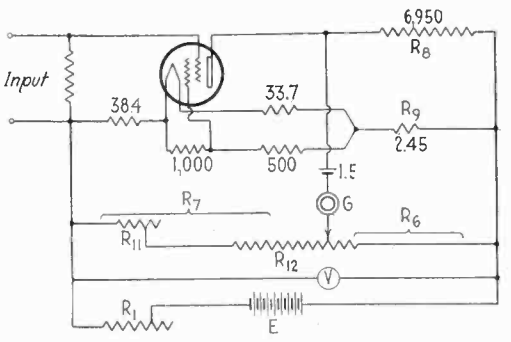
Further work on ultra-short wave tubes (12-15 cm. waves)

[E. GOSSEL, University of Erlangen.] Earlier results, namely, that the coaxial cylindrical positive grid and negative plate with their lead-in wires may vibrate together, or that the grid spiral may vibrate as one whole wavelength, were confirmed. When the length of the circuit connected to the grid is changed, a series of values are found at which the tube generates maximum energy at the same wavelength. When instead of leading the wires coming from the ends of the grid spiral in a straight bend to the base of the tube, the grid is shorted by a second spiral of the same dimensions, the grid potential being applied at its center, the tube is capable of giving strong vibrations of wavelength 22.5 cm. and 14 cm. In this case the electrical oscillations take place in the planes parallel to the turns of the spiral, not parallel to the axis as is the case with a single spiral and a straight bend. It is also observed that on changing the tuning of the plate grid circuit values are found at which this circuit withdraws energy from the oscillating grid system so that the energy radiated by the grid passes through low values. The heating circuit may also be set into resonance for certain values of the electron emission.—*Hochfr. Techn. & El. Ak.* 42: 1-10. 1933.

✦

An improved balanced circuit for electrometer tubes

THE FP-54 tube can draw both its filament and plate currents from one battery, but for stable operation the resistances have to be appropriately chosen. The characteristic of the tube is first obtained under approximately the conditions under which it will be used in the balanced bridge. In arranging the bridge



the tube can be thought of as a combination of a resistance R and an effective emf. E. Zero current will be obtained in the bridge provided that $R_8/R_T = E_B/(E - E_B)$, and $R_7/R_8 = R/R_8$ and a suitable value of R_8 can be calculated. Varying R, makes the reading of the bridge galvanometer pass through a minimum which can be reduced to zero by adjusting R_{11}. — *Rev. Scient. Instr.* 4: 429-433. 1933.

Initial impulse indicator

[*Continued from page 257*]

gardless of any subsequent events until S_1 is opened, clearly indicating where the trouble originated.

Figure 3 shows an oscillogram of an arc-back on a three phase half-wave outfit. The oscillograph elements were inserted in the anode leads of the tubes so that the normal direction of current flow gave a deflection above the zero axis. Several cycles after load was applied an arc-back occurred in tube No. 2. This caused an overload on tube No. 3 causing it to arc back in the next half cycle. Before the breakers opened, an arc-back occurred in the tube No. 1 as the result of a second failure of tube No. 2. Under these conditions if simple reverse current relays had been inserted in the anode leads, all three would have indicated a fault which would not have helped to locate the faulty tube. Using the initial impulse indicator, however, the tube in the second position was turned on, clearly indicating where the trouble was.

A six tube initial arc back indicator has been built in portable form. Six "clamp on" current transformers are carried in the bottom section of this portable device which make it possible to investigate trouble in any outfit having six or less tubes.

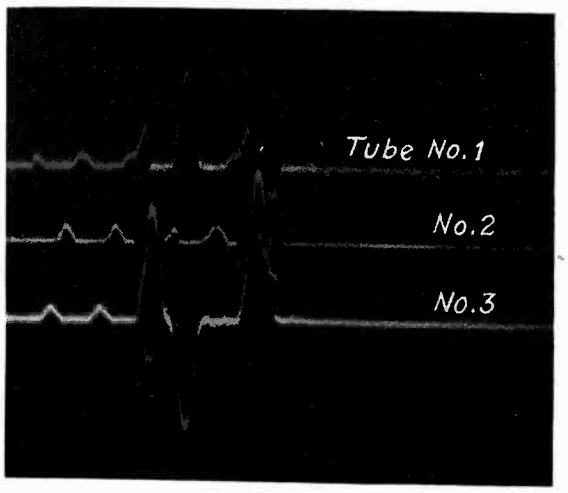


Fig. 3—Oscillogram of arc-back on three-phase half-wave rectifier

Other applications of this indicator will doubtlessly be found both in the field of industry and in the field of amusements.

✦ ✦ ✦

Loudspeaker cost vs. quality

[*Continued from page 256*]

1. Better extreme high frequency response can be obtained with small inputs due to the reduced voice coil mass.

2. Slightly improved polar characteristic.

The advantage of (1) is lost because the speakers are operated near their critical level and are required to show little distress with a distorted set output.

The advantages of the large speaker are:

1. Higher energy and loudness efficiency.

2. Absence or minimization of transient distortion at fundamental resonance. This permits high fidelity when it is wanted since it permits the set designer to introduce the low frequency resonance electrically so that it is under control in either a continuously variable or semi-permanent adjustment.

3. Low steady state distortion. Since existing distortion contributes very little to the loudness efficiency it could be considerably reduced at but slight loss in loudness efficiency.

4. Operation far below critical level permits the effective frequency range to be extended further than it is in small speakers.

5. Moderate excursion results in only slight changes in the physical constants of the mechanical system with life (in 5-inch speakers, the stiffness of the annulus sometimes changes so rapidly that distortion measurements at resonance with full input cannot be made before the resonant frequency drops).

6. More conservative voice coil clearance with improved alinement life expectancy.

7. Conservative temperature rise with further improved life expectancy.

The use of the 5-inch speaker has been made possible because of the very surprising amount of distortion the public will tolerate[3]. In some unpublished tests of permissible distortion in music with 3,000 cycles cutoff, we have found that with an inexperienced listener, 40 per cent second harmonic distortion can be tolerated in the absence of a distortionless source with which to compare it.

Another factor has been the public acceptance of very small sets which necessitated small speakers if the set was to be completely self-contained. The present move toward the use of a separate speaker with good fidelity should provide the portability and appeal of the small set with the fidelity and advantages of the large speaker and baffle.

In addition to the separate speaker trend, there appears to be a general increase in interest in high fidelity receivers. Any general improvement in this direction will probably have to result from a change in the public's interest in sets which sound like a radio to sets actually built to reproduce the original with good fidelity. There will undoubtedly be a transition period during which many sets will be arranged so that high fidelity reproduction will be possible and so that the "boom," middle high frequency peak and the high frequency cutoff can be taken care of by distortion controls.

The psychological fact that one is listening to an artificial source of music seems to have a bearing on this point. Even those whose ears have been trained to musical appreciation seem to be easily misled by this factor. The number of times is legion that a trained musician has termed as "perfect" a specimen of radio reproduction which was really limited in tonal range, severely compressed in volume and full of distortion.

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[1]The relative loudness efficiency of two speakers may be defined as the reciprocal of the power input for a specified impedance to give the same loudness. See I.R.E. 1933. Report of the Standards Committee, page 164.

[2]See Rayleigh Theory of Sound, Vol. 2, page 165. Cone excursion given in May, 1932, *Electronics*, page 154 were too high because of exponent of π.

[3]The permissible distortion in speech Frank Massa, May, 1933, I.R.E. Proceedings.

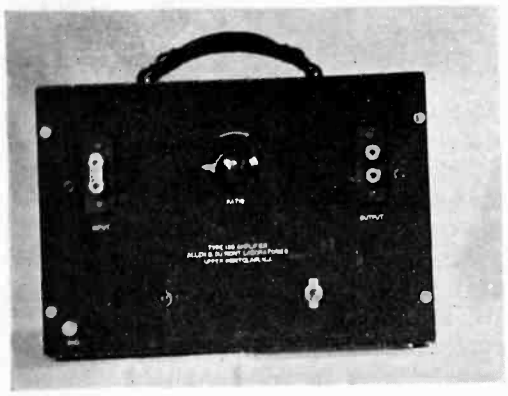
This paper by Mr. Knowles was delivered in abbreviated form at the recent annual convention of the Institute of Radio Engineers.

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Amplifier for oscillograph

To EXTEND THE RANGE of the cathode-ray oscillograph a special high quality a-c operated amplifier has been developed by the Allen B. Du Mont Laboratories, 9 Bradford Way, Upper Montclair, N. J. This amplifier may be used for the measurement or observation of many effects which of themselves are not of sufficient magnitude to operate the cathode-ray tube directly but which nevertheless should not be entrusted to



an ordinary amplifier for their faithful reproduction. It may also be used for many laboratory problems not connected with the cathode-ray oscillograph.

This Du Mont Type 136 amplifier is a three stage unit with power supply which has a voltage amplification of 500 and will deliver 50 volts r.m.s. to the cathode-ray tube. The input impedance is one megohm and the output impedance is 7000 ohms resistive. The ratio of output to input voltages does not vary more than 3 per cent from the 1000 cycle value between 10 and 100,000 cycles in which range the phase shift is proportional to frequency, there being a lag of 8 degrees at the upper frequency. The ratio of output to input voltages does not vary by more than 5 db. from the 1000 cycle value between 100 kc. and 900 kc.

The amplifier is priced at $120, complete with tubes.—*Electronics.*

✦

Transformers and chokes

CENTRAL RADIO CORPORATION, Beloit, Wisconsin, has added a transformer and choke division to its socket line. This new division will specialize in small transformers, audio frequency and filter chokes, featuring new designs in this field. Exhaustive field and laboratory tests over a period of two years have proved the soundness of the new designs. Standard mounting centers have, of course, been adhered to. Some of the features of the new device are greater inductance, smaller sizes, lower cost and greater breakdown voltages, as well as a new and convenient lug terminal. J. C. Snell will head this new division.—*Electronics.*

✦

Photronic Kit

THE WESTON ELECTRICAL INSTRUMENT CORPORATION, 614 Frelinghuysen Ave., Newark, N. J., has just announced a new, inexpensive Photronic control kit which is being marketed especially for those engineers and manufacturers who prefer to do their own experimenting with photo-electric control for mechanical equipment, operations and for processes of various kinds.

The kit contains all the equipment necessary for the engineer to start immediate experiments. The equipment can be used as a smoke detector, burglar alarm, turbidity detector, door opener, counter for all classes of service, safety device on machines, etc.

The cell included in the kit is the Weston Photronic cell which has the peculiar faculty of transforming light energy directly into electrical energy, and operates the Weston relays without the use of any auxiliary apparatus or batteries. As far as is known, the cell has unlimited life and the output is constant. Its spectral response is about the same as the human eye, so that it is extremely sensitive to color changes and is finding wide application wherever processes must be controlled by changes in color.—*Electronics.*

✦

Ignition filter

C. M. SHERWOOD & COMPANY, 80 Seventh St., Long Island City, have developed an ignition filter for the protection of automobile radio sets, which has as its feature a low resistance of only 200 ohms, in comparison with resistances up to 40,000 ohms, of other forms of spark suppressors. This low resistance insures a hot spark, according to Mr. Sherwood, and so results in improved automobile performance, eliminating loss of power and speed, production of carbon, sluggish acceleration, increased gasoline consumption, and sticky valves, all of which are caused by weak ignition sparks failing to fire the fuel gases in the cylinders.—*Electronics.*

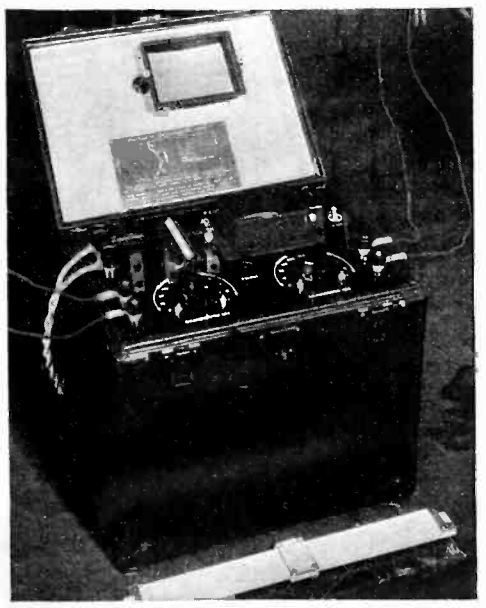
New series F formica

A NEW PRODUCT KNOWN as Series F Formica is being offered by The Formica Insulation Company of Cincinnati, Ohio. This consists of a Formica facing in various solid colors on metal and on hardboard. The material is used for panels in cabinets of various kinds where good color, good surface, durability and resistance to chemicals and liquids of various kinds is desired. The coating on metal is flexible and will not easily chip off as occurs with many enamels used on iron. —*Electronics.*

✦

A portable oscillograph

AN ENTIRELY NEW OSCILLOGRAPH, differing greatly from previous designs, has been developed by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., using a new type of optical system and galvanometer. This new instrument may be used as conveniently as an ordinary voltmeter or ammeter, and has other characteristics which will extend the range of application of oscillographic instruments.



The instrument is entirely self-contained and may be operated from a 110-volt, 60-cycle lighting circuit without auxiliary attachments. The oscillograph is very compact as shown by its over-all dimensions which are 8 in. by 11½ in. by 11 in. Its total weight is approximately 18 lbs. Both galvanometers may be used for measurements of potentials up to 300 volts or currents up to 10 amperes without the use of external resistors.—*Electronics.*

Insulating sleeving

WILLIAM BRAND & COMPANY, makers of electrical insulating materials, 268 Fourth Ave., New York City, have produced a new saturated sleeving which offers a very high resistance to extreme breakdown voltages. This new sleeving replaces untreated sleeving, and permits a rigid form of insulation on lead wires, etc., allowing assemblies in places where soft sleeving offers considerable difficulty. The new material remains perfectly round, and retains its resiliency. Tests made of the yellow sleeving have shown it to withstand breakdown potentials of 6,900 volts.—*Electronics.*

✦

Molybdenum and tungsten

THE AMERICAN ELECTRO METAL CORPORATION, with factory at Lewiston, Maine, and offices at 65 Madison Ave., New York City, is producing very pure molybdenum and tungsten. Its molybdenum wire is made up in accordance with customers' specifications, in various diameters and in any temper, suitable for grids in radio tubes, supports for incandescent lamps, and supports for electrodes for all kinds of vacuum tubes, including X-ray tubes. A special field for ribbon and heavy wire is for electric furnaces where a high temperature is required. Molybdenum is also made in other forms, such as rods, sheets, "boats" for annealing furnaces, plates, shields for X-ray tubes, etc.

Besides molybdenum, the company supplies as a specialty tungsten rods in large quantities for the manufacture of tungsten contacts; tungsten targets for X-ray tubes and all kinds of internal parts for X-ray tubes. It has also developed a tungsten sheet with a guaranteed purity of 99.5 to 99.7 per cent. This sheet is exceptionally ductile in consequence of its purity. The sheet can be bent and stamped into shapes. It can be supplied down to a thickness of 0.050 mm. Upon special request it can be supplied as thin as 0.030 mm.—*Electronics.*

✦

Radio wires and cords

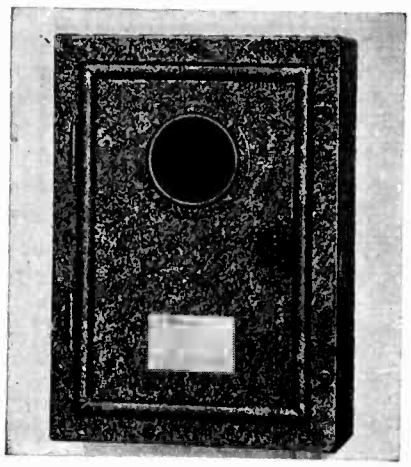
THE RADOLEK COMPANY, 601 West Randolph St., Chicago, is distributor for the Lenz Electric Manufacturing Company, 1751 North Western Ave., Chicago, handling its radio cords, cables and wires. These products include Lenz wire, radio speaker cords of both magnetic and dynamic types, extension cords, headset cords, microphone cables, shielded cables, and shielded antenna conductors.

Shielded cables are used in connection with automobile-radio, public-address systems, and other sound equipment. The closely woven shield of annealed tinned-copper wires acts as a static reducer and eliminates various disturbances. On account of the short aerial used with auto radios, the Lenz company builds antenna cables of ½-inch overall diameter. This is accomplished by using a cotton filler before applying the copper shield. A braid of cotton treated with weatherproofing applied over the copper shield can be furnished if desired.—*Electronics.*

✦

Elevator levelling relay

IN THIS WESTINGHOUSE UNIT, having three housings, light-sensitive tubes in two outer housings are illuminated by a lamp in the center housing. Vanes in elevator shaft at floor level pass between housings, being so located as to bring car to the exact floor level. If car is off level in one direction one phototube is illuminated and if off in the opposite direction the opposite phototube is illuminated, resulting in inching of



elevator motor to bring car in correct position within ⅛ inch of floor level. Some 36 of these are installed at Radio City, New York, and eighteen are installed in the new Chicago postoffice. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—*Electronics.*

✦

Wire-wound resistors

A COMPLETE LINE OF wire-wound resistors has been placed on the market by the Atlas Resistor Company of 423 Broome St., New York City. The resistance wire is wound on special-process porcelain tubes and is of the finest grade enameled nichrome. The range of resistances available runs from 50 ohms to 100,000 ohms and varies from the small 2-watt sizes to the large 100-watt units. Special sizes can be made upon application.

By employing the pack-winding method, these resistors have been made as physically small as is consistent with good engineering practice. Owing to the special enamel varnish used, heat radiation is greatly facilitated. This insures long life and permanency of resistance values.—*Electronics.*

Microvolter

FERRIS INSTRUMENT CORPORATION, Boonton, N. J., has developed its Model 10B microvolter as a convenient, portable unit for sensitivity measurements on radio receivers. It is intended for factory and field testing, and for much of the use in laboratory and development work where all the features of a more expensive signal generator are not needed.

It covers a frequency range of 150 to 20,000 kcs. by means of six coils included in the instrument. This permits measurement not only at broadcast and intermediate frequencies, but at practically all frequencies covered by the vast majority of aircraft, police and other high frequency receivers.—*Electronics.*

✦

Transformers, Sockets

THE CENTRAL RADIO CORPORATION, 156 Roosevelt Ave., Beloit, Wis., has developed a line of transformers and chokes designed to conserve space while providing the same or improved operating characteristics. The line includes microphone-coupling transformers, speaker transformers, filter and output chokes. Class A and Class B audio transformers are also available for any of the new tube combinations in the small dimensions which characterize the CRC line.

The company also makes the CRC socket in all types, employing heavy 26-gauge cadmium-plated clips, with extra heavy solder lugs, and strong wiping contacts.—*Electronics.*

✦

Turntable for transcriptions

THE SYNCHRO-MOTIVE INSTRUMENT COMPANY, Chrysler Building, New York City, has developed turn-table equipment for reproducing broadcast transcriptions, which gives accurate speed regulation "without waver."

The equipment is made in three different models, Model "ST" is a 33⅓ r.p.m. synchronous motor used for reproducing 33⅓ r.p.m. recordings only. Model "CT" is a combination 33⅓ and 80 r.p.m. synchronous motor for reproducing both 33⅓ and 80 r.p.m. records. Model "DCT" is a combination of two model "CT" units, and is equipped with a mounting panel for fading controls. With this model it is possible to fade from 33⅓ to 80 r.p.m. recordings through the same mixing circuit, without making any changes in the pick-up input circuits.

The change in speed is controlled by a switch. These machines can be supplied with Audak pick-ups to play lateral and vertical-cut records.—*Electronics.*

B power device

The B-power supply unit produced by Herman A. DeVry, Inc., 1111 Center St., Chicago, Ill., is not merely a vibrating interrupter, but a means of obtaining a true alternating current from a battery source. The frequency (150 cycles) remains constant under wide variations of d.c. input voltages, as the frequency is directly dependent upon the weight and tension of the armature.

Being compound-wound, the unit provides automatic voltage regulation under varying load conditions. This is accomplished by automatically increasing the amplitude of the vibrating armature when the transformer secondary load is increased.

The variation of current in the primary of the power transformer is dependent upon the pressure and resistance of the contact surfaces. Increased pressure caused by the increase in amplitude raises the primary voltage when the secondary load is increased.

The standard DeVry B power supply for auto radio sets delivers 220 volts at 40 mils. The unit in the DeVry sound-on-film recorder delivers 650 volts at 40 mils. The same converter unit may be adapted to many other electronic devices.—*Electronics.*

✦

Motor overload protection

FOR THE OVERLOAD PROTECTION of fractional-horsepower single-phase motors, the Square D Company, industrial controller division, Milwaukee, Wis., offers the new "Knockout" overload breaker. It is designed to mount on and wire into a standard $\frac{1}{2}$-in. knockout. The case is made of bakelite and the overall dimensions are only $2\frac{7}{16}$ in. high, $1\frac{3}{8}$ in. wide and $1\frac{3}{4}$ in. deep. The breaker is of the thermal, melting-alloy type. After an overload trips the breaker, it is reset from an indicating button; no replacement parts are required. The contacts are silver to silver, single pole, double break. The maximum rating is $\frac{3}{4}$ hp., 110 or 220 volts, a.c.—*Electronics.*

✦

Rectifiers

THE SQUARE D COMPANY, Detroit, Mich., has increased its copper oxide and tube rectifiers.

The Square D "Rectifilter" converts alternating current to direct current merely by connecting the input to any regular a.c. source of supply. Models are manufactured to power any equipment requiring d.c. Units delivering output with a degree of a.c. component down to 0.0002 volts are available. Such requirements as telephone switchboards, signal and clock systems, fire and police signal systems, sound-on-film and broadcasting can be supplied.

One of the new Rectifilter units equipped with a copper-oxide dry-plate rectifier, is designed for telephone switchboard service and delivers 24 volts at 2 amperes from a 115-volt a.c. source.

Another model, designed particularly for apartment house telephone and other interphone systems, because of the simplicity of the Rectifilter design, can be stocked by dealers and installed within a few minutes in place of batteries by connecting the a.c. line and the d.-c. load to the proper terminals. —*Electronics.*

✦

Crystal microphones

THE BRUSH DEVELOPMENT COMPANY, 3715 Euclid Ave., Cleveland, Ohio, has developed a new line of Brush grille-type microphones, employing Rochelle-Salt crystals. These microphones employ a new principle which, the makers believe, will prove revolutionary in sound production. Moreover, in employing this new principle, the line of microphones gets away from the difficulties which are inherent in diaphragm types, inasmuch as the sound-wave passes through the microphone with no subsequent distortion due to pressure doubling or cavity resonance.

The following types are now available:

Type G-20—The general-purpose studio microphone. It consists of twenty "sound cells" connected to give the required output—mounted in monel-metal cage and plug.

Type G-1—Single "sound cell" in case, must be within about 30 ft. of preamplifier. Ideal where microphone must be concealed in film recording, for announcing, for use in parabola and as "lapel" microphone.

Condenser head substitutes may be used to replace present condenser head in amplifier, converting condenser into crystal microphone, doing away with frequent adjustments and greatly improving the response.—*Electronics.*

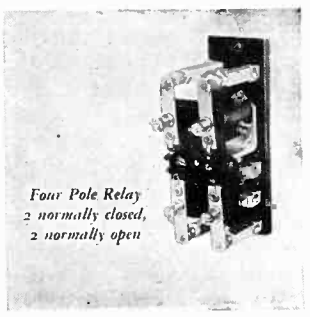
✦

Condensers

THE NEW "SURGPROOF" line of condensers, developed by the Tobe Deutschman Corporation, Canton, Mass., includes many radically new condenser units that will meet every service requirement. The experience obtained from the development of Tobe "Filterettes," in which condenser failures absolutely cannot be tolerated under any circumstances, has fostered the production of the "Surgproof" condenser which, as its name signifies, has a safety factor great enough to allow the condenser to withstand the surges and transient voltages that are responsible for so many condenser breakdowns.—*Electronics.*

Transfer relay

WARD LEONARD ELECTRIC COMPANY, Mount Vernon, N. Y., announces a relay adaptable to applications where the circuit requires up and down contacts separate from each other. It is particularly suitable for transfer purposes where it is necessary, upon operation of the relay, that one or more circuits open and one or more separate and independent circuits close.



The relay is equipped with four poles, two of which are normally open and two normally closed. Contacts may be easily rearranged for single-pole operation.

Stiff-metal switch blades, or contact fingers, spring shackled and equipped with ample size silver-to-silver contacts to allow a comparatively high ampere rating make the relay a desirable unit for heavy duty relay or light duty contactor service.—*Electronics.*

✦

Soldering-iron pyrometer

THE CORRECT TEMPERATURE at the tip of a soldering iron varies with the kind and size of the work and the rate at which the operation is being done. If the temperature which gives the best results is known for a certain class of soldering work, the source of heating energy or the size of the iron used may be varied to give this desired temperature continuously, thus avoiding all trouble due to underheated or overheated irons.

The Weston Electrical Instrument Corporation, Newark, N. J., has a model 659 pyrometer which indicates the temperature of the soldering iron tip accurately and quickly. The instrument consists of a $3\frac{1}{4}$-inch panel type meter connected to a special thermocouple, which is located in a small bead of solder at the center of a lava disc on the base of the stand. Its scale is calibrated 32 to 800 degrees Fahrenheit.

To measure the temperature of the soldering iron tip it is only necessary to place the tip in contact with the solder on the disc which becomes melted and transmits heat to the couple. This causes the instrument to indicate directly the temperature of the iron itself. The readings obtained are practically instantaneous.—*Electronics.*

U. S. PATENTS
IN THE FIELD OF ELECTRONICS

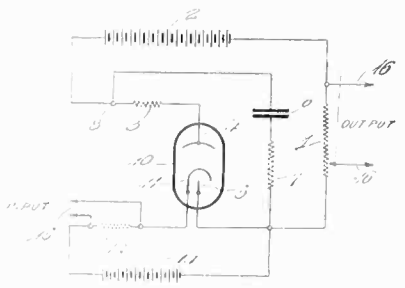
Electron Tube Applications

Voltage indicating apparatus. A d-c source, the voltage of which is to be kept within a desired range and the method by which glow tubes can be connected across various portions of this voltage, one tube breaking down when a voltage reaches the upper limit of the desired range and the other tube breaking down when the voltage reaches the lower limit. P. H. Crago, assigned to Union Switch & Signal Co., filed March 29, 1932. No. 1,918,834.

Cathode-ray sweep circuit. Method of producing stationary images of re-current alternating waves consisting in electrostatically locking the sweep frequency with the phenomena to be observed. F. G. Patterson, assigned to G. E. Co., filed July 23, 1931. No. 1,919,985.

Thunderstorm indicator. Method of indicating the presence of electrostatic charges, such as thunderstorms or electric field potentials. Ross Gunn, Washington, D. C. Filed March 17, 1930. No. 1,919,215.

Frequency division system. A three-element gaseous discharge tube, condensers, etc., for effecting divisions in frequency energy. R. M. Page and W. F. Curtis, Washington, D. C., filed Dec. 24, 1930. No. 1,919,251.



Signal control for demand meters. Combination of a three-element tube and a demand meter. James Hyslop, Terre Haute, Ind., filed Dec. 27, 1932. No. 1,919,514.

Distance determination. Method for measuring distance by means of sound waves including time delays and amplifying tubes. Charles Eisengapf, assigned to Siemens & Halske. No. 1,919,015.

D.c.-a.c. system. Apparatus for transmitting energy between direct and alternating current circuits comprising thermionic tubes and a transformer with a-c and d-c windings. G. A. Sabbah, assigned to G. E. Co., No. 1,918,870.

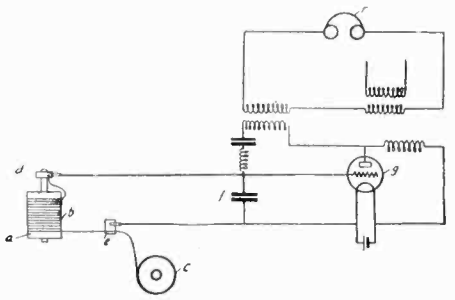
Power converting apparatus. Method using vapor discharge tubes, resonant circuits or charged capacitator circuits for providing a.c. from d.c. No. 1,919,976 and 1,919,977 to A. S. Fitzgerald, assigned to G. E. Co.

Vacuum interrupting apparatus. A circuit interrupter comprising a highly evacuated envelope and electrodes capable of being moved. D. C. Prince, assigned to G. E. Co. No. 1,919,987.

Electrical measurement circuits. Method of comparing an unknown impedance with a known impedance by means of a tube bridge circuit. G. A. Stone, assigned to Central Scientific Co., filed Oct. 27, 1931. No. 1,919,538.

Sorting device. Operation of a number of light sensitive cells in series for sorting articles. V. K. Zworykin, assigned to W. E. & M. Co., June 16, 1927. No. 1,922,188.

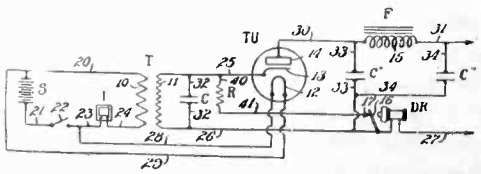
Manufacturing accurate inductance. A method of winding inductance coils having accurate predetermined inductance value by connecting the coil to an oscillator during the winding, varying the frequency of oscillation in accordance with variation in the inductance of the coil, comparing the frequency produced with a standard frequency and arresting the coil forming operation when the varying frequency reaches a predetermined value. W. F. Ewald, assigned to Telefunken, Sept. 19, 1930. No. 1,921,869.



Gyro system. An electrical non-contacting thermionic tube follow-up system for gyroscopic compasses. D. A. Whittkuhns, assigned to Sperry Gyroscope, Nov. 4, 1930. No. 1,921,983. See also No. 1,921,982 to Sperry on a remote control system.

Control circuits. Patents Nos. 1,921,786 to 1,921,789 inclusive to C. G. Suits, assigned to G. E. Co., filed between January and July, 1932, on non-linear circuits, saturable core reactor apparatus, etc.

B. eliminator protection. A step-up d-c converter comprising a transformer, an interrupter and a rectifier with a relay connecting across the filter connection a resistance approximating the normal output load which is removed when the normal load is put on the tube. W. W. Garstang, Indianapolis, Ind., July 30, 1932. No. 1,921,461.



Radio Circuits

Wave repeating system. Method by which signals from a local broadcasting station can be picked up at a receiver station and relayed to another receiver on a different frequency. Each receiver station uses directive receiving and transmitting antennas and somewhat different frequencies for receiving and transmitting. A. N. Goldsmith, assigned to R.C.A. Filed April 30, 1932, No. 1,918,262.

Short-wave broadcasting. A receiving system for relaying signals of the order of one meter or so using directive transmitting and receiving antennas. Fritz Schröter, assigned to Telefunken. Filed April 5, 1930, No. 1,918,291.

Multi-element tube circuit. Radio receiver using a multiple function tube having elements of an amplifier and two rectifiers with circuits for rectification, automatic volume control, and a-f amplification. P. O. Farnham, assigned to R. F. L., Inc. No. 1,919,160, filed Nov. 4, 1932.

Remote-control circuit. Patents granted to Bowden Washington and Wilson Aull, Nos. 1,918,674 and 1,918,683, assigned to Remotrole Corp., on methods for remotely operating and controlling radio receivers.

Automatic control system. Method by which at least two independent station selector switches can be operated which will tune all the circuits in a receiver to the desired station. W. V. B. Roberts, assigned to R.C.A., filed June 27, 1929. No. 1,918,826.

Stabilized receiver. Method for using the capacitance between stators of tuning system condensers for producing variable feed-back for neutralization at the short-wave end of the spectrum. W. V. B. Roberts, assigned to R,C.A., filed April 15, 1929. No. 1,919,906.

Interference suppressor. A band-pass filter system for selecting desired electrical oscillations of a given frequency band and suppressing frequencies outside of this band. L. L. Jones, Oradell, N. J., filed March 6, 1928. No. 1,919,948.

Radio direction finder. A two-loop system with a commutating means for reversing the direction of one of the loops. H. Antranikian, Paris, France. No. 1,920,159.

Amplification, Generation, etc.

Sound and image transmission. Simultaneous transmission of electric currents, one having a characteristic corresponding to the appearance of a speaker and the other variation corresponding to his speech. F. M. Ryan, assigned to B.T.L., filed April 19, 1927. No. 1,919,804.

Image reproducing system. Method of reproducing a picture at a distance comprising projecting a moving scanning light spot of constant intensity upon a first picture reproducing screen and moving a second screen relative to the first screen. J. J. Rogan, assigned to Hygrade Sylvania Corp., filed Nov. 22, 1929. No. 1,918,827.

MOLDED CARBON VOLUME CONTROL

by

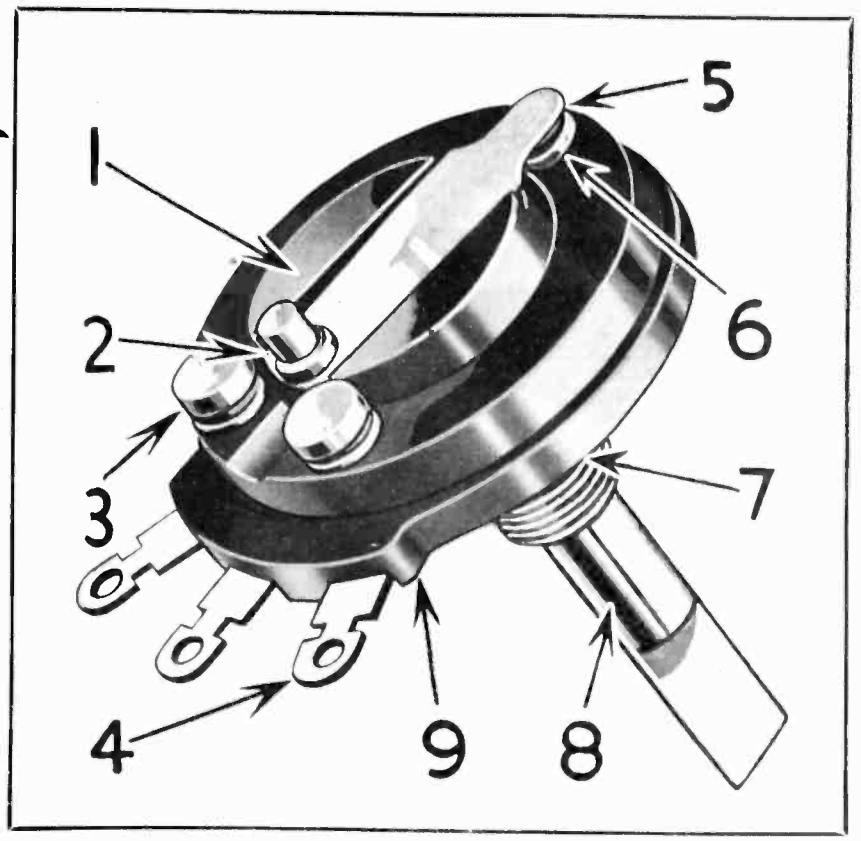
STACKPOLE

Keeps pace with Radio Progress

9

FEATURES

of design which promote performance



1 Protection offered in fully insulated bushing and shaft

A bakelite hub carries the spring arm and the contact for the moving element. The shaft is molded into the other end of this bakelite hub. Mounting bushing and shaft are thus fully insulated from entire Control Resistor.

2 Accurate switch operation

The cam dog which operates the A.C. switch on switch type variable resistors, is assembled as a composite part of the moving arm member. Accurate switch operation in respect to the resistance curve or hop-off value is assured.

3 Stable and solid assembly

Rugged stop pins are accurately located through the resistor element and the bakelite frame and hold the entire assembly into one solid form.

4 Easy assembly

The lugs of the resistor as well as those on the AC Switch are tin dipped to facilitate the soldering of connecting wires.

5 Smooth action and noiseless
6 operation

A one-piece special tempered spring arm maintains constant spring tension against a nickel chrome, highly polished, non-corrosive sliding shoe. Smooth and easy rotation of the variable resistor arm is assured.

7 Simple mounting

A standard brass bushing for one-hole mounting is fully insulated from the arm and resistor element.

8 Quiet, easy operation

The shaft is of non-rusting cadmium plated steel, perfectly fitted in the bore of the brass bushing to provide smooth and quiet operation.

And

9 *A New, Permanent, Molded Carbon* RESISTOR ELEMENT

Stackpole offers the first control of its type and the first compact variable resistor which is permanent and unaffected by humidity.

The thick molded carbon resistor element, mounted on bakelite frame, is made in much the same way as permanent carbon resistors. Its hard glass-like surface is the result of firing at high temperatures and assures imperviousness to humidity—hard usage and varying temperatures. Stackpole Molded Carbon Volume Controls will carry considerable current, are free from capacity effect, and have low heat and voltage coefficient. They are smooth and quiet in any circuit.

Made in any value from a few hundred ohms to a couple of megohms with any desired resistance taper and any hop off or fixed value of resistance at either or both ends.

STACKPOLE CARBON CO.

ST. MARYS, PA.

More than 50% of the new radio sets made today use Stackpole fixed Carbon Resistors in their initial production.

Steatite

unsurpassed as a high-frequency ceramic dielectric is now commercially available for service in the products of manufacturers in the electronics and communications industries.

Tried and perfected during nearly half a century of development and manufacture, Steatite is today placed at the disposal of engineers in a form best suited to their requirements. Lower in radio frequency loss than any insulator in its particular class, remarkably strong, resistant to fracture, and non-hygroscopic, Steatite may be cast, machined, extruded or moulded in a variety of shapes and sizes to specifications.

PROPERTIES

Power Factor
.09-.20%*

Dielectric Constant
5.0-5.8*

Water Absorption After 24 Hrs. Immersion
None

Tensile Strength
7,850–12,000 lbs./sq."

Transverse Strength
17,000 to 19,800 lbs./sq."

*Actual value depends upon frequency, temperature and composition.

The Dielectric Products Company, in association with the General Ceramics Company, the largest producer of its kind in America, will engage in the development, manufacture and marketing of Steatite compositions for application to all branches of the electronic and communications industries. Complete engineering data, cost and delivery information will be furnished promptly in response to general inquiries as well as to definite specifications.

●

J. L. Bernard and H. T. Carey, formerly of Isolantite, Inc., are now associated with the Dielectric Products Co., in New York.

DIELECTRIC PRODUCTS COMPANY

11 Park Place — New York, N. Y.

AmerTran Announces

NRA MEMBER U.S. WE DO OUR PART

New Lower Prices Improved Designs of AmerTran De Luxe Transformers

AmerTran De Luxe Transformers listed below are of the same high quality as similar units manufactured during the past 10 years but prices have been considerably reduced and designs have been revised to permit full advantage of new tube ratings. They are recommended as the best available standard equipment for use in precision amplifiers in broadcasting stations, recording studios, and laboratories.

New AmerTran SilCor Audio Transformers of modern design at popular prices

AmerTran SilCor Transformers have been developed to satisfy the demand for quality audio transformers at popular prices. They are similar in design and construction to "De Luxe" transformers but have core laminations of silicon steel instead of high permeability alloy. They are highly satisfactory for all usual requirements in public-address equipment and other commercial requirements.

	DE LUXE LINE Type No.	List Price	SILCOR LINE Type No.	List Price
Interstage: 1 pl. to 1 gr., 0 dB	D-12	$7.00	J-711	$4.50
Interstage: 1 pl. to p/p gr., 10 dB	D-21	8.50	J-721	5.00
Interstage: p/p pl. to p/p gr., 18 dB	D-51	10.00	J-751	6.00
Input: 200 or 500 w. to 1 gr., 0 dB	D-81	10.00	J-771	5.50
Output: 1-227 pl. to 200 or 500 w., 10 dB	D-31	8.50	J-731	5.50
Mixer: 200 or 500 w. to 200 or 500 w., 0 dB	D-91	8.50	J-791	5.50
Output: p/p 2A3 pl. to 15/7½/5/3½ w., 34 dB	D-64	18.00	J-822	5.50
Output: p/p 2A3 pl. to 500 and 15 w., 34 dB	D-103	18.00	J-752	5.50
Output: 500 w. to 15/7½/5/3½ w., 34 dB	D-135	18.00	J-831	8.00

NOTE: Above tabulation lists only nine popular types—complete catalog on request. List Prices effective August 1, 1933.

American Transformer Company
Transformer builders for over 31 years
178 Emmet St., Newark, N. J.

AMERTRAN TRANSFORMERS

Improved REMOTE CONTROL FLEXIBLE SHAFTS *for* RADIO

Automotive Pioneers—Since 1905 this organization has pioneered and sold a major part of speedometer shafts for the automotive industry. With its large facilities, it can assure quality and prompt delivery of auto radio remote control shafting.

Hundreds of Thousands of Feet of Fischer Remote Control Cables and Casings are now giving satisfactory duty in sets on the road. The sealed and squared Cable ends have won over scores of manufacturers to its use because of its ease in attaching more firmly to shaft tips and when used direct under set screw there is no possibility of unraveling.

The flexible Cables have the proper number of wire strands to eliminate back lash and give instantaneaus adjustment. The special twin ply Casing for the protection of the Cable is finely finished in black enamel. This perfect combination of Cable and Casing can be made in any desired size and length to given specifications.

Wire or write for samples and individual design data.

***The* CHAS. FISCHER SPRING CO.**
240 KENT AVE., BROOKLYN, N. Y.

CORNELL-DUBILIER CONDENSERS

Mica Condensers

For radio transmitter, laboratory, tube plant bombarder, high-frequency oscillator—no matter what your needs—there is a Cornell-Dubilier Mica Condenser. For instance:

Here is a popular priced mica condenser. Molded bakelite case. Rugged. Constant capacity. Moisture-proof. Extremely low electrical losses. Ideal for low-power transmitters, radio and audio circuits, laboratory apparatus, bridge circuits, etc. 1000, 2000, 3000 and 5000 volt A.C., .00005 to .10 mfd. units.

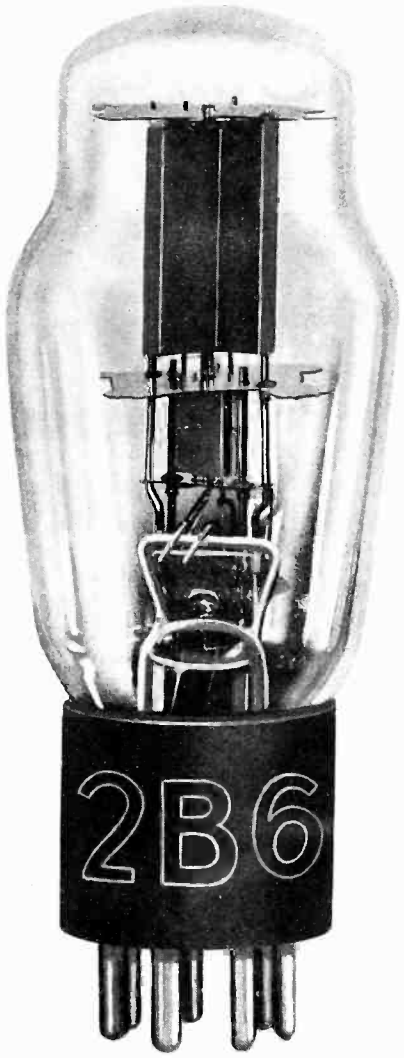
Just one of a large line of Cornell-Dubilier Mica Condensers for every radio, electronic and industrial purpose.

Write for new 1933 catalog covering the combined Cornell and Dubilier lines of condensers.

CORNELL-DUBILIER CORPORATION
4377 Bronx Boulevard New York City

CORNELL DUBILIER Dubilier REG. U.S. PAT. OFF.

1934 AUDIO-QUALITY



Super Triode

4 WATTS POWER OUTPUT •

HIGH SENSITIVITY •

Low Set Manufacturing Cost •

Technical Data Mailed Upon Request
Write

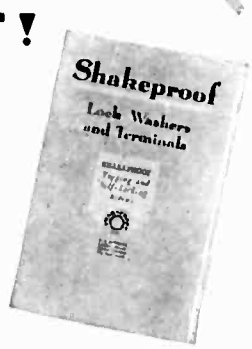
JRC JOHNSONBURG RADIO CORPORATION
JOHNSONBURG, PENNA.

Licensed by RCA and Revelation Patent Holding Co.

SHAKEPROOF

GIVE YOUR PRODUCT THE "VIBRATION CONTROL" TEST!

IF you would like to know how Shakeproof can improve the performance and lasting satisfaction of your product—make this simple test. First, equip one of your products with Shakeproof Lock Washers and pack it in a shipping case along with another taken from your regular stock. Then, turn these over to your shipping department with instructions to give them plenty of rough handling—just like the treatment they might experience in shipment to a dealer. Next, unpack them and examine each connection—what you see will tell you more about Shakeproof protection and why it cuts down complaints and repair costs than anything we can say. See for yourself—send for testing samples today!

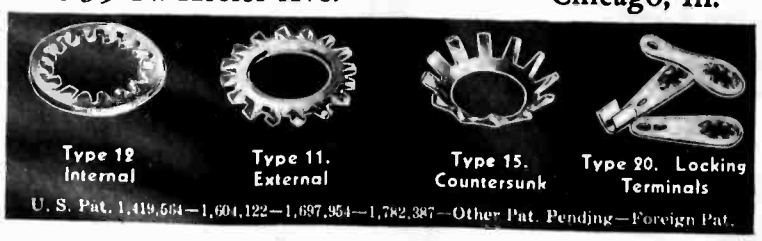


Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

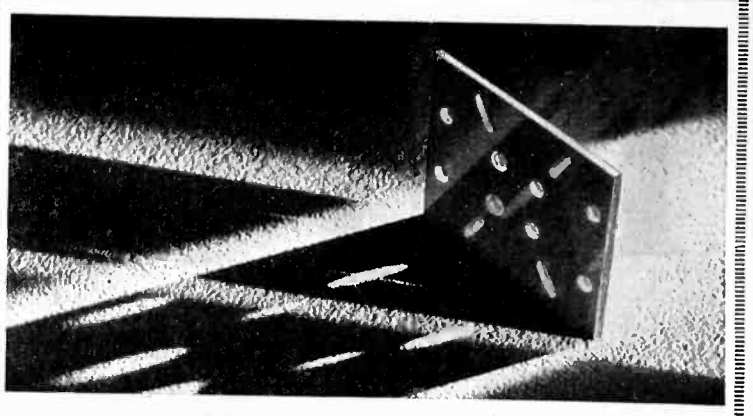
SHAKEPROOF
Lock Washer Company

(Division of Illinois Tool Works)

2539 N. Keeler Ave. Chicago, Ill.



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



For critical buyers of LAMINATED BAKELITE

Use of the most advanced automatic control equipment and the finest of raw materials, including genuine Bakelite resins, enable us to produce "Lamicoid" Laminated Bakelite parts which meet the severest specifications.

Ask us for samples of parts we have made for radio manufacturers and others. You are sure to be impressed by their clean-cut edges, fine workmanship, and other highly desirable qualities.

"Lamicoid" is furnished in various types, finishes and thicknesses; in fabricated form; and in sheets, tubes and rods.

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200 Varick Street, New York, N. Y.; 542 So. Dearborn Street, Chicago, Ill; 1330 Schofield Building, Cleveland. *Branches at* Birmingham, Boston, Cincinnati, Los Angeles, San Francisco, Seattle. *Canada:* Montreal, Toronto.

In all Volume Control design consider...

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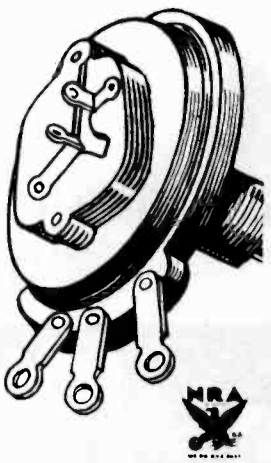
COLLOIDAL-GRAPHITED WATER



Forms on solids homogeneous, conducting coatings of graphite which are chemically inert.

The resistance can be readily varied by merely increasing or decreasing the concentration of the solution employed.

Colloidal - graphited water is achieving increased importance as a means for forming conducting, inert surfaces on the interior and exterior of glass envelopes of electronic devices.

For further details send for Technical Bulletin A11

ACHESON OILDAG COMPANY

PORT HURON, MICH.

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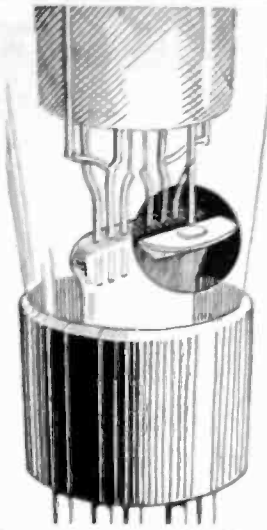
REDUCES
MATERIAL
AND LABOR
COSTS---
INCREASES
PRODUCTION



The New BAREX

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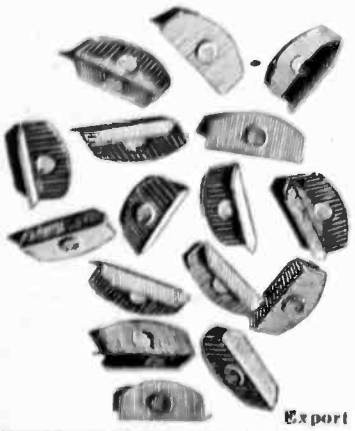
IMBEDDED

GETTER



Manufactured under letters patent No. 1922162.

A new type Barium Getter, securely bonded as integral part of metal flag — vaporizes completely, minimizes splash—for all tubes. Reduces shrinkage substantially—ask about it.

KING LABS., INC.
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SYRACUSE, N. Y.
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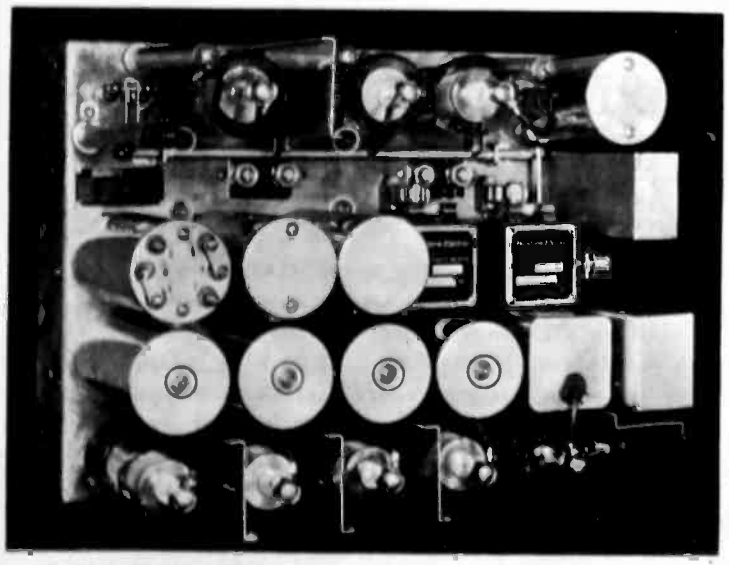

Western Electric 12-A two frequency superheterodyne aircraft receiver showing Elastic Stop Nuts used as standard throughout.

THERE is more dependable performance when radio apparatus is Elastic Stop Nut equipped.

Electrical terminal connections held with Elastic Stop Nuts are permanent and have low contact resistance. This lock nut will maintain balancing condenser adjustments for keeping the sensitivity and selectivity of high grade apparatus. Microphonic noises are eliminated on chassis mechanical connections held with Elastic Stop Nuts. Speaker rubber mountings fastened with Elastic Stop Nuts do not work loose.

Elastic Stop Nuts eliminate "loose nut" troubles on any equipment subject to vibration. Users in the electronic field include manufacturers of broadcast receivers, aircraft apparatus, automobile sets, and contractors to the government signal services, etc. Write for technical details.

ELASTIC STOP NUT DIVISION
A.G.A. CO.
ELIZABETH, N. J.

NRA

Where resistor service is exacting—they say CONTINENTALS are the most—

QUIET

THE WEBSTER COMPANY
AMPLIFIERS :: TRANSFORMERS
WEBSTER

Mr. Walter Boyd,
Continental Carbon Inc.,
9 South Clinton Street,
Chicago, Illinois.

Chicago, U.S.A.
Feb. 21, 1933.

Dear Sir:

No doubt you will be interested to hear of the experience that we have had with Continental Carbon Resistors. The use of these resistors has been very gratifying, and although audio gain is in excess of 100 D.B., we can truthfully say that our resistor trouble has been reduced to practically the vanishing point.

Unquestionably our requirements are considerably more severe than those encountered in the ordinary radio set [illegible]. The requirements of your resistors, however, have more than equalled our specifications.

Yours very truly,
THE WEBSTER COMPANY
John Elwood.

DEPENDABLE

The CLOUGH-BRENGLE CO.
Engineers and Manufacturers of Electrical Equipment
1134 W. AUSTIN AVE., CHICAGO

July 3, 1933.

Mr. Walter Boyd,
Continental Carbon Inc.,
9 South Clinton Street,
Chicago, Illinois.

Dear Mr. Boyd:

I thought you might be interested in learning that we have been employing 150,000 ohm and 1 megohm units in the output circuit of a commercial amplifier having about 105 db. gain consistently, and to date have not had to make a single replacement, either in the field or in our factory inspection because of noise in these units.

Considering the high gain, as well as the high resistance and small physical size of the units, we believe that this speaks very well for resistors of Continental manufacture.

With very best wishes, we are

Cordially yours,
THE CLOUGH-BRENGLE CO
Kendall Clough
Kendall Clough
Chief Engineer

Check CONTINENTAL super performance in your own laboratories

Continental can show you curves, but we know that actual performance on tests in your laboratory is the deciding factor. Let us supply samples. We are confident that you will be convinced.

CONTINENTAL CARBON Inc.

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CLEVELAND, OHIO

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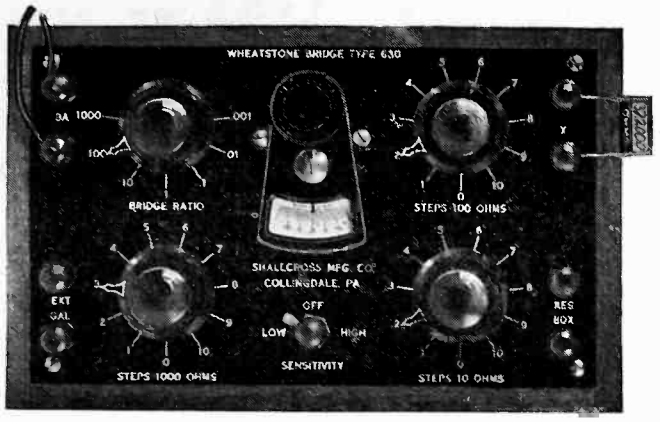
CANADA

Please send sample Continental Resistors for tests.

Name .....

Address .....

City ..... State .....



THE NEW Shallcross WHEATSTONE BRIDGE No. 630

This inexpensive, rugged, and reliable instrument can be easily assembled by electrical technicians. Good accuracy is attained by employing a set of very accurate SHALLCROSS Resistors and a sensitive L & N Galvanometer.

Range, .01 ohms to 11.1 Megohms

Bulletin 630-K describing this instrument available on request.

The accuracy of the No. 630 Wheatstone Bridge shown above depends upon

SHALLCROSS Wire-Wound Resistors

Calibrated to a precision of 1/10, ¼, ½ or 1% as required.

Bulletins describing Shallcross Resistors, Megohm Decade Resistance Boxes, and Radio Service Test Equipment, etc., are also available

SHALLCROSS MFG. CO., 700 MACDADE BLVD. COLLINGDALE, PA.

CANNON

Unique

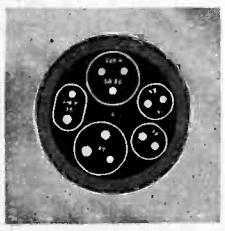
CABLE CONNECTORS

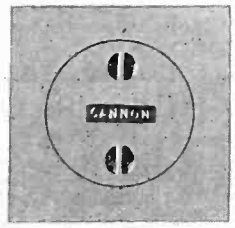
JUST why are CANNON Plugs unique? Because they are built to meet unique requirements. Witness our solution of a unique problem!

The problem: How to design 31 groups of five special outlets. Obviously, 155 floor boxes were out of the question. Cannon solved the problem by grouping five outlets in a single floor box (see illustration) so that all outlets could be used simultaneously, or each singly. The solution was worked out for exhibit booths in a scientific laboratory. Cannon now builds over 400 Cable Connectors!

There is a CANNON Plug For Every Cable Connector Use

Write for New Catalog.





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CANNON ELECTRIC DEVELOPMENT CO.
MANUFACTURING ENGINEERS
420 West Avenue 33 Los Angeles, Calif.

Eastern Representatives:
New York: Lewis & Sachs, 245 Fifth Ave.
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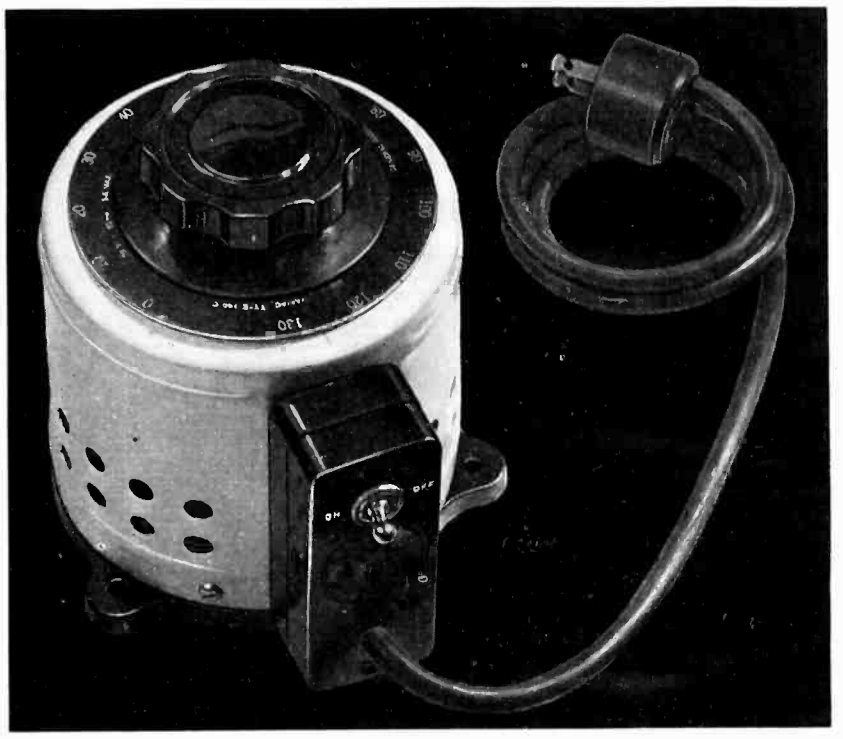
NEW

Adjustable Voltage Transformer



VARIAC*

Gives you variable A.C. Voltage . . range 0-130V . . . better efficiency and regulation than rheostat.

*PRONOUNCED VARY-ACK
TRADE MARK REG'D

OVERVOLTAGE or undervoltage, you can correct for both with the *Variac,* an adjustable power transformer that works as smoothly as a rheostat.

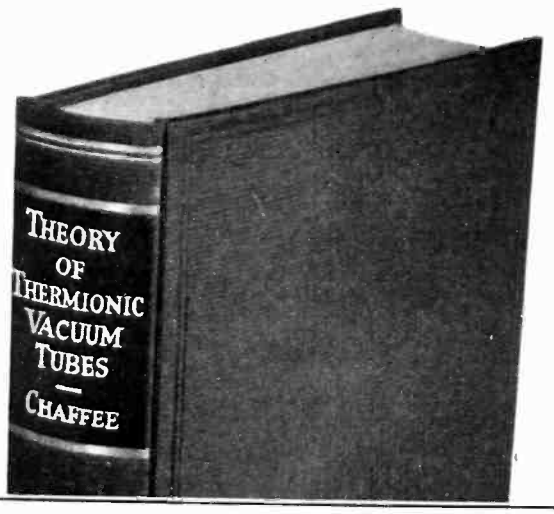
Unlike the rheostat, you can *increase* voltage. Unlike the rheostat, efficiency and voltage regulation are high.

Use a *Variac* wherever you need an adjustable voltage. It is ideal for correcting line voltage, for overvoltage and undervoltage testing, for speed control on small motors, for brilliancy controls in stage and sign lighting.

SPECIFICATIONS: Works on any 115-volt, 60-cycle line. Output, 5 amperes, 0-130 volts. Price, $16.50 as illustrated. Data on request.

GENERAL RADIO COMPANY

Cambridge . . . . . Massachusetts



5 important McGRAW-HILL Books *for the* Radio Engineer

RADIO ENGINEERING

by FREDERICK EMMONS TERMAN
Associate Professor of Electrical Engineering
Stanford University
688 pages, 6 x 9, 418 illustrations, $5.00

A COMPREHENSIVE treatment covering all phases of radio communication, written from the viewpoint of the engineer who is interested not only in qualitative descriptions of radio phenomena, but also in making quantitative analyses for facilitating design and research.

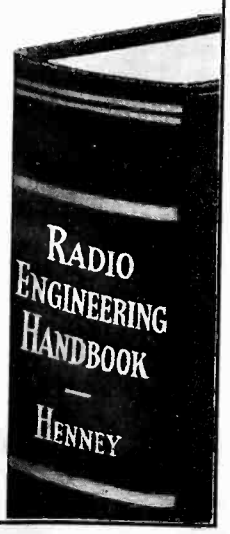
The first part of the book covers the theory of tuned circuits and the fundamental properties of vacuum tubes and vacuum tube applications. The latter part, specialized radio topics, such as radio receivers and transmitters, wave propagation, antennas, and direction finding. It is a complete reference book containing the fundamentals involved in most of the problems faced by the practicing engineer.

RADIO ENGINEERING HANDBOOK

Prepared by a staff of 22 specialists
under the editorship of
KEITH HENNEY
Associate Editor, *Electronics*
583 pages, 4½ x 7, 482 illustrations, $5.00

THIS book gives the radio engineering profession its own handbook, equal in all ways to the standard handbooks available in other fields of engineering. Written by engineers for engineers, the book is thoroughly technical, with broad emphasis on design. It is comprehensive and up-to-the-minute, covering all fields and aspects of radio engineering from fundamentals to latest practical applications.

Every section has been written by a specialist. Newest tubes and circuits, television, aircraft radio, short wave, photocells, etc., are covered, with emphasis throughout on design data, presented in a profusion of tables, charts, equations, formulas and diagrams, rather than descriptive matter subject to frequent change.



THEORY OF THERMIONIC VACUUM TUBES

Fundamentals—Amplifiers—Detectors
by E. LEON CHAFFEE
Professor of Physics, Harvard University
666 pages, 6 x 9, fully illustrated, $6.00

A LONG awaited book by one of the country's foremost authorities on vacuum tubes. Its purpose is to cover the foundation of the subject fully for those engaged in any branch of vacuum tube technique. It gives a comprehensive theoretical treatment of the fundamentals of thermionic emission and the vacuum tube, and, besides the general properties of the vacuum tube, covers in detail its use as an amplifier and detector. It avoids discussion of multifarious circuits, but covers those principles, an understanding of which makes possible the analysis of any circuit and any application.

The book has been in preparation eight years and embodies much original material developed by the author, some of it published here for the first time. Among this material is that on such subjects as the path of operation, large-signal regeneration, regeneration in coupled circuits, detection, nonlinear elements, etc.

HIGH-FREQUENCY MEASUREMENTS

By AUGUST HUND, Fellow of the American Physical Society, Member Institute of Radio Engineers. *International Series in Physics, 491 pages, 6 x 9, 373 illustrations, $5.00.*

A REFERENCE book for research workers, giving a thorough discussion of high frequency phenomena applied to measurements. The subject matter is treated critically, presenting up-to-date practice and theory. The applications are presented in a manner elementary enough to meet the needs of any one interested in carrying on high frequency measurements and research work. The book represents a considerable amplification and modernization of the author's *Hochfrequenzmesstechnik*, published in Germany.

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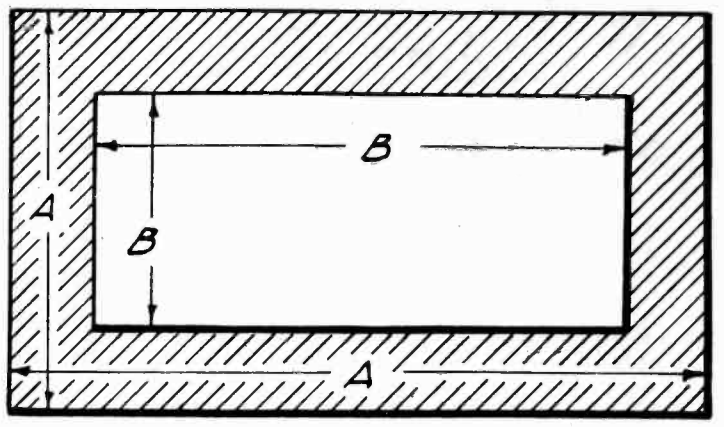
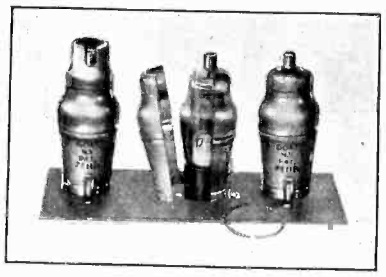


"A" showing size of chassis required for the old-fashioned "can" shields.

"B" relative size of the same chassis equipped with GOAT TUBE SHIELDS.



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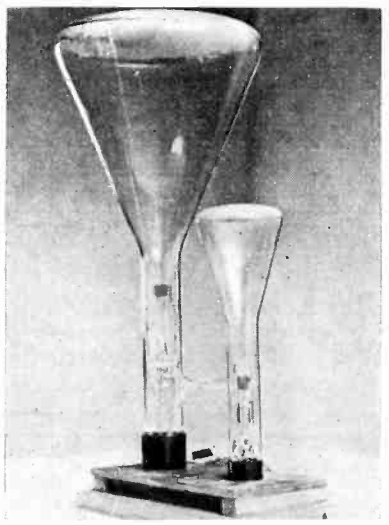

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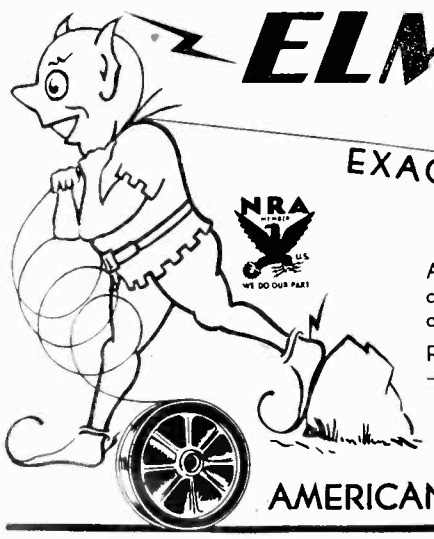

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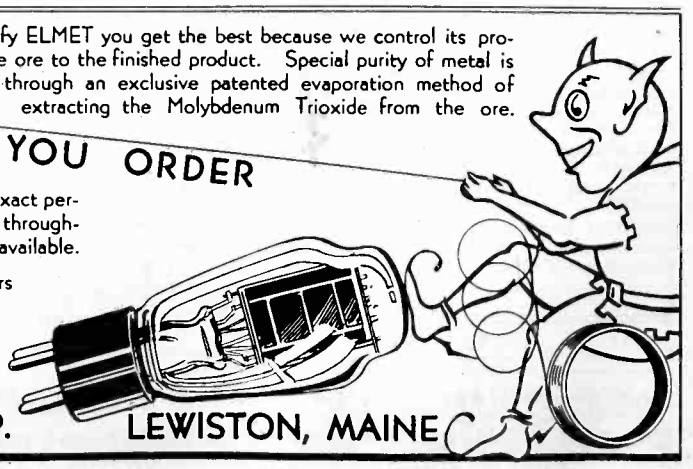

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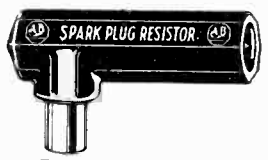

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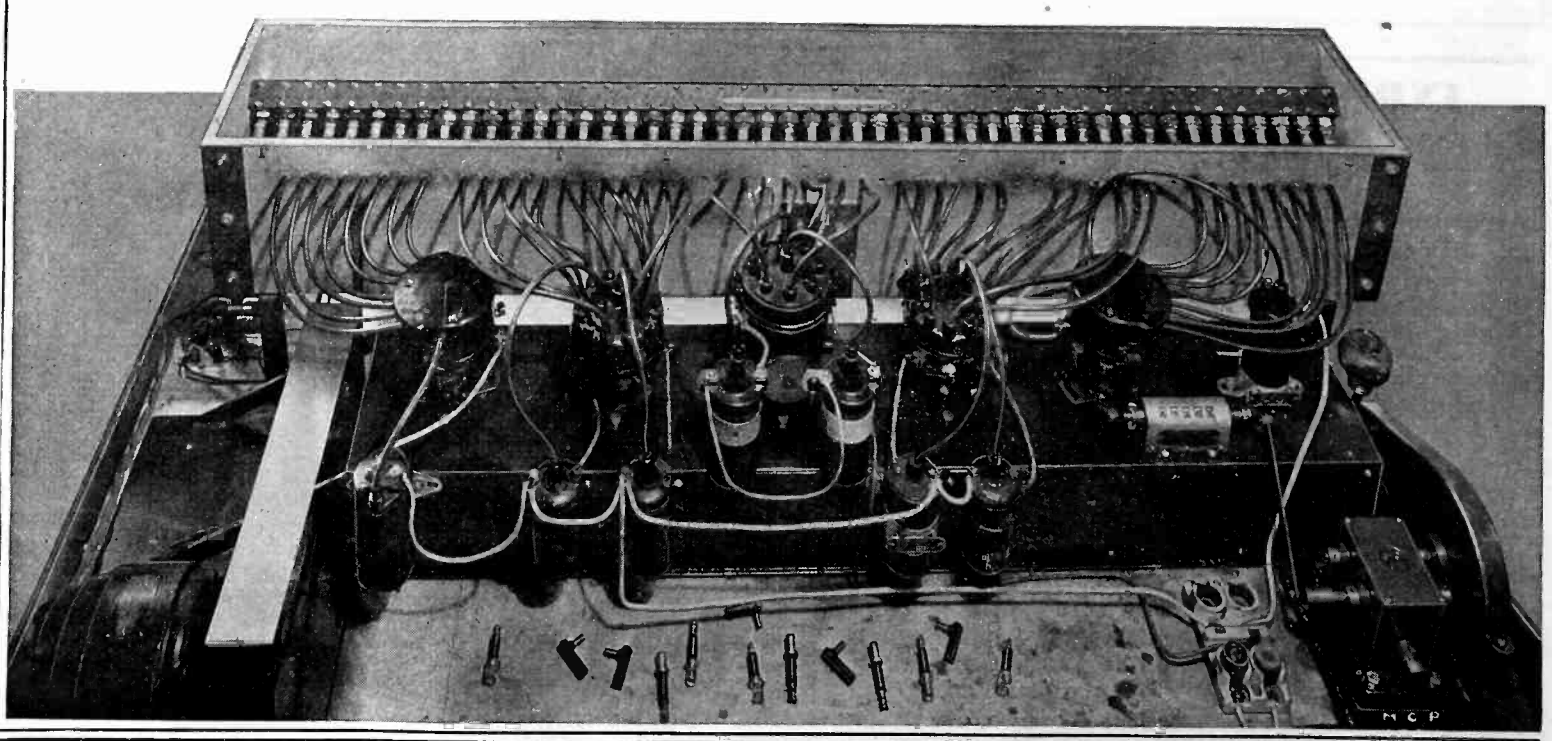

A-B

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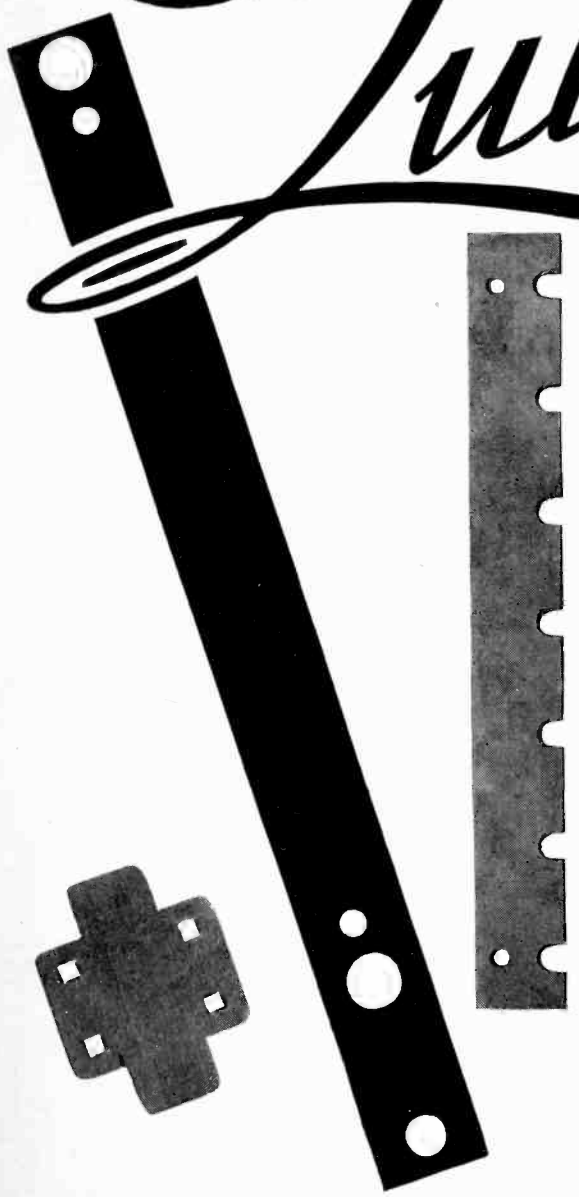

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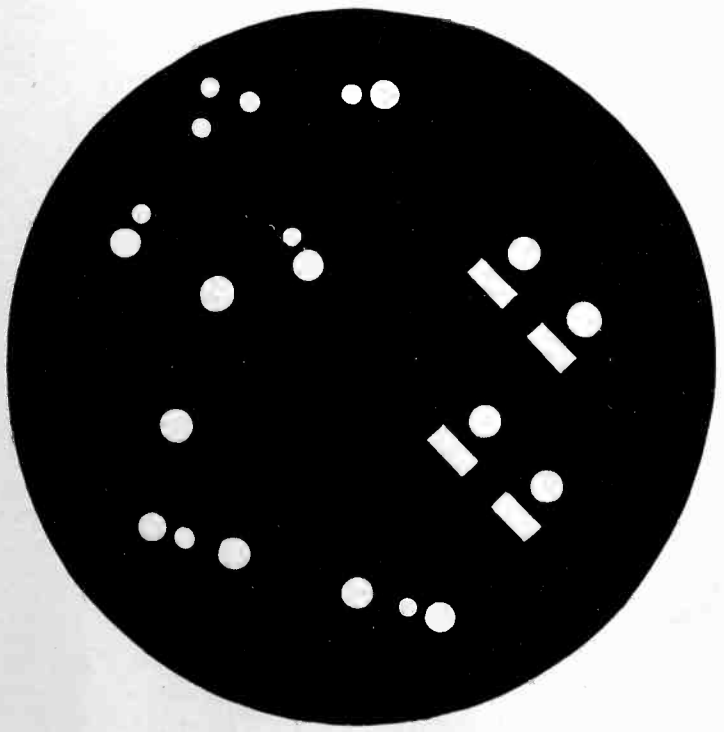

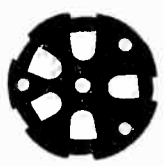

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