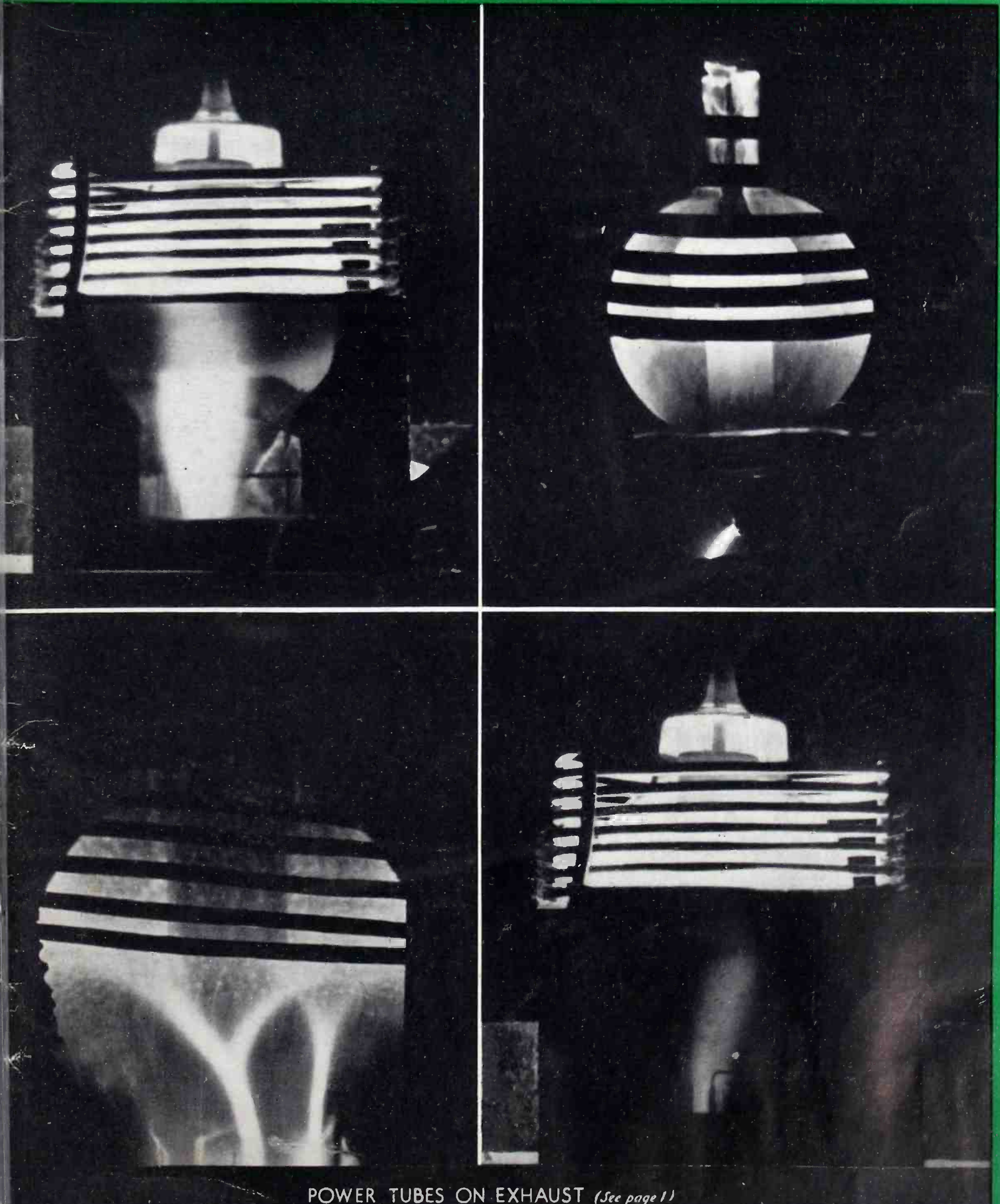
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



POWER TUBES ON EXHAUST (See page 1)

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An International Trend In Radio Styling

ALTHOUGH differing widely in many features of design, the radio cabinet styling of England, France, Germany and the United States now shows one important trend in common. Everywhere, the use of Bakelite Molded for the complete forming of both large and small cabinets indicates rapidly-growing interest in the advantages of this material for radio cabinets.

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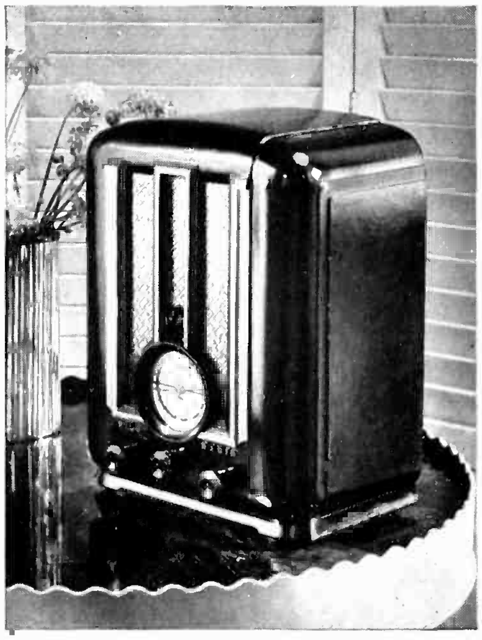

American "Pilot" cabinet of Bakelite Molded. Size: 12½" x 9½" x 6½".

German cabinet of Bakelite Molded in rich duo-tone color effect.

French battery set with Bakelite Molded cabinet in a variety of colors.

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THE MATERIAL OF A THOUSAND USES

ELECTRONICS

radio, communication and industrial applications of electron tubes . . . design, engineering, manufacture

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Contents • May 1936

COVER: *Mercury-vapor (General Electric) rectifiers. Upper left, lower right: pool-cathode tubes, FG-179, with heavy d-c current through them. Leica photos through red glass filter. Upper right: hot-cathode PJ-26. Lower left: glow discharges in FG-179. Note the cold anode.*

DEPARTMENTS

VOLUME 9 . . . NUMBER 5

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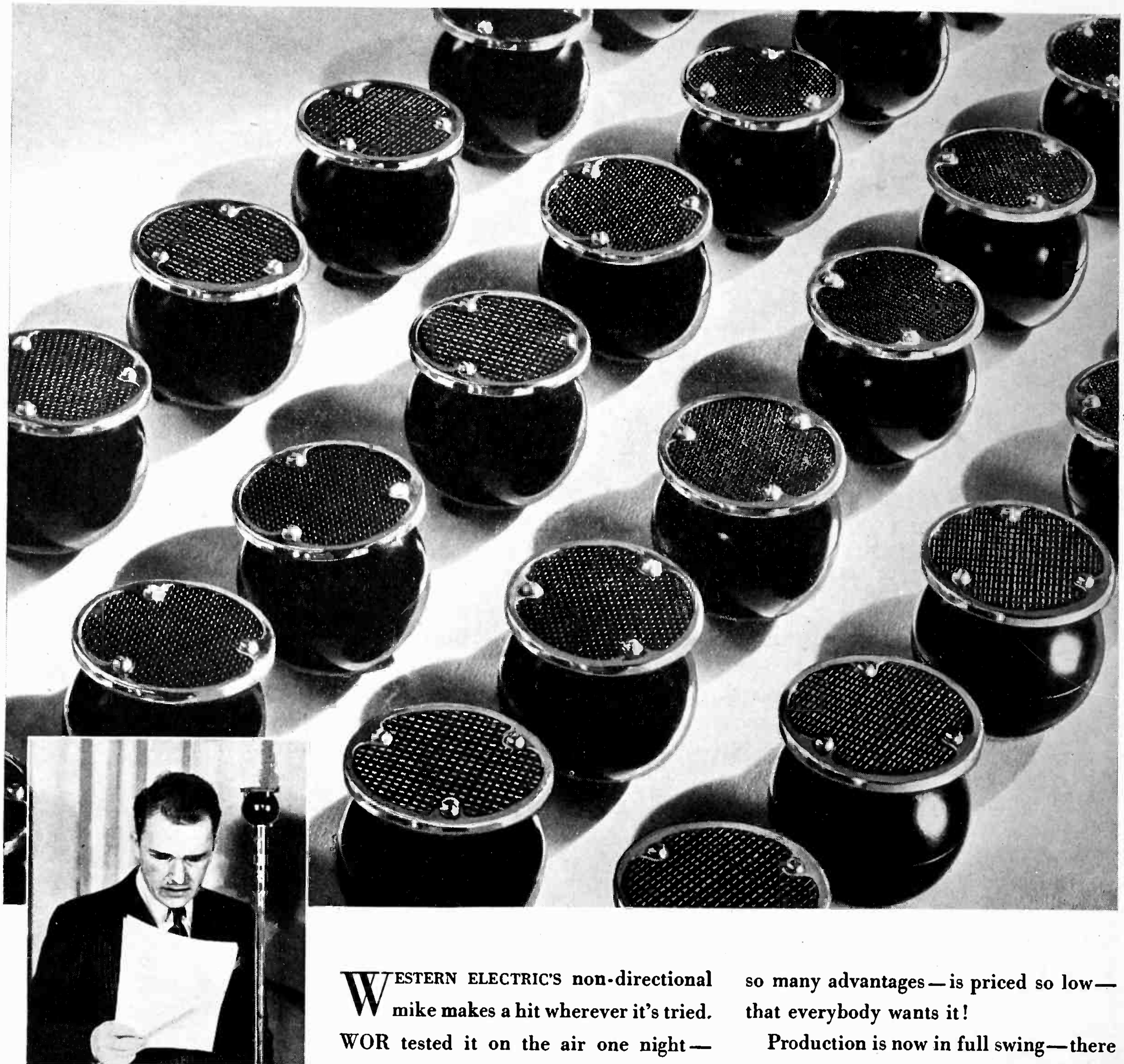

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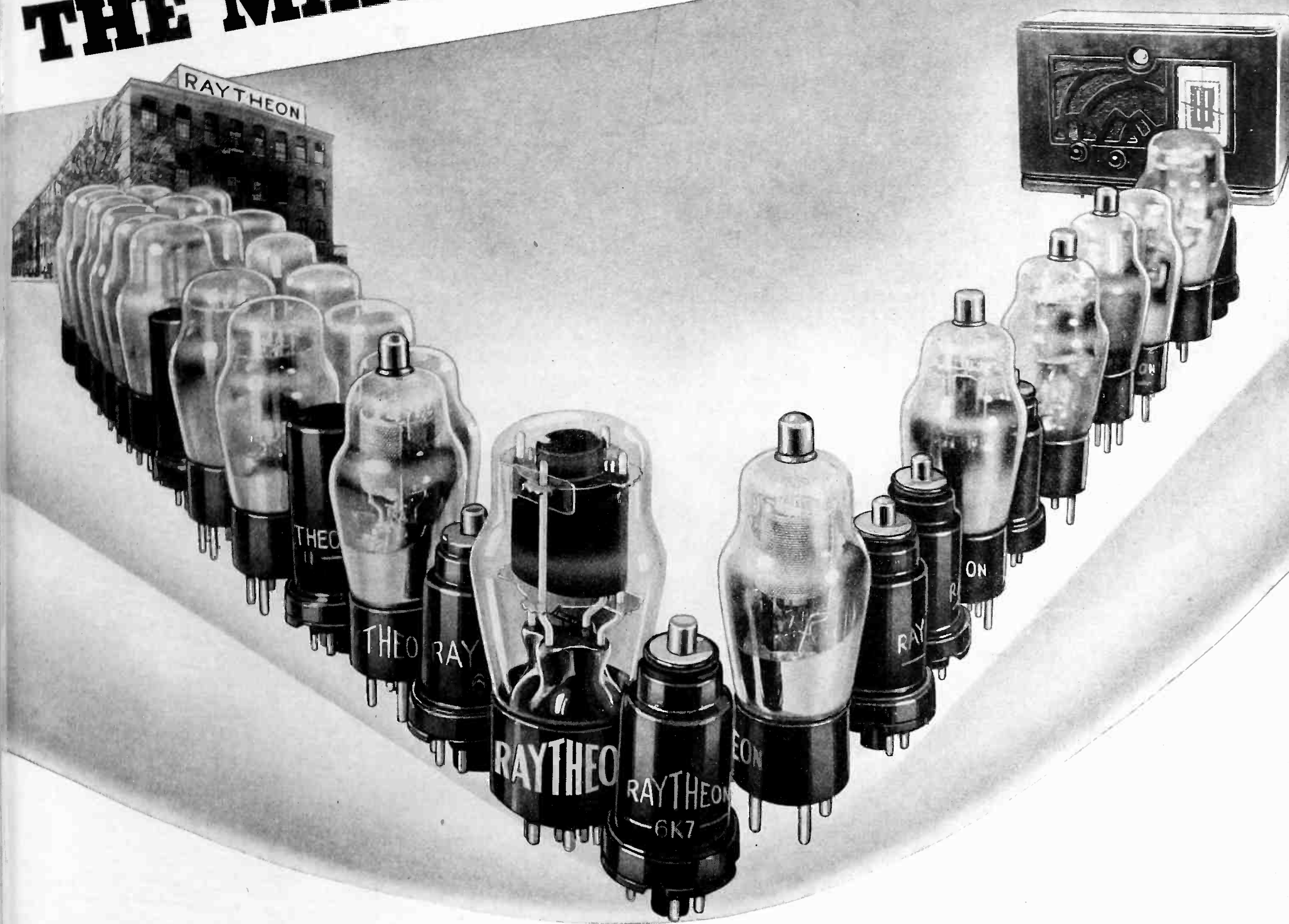

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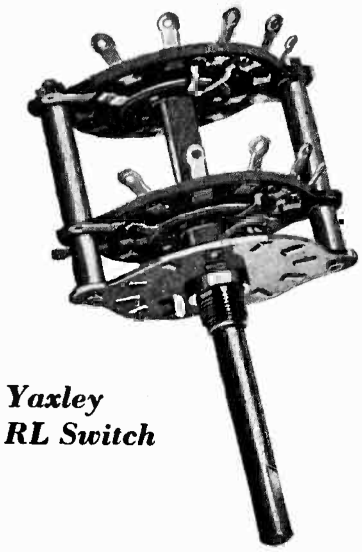

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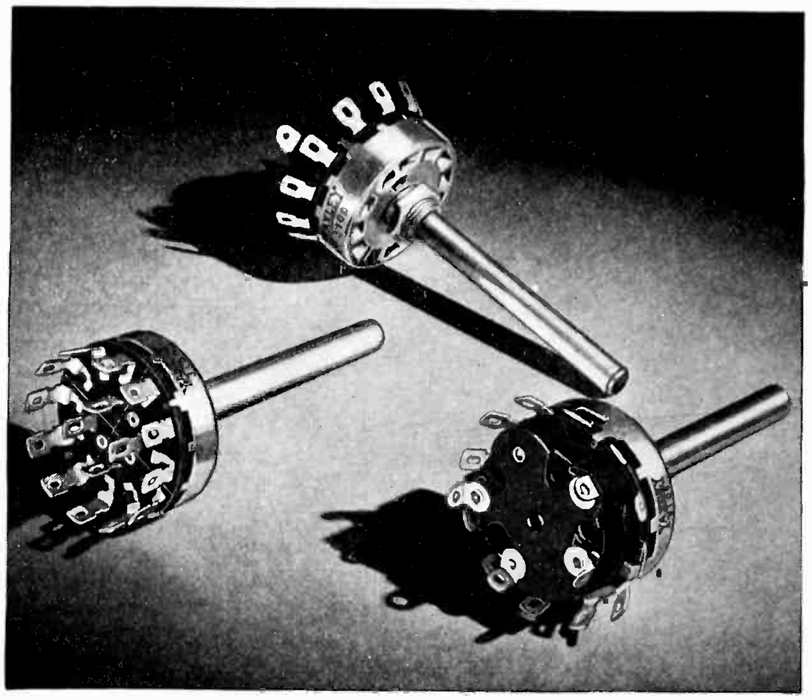

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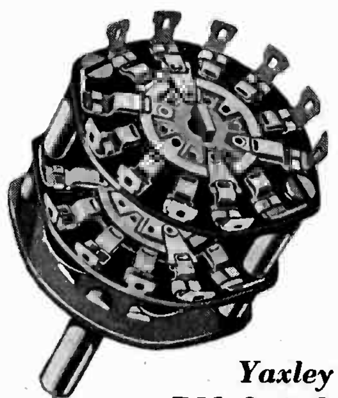

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ELECTRONICS

MAY
1936

KEITH HENNEY
Editor

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▶ **SPECTRUM** . . . We are happy to present for the third time *Electronics'* spectrum chart. Published in the first issue of the paper, repeated with few changes in April, 1932, and now completely done over, printed from new plates, and with additional information, this popular chart is again available to *Electronics'* readers.

In the four years that have elapsed since the second printing of the spectrum chart hundreds of letters have come to the publishers requesting copies for framing. Unfortunately the supply was exhausted long ago. In addition to those going with the magazine several thousands have been distributed; we have seen them on desk tops and framed and hanging on the walls of countless laboratories and offices.

A certain number of copies will be available, unfolded, and mailed in a tube at a price of 25 cents each. Readers who wish to place these copies in their Reference Sheet binders can do so easily by trimming the right margin somewhat and by punching the left margin.

▶ **AGGREGATE** . . . Radio frequency phenomena keep popping up in the oddest places. We have word that a Philadelphia contractor supplier is prepared to furnish a special sand and gravel aggregate for concrete foundations which are subjected to high-frequency currents. The aggregate is especially recommended for tower foundations of powerful transmitters. Apparently ordinary concrete, which has always been good enough for unthinking radio engineers, is an inferior product which heats up and wastes away under the influence of powerful r-f fields. Commercial and government stations as far away as Hawaii and Panama have already used the new material. Details will be found in the "Manufacturing Review" section of this issue.

▶ **BACK COPIES** of *Electronics* are practically non-existant. Readers desiring to sell issues for which they have no need can find a ready market if they will let the Editors know what they have to offer. Professor Houghton of Detroit Institute of Technology has spares which he is willing to swap for issues which he needs.

▶ **CONTRIBUTORS** . . . Two of Electronics' contributors have recently moved to new pastures. Dr. E. F. Lowry of the research laboratories of Westinghouse has become director of research of the Continental Electric Company at St. Charles, Illinois. Dr. Lowry is well known for his fundamental work on cathodes and has published two papers in *Electronics* (October, 1933 and December, 1935). The Continental Electric Company has long manufactured phototubes and carried on independent research and development.

A. J. Sanial (*See Electronics*, February, 1934) who has been at the Arma Engineering Company in Brooklyn for several years, following a sojourn in South Africa with Martin Johnson as sound engineer, has gone to Camden with RCA where he will work on sound equipment. Mr. Sanial worked with Fox Film in the early days of sound-on-film and disc.

▶ **INVENTORS BOTH** . . . On April 2, Mr. J. H. O. Harries of England dropped into the Editor's office to renew an acquaintance begun in 1931. He was greatly astonished when we told him, briefly, of the beam power tube described the night before by Mr. Schade at the I.R.E. Mr. Harries sailed within an hour, wrote the story in this issue (page 33) on the S.S. Ansonia, mailed it from Halifax. To date he has not seen Mr. Schade's paper.

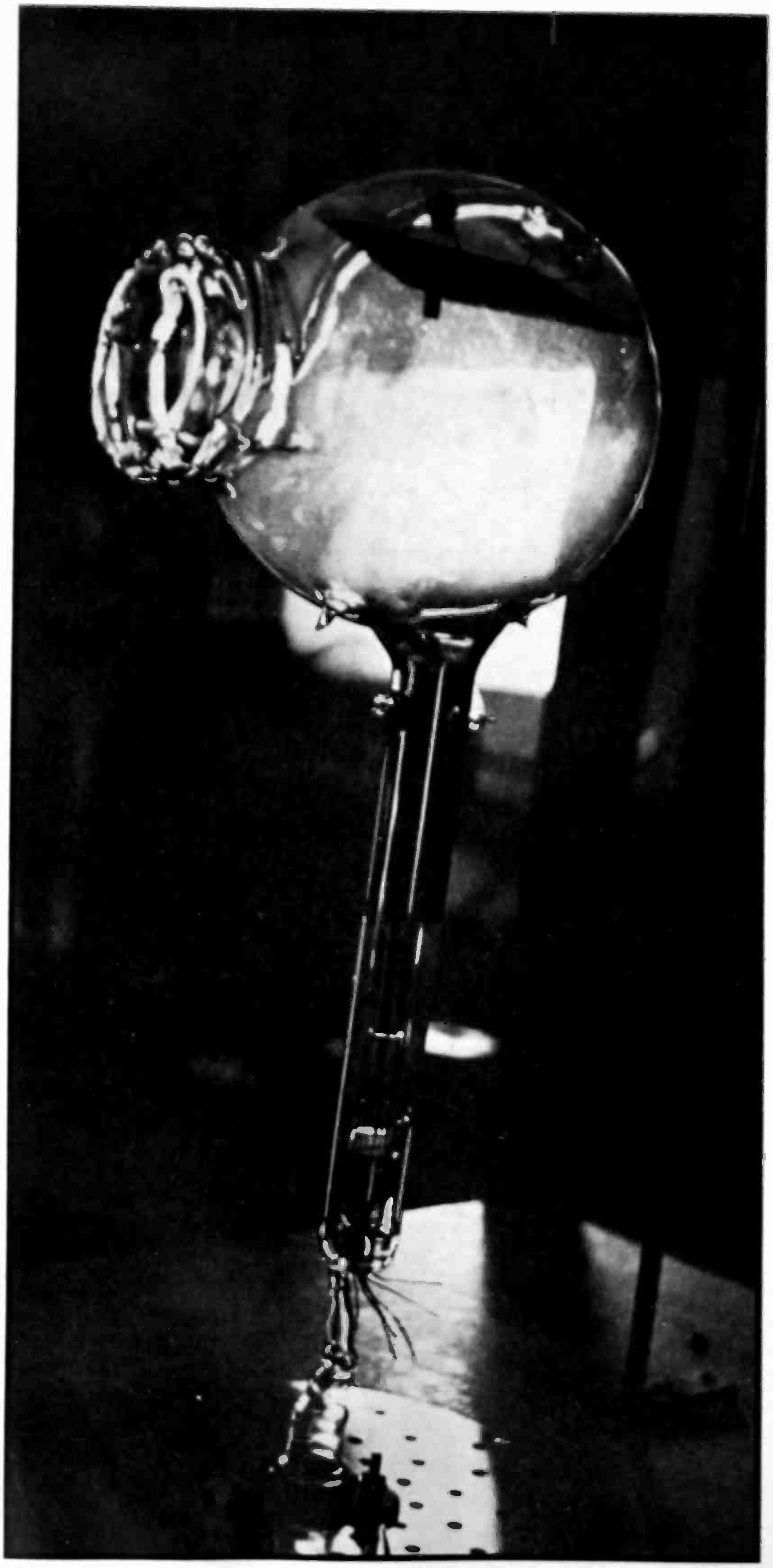
Thus it seems that again two independent inventors working at widely separated laboratories have developed devices that resemble each other very closely indeed.

▶ **RESEARCH IN NOISE** . . . Some time ago the RMA appropriated money for the development of methods of measuring automobile ignition noise. Mr. L. C. F. Horle was set to work on this job of such evident importance to both radio and the automobile industry. The preliminary stages of this work have been completed with the construction of the noise-measuring set described in this issue. It is hoped that funds can now be provided for a thorough test of the apparatus and for educational work among automobile people, that the frontal attack on ignition noise may be completed now before the wavebands in the ether, in which most of this noise occurs, are in great demand.

RMA should be congratulated on this manner of attacking a serious problem. No doubt there are other industry problems which may be solved in the same manner, viz, by hiring a competent engineer who, unbiased by commercial affiliations, may labor for the industry as a whole.

▶ **PRINT ORDER** . . . The following table showing paid circulation to *Electronics* presents a highly gratifying picture to the publisher and the editor. The actual number of copies distributed is somewhat greater than these figures, and in March the print order mounted to the 10,000 mark for the first time in the history of the paper.

September 1935	6902
October	7136
November	7239
December	7669
January 1936	8001
February	8417
March	8706
April	9141



MOSAIC IN THE MAKING

An iconoscope on the pump in the Hazeltine Laboratories, Bayside, New York. The square plate at the top contains the photoelectric mosaic which acts as the "retina" of the television camera

"Reported at Cleveland"

The I.R.E. Convention brings news from the front of the electronic development. A 40 kw.-60 mc. transmitter, the Doherty high efficiency r-f amplifier, simplified automatic tuning control

THE electronic industries have come to expect much in the way of news from the annual conventions of the I.R.E. This year the eleventh annual meeting, held May 11, 12, and 13 at Cleveland, is living up to the tradition. As this issue goes to press, some 600 members and guests are preparing to hear a program which runs the gamut, alphabetically speaking, from automatic tuning circuits to ultra-high frequency transmitters, and which includes a visit to the famous Lamp Development Laboratories of the General Electric Company.

The program of technical papers, outlined below, contains many reports of pioneering electronics. Several developments will have their first public presentation at the meeting; among these are the Doherty high-efficiency linear r-f power amplifier, which is expected to have much influence on broadcast transmitter design, and a new resonant-line transmitter which delivers 40 kw. at 60 mc. from conventional 200 kw. tubes.

H. W. Lord Describes Pictures of Mercury-Arc Spots

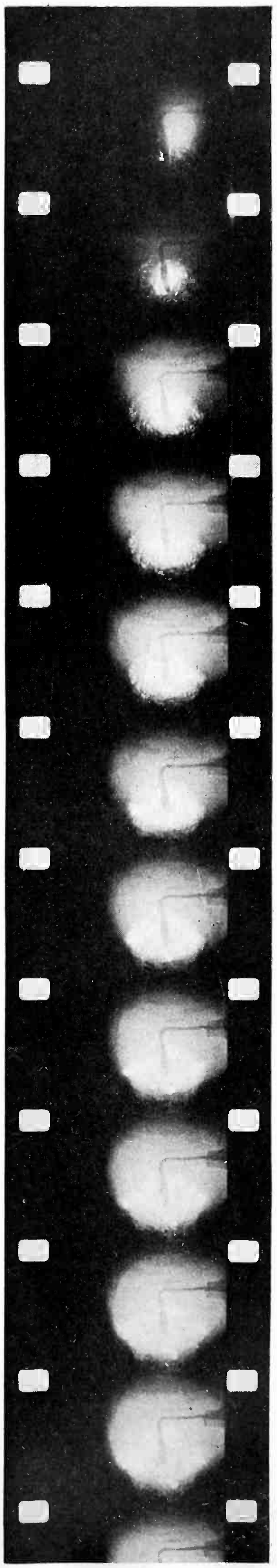
From advance information kindly made available by the authors, the following "forecast" of the convention papers has been prepared. The June issue will contain a complete report of the convention.

A research of interest to industrial tube users has been made on the ignitron type of mercury rectifier at the General Electric Laboratory in Schenectady. These tubes, which contain a pool of mercury on which the luminous cathode spot forms, have been photographed by the Eastman high speed movie camera (described in December, 1935 issue, *Electronics*, page 6) at picture speeds as high as 2000 per second. The pictures show the formation of the cathode spot, and the process by which it subdivides into many spots, increasing in number as the peak current is reached. In one of the runs, the tube was carrying a peak current of 1,150 amperes, carried by 75 spots. The area of the pool carrying these spots is only a small portion of the total area, indicating that a much higher peak current might be carried if necessary. The films also caught several phases of improper operation, including the formation of a spot at the edge of the pool, rather than at the ignitor, and the formation of an arc-back, in which glowing particles from the anode are shown to be moving at speeds of 75 meters per second.

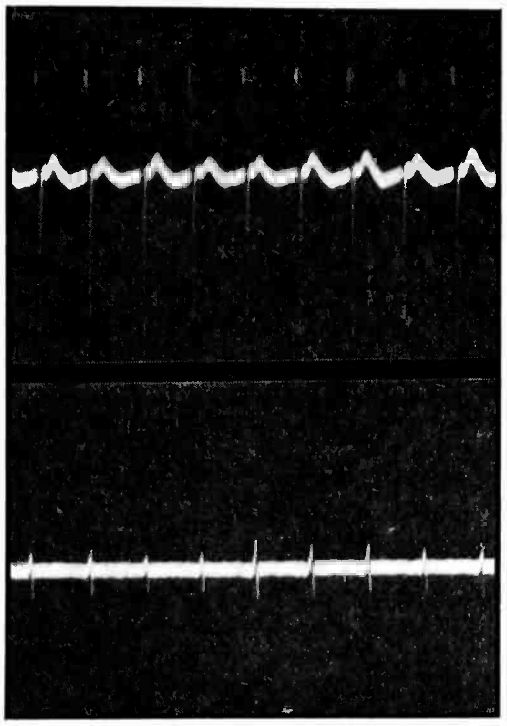
The National Bureau of Standards contributes two papers, one by J. H. Dellinger on "Radio Transmission Anomalies" (see "A New Solar Radio Disturbance" by the same author in the January issue of *Electronics*, page 25), and the other by S. S. Kirby and N. Smith on ionosphere studies, (see report of U. R. S. I. meeting, this issue). These papers reflect the important work on wave propagation, and its relations to natural phenomena, which has been carried out in Washington and elsewhere during the past year.

The "Frankenstein" Transmitter Developed in Camden

John Evans, of RCA Victor in Camden has been working for many months on a creation which would do justice to Count Frankenstein. It is a resonant lines transmitter designed to deliver high power on ultra-high frequencies, using conventional tubes. But the tubes are about the only conventional part of the job. In order to secure frequency



High speed pictures showing spread of cathode spots in ignitron tube



Noise (above) reduced to low level (below) by super-regenerative detector in new police receiver. Below, right, an electron gun adjustable from the outside of the tube, described by D. W. Epstein

stability approaching that of crystal control, resonant lines with temperature change compensating elements were developed. The resulting transmitter, resplendent in heavy copper bars, is a wonder to behold. The results speak for themselves. Forty kilowatts of useful power on frequencies between 40 and 60 megacycles, with a frequency stability of 0.001 percent for changes of 20 per cent in anode voltage, for 40 degrees Centigrade temperature change, and for filament voltage variations amounting to five per cent, all with the use of existing commercial tubes (type AW-200). A single-ended oscillator, followed by a push-pull amplifier is used, with many refinements in the way of phase stabilizers, and spurious oscillation eliminators.

80 watts at 120 cm.

Likewise in the u-h-f region of attack, but operating at still lower wavelengths is the multi-tube oscillator described by P. D. Zottu, also of RCA in Camden. Using eight type 834 tubes in oscillator units coupled to a common load, Mr. Zottu has been able to derive an output of 80 watts, at a wavelength of 120 cm., with an efficiency of 20 per cent, and using only 500 volts on the plates on the tubes. The oscillators use a modified concentric line set-up, which considerably simplifies the arrangement. At these frequencies, many interesting effects become apparent. For example, on a low loss line, a standing arc approximately three-quarters of an inch long can be struck, and will maintain itself.

Complete Police Two-Way Radio System Described

The practical application of u-h-f equipment in the police communications systems has been advanced in many ways during the past year. In a paper by Stewart Becker and L. M. Leeds, a complete two way police system developed by the General Electric Co. is described. The system operates in duplex. Two frequencies are used, one for receiving, the other for transmitting, but the same car aerial is used for both functions at the same time. To separate the transmitted energy from the relatively weak received signal, a very efficient and sharp cut-off filter is used in the aerial connection. This filter is made of a section of a concentric line, and is proportioned to give output points capable of separating the receive frequency from the transmit frequency.

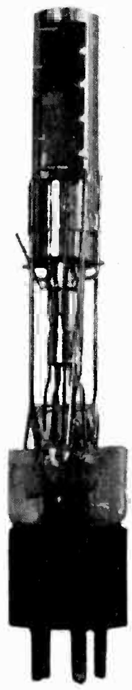
The receiver used is unusual in that it combines the features of the superheterodyne and the super-regenerative circuits, the former to obtain high selectivity and freedom from reradiation, and the latter to obtain noise-reducing and a-v-c action, together with high sensitivity. The receiver is more completely described in the Tubes at Work department of this issue (page 42). The car transmitter provides 15 watts, 100 per cent modulated. Station transmitters supplying up to 150 watts are also described. All of the equipment operates in the band between 30 and 42 megacycles.

Automatic Frequency Control

Papers especially concerned with receiver design describe a-t-c circuits, the effect of a-v-c on selectivity measurements, and the meaning and use of aural compensation. The first of these papers, by D. E. Foster and S. W. Seeley of the RCA License Laboratory describes the development of automatic frequency control circuits similar to that described in *Electronics*, in the March, 1935 issue, page 48. The idea of the circuit is the use of double rectifier and side-tuned circuits which produce a d-c voltage proportional to frequency departure. The d-c is applied to the grid of the oscillator tube, producing a change of oscillator frequency sufficient to compensate for the original departure from resonance.

A-v-c action investigated

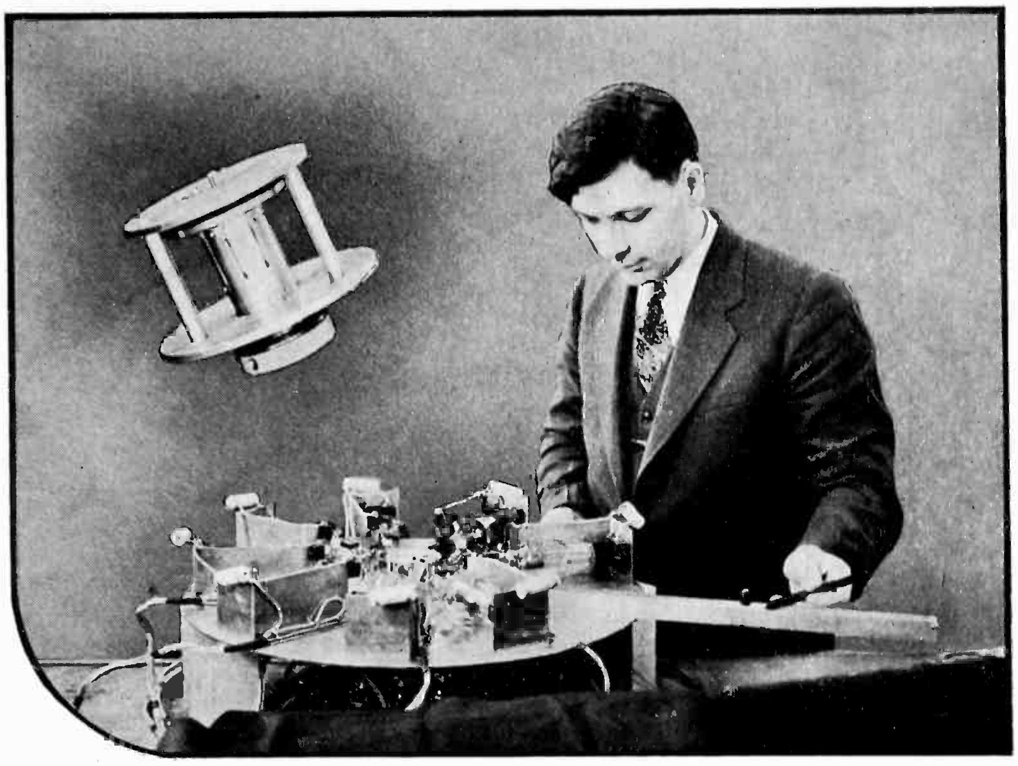
The effect of a-v-c action in a receiver on the measurements of overall selectivity of the set is examined in detail by Donald S. Bond, of RCA in Camden. Two methods, constant signal input, and constant output, are contrasted, and the effect of adjacent-channel fading on the measurement is given. The analysis is based on several different types of automatic gain control circuits.



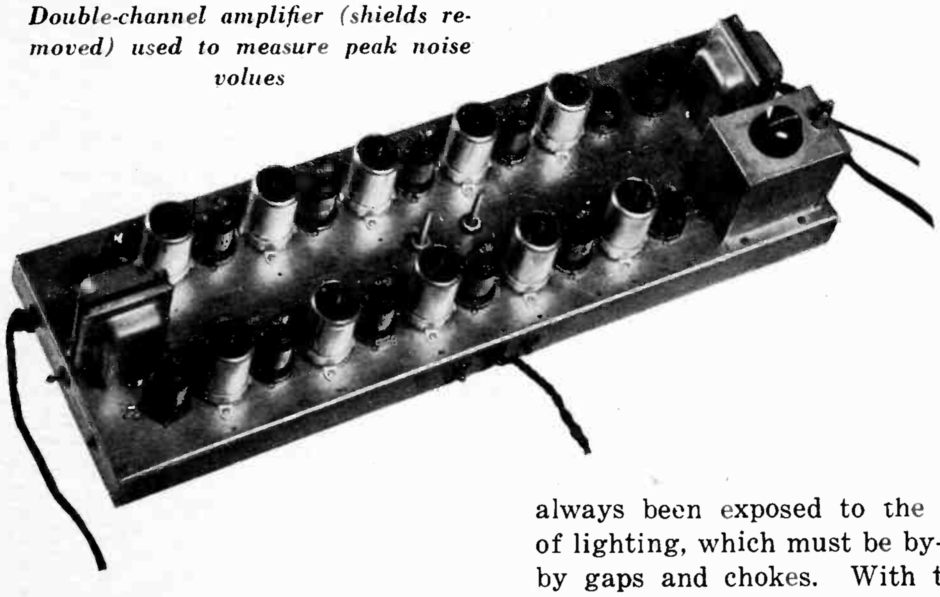
The paper by C. M. Sinnett (RCA Victor) describes the factor "aural compensation." Volume expansion, a topic with which Mr. Sinnett has had much experience (*Electronics*, November 1935, page 14) is only a part of the picture of true reproduction of pleasing tone quality and range. A new device, called an "audio discriminator," is used to determine the acoustic balance in a reproduction system. It makes use of variable-gain band-pass filters which can raise or lower the response of various frequency bands in the audio spectrum.

A paper by W. G. Wagener of RCA Radiotron, Harrison, gives some simple and highly useful methods of forecasting the performance of power and transmitting tubes on the basis of their characteristic curves, without actual testing. The method is based on a simple and quickly-performed analysis of plate-circuit and grid-circuit pulses, in terms of the d-c and fundamental a-c components, and the angle of flow. The subject, according to Mr. Wagener, is not particularly new, but the application of the method in practical cases brings out several interesting aspects of tube performance. The result is a coordinated procedure for calculating transmitting tube capabilities, which can be applied equally well to Class C r-f telegraph and telephone, Class B r-f linear amplifiers, grid modulated r-f amplifiers, and Class B a-f amplifiers.

The paper by W. H. Doherty of the Bell Telephone Laboratories on a new high efficiency modulated power amplifier circuit has been awaited with much interest. Announced several weeks ago, no detailed information on it has yet been released, and apparently the presentation at the Convention is the first public technical description of the circuit. Plate circuit efficiencies of 60 to 65 per cent *independent of modulation* are claimed for the new development. This unusual performance is obtained, to quote the author's abstract, "by means of the combined action of varying load distribution among tubes and varying circuit impedance over the modulation cycle." Actual measurements on a 50 kilowatt laboratory model of the amplifier are given in the paper.



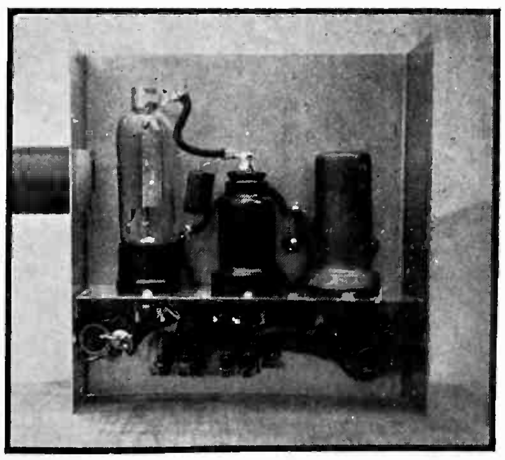
Eighty watts at 120 cm. from this resonant line (insert) 8-tube multiple oscillator, shown with P. D. Zottu who reports its achievements



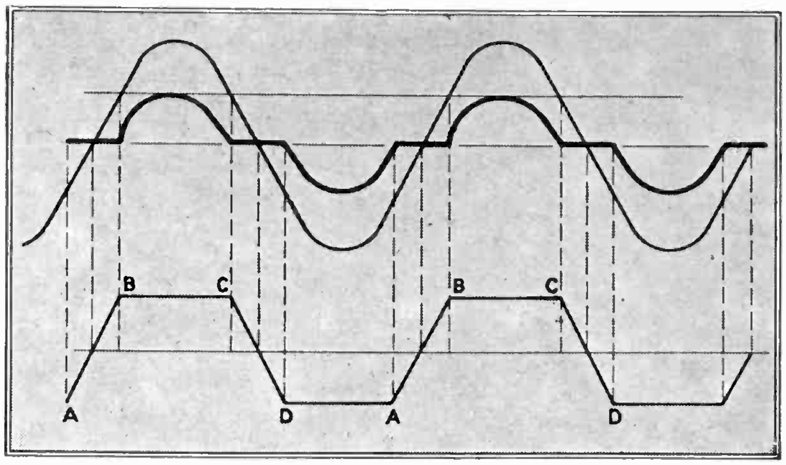
Double-channel amplifier (shields removed) used to measure peak noise volues

Another paper of interest to transmitter engineers, by J. F. Morrison and P. H. Smith, members of the Bell Laboratories staff, is a description of the shunt excited antenna, by which a vertical radiator of the type commonly used in broadcast stations today can be fed with the base grounded. Antennas of this type have up to now been supported on one or more expensive insulators; and the antenna has thus always been exposed to the hazard of lighting, which must be by-passed by gaps and chokes. With the antenna at the same d-c potential as the ground in the new system, the antenna acts as a perfect, lightning rod. Static charges which accumulate are immediately discharged to grounded instead of building up until an arc-over causes a temporary interruption of service. The new method of coupling to the antenna gives approximately the same performance and efficiency as the older methods now in use.

A theoretical paper by C. W. Carnahan of Hygrade-Sylvania in Salem, Mass., contains one of the first attempts to develop the transient response of typical amplifier circuits. In ordinary r-f and audio amplifiers, the response of the amplifier is sufficiently specified by its amplitude, and if necessary, its phase characteristic. But in television amplifiers, where the signal is not sustained but is a series of more or less unrelated transients, the transient response must also be given. Mr. Carnahan makes use of a Fourier series, taken over a period sufficiently long to prevent serious overlapping of transient terms, and yet short enough to be handled in a series of convenient length. By this means the indicial admittance of the amplifier, (the current response to a suddenly applied unit voltage), is calculated. A typical case treated in the paper is a screen-grid resistance coupled amplifier, in which the shunt capacities, and the series inductance in the coupling resistor circuit used to correct the loss of high frequencies, are both taken into account.



Two-stage photo-amplifier with two resistors and three condensers as circuit parts, described by F. H. Shepard, Jr.



By means of combining sine-waves with distorted forms (shown in heavy lines) the high frequency sweep voltage ABCD is produced, as reported by L. M. Leeds

Electron optics has one of its most important potential applications in television cathode ray tubes. Since the spot size is the absolute limitation of detail of a received television image, any aberration tending to increase the size of the spot is detrimental, and is receiving careful attention in development work. The problem of determining the optical constants, and correcting for the various distortions and aberrations which occur, are discussed in the paper by D. W. Epstein of RCA Victor. An experimental electron gun used by Mr. Epstein in this work contains sliding parts, which are adjustable from the outside of the tube, permitting a cut and-try process of adjustment during the actual operation. Theoretical curves of the optical constants of lenses equivalent to two coaxial cylinders are given, and it is proved that the only aberration damaging spot size in a well designed and constructed tube of this type is spherical.

Laurance M. Leeds of the G. E. Laboratories in Schenectady contributes a paper on a high frequency time axis for cathode-ray tubes, capable of tracing out one cycle of a 30 mc. wave. Oscilloscopes capable of this performance are of great utility in adjusting high frequency transmitters, detecting and tracing parasitic oscillations, and in fundamental high frequency research. The new circuit makes use of a portion of a sine wave for deflection purposes. If the portion between $\pi/6$ and $-\pi/6$ is taken, for example, the curve departs from a straight line by only 0.904 per cent., that is, it is linear to within the thickness of a trace line. The remainder of the wave is removed from the screen. A sine-wave distorting circuit is used to remove undesired portions, leaving only the required linearly changing voltage for the sweep.

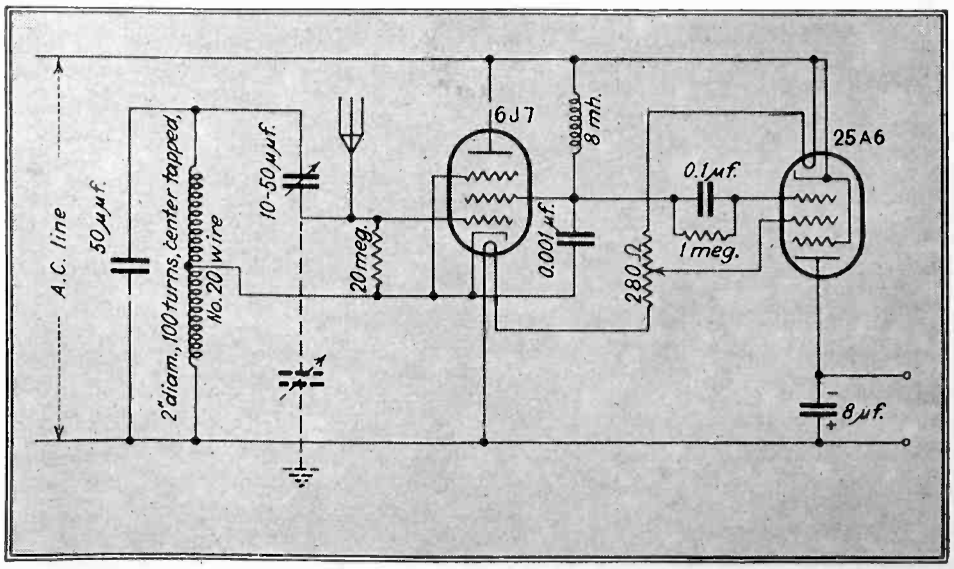
A paper which will be reported in full in a forthcoming issue of *Electronics* is "Applications of Conventional Tubes in Unconventional Circuits," by F. H. Shepard, Jr. of RCA Radiotron. When Mr. Shepard's first batch of unconventional circuits was announced before the Radio Club of America, and subsequently published in *Electronics* (September, 1935, page 38), the editors were besieged with requests for more of the same. Several of the circuits are of the practical 110-volt line a-c or d-c type and perform control operations with great reliability and with an absolute minimum of parts. Among the circuits discussed are a two-stage phototube amplifier relay circuit using two resistors and three condensers as circuit parts, and a capacity-operated relay, using metal tubes and working from the 110 volt line.

Analysis of Noise Characteristics

V. D. Landon (RCA Victor) discusses in his paper the difference between two types of noise, the smooth-hiss type and the sharp impulse type. The subject of noise is receiving much attention at present, and the distinction between the two types of noise has come into prominence because of the noise-silencing circuits (*Electronics*, March, 1935, page 8) which operate on noise peaks only. The work done by Mr. Landon combined a mathematical approach, using operational calculus, and an experimental confirmation, using a two-channel high gain amplifier. The main results are that smooth "hiss" noise has a peak value proportional to the square root of the band-width, while impulse noise has a peak value proportional to the first power of the band-width. One of the conclusions drawn from the work is that, in the design of noise limiting circuits, the amplifier ahead of the limiter should be as broad as possible, and the amplifier after the limiter as sharply tuned as is practical.

Cathode Ray Uses

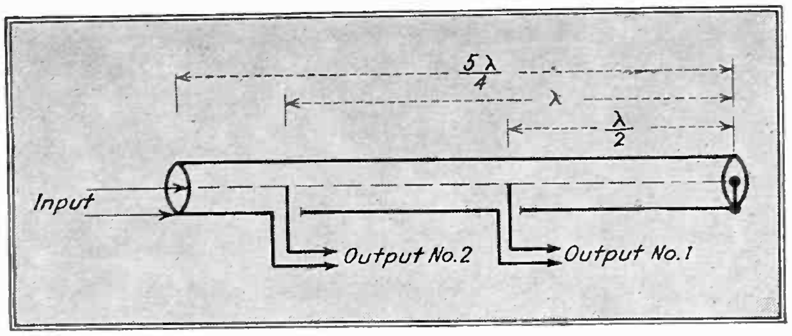
The uses of the cathode ray tube are expanding into many fields. One paper, by H. J. Schrader of RCA Victor, deals exclusively with the non-radio applications of the oscillscope and its accessories. Methods of measuring pressure by a piezo-



Circuit diagram of a capacity-operated relay using metal tubes and operating from a 110-volt line, developed by F. H. Shepard, Jr.

electric "microphonic" transducer, and of indicating torque and torsional vibration in mechanical systems are outlined.

R. W. Gilbert (Weston Electrical Instrument Co.), describes a new type of electronic device which may have many important applications in industrial control and measurement. It is a d-c amplifier which uses an electronic balancing mechanism to maintain the input and output voltage in a potentiometric null position automatically. The gain of the amplifier is thus made completely independent of the effects of non-linearity and variation of the circuit parts.



Method of using concentric-line sections to obtain frequency separation (filtering) whereby u-h-f signals can be sent and received simultaneously from the same antenna, used on police cars.

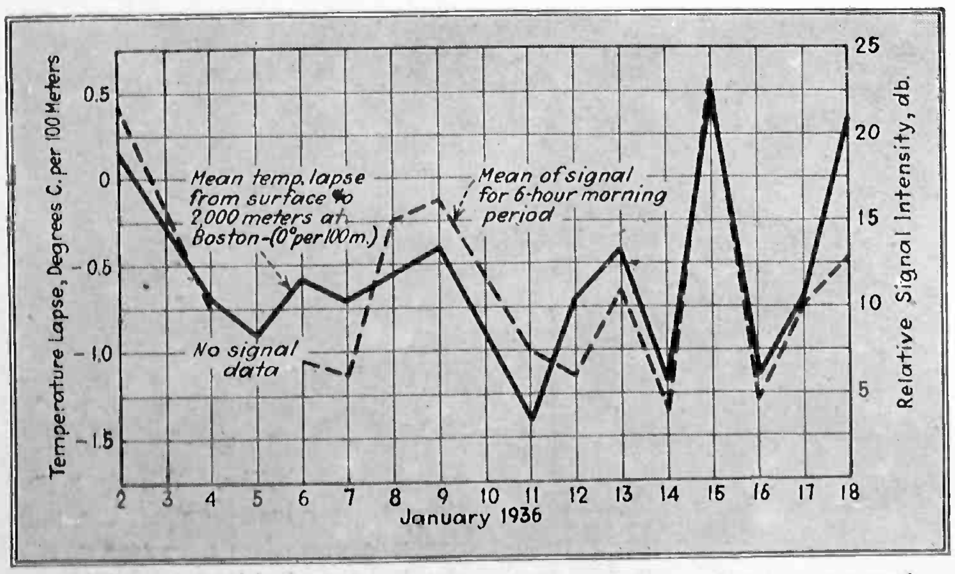
U. R. S. I.—I. R. E. Washington, May first

The joint meeting of the American Section of the International Scientific Radio Union and the I. R. E. was held May 1st, at the National Academy of Sciences in Washington, D. C. The keynote of the meeting was radio wave propagation and the natural factors affecting it. J. H. Dellinger reported on a new type of solar radio disturbance, which has already been mentioned here. L. V. Berkner and H. W. Wells (Carnegie Institution) described experiments on the polarization of radio waves near the magnetic equator of the earth.

The ionosphere continues to receive its share of attention. Messrs. Smith, Kirby and Gilliland of the Bureau of Standards reported on measurements made of various frequencies to determine the virtual heights of the various layers, and to correlate them with seasonal variations, etc.

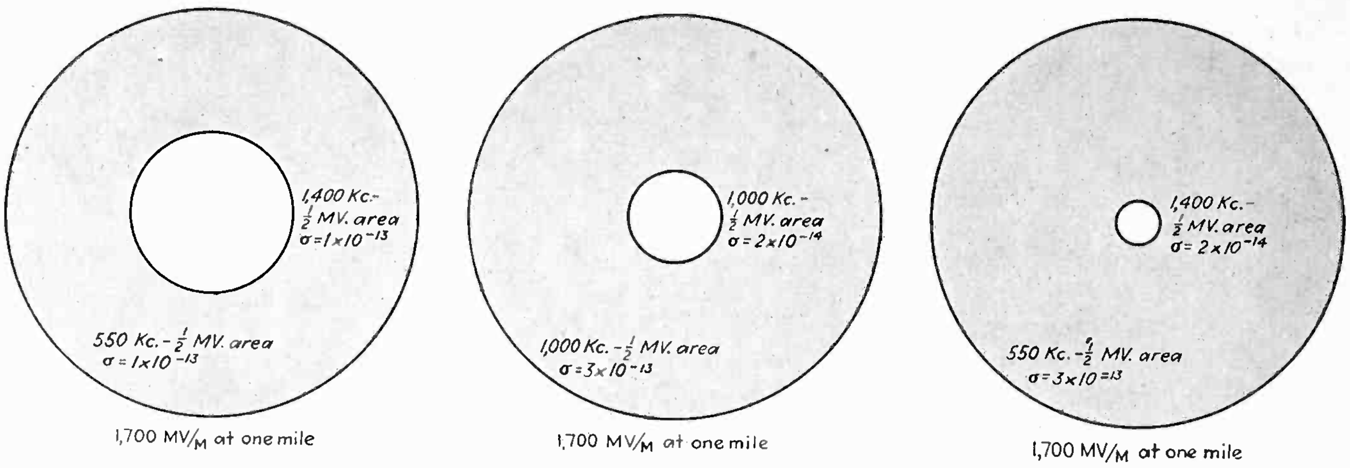
Ross Hull of the Headquarters Staff of the American Radio Relay League related experiments on the transmission of 60 mc. waves over long paths (Between West Hartford and Boston, about 100 miles). The work was done in cooperation with Dr. C. F. Brooks of the Blue Hill Observatory. The variations in signal level of these five meter waves were pronounced, indicating variable refraction-reflection effects in the atmosphere. One of the striking correlations made in the study is the connection of average signal level with the temperature differences between the high and low atmospheric regions. The stratification of the atmosphere produced by these sharp differences, up to a height of 2000 meters, has an important bearing on weather conditions, and it is expected that the five-meter signals can give a good indication of atmospheric conditions which may be used in weather prediction studies.

Practical cases of wave propagation were treated by R. K. Potter and A. C. Peterson of the Bell Laboratories, in "The reliability of shortwave telephone circuits." P. S. Carter and G. S. Wickizer of RCA Communications described the u-h-f transmission link between the RCA Building (Radio City, NBC studios), and the Empire State Building (RCA television transmitter). Propagation between the two buildings in line sight, on 177 mc., was studied with the idea of providing a flat response over a band-width of 3 mc. Changes in the directivity and angle of polarization which occur over this short path (less than a mile, air line) were observed and a theoretical overall response curve for an assumed combination of rays was compared with the response obtained experimentally.



Close correlation between temperature lapse and five-meter signal strength, from data collected by Ross Hull of the A.R.R.L.

Two papers (one before the American Physical Society and I. R. E.) were presented on the most interesting subject of hyper-frequency wave guides. G. C. Southworth of the Bell Laboratories, and W. L. Barrow of the Massachusetts Institute of Technology were the authors. Hyper-frequency waves (having a frequency higher than 2000 mc., wavelength less than 15 cm.) can be sent along hollow metal tubes or along dielectric wires, with comparatively small attenuation. The transmission is remarkable in that no return circuit is required for the energy. One type of wave having an axial magnetic component is transmitted with attenuation which *decreases* indefinitely as the frequency increases, a phenomenon having no parallel in communication practice. The practical nature of the development is still in some doubt, because of the difficulty of producing the necessary very high frequency waves, but the experimental results confirm the theory of the transmission to a remarkable degree. Papers on this subject are published in the April, 1936, *B.S.T.J.*



Figs. 1—3. Coverage areas, showing the effects of frequency and soil constants, all referred to a field strength of 1700 MV/M at one mile. The shaded areas show the increased coverage made possible by low frequency assignment, high soil conductivity, and by the combination of the two factors

Broadcast Coverage

Broadcast stations like newspapers must prove the size of their audience, and improve it. Here described are several technical aspects of the subject: methods of measurement, influence of soil, frequency

By RAYMOND F. GUY
Radio Facilities Engineer
National Broadcasting Company

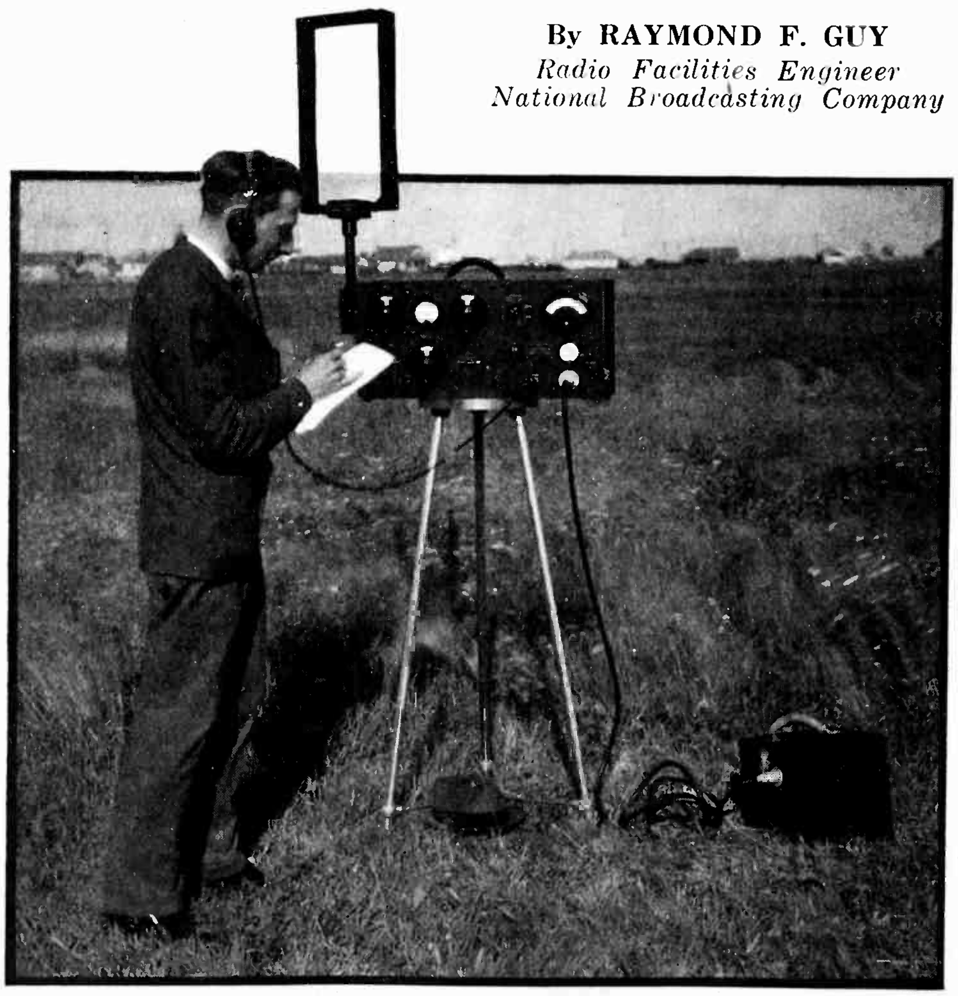


Fig. 4. A typical field-strength measuring set in use in the NBC coverage survey. The set covers the frequency range from 500 to 20,000 kc., and a signal range from a few microvolts to 6 volts

IN THE early years of broadcasting, coverage was thought of only in a rather hazy fashion and this state of affairs continued, with few exceptions, for some time. It was customary to express the effectiveness of broadcasting stations loosely in terms of the licensed power, disregarding such considerations as the operating frequency, the general effectiveness of the antenna in use, the character of the earth in the area being served, etc. The expression of effectiveness in this vague fashion left a great deal to be desired and with the rapid growth and development of commercial broadcasting, it became evident that more comprehensive means were necessary by which station coverage could be expressed, much as newspapers express their effectiveness by circulation figures.

In other words, a yardstick was required which showed the number of persons, receivers, or radio families which could be served with reasonable reliability. Whether or not they take advantage of the service depends upon the program material, the listener habits, etc. These factors have been studied by the statisticians, with the aid of telephone or postcard surveys, contests or other devices, but do not concern us at the moment, although they are quite interesting.

Field Intensities Required for Service

The research in coverage requires, basically, that the field intensity required for reasonably satisfactory service be known for the various conditions encountered. Receivers for many years have been built with sufficient sensitivity to take advantage of service as we evaluate it. It has been determined that:

Rural areas are reasonably well served with ½ millivolt per meter.

Suburban areas are reasonably well served with 2 millivolts per meter.

Smaller urban areas are reasonably well served with 10 millivolts per meter.

Crowded cities sometimes require as much as 25 millivolts per meter as in New York City in certain of its population concentrations attended by high noise levels and poor antenna facilities.

The Federal Communications Commission published data concerning the minimum signal strength required in rural areas, in suburban sections and in built up cities. The commission considers a signal strength of .1 millivolt per meter adequate for satisfactory reception under favorable conditions. Except for some of the very cheap models, receiving set manufacturers for many years have built receivers which produce full volume on a signal strength of .01 millivolt per meter. This service is not reliable and NBC set up a standard well above this figure after a thorough comparison of special mail analyses and measured signal intensities. In the absence of fading or interference the ratio of signal to noise level determines the service received. A noise level of 1 per cent of the program level is just noticeable, a noise level of 5 per cent is quite noticeable, but not necessarily a serious detriment to service, and a noise level of 20 per cent becomes very annoying and would be tuned out if a better ratio were received from some other station with equally attractive program material.

It is necessary to differentiate between primary coverage, which is reasonably reliable under any circumstances, and secondary coverage, which is obtainable only during the night-time hours, or which is subject to fairly frequent interruptions by static or other disturbances. Secondary coverage is important, but it is difficult of evaluation and is generally considered "bonus" coverage, despite the fact that large areas throughout the United States receive only this type of service. It became evident fairly early in the study of coverage that a fair determination was going to require not only field intensity measurements, but also an analysis of audience mail for each of the stations involved to properly determine the coverage of the NBC networks. Field intensity measurements furnish valuable information. So do audience mail analyses, but a combination of the two was found to be preferable to either alone. The decision was made to immediately survey all of the stations operated by or associated with the National Broadcasting Company.

Survey of NBC Networks

This survey was, and is, the most comprehensive and complete one ever undertaken in radio. Eighteen measuring cars were driven 232,218 miles throughout 1,250,000 square miles (40% of the area of the United States), to make 21,360 separate field intensity measurements on over 90 stations in only four months consecutive elapsed time. The 10, 2 and ½ millivolt contours of each of the 90-odd stations were measured and in certain cases additional contours

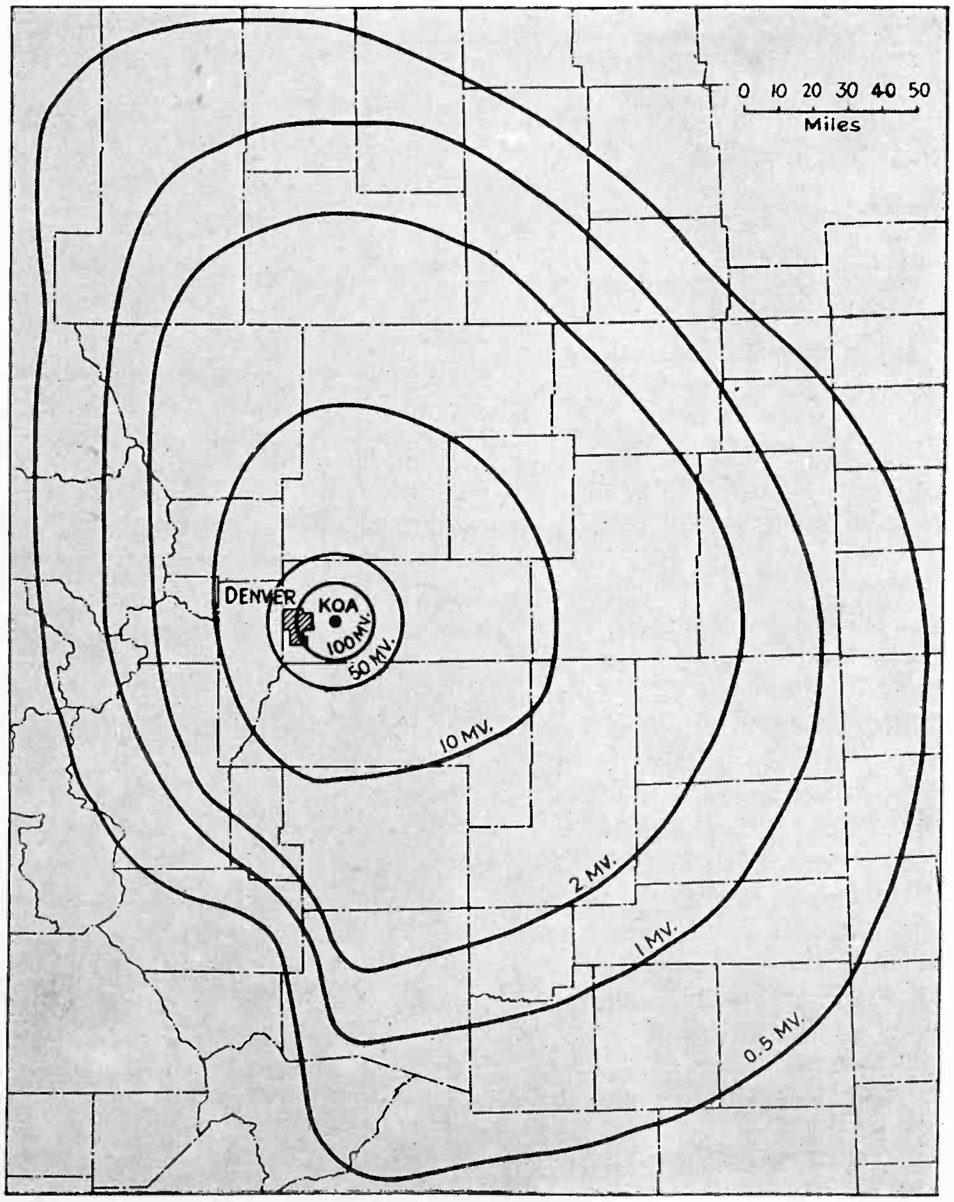


Fig. 5. A typical field strength map, of station KOA. The outer limit of the 0.5 millivolt signal gives the effective rural-area coverage. Note the peculiarly steep attenuation (small space between contours) at the left of the map, caused by the high mountain wall just west of Denver

were included, where it was considered desirable or necessary. The list of stations surveyed included 17 of 50,000 watts, 33 of 5,000 to 25,000 watts, 10 of 2,500 watts and over 30 smaller ones covering the entire United States, parts of Canada, and Mexico. Rapidly approaching winter weather conditions along the Canadian border made it necessary to assign crews to start simultaneously along the Canadian border and work southward to finish up along the Gulf of Mexico. A map of all the network stations was studied and a number of measuring routes were laid out for the utmost economy in traveling distance and time. The survey of a 50,000-watt station involves driving an automobile as much as 3,500 miles and for a 500-watt station as much as 600 miles. Accordingly the stations were divided up equitably among the 18 crews, so that they would all finish simultaneously. Each station area was carefully checked with a planimeter and in each case the networks or supplementary groups were treated first by stations and then by groups.

Mail Analysis

To give the proper weight to other factors, exclusive of field intensity, the most exhaustive mail survey in history was made. A count was made of audience letters received over a period of sufficient length to ensure that the figures were not the reflection of a temporary or abnormal condition, but that they constituted proof of a regular listening audience. For only brief periods had there ever been an attempt to analyze listener mail, county by county, for each of a large group of stations. NBC did so over many months, nearly 5,000,000 letters having been treated statistically and tabulated in a highly efficient machine system. In this study there were used over one and one-half million letters not especially solicited. Station by station, then by individual counties for each of the 90 stations, the contents of these letters were carefully tabulated. The results of the comparison of mail and field intensity results were extremely interesting and disclosed that differences between the two methods of evaluation were traceable to understandable and identifiable influences, proving for the first time the desirability of combining these two yardsticks.

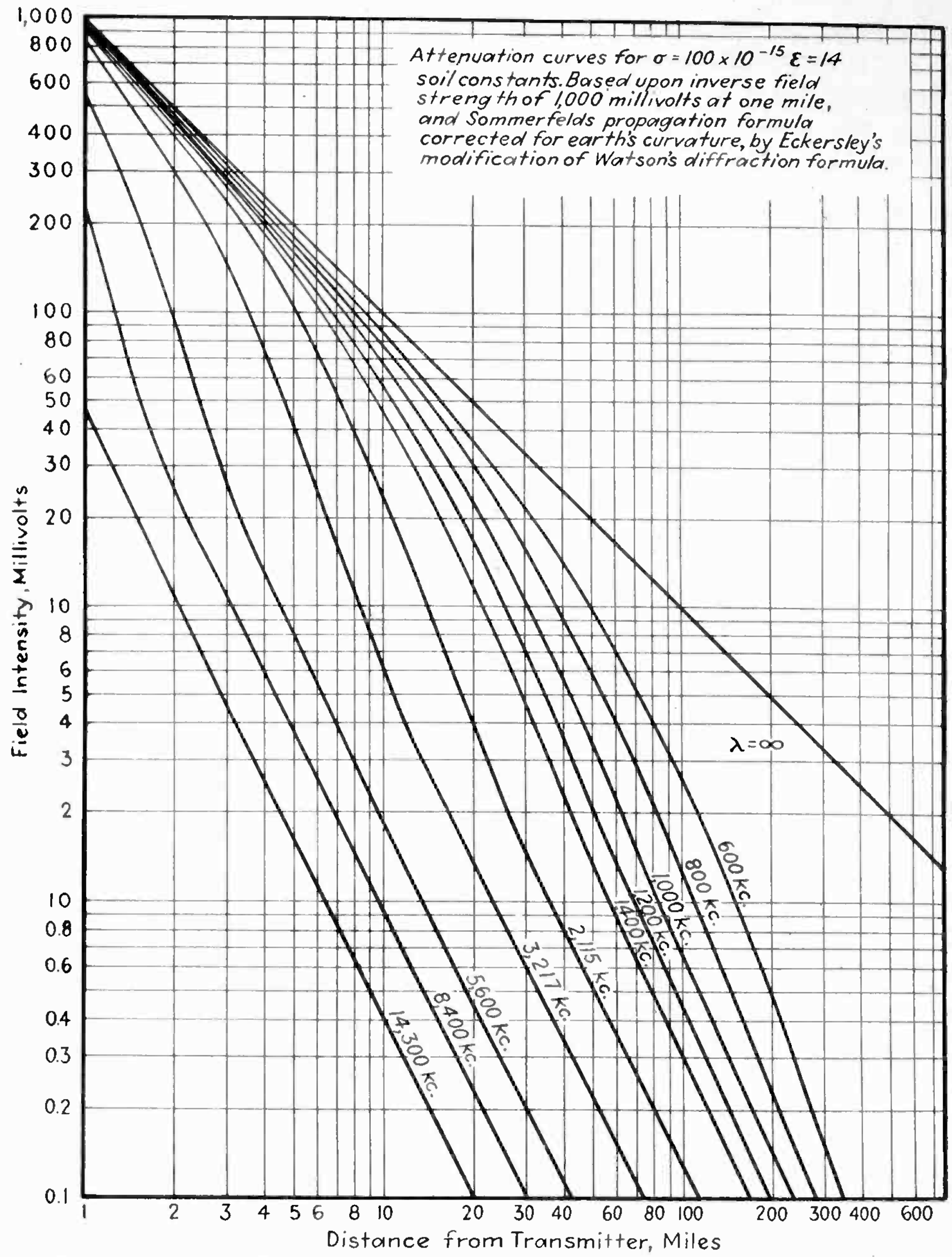


Fig. 6. Typical chart used to compute field intensities when the soil constant is known (in this case 100 × 10^{-15}), taking into account the effect of frequency assignment

The coverage of a station is dependent upon the following factors:

1. Power.
2. Antenna design.
3. Soil conditions as they determine the rate of decay of waves over the earth.
4. Interference from other stations.
5. Local noise levels.

The influence of power on coverage is well known. The field intensity produced from a station, exclusive of everything but power is proportional to the square root of the power increase or decrease.

$$E = \sqrt{P} \qquad (1)$$

Where E is the field intensity and P is the power.

Effect of Frequency Assignment

It is well known that the frequency assignment has a considerable effect upon the coverage obtainable in the primary area. Fig. 1 shows a comparison of coverage obtainable from a 50,000-watt station over average soil when operating on approximately the highest broadcast frequency in one case, and approximately the lowest frequency in the other case. An inspection of the expression for propagation of waves, following, will show the effect of λ, the wavelength.

The most satisfactory expression for computing field intensities along the surface of the earth is the Sommerfeld solution in the empirical form due to Van der Pol.

The field from an antenna decays for two reasons:

1. Dispersion, in which field intensity varies directly with distance.
2. Losses in the earth due to heating, at a variable rate.

These effects are combined in the

following Van der Pol expression:

$$E = \frac{E_o}{d} \cdot A \qquad (2)$$

where E = field intensity in microvolts per meter

$$E_o = 1.86(10^5)\,\frac{P}{d} \qquad (3)$$

if radiated power is known, or

E_o = field intensity in microvolts per meter at one mile in the absence of attenuation

d = distance in miles at which E is evaluated

P = radiated power in kilowatts

$$A = \frac{2 + .3p}{2 + p + .6p^2} \qquad (4)$$

where Sommerfeld's "numerical distance"

$$p = \frac{.842 - d}{\sigma\lambda^2 \times 10^{15}} \qquad (5)$$

where λ = wavelength in meters

σ = ground conductivity in emu which varies approximately from 4. (10^{-11}) for sea water to 10. (10^{-15}) for very dry earth.

Equation 4 neglects the dielectric constant of the soil which in most cases is permissible. Inclusion of the effect of the dielectric constant is treated in the literature.[1]

Soil Conditions

Unfortunately, soil constants have a very large influence upon the coverage of a radio station and except for locating a station to the best advantage within a small area, nothing can be done about it.

Fig. 2 shows the difference in coverage obtainable with a station of 50,000 watts and 1,000 kc. over the two extremes of soil conditions which might be encountered.

Once the soil constants have been evaluated by measurements, preferably by measurement of the rate of decay of field intensity with distance, the calculation of station performance using the above expression is comparatively simple. Field measurements of soil constants were obtained covering wide areas and prove very useful, although it is not the intent here to imply that calculations can or should supplant actual surveys for the determination of coverage. A number of representative soil constants σ for various sections of the United States are given below. They apply only to localized areas and are intended to show only the range of constants encountered.

[1]K. A. Nortin, "Propagation of Radio Waves over a Plane Earth,"—"Nature" June 8, 1935.

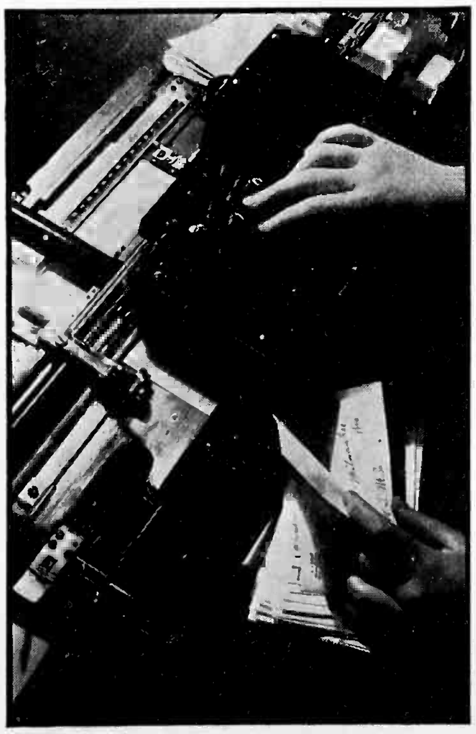
• • •

TYPICAL SOIL CONSTANTS

Texas, around Dallas and Fort Worth	$15\text{x}10^{-14}$
Upper Mississippi Valley	$1\text{x}10^{-13}$
Lower New Jersey	5 to $10\text{x}10^{-14}$
Vicinity of Pittsburgh	3 to $5\text{x}10^{-14}$
Salt Marshes	$1\text{x}10^{-12}$
Very dry earth, approximately	$1\text{x}10^{-15}$
Moist black loam	1 to $2\text{x}10^{-13}$
Mountainous country	5 to $10\text{x}10^{-15}$
Upper New York State	3 to $8\text{x}10^{-15}$
Area about Chicago	$1.25\text{x}10^{-13}$
Denver, except to West	$1\text{x}10^{-13}$
Central Massachusetts, approximately	$4\text{x}10^{-15}$
Ohio	$1\text{x}10^{-13}$
Pennsylvania	3 to $7\text{x}10^{-14}$
North Carolina, around Charlotte & Raleigh	2 to $5\text{x}10^{-14}$
Upper New Jersey exclusive of Mountains	7 to $10\text{x}10^{-14}$
South Atlantic States, approximately	3 to $5\text{x}10^{-14}$
Sand, approximately	$3\text{x}10^{-14}$

• • •

The moist level prairies of the plains states have good conductivity, while the rocky, mountainous states are poor. Sand has poor conductivity, as have most areas of glacial origin. The lower Mississippi Valley, moist and fertile, has good conductivity.



Automatic indexing and sorting machines were used to tabulate the millions of letters in the NBC mail survey

The antenna design can influence the coverage of a station considerably, not only in its general efficiency including its primary area, but also in its characteristics for the reduction of fading. This is a broad subject and will be treated in a separate article on antennas, which will appear in a forthcoming issue of *Electronics*.

Figures 1 and 2 show the influence of frequency and soil constants upon coverage. Figure 3 has been prepared to show the accumulative effect of figures 1 and 2. Figure 5 shows a complete field intensity coverage survey, of station KOA, the Mountain States outlet of the National Broadcasting Company at Denver. The final results of the combined study and evaluation of the coverage of a group of National Broadcasting Company network stations represent the work of many years study of coverage surveys, the tabulation of thousands of letters and thousands of field intensity measurements without which an accurate evaluation of the coverage could not be determined.

The illustration shows the type of equipment used to measure coverage. The instruments, consisting of essentially high grade receivers with calibrating systems, recorders, etc., are mounted in sedan delivery bodies. The calibrating system provides a fixed known calibrating voltage which is compared with the unknown voltage being received by means of attenuators, the contents of the loops having been determined in advance.

Figure 4 is a photo of a field setup of one of the field intensity measuring sets used in coverage survey work. It was developed for the NBC to cover a frequency range of from 20,000 kc. to 500 kc. and a voltage range of a few microvolts to 6 volts.

Figure 6 shows a chart used for computing field intensities when the soil constant is $100\text{x}10^{-15}$, a typical value. A reference level of 1,000 microvolts at one mile is used.

Editor's note: This is the first of two articles on the coverage problem by Mr. Guy. The second, treating antenna design problems, will appear in an early issue.

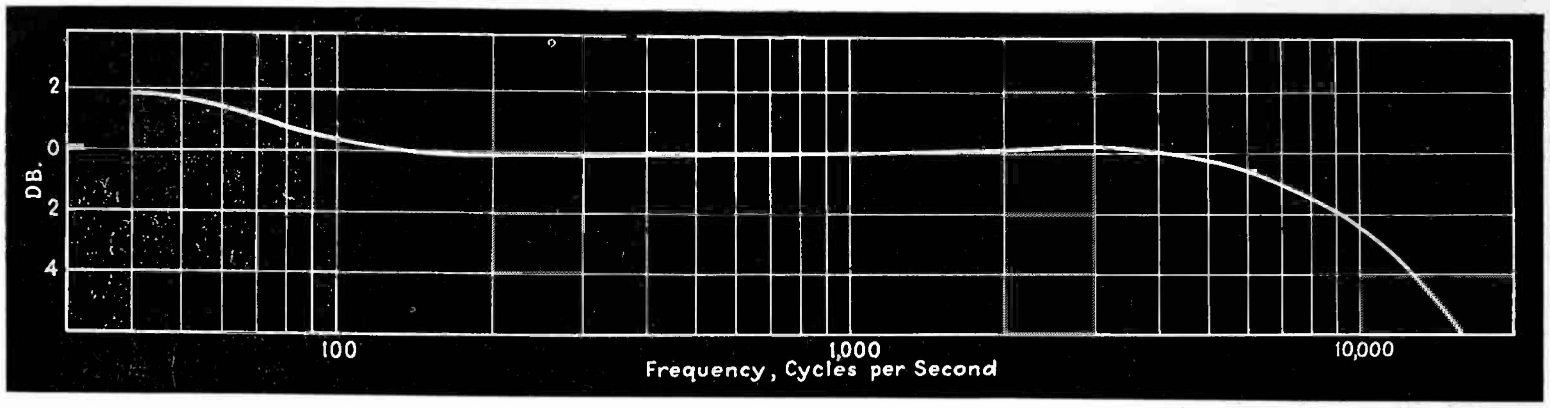


Fig. 3—The frequency characteristic of the oscillator

An A-c Operated Beat Oscillator

Details of a low cost laboratory-type instrument, built of standard parts and capable of delivering half a watt at frequencies from 40 to 15,000 cycles per second with very low distortion

By S. J. HAEFNER
and
E. W. HAMLIN

Union College, Schenectady, N. Y.

AN audio oscillator calibrated to give a frequency which may be varied continuously over a wide range and capable of supplying approximately five hundred milliwatts of audio power with a harmonic distortion less than two per cent is highly desirable for communication laboratory work. The usual method of fulfilling these conditions consists in heterodyning two voltages of slightly different radio frequency. The output frequency is varied by changing the frequency of one of the oscillators, by means of a variable capacity in its oscillating circuit. There is a tendency, however, for the two radio frequency oscillators to pull into zero beat when low audio frequencies are being produced. To avoid this automatic synchronization of the radio frequency waves, buffer amplifiers may be employed between each of the oscillators and the detector. A system using balanced detection of the radio frequency envelope also avoids coupling between the two radio frequency oscillators.[1] Both of these schemes involve considerable apparatus in addition to the radio frequency generators and detector.

The present paper describes a beat note oscillator using screen-grid tubes as high frequency generators.[2] It is possible to avoid pull-in by electron coupling of the radio frequency outputs of the oscillators to the detector. The oscillating circuit proper consists of the screen, used as the anode, with the control grid and cathode as the other two elements of a triode oscillator. The inductance L_1 and capacity C_2 of Fig. 1 form the tank circuit of the oscillator. Energy is taken from the coil, L_2, in the plate circuit. The coupling between the oscillator and plate circuits is accomplished by variations in the electron stream from the cathode to the plate. Since the screen-grid tubes act both as oscillators and as coupling devices considerable simplification results. Also electron coupled oscillators are inherently more stable in frequency than the ordinary triodes under the slight voltage variations occurring in alternating current operation.[3]

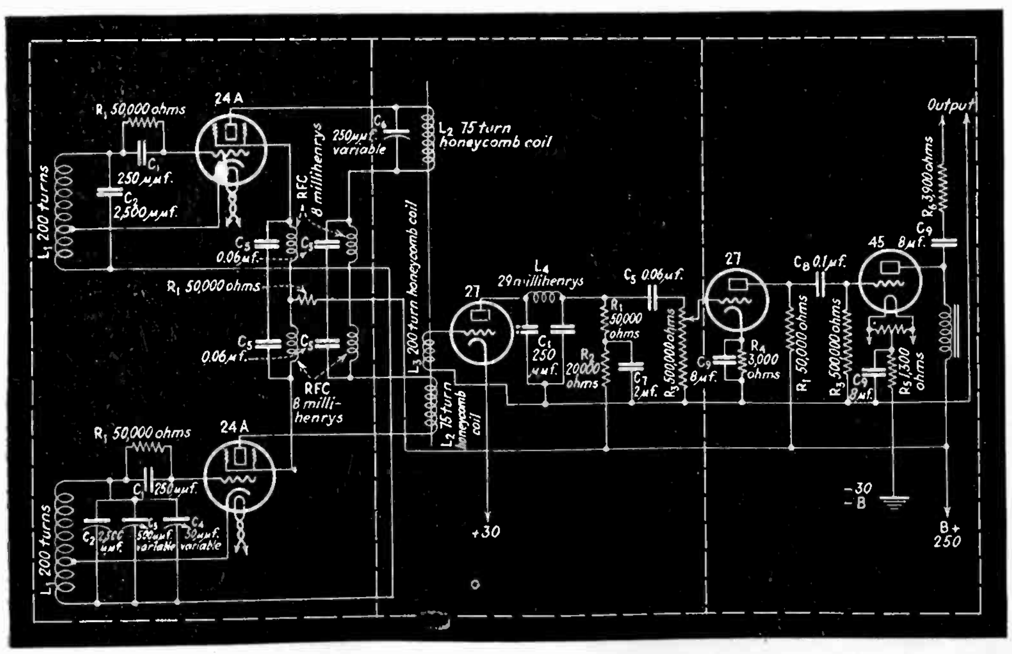
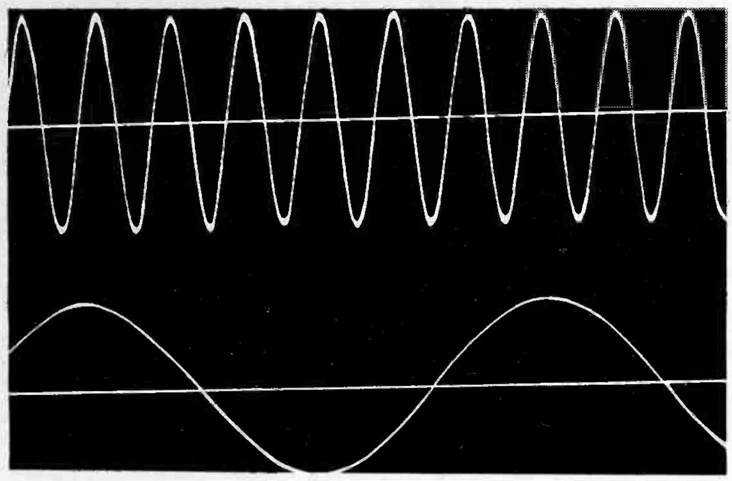


Fig. 1—Diagram of the beat oscillator. Electron-coupling contributes to the frequency stability of the circuit

The circuit diagram is shown in Fig. 1. Two type 24-A tubes are



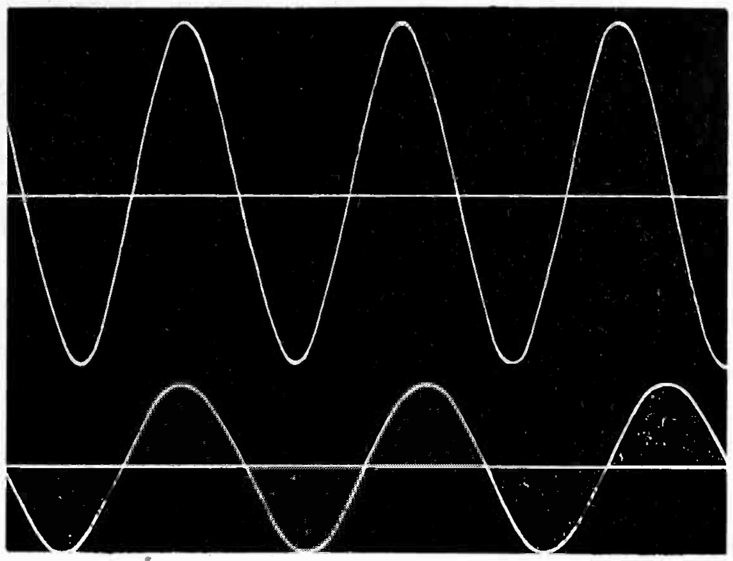


Fig. 2—Oscillograms of wave-forms produced at 360 and 60 cycles per second. The lower wave in each case is a 60-cycle timing wave

employed as electron-coupled radio frequency oscillators. The screen grid, acting as a plate, and the control grid and cathode are used as a triode in a conventional Hartley circuit. In the fixed frequency oscillator, which is the upper one in the figure, the plate output circuit of the 24-A tube is a tuned coil (L_2 and C_6), which is coupled loosely to the detector grid coil. The plate coil of the variable frequency oscillator is not tuned, and is closely coupled to the grid coil of the detector. Radio frequency chokes and by-pass condensers, (C_5), are provided to eliminate coupling due to common impedance of the "B" supply.

A type 27 tube is used for plate detection. Its output is passed through a low pass filter (L_4, C_1) with a cut off at about 100,000 cycles to attenuate radio frequency components. A volume control at the input of the amplifier provides control of amplitude of audio frequency output. The amplifier itself is resistance coupled, and employs a type 27 and a type 45 tube.

In order to keep the harmonic content of the audio wave low, it is necessary that the output of one of the oscillators to the grid of the detector be considerably less than the other and that one of the radio frequency waves be free from harmonics. Simply tuning the plate coil of the fixed frequency oscillator provides enough filtering to give good wave form. Oscillograms of the 60 cycle and 360 cycle waves are shown in Fig. 2.

To have a constant audio output over a wide range of frequency the fixed frequency plate coil should be loosely coupled to the detector grid coil. Fig. 3 shows the variation of the output as a function of the frequency, expressed in decibels. It should be noted that the terminal voltages used to compute this curve are measured across a 3,900 ohm resistor which is capacity coupled to the plate of the 45 output tube. The output curve could be made flat at 10,000 cycles by using an output transformer with a tuned primary.

If the coils and tubes of the radio frequency oscillators are individually shielded it is not necessary to provide elaborate shielding between the component circuits. Dashed lines on Fig. 1 represent single sheets of copper or brass and complete the shielding of the oscillator.

In construction the apparatus is mounted on three shelves with the disposition of individual parts outlined below.

The radio frequency oscillator coils L_1 are shielded by the two outside tube shields fastened to the lowest shelf, and the 24-A tubes by the two inside tube shields. The main variable condenser C_3, of 500 $\mu\mu$f capacity, are placed directly above the tube shield cans.

The coupling coils L_2 and L_3 are located on the second shelf but are hidden from view by the 27 detector tube, the coils L_4 of the low pass filter, and the variable condenser C_6, which tunes the plate coil of the fixed frequency oscillator. C_6 is adjusted by means of a screwdriver through a hole in the side of the cabinet.

The third shelf holds a two stage, resistance coupled amplifier using type 27 and 45 tubes. The amplifier tubes are mounted on the front of the panel to keep the temperature change within the cabinet at a minimum.

Binding posts placed on the front of the cabinet are used to supply heater and plate voltage from a conventional alternating current power pack. The output terminals are located on the upper right face of the panel. Just below the output terminals are two binding posts used to supply bias voltage to the detector from a 30 volt tap on the voltage divider of the power pack. A vernier dial is used as the main control. The volume control is located above and the trimmer condenser control below the main dial.

The mechanical and electrical layout of the radio frequency oscillators is made as symmetrical as possible to minimize frequency drift. If after a period of heating of about two hours the output frequency is brought to zero beat with the note from a standard one thousand cycle tuning fork it will subsequently deviate from zero beat by not more than one cycle per second. The initial calibrating point on the dial of the main variable condenser, C_3,—which should be designed to give a logarithmic variation in the audio frequency[4]—is set by means of a trimmer capacity, C_4, of Fig. 1. Once "set" on this point the oscillator will hold its calibration.

[1]Terman, F. E. "Radio Engineering" McGraw-Hill Book Co., New York, 1932 Edition, pp. 630-631.

[2]Terman F. E., "Measurements in Radio Engineering," pp. 302-303.

[3]Dow, J. B. "A Recent Development in Vacuum Tube Oscillator Circuits" I.R.E., Vol. 19, No. 12, p. 2095, Dec. 1931.

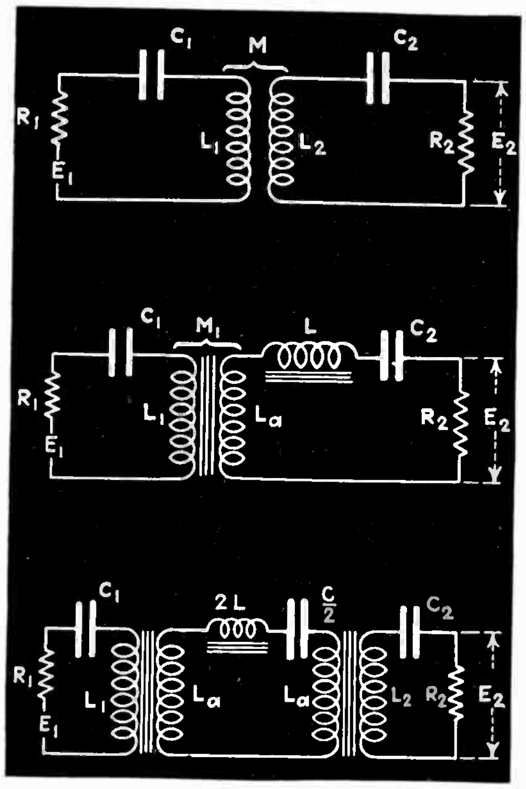
[4]Mead, M. S. "Bent-frequency Oscillators," G. E. Review, Vol. 32, No. 10, p. 521, Oct. 1929.

High Q Audio Reactors

Tuned resonant coupled circuits are the stock in trade of the radio man; but they can be used effectively at audio frequencies as well

By **P. F. BECHBERGER**

Designing Engineer
Ferranti Electric, Inc.
New York City



Figs. 1, 2, and 3 showing a single resonant transformer and the equivalent of two constant-K filter sections

FOR many years radio engineers have been using coupled resonant circuits. Many applications can be found for coupled circuits in the range of audio frequencies; they are of value in carrier telegraphy, multiple control over a single line with several frequencies, and for sound effects. In fact, their use parallels that of filters. The use of such circuits at audio frequencies has been limited by several factors—the major deterrent being the difficulty of obtaining the low coefficients of coupling required for passing narrow frequency bands without at the same time obtaining bad external fields. This article is intended to show the manner in which coupled resonant circuits can be practically applied to audio frequencies.

Figure 1 shows a typical coupled resonant circuit. The condition for optimum coupling has long been known to be:

(1a) $R_1 = \omega_0 L_1 K$

and (1b) $R_2 = \omega_0 L_2 K$

where (2) $K = \dfrac{M}{\sqrt{L_1 L_2}}$

and (3) $\omega_0 = \dfrac{1}{\sqrt{LC}}$

where C is expressed in farads and L in henries. Under these conditions there is zero attenuation at resonant frequency provided the reactances have no losses. For the width of the frequency bands usually desired, coupling coefficients K of the order of a few hundredths to a few tenths are used. The requirements that a transformer have a high Q in both primary and secondary, and have low external field are quite opposed to the requirement of a low and accurately predictable coefficient of coupling.

By the use of an external inductance in either the primary or secondary circuit, the combined transformer and inductor can be made to satisfy all the practical requirements. In Fig. 2, the "leakage inductor" L is placed on the secondary side. Conditions of optimum coup-

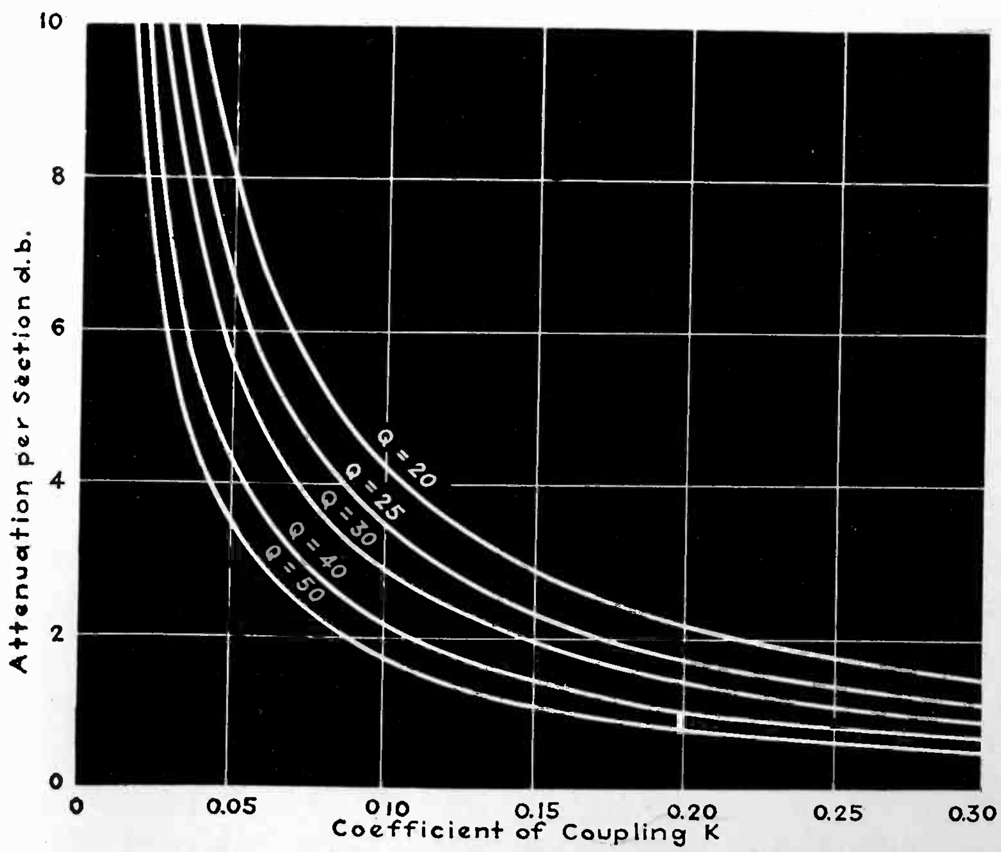


Fig. 4—Relation between coefficient of coupling, K, and attenuation

ling as expressed by equations 1a, 1b, 2, and 3, hold if the following are true:

$$(4)\quad L_2 = L_a + L$$

and $$(5)\quad L_a = \frac{K^2}{K_1^2} L_2$$

where $$(6)\quad K_1 = \frac{M_1}{\sqrt{L_1 L_a}}$$

If greater selectivity is desired than obtainable by the circuit shown in Fig. 2, additional resonant circuits can be added, as indicated in Fig. 3. The characteristics of these circuits correspond roughly to those of constant-K band pass filters; the circuit of Fig. 2 being equivalent to one section and that shown in Fig. 3 equivalent to two constant-K filter sections.

In some places, parallel instead of series capacities can be used, giving somewhat greater attenuation at higher frequencies, and correspondingly less at lower frequencies. By use of transformer ratios, the impedance of all but the end circuits can be chosen at will to accommodate available values of reactors or condensers, to secure values at which maximum Q can be obtained, or to meet other requirements. Also, source resistance and load resistance of widely different values can be properly matched.

If outside the desired band of frequencies there are certain other frequencies that must be particularly discriminated against, either a capacity or inductance element can be parallel by a reactance of opposite sign, the two being tuned to anti-resonance at the undesired frequency and having such values as to give, in combination, the correct value of reactance at the pass resonance frequency. This "wave trap" arrangement gives a characteristic corresponding roughly to that of the M-derived filter.

Thus, it can be seen, that while the relations of the elements involved are relatively simple, coupled resonant circuits possess a very considerable degree of flexibility.

Attenuation

It is often desirable to predict the attenuation at resonant frequency of a group of coupled circuits. Figure 4 shows the relation between coefficients of coupling K, the Q of the circuit (Q, here meaning $\omega_0 L/R$ of the circuit) and the attenuation per section.

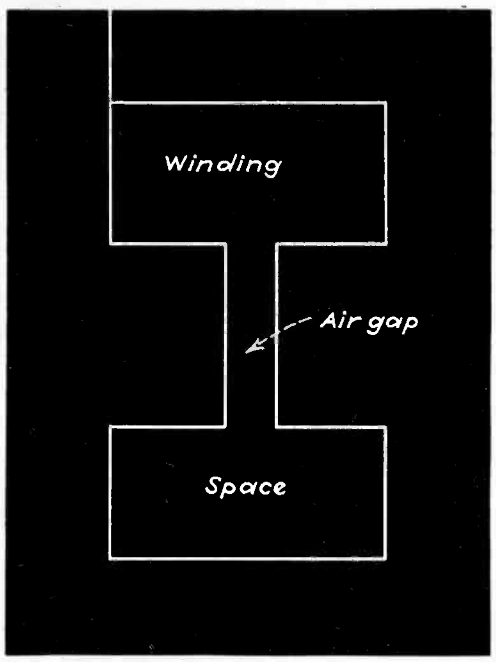


Fig. 5—Desirable core structure for inductances described

Reactors having desirable values of Q in the audio range can be built from commercially available laminated core materials. A very desirable core structure consisting of F-shaped laminations with an airgap in the central leg is shown in Fig. 5. By cutting the central tongues to proper length, airgaps can be made to give maximum Q at any desired frequency. With practically all the magnetomotive force drop occuring in the airgap where it most effectively balances the magnetomotive force produced by the winding, there is extremely low external field. From the viewpoint of effect of external field on this structure, the reluctance of the center leg is many times that of the rest of the core, and most of the magnetic material acts as a shield to fluxes from external sources, conducting them around, not through the winding. In both respects, this type of structure can be considered "self shielding."

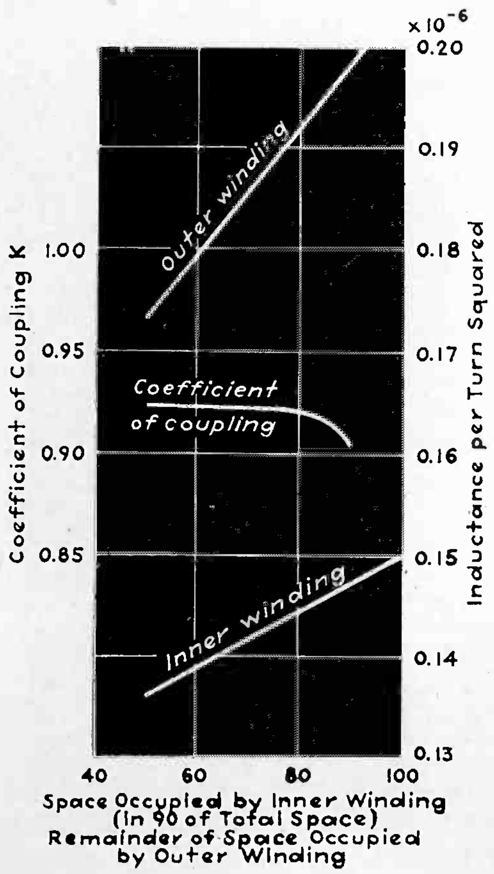


Fig. 6—Design data for core structure shown above

For a given size of core structure, the inductance per turn squared of any winding is independent of the turns in the winding provided each winding occupies the same position with regard to the core. The inductance per turn squared, however, does vary with position, this being due to the outer turns encircling more flux than the inner turns; and this effect, expressed in terms useful for practical design purposes, is shown in Fig. 6.

Both the permeability and the hysteresis loss of the core material vary with flux density. These variations become evident in changes in inductance and resistance of a reactor with changes in current. The magnitudes of such changes in one size of reactor are shown in Fig. 7. Both of these factors are of importance because of changes in characteristics they produce in circuits in which they are used, at different power levels.

Q Varies with Dimensions

At this point it is interesting to note that if the dimensions of a reactor are increased proportionally, the Q will increase as the linear dimension, thus, to double the Q of a reactor, its weight must be multiplied by eight. The stability of a reactor, as discussed in the preceding paragraph, also increased with Q.

The coefficient of coupling K in the transformers must be quite accurately predictable; Figure 6 shows how K varies with percentage of winding space occupied. Coefficients of coupling are quite easily measured by determining the ratio of inductances of one winding with the

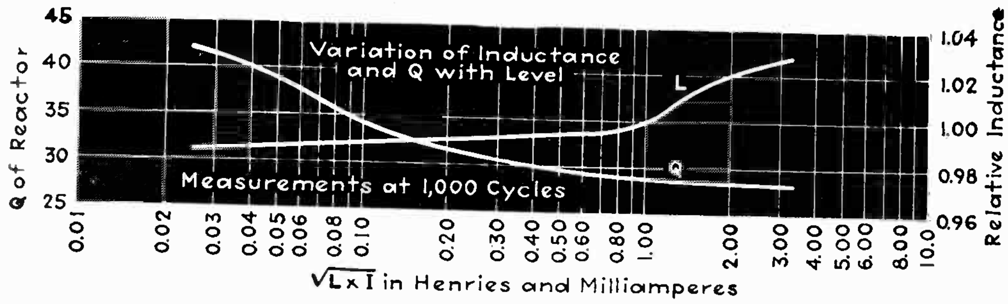


Fig. 7—Effect of flux density on important coil characteristics

other open and shorted, the relation being

$$(7)\quad K = \sqrt{1 - \frac{L\,\text{shorted}}{L\,\text{open}}}$$

For the coefficients of coupling usually used, more efficient transformers can be built, with one winding occupying most of the winding space and having a high Q, while the other winding occupies only a small portion of the available space; that portion of the total space being approximately equal to K, the coefficient of coupling of the circuit in which the transformer is to be used. The smaller winding is used in the circuit with the added "leakage inductor," it constituting only a small portion of the inductance of that circuit. In this manner, the Q of the circuits involving transformers is practically as high as could be obtained using only reactors with windings occupying the full winding space. As an illustration, actual calculations involved in the design of a simple two section circuit (Fig. 3) will be given. The circuit chosen has a coefficient of coupling K of 0.10, operates from a 500 ohm imput into a 500 ohm load with a resonance frequency of 1000 cycles. From equation 1a

$$L_1 = \frac{R_1}{\omega_0 K}$$

Substituting values

$$L_1 = \frac{500}{6.283 \times 0.10} = 0.796 \text{ henries}$$

As the input and output impedances R_1 and R_2 are the same, L_1 equals L_2, and C_1 equals C_2; also the two transformers are identical.

From equation 3.

$$C_1 = \frac{10^6}{L\,\omega_0^2}$$

Substituting

$$C_1 = \frac{10^6}{0.796 \times 6283^2} = 0.0318\mu f$$

By using for the transformers an inner winding of 2235 turns, which occupies 85 per cent of the available space (predicted by standard coil construction), the inductance per turn squared is 0.146 x 10^{-6} henries (from Fig. 6), and the correct inductance of 0.796 henries is obtained. For the reactor L, a winding occupying the full window and having 2810 turns was chosen, the inductance per turn squared being 0.15 x 10^{-6} (from Fig. 6) resulting in an inductance of 1.18 henries.

Returning to the transformers, the remaining 15 per cent of the space not occupied by the first winding is to be filled by the second winding. Referring to Fig. 6, the coefficient of coupling K is found to be 0.915. From equations 4 and 5 we have

$$L_a = \frac{L}{\left(\frac{K_1^2}{K^2} - 1\right)}$$

Substituting values

$$L_a = \frac{0.59}{\left(\frac{0.915}{0.10}\right)^2 - 1} = 0.0072 \text{ henries}$$

From Fig. 6, the inductance per turn squared is 0.195 x 10^{-6}. An outer winding of 192 turns will give the proper coupling and inductance.

Operating at a level giving a Q of 35 in the windings, it is safe to assume a circuit Q of 30, the reduction being mainly due to condenser losses. Referring to Fig. 4 the attenuation per section is 2.9 db, resulting in a minimum attenuation at 1000 cycles of 5.6 db for the complete circuit. The two transformers and the reactor used in the circuit of Fig. 8 weigh only 2¾ pounds each. The resulting attenuation characteristic is given in Fig. 9.

It is hoped that this application of coupled resonant circuits and high Q reactors may prove of value to those confronted with problems in this field.

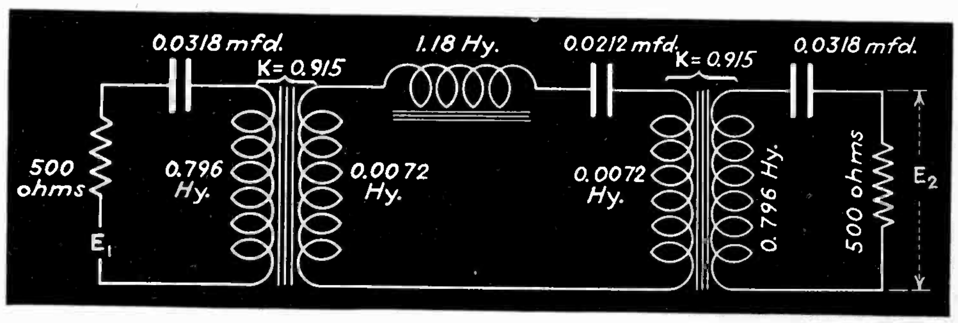


Fig. 8—Complete two stage circuit giving minimum attenuation at 1000 cycles

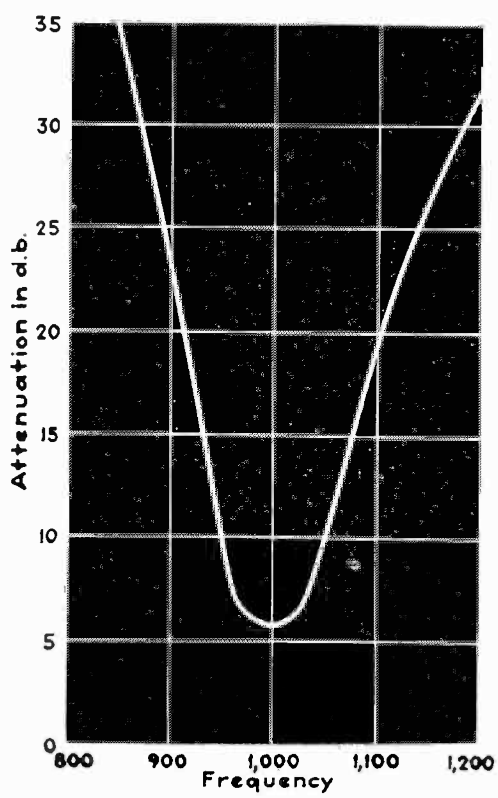


Fig. 9—Attenuation characteristic of circuit of Fig. 8

High Power Frequency Modulation

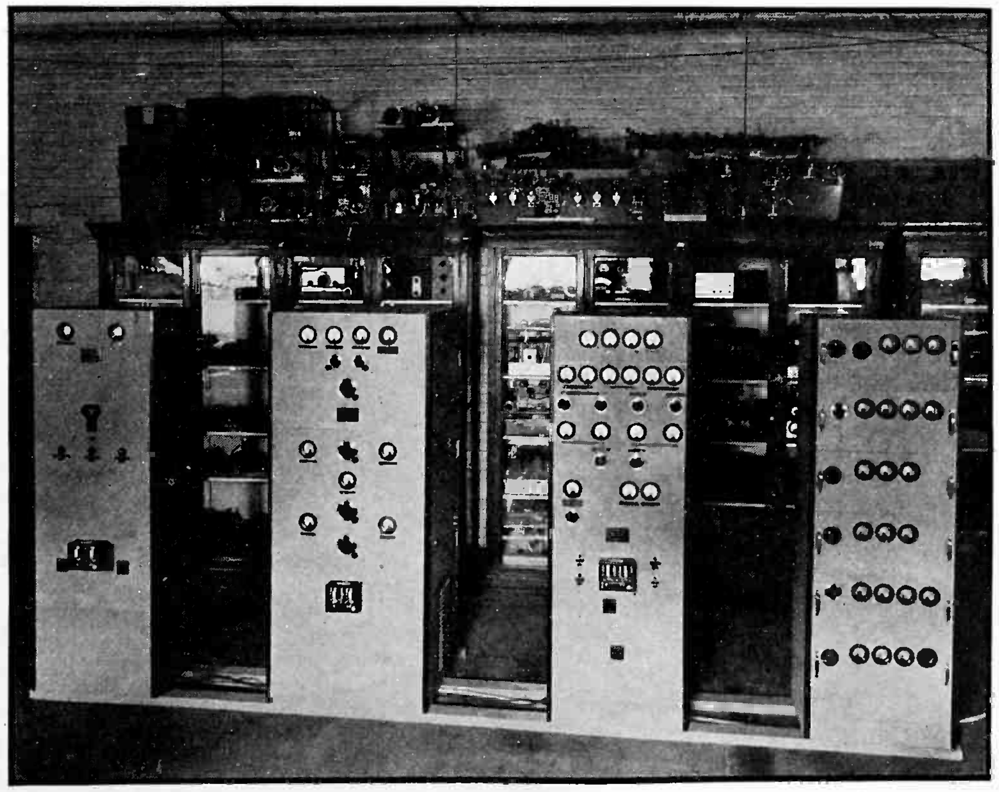
Major E. H. Armstrong applies for license for 40-kilowatt frequency-modulated transmitter to operate in vicinity of 40 megacycles. Tests on 2½ meters indicate noise-voltage reduction of 20 to 50 times

SINCE the announcement several months ago of a successful system of frequency modulation by Major E. H. Armstrong, and the subsequent demonstration of its noise-reduction capabilities, a considerable amount of testing and development has been undertaken by its inventor toward the ultimate goal of commercial operation. On the 30th of April it was announced to the Editors that this development program had progressed to the point where really high power transmissions were not only possible, but advisable in order to demonstrate the extreme range of the frequency modulated signals. Accordingly Major Armstrong has applied to the Federal Communications Commission for permission to operate under license a forty-kilowatt frequency-modulated transmitter. The frequency of operation applied for is above 40 mc., and the band-width required for the full swing of the signals is 200 kilocycles.

All of the apparatus of the transmitter is now in readiness, with the exception of a high-power rectifier of conventional design, for supplying the plate voltage for the final amplifier, which will be ready in July. The master oscillator frequency (see *Electronics*, November 1935, page 17 for a complete description of the transmitter principle) is 200 kc. The voice frequencies are mixed with the 200 kc. output through a balanced modulator and side-band amplifier; the two are then multiplied at low level from 200 kc. to approximately 16,000 kc. In this frequency multiplication process, the necessary wide frequency swing is attained. A further stage then triples the frequency to approximately 48 mc. (the exact central frequency being adjustable according to the frequency assignment). The output of this tripler is approximately one kilowatt. Two additional stages of amplification follow the one kilowatt level, but this amplification is completely linear and involves no frequency changes of any sort. The final stage (type AW-200 tube) supplies 40 kw. to the antenna.

The receiver used in the tests contains a total of 21 tubes, including four acorn pentode tubes for the 2½ meter r-f and heterodyne circuits. The bulk of the receiver is composed of i-f amplifiers and limiters, 12 tubes in all, followed by the double-detector conversion stage and the audio output.

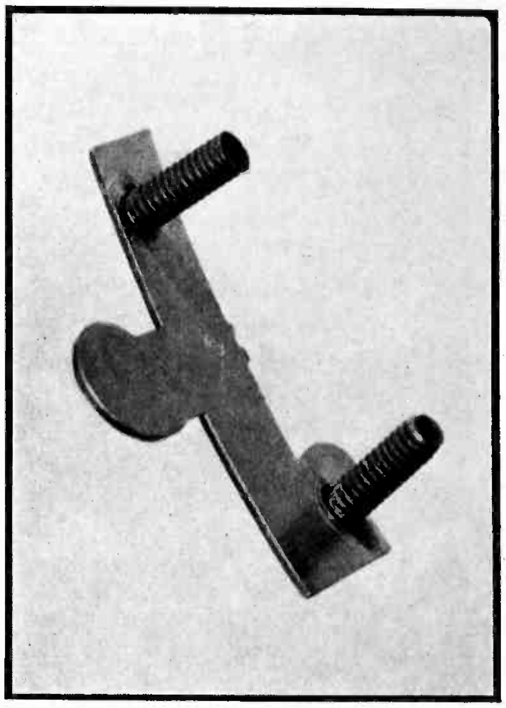
Although the noise-reducing ability of the f-m system is by now well accepted, if any additional proof was necessary it was given in a demonstration witnessed by the Editors, in which station W2AG, in Yonkers, N. Y., eleven miles air-line from the receiving apparatus, transmitted 2½ meter f-m signals, with an antenna power of approximately 350 watts. The transmitter had provision also for transmitting the same program by amplitude modulation, on the same frequency with equivalent power (corresponding to half the carrier power of the f-m signal, whose amplitude does not vary). The program was switched back and forth from f-m to a-m transmission. The noise was then balanced by ear in a potentiometer circuit; the setting of the potentiometer showed that equivalent noise was produced in the f-m system only when the over-all gain was approximately fifty times as great as that of the a-m receiver, giving a power ratio of 2500 to 1. According to Major Armstrong, this is probably the upper limit of improvement, especially under conditions of high ignition interference, but noise voltage reductions of from 20 to 30 occur under any practical condition.



The exciter stages (up to 1 kw. level) of the new f-m transmitter, which will drive the final stage to 40 kw. output. The original f-m equipment may be seen on the shelf above and behind the new units

Electronic Welding Timers

An experience story of the Welding Timer Corporation in designing, manufacturing, selling and servicing timers which utilize vacuum tubes in common use in home radio receivers



Steel studs welded to brass name plate

By PAUL G. WEILLER

A MOST successful application of electronics in industry has been utilized in the welding timer. The application of accurate short time welding to resistance welding is developing a major change in this branch of fabrication. For more than twenty years resistance welding was the step-child of the sheet metal shop. Now, however, the timer is encouraging it to throw off its Cinderella clothes and take its rightful place among important structural processes.

Where spot welding was originally applied only to sheet steel and assemblies which called neither for good appearance nor great reliability, it is now employed for the production of an infinite variety of metal objects ranging from battleships to wrist watches, from auto bodies to minute instrument parts. This great expansion of the field for resistance welding is entirely due to the scientific use of timers which permit proper and very accurate regulation of the welding power.

Today all metals can be resistance welded. Stainless steel, brass, copper, aluminum and carboloy can be joined with the same material or with practically any other metal. While the older types of timers did fairly creditable work down to one-tenth second, it soon became necessary to go below even this short time. The best welding jobs are done with current admission periods of two cycles and less. In a few extreme cases as little even as one-fourth cycle is being used on a commercial scale.

Timers now in use belong to three main categories. They are: *mechanical timers*, which accomplish timing by cams or other mechanical motions; *electro-mechanical timers* with a vacuum tube circuit controlling a magnetic switch; *all-tube timers* which accomplish both the timing and making and breaking of the welding current by vacuum tubes.

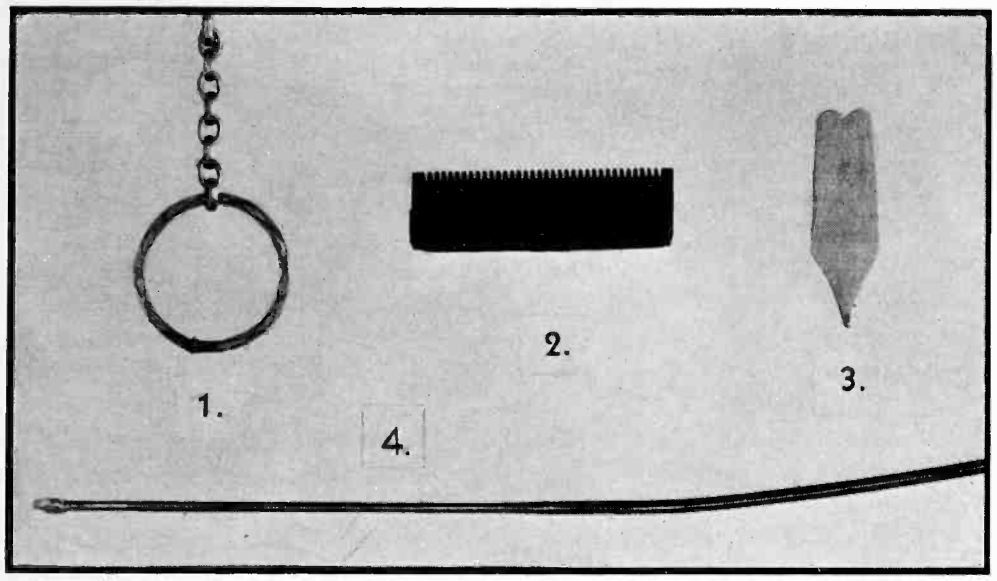
Mechanical timers have never attained great popularity. Electro-mechanical timers have found their main field in places where the requirements as to accuracy were not too exacting and the welding time was one-tenth of a second or more. Several thousands of such timers are in use. They are giving good service in less exacting applications. Heretofore, however, in all applications which required very short time, (between one-half cycle and one-tenth second) or great accuracy, all-tube timers had to be installed. Electro - mechanical timers are simple, small in compass and relatively inexpensive.

All-tube timers are more costly, more complicated, more bulky and require expert maintenance. The replacement cost of a considerable number of mercury tubes, even with a life of several thousand hours, is a substantial item. It was therefore desirable to provide a timer which would be equal in simplicity, reliability and cost of up-keep with the electro-mechanical timers and yet would approach the performance of the all-tube jobs.

These requirements could be fulfilled by an electro-mechanical timer which would permit working down to one cycle. Such a timer must outlast several millions of operations while the wearing parts must be easily replaceable and inexpensive.

On the face of it it seemed that improving electro-mechanical timers without necessitating basic changes would be sufficient. This, however, proved to be far from true. Standard contactors, even those specially designed for welding service, have quite definite limitations. It became necessary to depart from standard practice to obtain the desired results.

Our first problem appeared to be the selection of the most suitable types of tubes. A number of purely practical considerations entered into this phase of our design. Flexibility and general popularity of the new controlled rectifiers seemed to make them very desirable. Their ability to carry considerable current had vast appeal at first glance. However, their sensitivity to temperature changes, stray electrostatic and magnetic fields and the fact that they are not generally available weighed heavily in favor of an attempt to build a timer entirely around some standard type of radio tube. The types which we use are quite uniform and have an exceedingly long life. After trying a number of tubes and circuits, we decided to use as rectifiers, types 80, 82, and 83. As control tube, we are using two type 27's in parallel. As the entire current drain on these tubes is only a maximum of ten



Examples of tube-controlled welding: 1. Butt welded brass ring; 2. Automatic razor part; 3. Irridium point on stainless steel pin; 4. Stainless steel side bar for eye glasses

milliamperes, they have a long life.

The control power supply consists of a transformer protected by fuse and a more or less conventional rectifier and filter. The fuse presented a problem. A fuse of only sufficient size to stand the normal current demand of the transformer would often blow out when the apparatus was put on the line due to the heavy current drain caused by the initial charge of the filter condensers. The control power is preferably taken from the light line because the latter is less subject to voltage variations always present in plants where heavy equipment is supplied from lines never too amply dimensioned. This is particularly true where several large welders are in operation.

Spot welders often draw as much as three times the rated current, a fact left out of consideration by the majority of welder users. Consequently, instantaneous voltage fluctuations of as much as 20 per cent are quite common. Voltage regulators have been tried but did not meet with particular success on short time welding as all of them have a definite time lag.

The power necessary to operate the large contactors is taken off from point *C* between the two chokes. This is to minimize the effect of the surges on the tube circuits. It is a function of the second choke to prevent this transfer of energy from one circuit to the other. Condenser *D* between grid and cathode is the timing condenser. Variable resistor *R* is the timing resistor. Relay *F* is in the plate circuit of triode *G* and will close when the current reaches a pre-determined level. The operation of the circuit is as follows:

When the operator steps on the welder pedal, switch *H* is closed. This energizes contactor *I*. The latter starts on its closing motion. Auxiliary blade *K* is mechanically connected to the contactor blade and is electrically connected to the grid. As the contactor starts its travel, auxiliary blade *K* departs from the contact which is grounded and after a short travel makes contact with *M*. Before circuit *KM* is closed and before the blade of contactor *I* reaches the end of its travel, *M* is connected to cathode through timing resistor *R*. The result of this movement is that condenser *D* begins to discharge through timing resistor *R*. As condenser *D* has been charged to a high negative potential, thus blocking triode *G*, the discharge will start. After a time determined by the setting of resistor *R* the plate current will have sufficiently increased to attract the armature of relay *F*. When relay *F* breaks away from its back contact, contactor *N* will start to open and thereby end the current admission period to the welder.

When the operator releases the welding pedal, switch *H* opens and contactor *I* releases. *K* and *I* complete the circuit which charges condenser *D* negatively. Relay *F* releases and makes with its back contact which in turn causes contactor *N* to close. This resets the timer ready for its next operation.

The important point in this whole sequence is the fact that contactors *M* and *K* make before contactor *I* closes. Contactor *X* begins its opening before contactor *I* is completely closed. As both of them are connected in series in one leg of the welder primary, no current is admitted except during the time when both contactors are closed. This time can obviously be varied by varying the time interval between the closing of *M* and *K* and the operation of relay *F*. It is a fact, therefore, that contactor *X* can be opened even before contactor *I* closes regardless of the actual operating time of either

Welding timer "on location"

contact. The time interval between the closing and the opening is controlled by the setting of the resistor. Therefore it is possible to obtain a current-admission period to the welder of any desired short duration independent of the time necessary to operate the individual contactors.

Circuit and Apparatus Interrelations

While the basic circuit is extremely simple, its operation is really highly complicated. The circuit consists of a number of meshes which are interrelated. Any phenomena occurring in one mesh are reflected to some extent in all others. It required a close study of these phenomena to balance the circuit elements in such a fashion that these feed-back effects were eliminated or reduced to negligible proportions. A close study of relay and contact operation was made to prevent the effects of sticking of contacts and other mechanical difficulties from resulting in unwanted variations of timing. The small relay is handling 300 volts d.c. and one-quarter ampere in the larger timers. This required particular care in the choice of contact materials and in dimensioning the circuit elements.

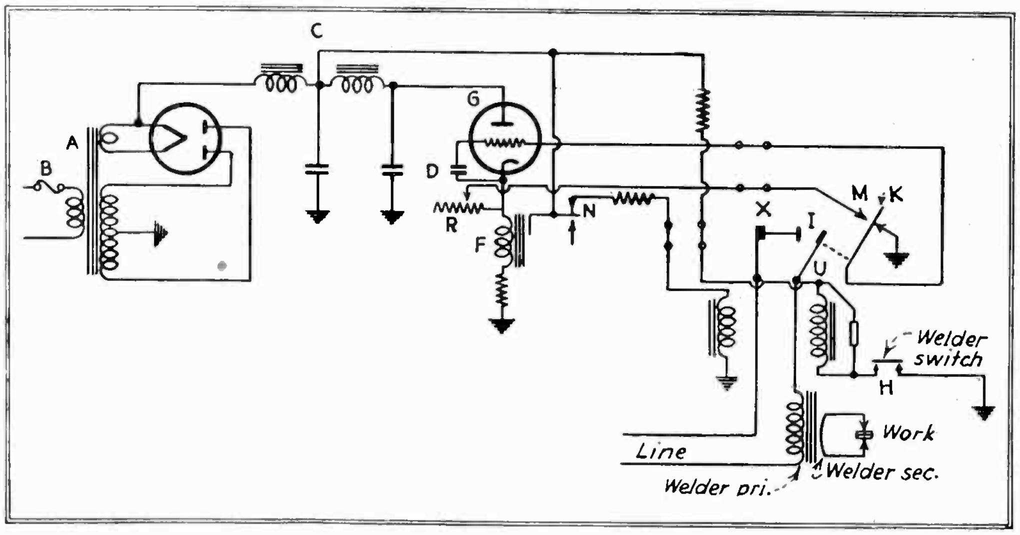
The design of the large contactors offered even greater difficulties. To shorten the time of operation, reduce mechanical wear and gain uniformity, it became necessary to reduce the travel of the contactor to as little as one-quarter inch. The effect of the magnetic gaps on time factor of the circuits had to be studied and means had to be devised to hold these gaps rigidly constant. A neon lamp had to be added to one of the contactor circuits not only to protect it against high voltage surges caused by sudden opening of the circuit but also to obtain a definite discharge time. If copper to copper contacts were used, the unavoidable partial welding of contacts would tend to cause irregularities in opening time. This was avoided by using a copper block against a copper graphite composition. The same care had to be used in determining spring tensions, shaft sizes and bearings and other mechanical design details. The result was a device which, while it is rugged, durable, fool-proof, and easy to maintain, has answered all requirements of accuracy and reliability.

Our experiences have been varied. In many cases things we greatly feared did not materialize. On the other hand, we have found items of sales resistance and engineering difficulties which we did not expect. In the first place, let it be noted, that we have found practically no prejudice against using glass tubes. This was rather surprising. This may be due to the fact that the tubes used are so placed and are in such relation with the balance of it that they do not appear to be a prominent part of the finished product. It was often suggested that this supposed prejudice be avoided by using metal tubes. As, however, the larger types of rectifiers are not as easily obtained as metal tubes, there would have been very little object in using part metal and part glass tubes.

Some field problems relate to engineering factors; others belong in the realm of psychology. They are the result of a frame of mind of the user of electronic devices; and sometimes of factory conditions peculiar to certain trades. They are of paramount importance for designing and engineering electronic devices. After all, the customer must be satisfied, and to design a device in such a way that it will appeal to prospective customers so far as this can be done, is very much more expedient than to design it entirely on the basis of engineering and scientific consideration and then to spend a large amount of time and effort in educating the purchaser to what the designer believes is true.

When these timers were first presented to the industry, we were expecting service to be a major problem. Fortunately, this proved to be an exaggerated fear. Service due to failures of any parts in our timers has been quite negligible. Trouble, however, came from sources which we did not expect. Of the failures the greatest proportion were due to partial shorting of contactor coils. These failures were quite difficult to detect because as a rule only a portion of the coil was shorted and the short was effective only at the relatively high voltages with which a coil was regularly operated. To the ohmeter or resistance bridge, the coil shows the rated resistance.

Most of our service difficulties have been due to the necessity of teaching the user how to get the best results. If our men had only to teach the operators all about timers, this would have been very simple, but it often became necessary to completely revamp the welding processes in their respective plants. This included such things as suggestions as to proper type of electrodes, suggestions as to design of welding fixtures, selection of the time and power best suited to their particular production, and sometimes even changes in the structure of the welder itself.



Circuit used by Welding Timer Corporation employing ordinary radio tubes

Pitfalls and hurdles were numerous. There were so many things where knowledge was nonexistent or not generally available. One of these was the behavior of contacts under heavy current.

Another interesting factor was met in attempting to give our timers a practical workable rating. Very

[*Continued on page 38*]

Beacon Marker Transmitter

At broadcast station WBNS a radio marker was designed and installed for the benefit of aircraft, to lessen the hazard to the pilot and craft, and to provide him with signals for use in bad weather

By
LESTER H. NAFZGER
Chief Engineer
WBNS—WCOL

EARLY in 1936 station WBNS, in cooperation with the Department of Commerce and the local airport, decided to install some type of radio marker for the WBNS 400 foot vertical tower to aid flyers in bad weather.

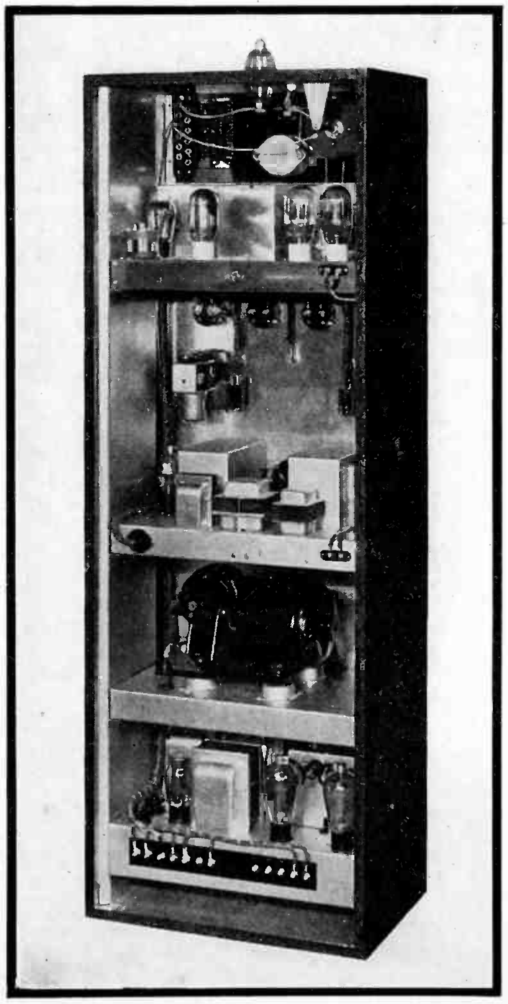
Primary specifications were to have automatic keying of five dashes to a character and twenty characters per minute with sufficient power to be 10 per cent louder at one mile from the tower than the local radio range signal. The frequency was to be sufficiently close to the radio range to form an audible beat tone. Modulation of the beacon marker transmitter was to be 120 cycles.

The Collins Radio Company agreed to build the transmitter to specification and incorporate helpful suggestions at various points. (The tower is shown on the cover of the April issue of *Electronics*.)

The tube component of the transmitter consists of a type 47 oscillator driving one type 841 which in turn drives two type 841 tubes in parallel. Keying is accomplished by means of a motor with a moulded cam opening and closing the grid circuits of the type 841 tube stages with the aid of a small roller following the indented cam. Modulation is accomplished directly in the power supply which consists of two type 866A tubes and no filtering of the rectified voltage. The crystal is the type AT cut with heater built in as a part of the holder. A separate power supply using a type 5Z3 tube provides power to the crystal oscillator stage. All circuits are conviently metered. A shorting switch around the automatic keying provides a convenient manner to tune and adjust the transmitter. For convenience of the operating staff a small neon bulb is mounted in the antenna adjustment panel. The neon brilliantly follows the keying of the transmitter. The transmitter has a maximum output of 30 watts and is enclosed in a black crinkle finished cabinet.

Frequency Monitor

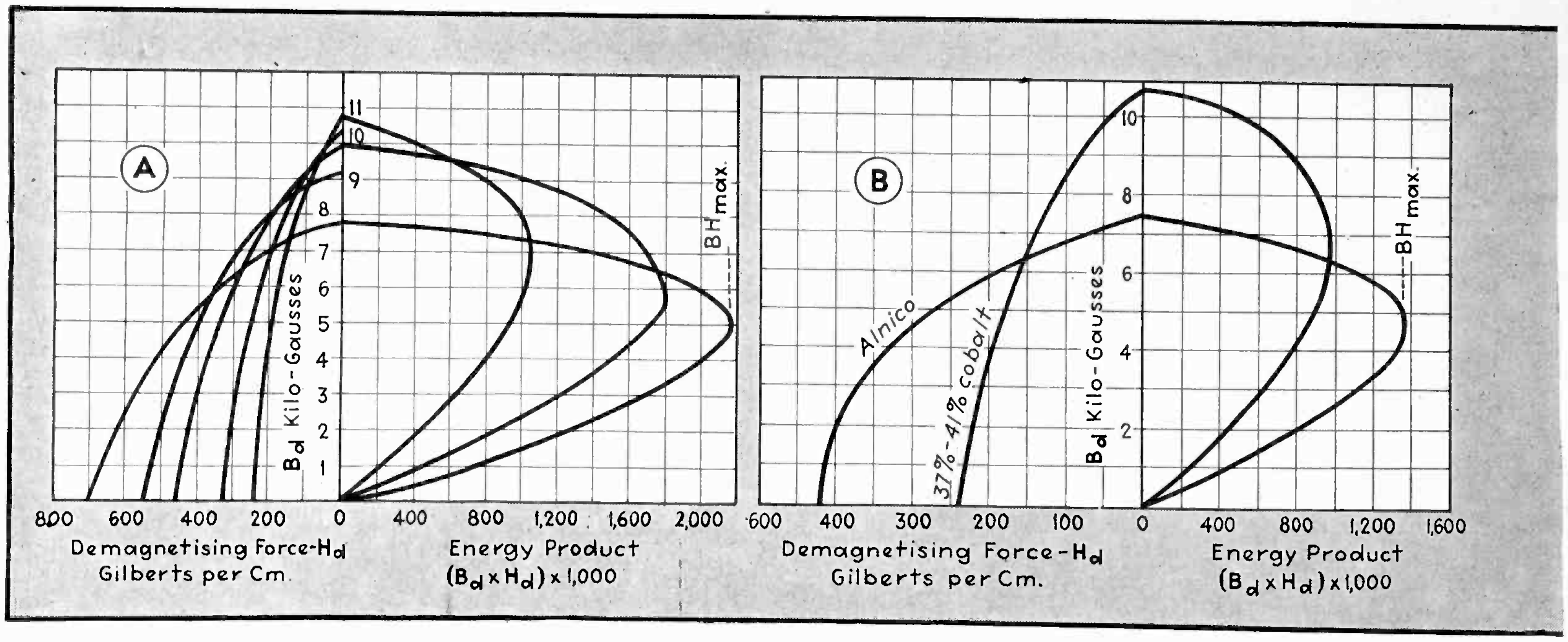
The necessity of an accurate frequency checking indicator was considered. Available methods of checking consisted of a wavemeter or some type of crystal beat oscillator with headphones. In conjunction with the Collins Radio Company a unique and accurate frequency checking instrument was devised. This instrument, known as the type 14-A, combines both visual and aural monitoring. The circuit consists of a type 24A tube as oscillator using the same type crystal and holder as that found in the 30-A transmitter and of course ground to the same frequency. A small pickup coil is wound on the same form as the oscillator tank circuit coil and delivers oscillator voltage to the grid of a type 2B7 tube, the pentode portion of which acts as a buffer. The plate circuit of the 2B7 tube is tuned to the oscillator frequency and coupled to the diode portion of the 2B7 which acts as a detector. R.F. is fed to the monitor instrument from the transmitter by means of a small coupling coil wound on the same form as the plate circuit coil of the 2B7 tube. The diode current is read on a microammeter and the aural beat is received by means of a jack which breaks into the diode circuit when headphones are inserted.


Rear view of beacon transmitter, showing keying assembly on next to bottom shelf

A slow beat between the transmitter frequency and the monitor oscillator will give an appropriate swing on the microammeter and as the beat becomes higher it can be readily heard with headphones inserted in the jack.

Present and Future Operation

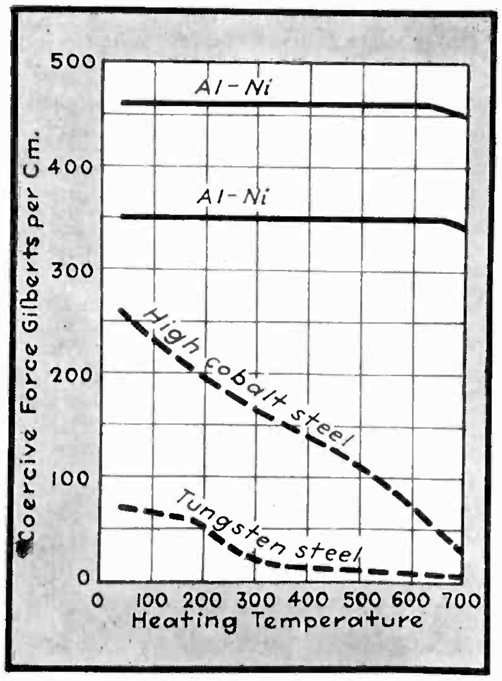
In operation several months, many valued reports have been received. The transmitter, licensed as WOEX, has proven to be of great value to the airlanes, operating continuously, 24 hours of the day on a frequency of 392.2 kc. with 15 watts into the antenna. Though constructed to cover the immediate territory and using a single wire antenna thirty feet high and 250 feet long, the transmitter has consistently been checked to the borders of the state.



The New Permanent Magnet Alloys

Recently developed combinations of nickel, aluminum, iron, and other elements have produced magnetic materials of unusual strength and permanence, of great promise in the design of loudspeakers, microphones, relays

FOR many years permanent magnet materials containing tungsten-chrome, and carome-manganese and cobalt steels have been known and used, especially in measuring instruments and in similar applications where their high cost was not a serious detriment. Such materials could have been used advantageously in radio sets, especially in the field structures of dynamic speakers, but the size, weight and cost of permanent magnets for this purpose have prevented their use, except in small quantities for special applications. With the advent of new alloys having quite unusual magnetic properties, however, it seems that the whole subject of permanent vs. electro-magnets must be reviewed, and it seems likely that many pieces of electrical equipment, both in the radio field and out of it, will be redesigned about the new materials. This prospect has led to much speculation on the magnetic and physical properties of the materials, their uniformity, cost, and availability from commercial sources.

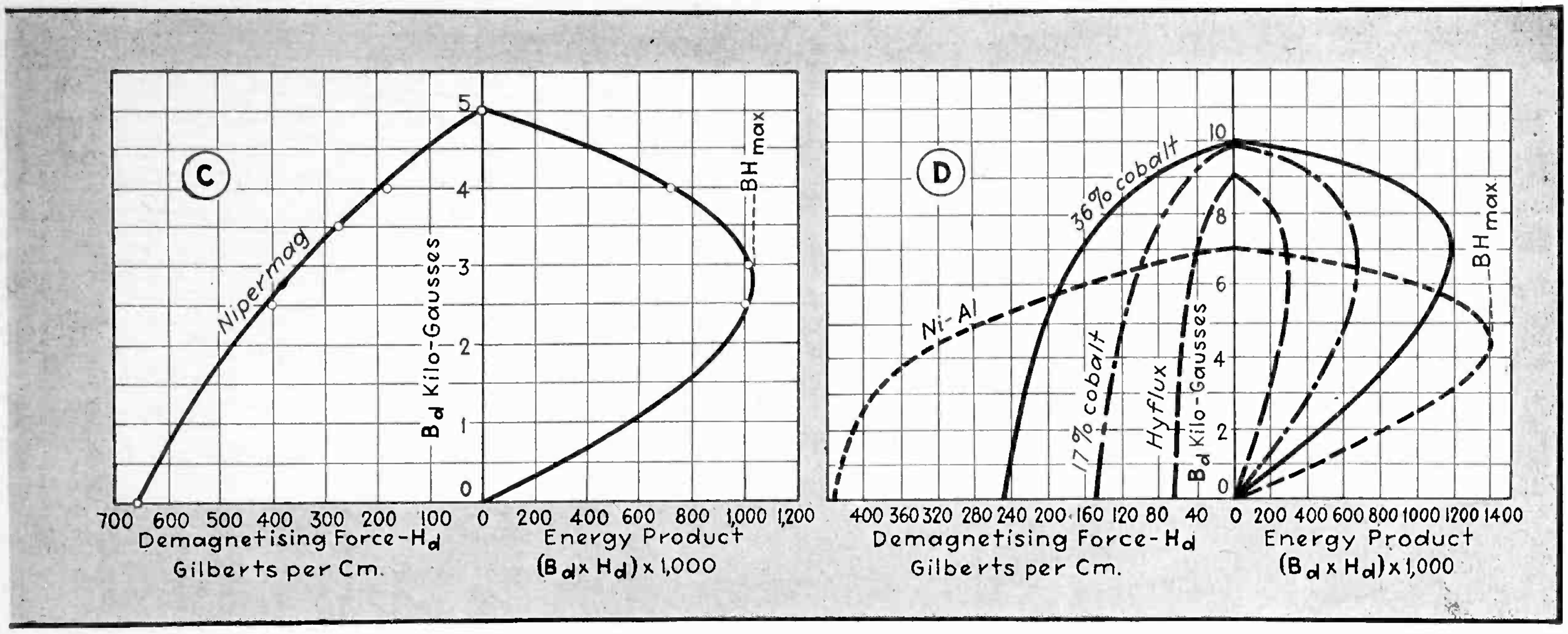


Effect of heat on the Ni-Al alloys compared with tungsten and cobalt steel

How the New Alloys Were Developed

The history of the development goes back to 1921 when G. R. Brophy of the General Electric Co. applied for a patent[1] on a heat-resisting alloy containing Al, Ni, and Fe. This alloy was intended to withstand high temperatures without forming an oxide coating or scale; its magnetic properties were not suspected, at least they are not mentioned in the patent specification. Ten years later, in 1931, Professor Tokushici Mishima applied in Japan (and in the U. S. in 1932) for a patent on a "Magnet Steel Containing Nickel and Aluminum." The most general claim under this patent,[2] issued on Jan. 14, 1936, is: "A permanent magnet comprising 5 to 40 per cent. nickel, 7 to 20 per cent. aluminum, from trace to 1.5 per cent. carbon and the remainder substantially iron." The carbon mentioned is that present if steel is used instead of iron. Other patents[3] issued to Mishima at the same time are concerned with alloys of Al, Ni, Fe, with other elements such as copper, vanadium, chromium, manganese, etc. One patent[4] mentions cobalt specifically as one of the constituent alloys.

In 1933, W. E. Ruder of G. E. applied for a patent[5] on "A Permanent Magnet and a Method of Making It." This patent which was issued on Feb. 13, 1934, claims "1. An age-hardened alloy magnet consisting of about 6 to 15 per cent. aluminum, 20 to 30 per cent. nickel with



Demagnetization and energy curves of different magnetic materials. The demagnetization curve (at left in each case) intersects the B axis at the residual magnetism value and the H axis at the coercive force value. (A) Nickel-aluminum-iron-cobalt alloy produced by the Continental Motors Corporation, showing the wide range of values obtainable by different percentage compositions and heat treatments. (B) Alnico, as manufactured by the Simonds Saw and Steel Co., contrasted with high-cobalt steel. (C) Nipermag, manufactured by the Cinaudagraph Corporation (curve taken on a typical foundry casting). (D) Nickel-aluminum alloy manufactured by the Indiana Steel Products Co., contrasted with various cobalt steels. See also Archiv für Technisches Messen, April 1934

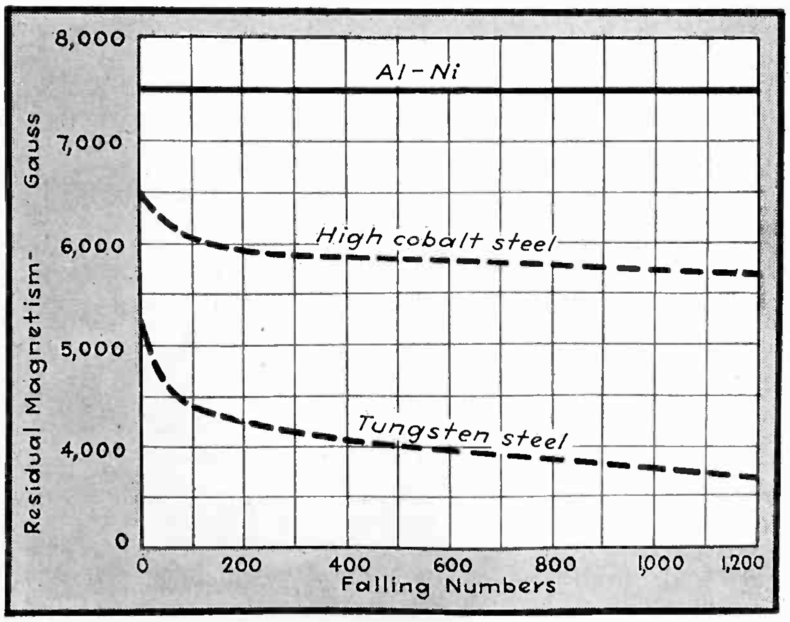
the remainder iron." The patent also claims a method of heat treatment to improve its magnetic qualities. This patent and the Mishima patent[3] overlap, and appear to be two different issued patents on the same material, a fact which has caused much confusion. A later patent[6] issued July 31, 1934, to Ruder claims "1. An age-hardened alloy magnet consisting substantially of 6 to 15 per cent, aluminum, 12 to 30 per cent. nickel, an appreciable quantity up to 10 per cent. cobalt with the remainder iron." This patent (which likewise conflicts with a Mishima patent[4]) is the basis of the General Electric alloy "Alnico." Other patents, notably one issued to H. T. Faus,[7] have been issued on the method of fabricating the alloy so as to produce the best magnetic properties.

The activity in developing these permanent magnets is by no means confined to America or Japan. In England and in Germany much work has been done. In the former country, an English engineer, Alfred C. Catherall, has developed a material which has found its way into a large production of English dynamic speakers. This material, "Nipermag," has recently been introduced to this country. Details on the chemical and physical constitution of this material have not been released for publication but it is understood that it differs considerably from Alnico.

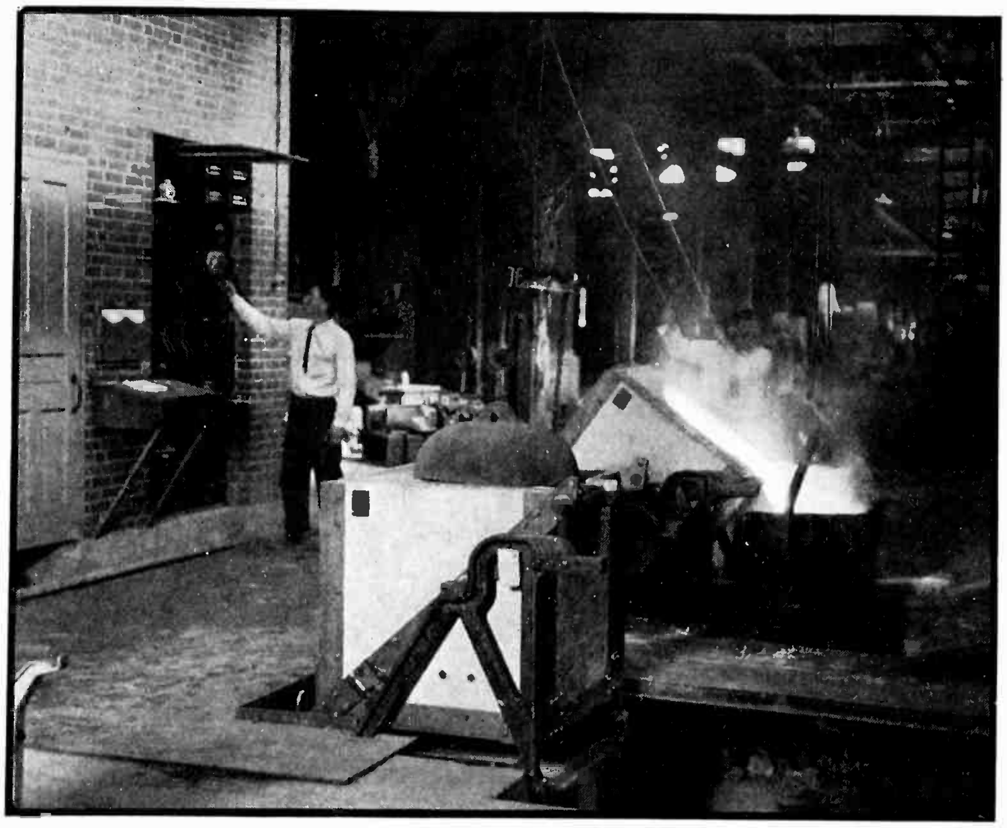
The suitability of an iron or steel alloy for permanent magnet service depends on three factors: its residual magnetism (B_r), coercive force (H_c) and maximum energy (BH_{max}).

Residual magnetism: When the alloy is magnetized by subjecting it to the field of another electromagnet, a certain flux density remains in the alloy when the electromagnet is shut off and removed from the material. This flux density, measured in lines per square centimeter (or gauss), is the magnetism remaining when the external excitation (supplied by the electromagnet) is removed; and is variously called residual magnetism or induction, or retentivity.

Coercive force: The residual magnetism in a permanent magnet may be removed by applying a field from an electromagnet so that the latter's field "bucks" the field of the alloy. The amount of external magnetic excitation, expressed in gilberts per centimeter or ampere turns per inch, required to reduce the residual magnetism to zero is called the coercive force. The higher the value of coercive force, the less easily can the magnet be demagnetized, and in general the



Ni-Al alloys suffer practically no loss in magnetism when dropped, compared with cobalt and tungsten steels



Nipermag in the making, in a foundry in Lebanon, Pa. Very exact control of fabrication is necessary to produce high magnetic strength

more permanent will be its characteristics. The new alloys are distinguished by their very high coercive force. Their residual magnetism is not as high as that of the best cobalt steel.

Maximum energy. The **BH** curve is usually called the available energy curve. It shows the relation between flux density and the product of the coordinates of the demagnetization curve. This curve, since it represents the energy per unit volume of magnetic material which is usable for maintaining a field in the air gap, indicates at the point $\mathbf{BH}_{max}$ the flux density for which a magnet should be designed in order to use the material most efficiently. By comparing $\mathbf{BH}_{max}$ values of different materials, the relative suitability of the materials may be determined, all other factors, such as cost, being equal.

In the design of magnet structures, as for example, a field structure for a dynamic speaker, the material is worked at the flux density corresponding to the maximum energy. The amount of material (on which weight and cost depend) required to produce this flux density in an air gap of given length and area depends on the demagnetizing force and induction at $\mathbf{BH}_{max}$. Other factors being equal, the higher the $\mathbf{BH}_{max}$ value, and the higher the demagnetizing force at that point, the smaller the magnet structure can be. It is therefore due to the fact that the new magnetic alloys have high $\mathbf{BH}_{max}$ values and high coercive force that structures formerly proved to be impractical from a weight and cost standpoint can now be achieved.

There are several other less well defined factors which influence the suitability of permanent magnet materials. To be useful, such magnets must be "permanently permanent." They must be able to retain their residual magnetism even when subjected to strong external fields, either direct or alternating, or when subjected to mechanical shock.

Regarding most of these requirements, the new alloys present a very good record. They are permanent when given ordinary care, as has been shown by laboratory tests and by the large number of speakers in England, now in use for as long as two years, which use one of the forms of the alloy.

The new materials are certainly not without their disadvantages however. The most obvious are their extreme hardness, which makes it necessary to machine them by grinding rather than with cutting tools, and their tendency to be brittle, which means that care must be taken in handling them. Another disadvantage, which may be overcome as time goes on, is the difficulty of fabricating the alloys.

The cost of the new magnet materials has been the subject of much speculation. No information of this point was available at the time of going to press except in very general terms. A typical composition of Alnico, as reported by the International Nickel Company is 20 per cent. nickel, 12 per cent. aluminum, 3 to 5 per cent. cobalt and the rest iron. At current market prices this means that the raw materials cost from 17 to 21 cents per pound (of which 7 cents is for nickel, 3 cents for aluminum, from 6 to 10 cents for cobalt, and 1 or 2 cents for steel).

Quantitative Data on the Alloys

According to information believed to be reliable there are two different forms which are of commercial importance. One is the General Electric development Al-

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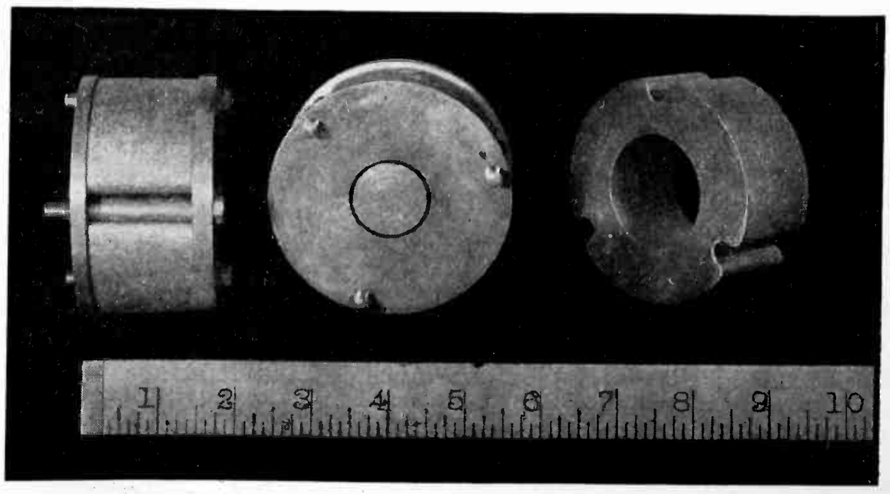
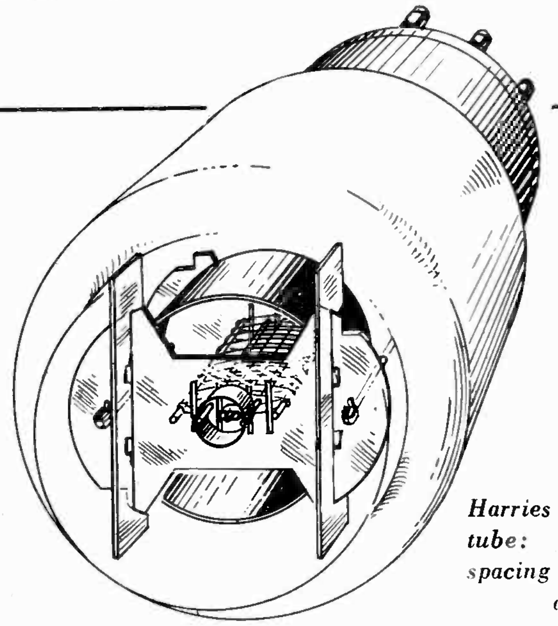


A typical dynamic field structure using one of the new alloys. The alloy casting at the right is assembled with the iron pole pieces and the whole unit magnetized at once

"Critical Distance" Tubes

Another encouraging sign that new methods of making electrons perform in high vacuum are under way is this new tube which has the low distortion of a triode and the high sensitivity of a pentode

By J. H. O. HARRIES
London, England



Harries AC/Y power tube: Note the wide spacing between cathode and anode

SOME years ago the author was faced with the problem of producing improved tubes for use at the very high frequencies. An investigation showed an unexpectedly extensive gap in the existing knowledge of multigrid tubes, and considerable research was carried out to fill up portions of this gap which seemed useful.

A preliminary part of this investigation showed that it would be very desirable to increase greatly the distance from the cathode to the anode, if this could be done without adversely affecting the ratio of anode current to anode voltage. The advantages would be the decreased interelectrode capacities, the prevention of the retrograde passage of secondary electrons, and the production of long deflectable streams.

Triodes or diodes cannot have this distance increased because the anode current falls off as the square of the distance between the two electrodes. In a multigrid tube, however, the situation is somewhat different and steps were undertaken to investigate thoroughly the anode space.

The investigation brought to light methods whereby (contrary to existing theory) the anode space could be lengthened without adversely affecting the ratio of the anode current to the anode voltage producing the current—indeed, the anode saturation voltage could be made lower with a long space than in any other way. Thus new types of electrical characteristics are made available, and a new vista is opened in the tube art. The full theory was published in April *The Wireless Engineer* (London); only a brief resume will be given here.

Figure 2 shows the anode current-anode voltage characteristics of a high vacuum tube having a movable anode, for different distances of the anode from a positive mesh grid. (An important part of the work was the realization that to produce a long stream it was quite unnecessary to obtain focussing by the use of an "electron gun." Electron guns intercept far more current than they pass to the anode.)

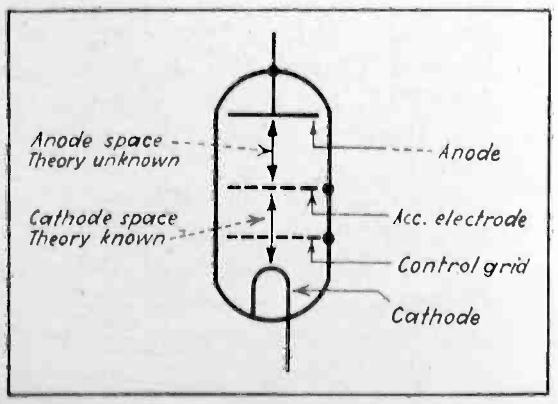


Fig. 1—Simple multi-element tube

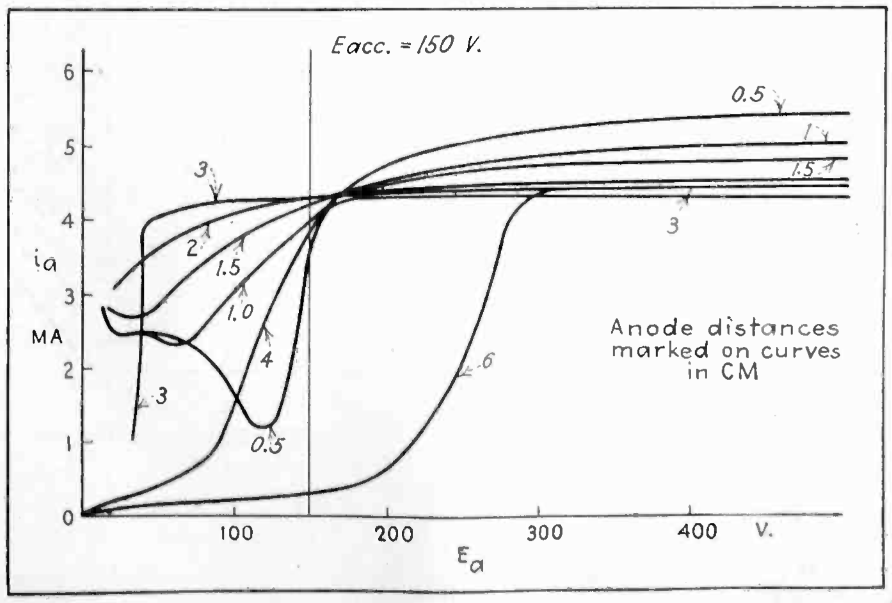


Fig. 2—Effect of varying anode to cathode distance

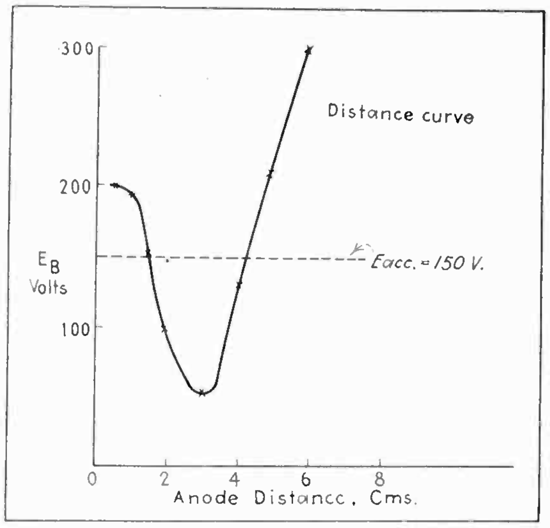


Fig. 3—Critical nature of the anode-cathode spacing

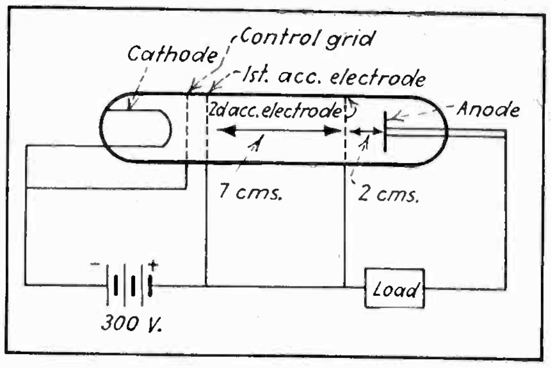


Fig. 4—Screen and anode placed at the "critical distance"

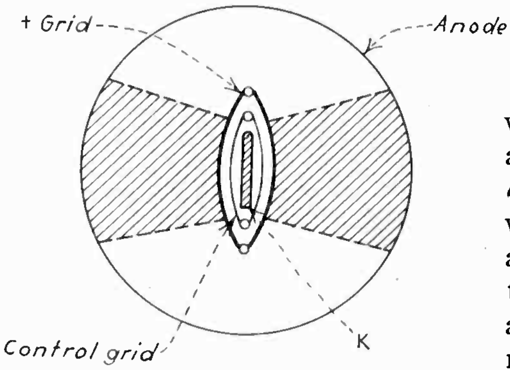


Fig. 5—Ray of electrons in the new tube

At short distances the familiar dynatron characteristic appears. At very long distances there is a peculiar phenomenon. There is no anode current (except a few stray electrons) until the anode voltage reaches quite a high value; at this value, called the "anode breakdown voltage," the anode current rises suddenly to a saturated value and remains at about this value however much the anode voltage is further increased. In between these distances there is a "critical anode distance" at which the dynatron characteristic is absent and the saturation anode voltage is very low. It may be, indeed, lower than with any other way of designing the anode space; and is considerably lower than the accelerating voltage. It is not surprising that the dynatron characteristic disappears at distances greater than very short ones; but the facts that the saturated anode current is independent of the distance, and that at distances great enough to eliminate the dynatron kink, the saturation voltage, or knee voltage, is very low, are remarkable.

A Long Stream Tube

Figure 3 shows the anode breakdown or "knee" voltage plotted as a function of the distance. The curve sums up the phenomena conveniently, and is called a "distance curve." The anode critical distance is that corresponding to the minimum of the curve.

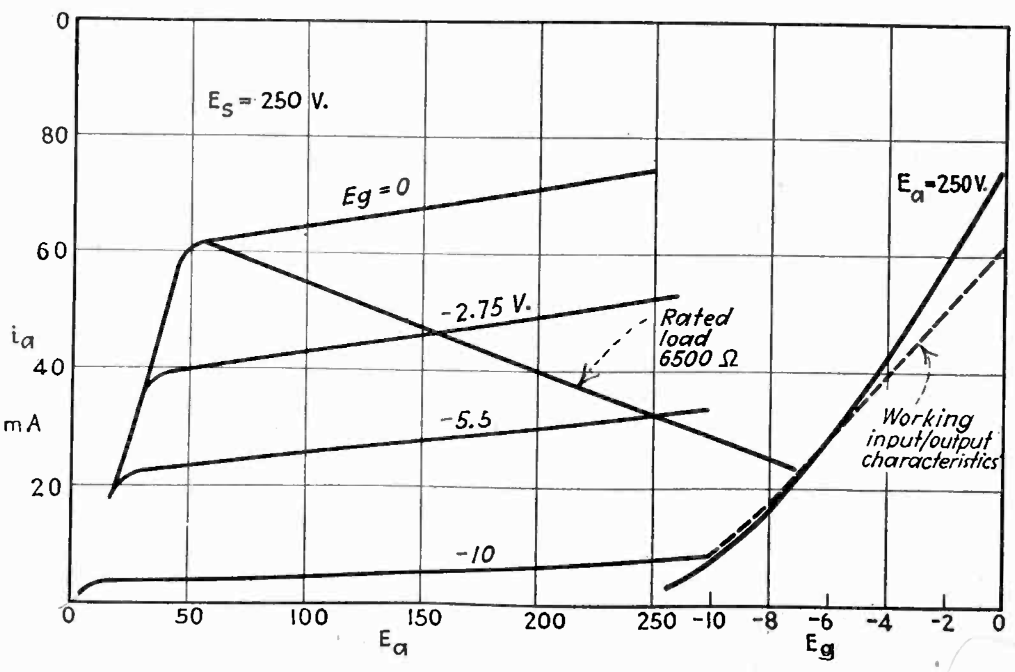


Fig. 6—Plate characteristics of the Harries power output tube

Consider Fig. 4. Here is shown a very long stream valve in which the anode and G_2 are spaced at the anode critical distance. The tube as a whole then has a very low "knee" anode voltage, and the characteristics, from a power handling and amplification point of view, and as regards anode current to voltage ratio, are actually superior to those of the older short stream tubes; in addition, the tube as a whole becomes an extremely efficient low capacity ultra-high-frequency amplifier, and is also a solution to the old deflection tube problem previously mentioned.

New Power Output Tubes

Thus all the advantages originally aimed at were attained; in addition, it was found that there are others not foreseen. The principal one is that the characteristics to the right of the knee are more linear than those of any other known multigrid tube, and that an extremely efficient multigrid power output receiving tube may, for instance, be produced in this manner. Tubes of this kind are on the market in England. Types AC/Z, AC/Y, Z220 and Y220 made by the High Vacuum Valve Co. of London, EC 1, under license from Harries Thermionics, Ltd. of London, W. C. 1, a research corporation. See *Wireless World*, August 2nd, 1935.

The stream is "electronically focussed" in these tubes by dimensioning the cathode and grids to direct the electrons to enter the anode space in a compact beam shown shaded in Fig. 5.

The characteristics of a typical Harries tube and those of an exactly corresponding pentode are shown respectively in Figs. 6 and 7. Note the "S" shaped curvative of the working input/output characteristic of the pentode, and the triode-like comparative straightness of that of the new tube.

The virtues of this new type of tube are as might be imagined from an inspection of the characteristic curves. They have the low distortion which is true of triodes operated in Class A, and the power sensitivity of pentodes. An investigation by means of a General Radio wave analyzer in which two waves, one of 1,000 cycles and one of 75 cycles were impressed on the grid of the tubes showed that the Harries tube and the triode had about the same output distortion. (In this test a strong 75 cycle note modulates the weak 1000 cycle tone, the ratio being about 9 to 1.) But the new type of tube requires only 4.5 peak grid volts to drive it, while the triode requires 30 volts.

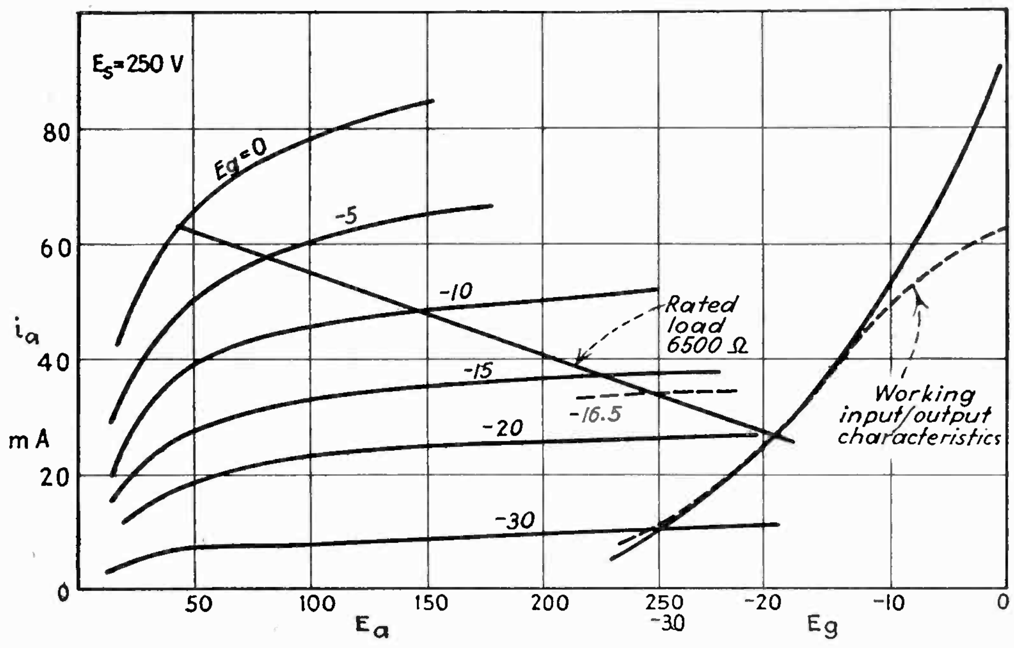


Fig. 7—Plate characteristics of a typical pentode, the 42

From the standpoint of preventing secondary emission troubles, the new tube is a distinct advance. Up to this time the suppressor grid has been the only means of attack. The method of "critical distance" described here is the newer method. Tubes can employ both methods, of course. The author has made tubes employing grounded deflecting plates to produce suppressor action, but has found that the present electron optical focussing of the electrons gives better performance and avoids the use of two extra elements in manufacturing. Linearity of characteristic is reduced by the presence of grounded plates producing comparatively low velocity electrons.

For the early work on this interesting and useful phenomenon of "critical distance" the reader is referred to British Patents 380,429 and 385,968.

Magnet Alloys

[*Continued from page 32*]

nico, which is being manufactured under license by at least three alloy foundries. The other is Nipermag, a British development recently introduced to and now manufactured in this country. Curves prepared by four companies are reproduced in the accompanying figures. In addition, tests on the aluminum nickel alloy published in *Archiv für Technisches Messen* (April, 1934) are given to show the effect of heat and mechanical shock (falling) on the magnetic properties.

Properties of Alnico

The necessary magnetizing force required to bring Alnico up to saturation (which is necessary to insure maximum residual flux) is given as 2,000 oersteds which is equivalent to 4,040 ampere turns per inch.

The specific gravity of the material is 6.9, it is resistant to corrosion, and must be cast in the required shapes, since it is comparatively unmachinable except by grinding. In demagnetization tests, Alnico bar magnets reduced in total flux less than one per cent. after being subjected to an a-c field of 100 ampere turns per inch for one minute. When subjected to severe vibration at 120 cycles per second for one-half hour, the decrease in total flux was less than one per cent.

Properties of Nipermag

Saturation of Nipermag is obtained at about 1,800 gilberts per centimeter. One of the advantages claimed for the alloy is a high degree of uniformity; the few rejects which do occur can be remelted, thus lowering overall costs. The specific gravity is about 7.0. Nipermag, also, can be machined only by grinding, and it is recommended that it be handled in the magnetic chuck of a surface grinder. The pole faces are the only surfaces ground, all other surfaces being sand blasted. The high coercive force of the magnet, plus experience tests made abroad, indicate that the material has high stability and permanence.

Applications of the New Alloys

At the time of writing, the most important applications of the new materials in the radio field are dynamic loudspeaker fields and the field structures of velocity and dynamic microphones. In other electrical fields, the magnets are used for blowouts in relays, holding-in magnets of large switches, in latching and timing relays, and for other control apparatus. They have also been in use for the field structures of small motors and magnetos, wind generators, and in headphones.—D.G.F.

The U. S. Patents referred to in this article are:
1. No. 1,633,805, issued June 28, 1927, to G. R. Brophy, assignor to G. E. Co.
2. No. 2,027,994, issued Jan. 14, 1936, to T. Mishima.
3. Nos. 2,027,995, -996, -997, -998, -999, and 2,028,000, all issued Jan. 14, 1936. to T. Mishima.
4. No. 2,027,996.
5. No. 1,947,274, issued Feb. 13, 1934, to W. E. Ruder, assignor to G. E. Co.
6. No. 1,968,569, issued July 31, 1934, to W. E. Ruder, assignor to G. E. Co.
7. No. 1,989,551, issued Jan. 29, 1935, to H. T. Faus, assignor to G. E. Co.

A "Mass-less" Pick-up

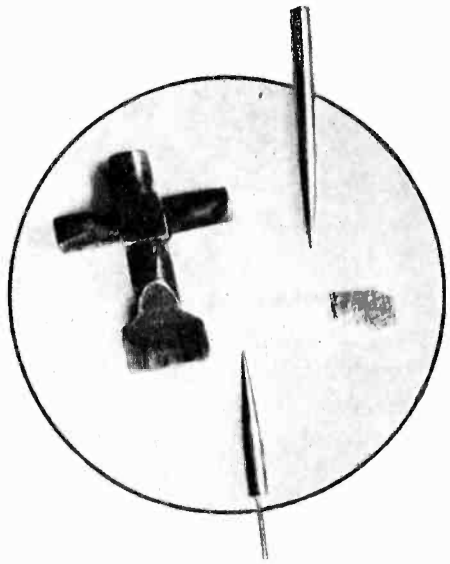
New mechanical and magnetic design reduces armature weight of phonograph pick-up to widen frequency range, to lengthen record life, to reduce noise, and to give better response to sudden changes of volume

By W. N. WEEDEN

FOR more than a decade the design of the magnetic phonograph pick-up has progressed but little, experiencing no fundamental improvement. The one inherent stumbling block, *moving mass*, is the limiting factor today as it was in 1925.

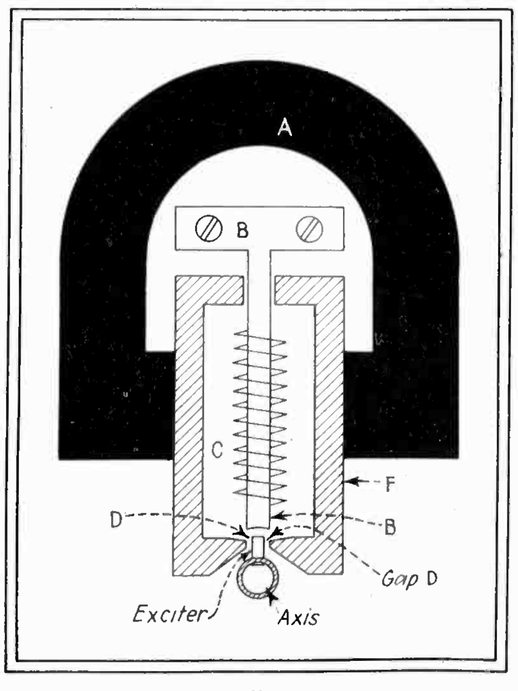
In some few instances, the working parts of the pick-up have been refined to extend the range but 6,500 cycles has been about the top in commercial units.

Wide-range recording, production of low noise record materials, demand for high fidelity record reproducing apparatus for radio and for home have proved to be stimulating influences, however, and it is a pleasure to record here for readers of *Electronics* the results of much research on the part of Maximilian Weil of the Audak Company, leading finally to a new unit in which the bugaboo of armature mass has been largely eliminated.



The exciter (the small oblong piece of steel) compared with present-day unit armature. Old and new needles; all somewhat enlarged

This armature mass not only resonates within the desired frequency range of the unit, but also determines the upper limit of reproduction. This is caused by the fact that the transmission of such a structure decreases in efficiency above resonance, locating its cut-off at a frequency which is seldom higher than 4500 cps and may be much lower. This mass also possesses sufficient inertia to seriously limit high frequency response, without taking resonance into consideration, and to prevent the following of rapid changes in amplitude or frequency, resulting in a very unpleasant form of distortion best described as "hang over."



"Relayed-frequency" unit construction

Damping is normally employed to reduce the magnitude of the resonant peaks and to limit the "hangover" and helps to produce a fairly satisfactory frequency characteristic. Unfortunately this damping greatly increases needle-point impedance and adds to the inertia in resisting suddenly applied forces. While reducing the level of resonant peaks, damping also greatly reduces the average efficiency of the unit. Increased needle-point impedance seriously affects record life, which is none too long at best.

While formulating the requirements of a new type of magnetic unit, it was decided to aim at the performance of the highly developed microphone used in recording, and that nothing short of equality with it would be tolerated. Its voltage output should be nearly equal to present day commercial pick-ups, and it must be dependable and mechanically sturdy. Furthermore a pick-up may be subjected to a temperature rise of 40 to 50 degrees F. within a half hour as measured within the acoustically sealed turntable compartment of a modern multi-tube radio combination. In summer this temperature rise may be even greater. Finally, a microphone is handled with care, while a pick-up unit may not be properly handled.

In searching for a means to drastically reduce moving mass, the moving coil was carefully investigated. It was soon discovered that even by employing a coil of minute proportions coupled to a delicate stylus, its resonant frequency could only be raised above 8500 cps with the greatest of difficulty. In addition, a complicated and delicate system of springs with a centering-damping rubber diaphragm was found necessary. This form of construction gave a unit which was quite frail and required careful handling in addition to delivering a very small output.

Two years of research evolved the unit shown in the figures. Although it is small, neither efficiency, performance nor ruggedness have been sacrificed. When in use, it lies flat on the record—extending but little above the motor shaft on many turntables.

Ruggedness was achieved by fine mechanical design plus precision work on the minute parts. The foundation of the unit is one of the most complicated bakelite mouldings ever made. It is so arranged that projections and threaded inserts secure the various parts so firmly that no shock received in normal use can disarrange them.

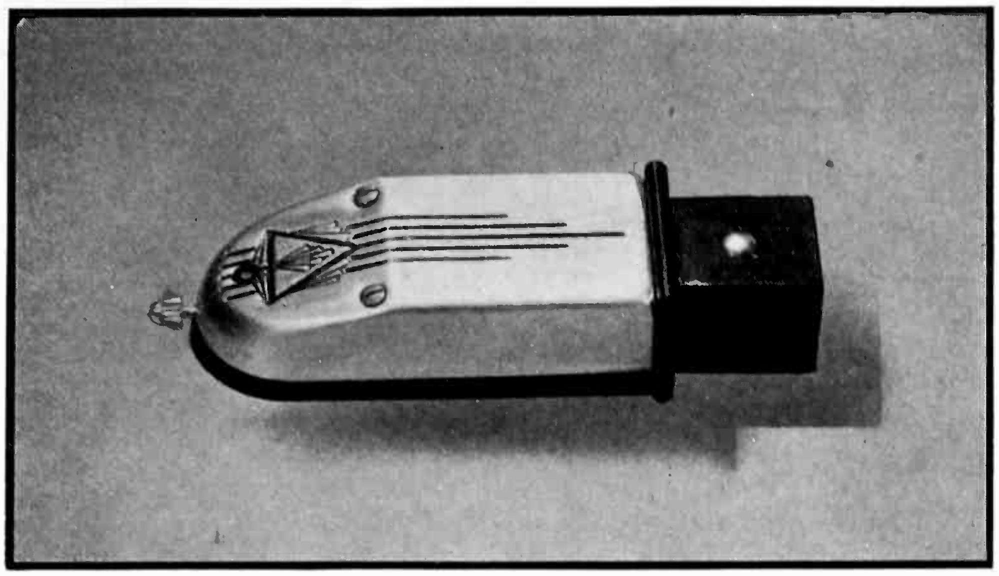
Although the ratio of the masses of the exciter of this new unit to the armature of the average magnetic pick-up is of the order of 1 to 50, this does not represent the total improvement. The figures are really representative of only that portion of the moving elements operating in the magnetic gap. With the standard armature the mass of the central portion, or axis, is relatively large and is of magnetic material because it forms the return path of the magnetic circuit.

In the new moving element, however, the "exciter" only is of magnetic material, while the axis and needle chuck (a single piece of tubing) and the screw (with the cap hollowed out) are of duralumin greatly reducing the total moving weight.

In operation, the exciter (as the inventor refers to it in his patents) relays the flux to the fixed armature.

The reduction in moving mass results in the location of exciter resonance above audibility. Freedom from resonance insures freedom from shock-excitation of the moving system by impulses of large amplitude, eliminating an unpleasant "ring" often noticed in phonograph reproduction.

With the elimination of resonance, damping also may be discarded, lowering the needle-point impedance to such an extent that record life will be increased many times. This is particularly important with the new high-fidelity records, and to the use of pressing materials which will still further reduce surface noise.



The complete Audak pick-up unit

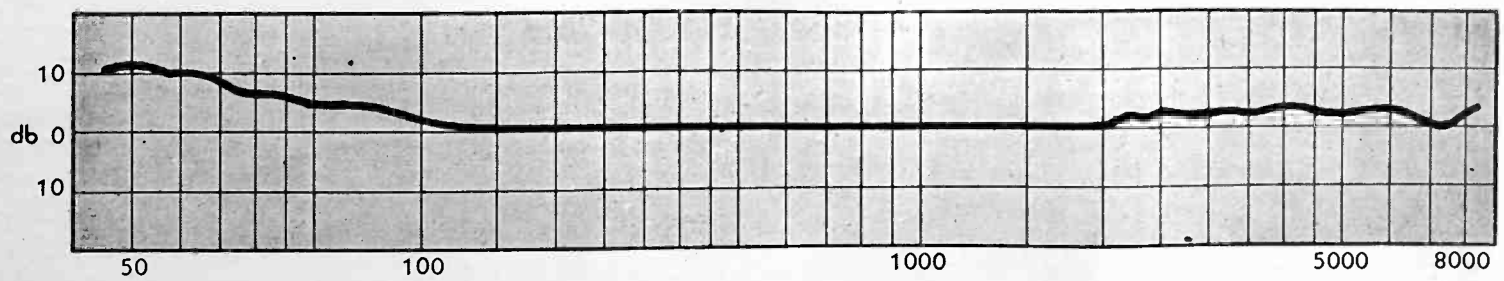
The elimination of damping makes possible the mounting of the exciter in bearings which permit the needle to oscillate with but little greater restriction than that of the ribbon in a velocity microphone. These bearings are so widely spaced, however, that there is but little motion in any direction but the normal. Also, the exciter can be set up in its bearings with far greater accuracy than when damping is interposed between the bearing and axis.

In addition to prolonging record life, this freedom of lateral motion permits the reproduction of transients with greater realism than heretofore possible.

With needle-point impedance virtually eliminated, the needle will follow low frequencies of maximum amplitude with only 1.25 ounces on the needle. For a greater margin of safety on records which are not cut quite so deeply as desirable, a weight of 1.5 ounces proved most satisfactory and the standard unit operates with this needle weight. 1.25 ounces is the lowest weight capable of holding any unit on the record. Even the moving-coil unit exceeds this, requiring approximately 1.75 ounces for satisfactory operation.

Much time was devoted to the development of a magnetic circuit which would most efficiently utilize the infinitesimal changes in flux produced by the oscillation of the exciter at greatly reduced amplitudes (approximately 5% of needle displacement). That this was accomplished with no loss of efficiency will be realized when the average output is considered as —25 db. Many units have produced 5 db greater output, while a few show 5 db less. It goes without saying that this efficiency is partly due to lack of damping.

On the sketch of the mechanical and magnetic design A is the permanent magnet of cobalt steel and of large cross section. B is the "stationary armature", constructed of a high permeability alloy, surrounded by the coil C. A small gap D will be noted between the lower leg of F and the stationary armature B. (This gap is shown many times its actual size.) The exciter E oscillates in this gap, generating a far greater



Frequency response of the new pick-up

current in coil C than would be the case were the exciter to act as the armature alone.

Another advantage of this design is the removal of the hardened steel needle from the magnetic circuit, as in the standard pick-up, and placing it at the end of the exciter axis—well away from the magnetic circuit. This eliminates a certain amount of distortion, caused by the coercivity of the needle, which becomes of increasing importance at high frequencies.

To facilitate insertion of the needle an opening is present in the housing directly over the needle chuck. The needle point is inserted into its chuck through this opening, and is pressed down until its butt is flush with the housing. This procedure is much simpler than the location of the opening in the bottom of the chuck, usually accomplished by the sense of touch. The primary purpose of this original method of needle insertion is to insure the proper position of the needle in its chuck—relative to mass above and below the axis. As will be pointed out, slight differences in needle mass affect the performance markedly, so that this precaution is helpful in securing the finest performance from the unit.

When it is considered that the ratio of needle to armature weight is of an entirely different magnitude than that of needle to exciter weight, it will be seen that needle length and weight exert a far greater influence on the operation of this unit than on that of the moving armature pick-up. This is largely caused by the needle weight exceeding that of moving element in the new unit.

New Needle Designs

If a needle with a radius at the point greater than 0.002 inch is used, the loss in high frequencies will be immediately noticeable, provided that the record being reproduced is of the high-fidelity type.

Substitution of a half-tone needle will result in an increased low frequency rise. To many individuals who enjoy predominance of the lows, this versatility should prove desirable. In addition certain records lack in apparent bass, and may be improved by a half-tone needle.

For those desiring extremely wide range reproduction, a special needle has been made available. This needle is ground to closer limits than is customary, and was designed to reduce its mass by a factor of 3, all taken from the upper half. Its decreased top mass results in less rise at both high and low frequencies. That at low frequencies is limited to approximately 3 db. The upper limit of the pick-up is extended because of the decreased moving mass.

For dubbing, broadcasting and other precision work, the unit can be furnished with certain structural modifications which will give a variation of less than 3 db between 40 and 8000 cps.

Although measurements cannot be made at the present time below 46 or above 8000 cycles due to limitations in constant frequency test records, the pick-up seems to show no tendency to drop off at either the high or the low frequency end.

• • •

Electronic Welding Timers

(Continued from page 28)

little information is to be had on the amount of current welders are drawing, particularly on short time welding if one realizes that the prevailing power factor of good welding transformers is less than 20 per cent; and that of secondary voltage much less than 10 per cent is actually used in work performed on the material to be welded. It is easy to see that theoretical consideration would not get one very far here.

To get out of this blind alley we were forced to design an instrument which would be capable of measuring currents of the duration of only 1/60 of a second with sufficient accuracy and consistence. When this was done we found that welders made by reputable manufacturers drew from two to three times the rated current according to the type of work that was done. We also found that the rating methods differed widely from manufacturer to manufacturer and also between welders.

We had to study the effect of different voltages on the carrying capacity of our contactors. They are now being used satisfactorily on anything from six volts d.c. to 600 volts a.c. The gist of this long story is that there is a great deal more to be successful design of electronic devices than just electronics, but on the other hand, electronic devices can and will be used by industry in increasing proportions because the field is very wide and the applications will be successful when there is a proper balance of good engineering with proper electronic design.

• • •

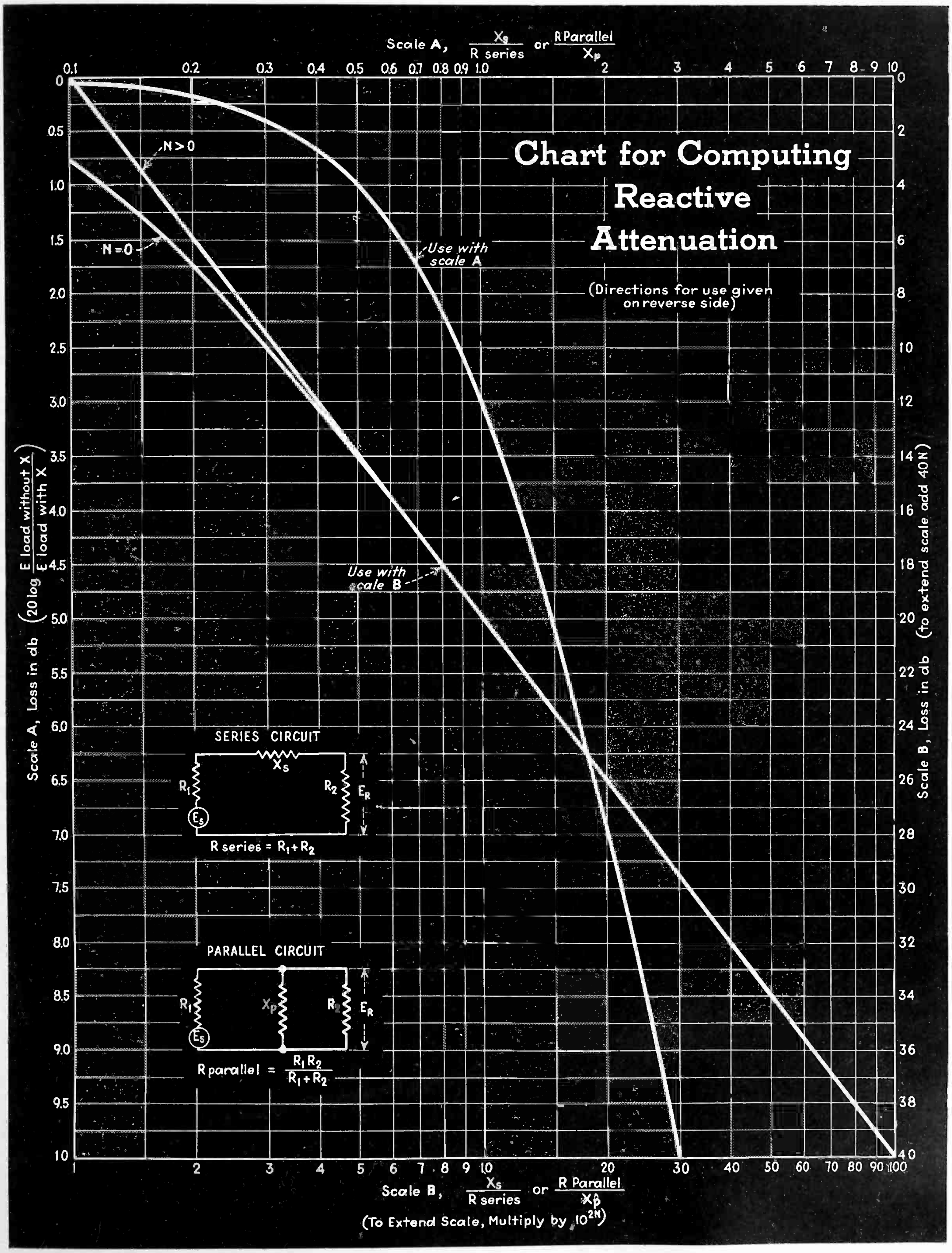
Book Review

Radio Engineering Handbook, Second Edition

EDITED BY KEITH HENNEY. *McGraw-Hill Book Company, Inc., New York City, 1935. (XI plus 850 pages, including index and many charts and illustrations, flexible covers, $5.00 net).*

IN COORDINATING the work of twenty-eight co-authors who have prepared the text for the revised edition of this now well-accepted handbook, Mr. Henney has performed a further service to radio engineering. From the first page of the mathematical tables, which include the current Federal Communications Commission requirements as to frequency tolerance and broadcast station geographical separations, all the way to the inside back cover (devoted to a chart of tube base connections) the book is largely new, some 300 pages having been added to the earlier edition. An entirely new section on "Antennas" contains much useful information both as to directive systems and broadcast radiators of the types recently adopted. The re-written chapter on television reflects the cathode ray tube technique which is now considered essential for the attainment of the objectives that have been discussed for so many years. As to broadcasting, which may be said to have supplied the life-blood of radio for the past decade, the section by Carl Dietsch offers many constructive suggestions directed toward improved performance.

Of course, it is not possible in a review of reasonable length to comment adequately on so comprehensive a book as this. Every engineer knows what a "Handbook" should be, and Mr. Henney's compendium succeeds in giving enough factual information to be helpful in a field that now requires a library for comprehensive treatment. Whether the reader wants to know what is being done in tube design or in so specialized an application as facsimile transmission, he will find it either stated or suggested in this really admirable reference work.—J.V.L.H.



ELECTRONICS REFERENCE SHEET

Computing Reactance Attenuation

The chart on the reverse side of this sheet has been prepared to aid attenuation calculations which take into account the presence of series or parallel reactances, useful in predicting audio-transformer frequency response, etc.

ATTENUATION calculations are usually made on the assumption that the circuit elements involved contain resistance only. In many cases, such as in the design of resistance attenuators and pads, this assumption is correct or at least so nearly correct that no serious error results. But in many cases, the reactance present in the so-called "resistance" elements is large enough to affect the result by an error of several db. When this occurs, especially in rating audio equipment which must be flat to within a small fraction of a db, the reactance present must be taken into account. The chart printed on the reverse side of this sheet has been prepared by Mr. P. F. Bechberger, Designing Engineer of Ferranti Electric, Inc., New York, N. Y. to aid in computing attenuation due to reactive components, for series and parallel cases.

Series vs. Parallel Circuits

Consider the series circuit, containing a source of emf, the source resistance R_1, the load resistance R_2, and a reactance X_s in series between R_1 and R_2. Then in computing the attenuation caused by the presence of the reactance, the following expression is set up:

$$\text{Loss in db} = 20 \log_{10} \frac{\text{voltage across load without } X_s}{\text{voltage across load with } X_s}$$

The same expression can be used for the parallel circuit, in which the source of emf and the source resistance are shunted by the load resistance and load reactance in parallel. In this case the parallel reactance X_p causes the change in the load voltage, the ratio of voltage change being expressed in db by the above expression.

It turns out that the attenuation so introduced can be expressed in terms of the ratio of the reactance to the series resistance in the series case, or by the ratio of the parallel resistance to the reactance in the parallel case. In the chart the relation between the attenuation and these ratios is given. The reactance-resistance ratios are formed by taking the series resistance $R_1 + R_2$ and dividing into the reactance in the series case, or by dividing the parallel resistance $(R_1R_2)/R_1 + R_2)$ by the reactance in the parallel case. The scales for the resistance-reactance ratio run from 0.1 to 10.0 in the scale A, and from 0.01 to 1.0 in scale B. If it is desired to extend scale B upward, the scale value may be multiplied by any even positive power of 10 (by 10^{2N}), and by adding $40N$ to the horizontal attenuation values for scale B. When the scale is so extended, the curve marked $N>0$ should be used. In this manner all the values of X and R_{series} or $R_{parallel}$ likely to occur can be accommodated.

The usefulness of the chart is particularly apparent in the case of the audio frequency interstage coupling or output transformer. At high frequencies, the leakage inductance of such transformers may produce a noticeable reactive component in the load presented by the transformer. The attenuation thus introduced is a function of frequency which must be calculated; the chart permits rapid determinations of the db loss produced by this effect. At low frequencies, the response of transformer and resistance-capacity coupled stages can likewise be determined directly from resistance, inductance and capacity values.

Numerical Examples

As a numerical example of the use of the chart, consider an output transformer which is fed from push-pull 2A3's. The source resistance (R_1) in this case is the plate resistance of the two 2A3's in series, approximately 1600 ohms. The load resistance R_2 is the plate to plate resistance offered by the transformer which is in this case 3000 ohms. The transformer has a leakage resistance of 0.026 henries, referred to the primary, which at 10,000 cycles, gives a series reactance X_s $(2\pi fL)$ of 1630 ohms. Then X_s/R_{series} is 0.354, which, referring to scale A on the chart, gives an attenuation of 0.5 db. Since the ratio X_s/R_{series} increases linearly with frequency, the ratio at 15,000 and 20,000 cycles can be calculated by proportion, giving values of 0.516 and 0.708 respectively, with attenuation, taken from the chart, of 1.05 and 1.75 db. The leakage reactance referred to here may often be measured by shorting the secondary terminals, and measuring the primary reactance.

Low Frequency Response

If the same transformer has a primary inductance of 11 henries, the attenuation at low frequencies is computed as follows: The primary reactance (which is in parallel with the load) at 30 cycles is 2080 ohms. The parallel resistance of tube output and load, $R_{parallel}$ is $(1600 \times 3000)/(1600 + 3000)$ or 1040 ohms. The ratio $R_{parallel}/X_p$ is 0.5, and the attenuation, taken from the chart (scale A) is 1.0 db. Since the ratio is inversely proportional to frequency, its value at 15 and 10 cycles is 1 and 1.5 with attenuations of 3.0 and 5.1 db respectively.

From the examples it is clear that if the attenuation is known at one frequency, the attenuation at other frequencies may be determined without a knowledge of the actual values of resistance and reactance.

RMA-SAE Study Noise

Two-fold investigation made to determine effect of noise suppressors upon automobile operation and economy, and to develop methods of measuring ignition radio interference

FOLLOWING several conferences between members of the Engineering Division of the RMA under the lead leadership of W.R.G. Baker and engineers of the Society of Automotive Engineers headed by P. J. Kent (Chief Engineer, Chrysler Corporation), a two-fold attack upon the general problem of ignition interference to radio reception has been made. Through the courtesy of the two engineering organizations the following report is possible. Mr. Virgil Graham, RMA Standards Section chairman, and J. P. Filgate, Bosch, were most active in this work.

One portion of this investigation naturally had to do with the effect of noise suppressors upon the operation of the car. This part of the general study was taken over by the SAE and the results are given below in summarized form.

The second portion of the problem relates to the measurement of the interference produced by ignition systems. The RMA took over this job, appointed L.C.F. Horle as a consultant, and appropriated money for an investigation to lead to the development of measuring equipment. At a recent meeting of the SAE-RMA joint committee on ignition interference, Mr. Horle described the results of his work and demonstrated the first model of a proposed measuring set.

Auto Ignition Noise Peaks in 30-40 mc. Region

Mr. Horle's investigation confirmed interesting facts discovered by others who have measured ignition radiation, especially the findings of a study made by the Canadian Department of Marine, Radio Section. Among other data is the fact that a strong peak of interference exists in the band of 30 to 40 megacycles, where local short-wave broadcasting is now getting a most encouraging start. No matter what kind of car, or how long are the ignition circuit leads or other variables this peak occurs, indicating that some factor besides the ignition system is determining the wave lengths of the radiation. Another fact, already known, is the extremely peaked nature of these interfering noises. Thus any device measuring average values of voltage, or power, cannot indicate truly the effect of the interference. A single wave may take place in a few microseconds and not be repeated for a hundred thousand microseconds. Therefore the measuring device must measure the peak voltage of the interference, not its average or r.m.s. value.

The RMA Experimental Noise-Measuring Set

The measuring set demonstrated by Mr. Horle consisted of a modern high-gain selective superheterodyne receiver. The diode detector was used as a gate with two degrees of opening (5 and 10 volts) and the a.v.c. was disconnected so that the r-f gain could be controlled manually. In operation the noise is picked up, the operator determining whether it falls within the 5 or the 10 volt class. Then the gain is decreased until only the tops of the noise voltage are getting into the a-f circuit through the diode gate. The setting of the gain control is then a measure of the input noise voltage. The receiver functions on voltages as high as 0.1 volts and has a sensitivity of 5 microvolts/meter on all but the highest frequencies.

Since it is desirable to measure peak values, it is necessary to preserve the waveform of the noise signals. Fortunately there is not much distortion in r-f and i-f amplifiers. A receiver is a happy choice of measuring equipment since it is a receiver in which the annoyance is finally heard, and any change in waveform encountered will be the same as is met with in actual practice. The a-f system acts as the indicating mechanism. The receiver tunes from 0.2 to 40 megacycles and thus covers the entirely useful range.

To free the system from unwanted coupling except through the diode, a high and stable source of "barrier" voltage is provided for the peaks of input to jump over. This is a battery which also provides gain-control bias for the i-f and a-f amplifiers.

Effect of Suppressors on Car Operation

SAE made various tests to determine what effect, if any, resistance type suppressors had on car economy and operation. The following states the results of these investigations. For wide open engine operation, any resistance value likely to be used in practice has no noticeable effect on present day cars. With new plugs, engine running at 1,200 r.p.m. suppressors have no effect on gas economy unless there be a slight improvement in economy. At idling engine speeds, suppressors tend to increase missing. Suppressors tend to increase cold starting time, or to increase difficulty in starting in cold weather. No effect of suppressors was discovered on the life of breaker points at 800 r.p.m. with 8.5 volts. It is to be noted that these are "tendencies" and not absolute statements of fact. Thus an engine may not miss at all with or without suppressors, but if it misses without, it will tend to miss more with resistors.

Present plans are to test the measuring equipment on as many makes and models of cars as possible and perhaps to demonstrate the apparatus to automobile manufacturers in Detroit. It should prove to be very valuable in ignition research.

TUBES AT WORK

THUGS beware! G.E. designs a new police radio receiver. A neon tube device detects grounds; phototubes aid the British test roadway illuminations; and other tubes are at work as outlined below.

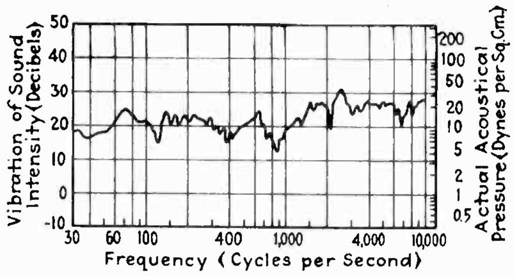
New Police Superheterodyne Uses Super-regenerative Second Detector

A NEW POLICE SERVICE receiver, believed to be the first commercial instrument to combine the superheterodyne and super-regenerative circuit, has been designed by the General Electric Laboratories, Schenectady. The receiver is designed for fixed frequency operation in the 30 to 42 megacycle frequency range. The tube line-up consists of a conventional r.f. amplifier (type 78), feeding a unit oscillator mixer (a 6F7) which supplies an i-f signal to a duo-diode pentode (a 6B7) whose diode sections are used for conventional a.v.c. The second i-f amplifier is a 6F7 triode-pentode, the triode section of which is connected as a super-regenerative second detector of the grid-tickler type. The second detector is followed by a double triode (type 79), one section of which generates the quench frequency voltage, the other acting as a driver for the output power tube, which is a type 41. The intermediate frequency is 9 megacycles, the quench frequency about 20 kilocycles. The i-f coupling is of the inductive type, using conventional transformers, capacitively tuned.

The use of the super-regenerative second detector circuit is made in the interest of noise reduction and automatic volume control. Experience with amateur receivers operating on much higher frequencies has shown that super-regenerative detectors are capable of discriminating against noise of the highly damped oscillatory type, such as produced by automobile ignition systems, and further that the super-regenerative circuit provides inherently a rapid automatic volume control action. Since the circuit is most sensitive when no signal is being received, a large amount of noise, particularly tube and circuit noise, is received in the absence of a signal. To counteract this effect, a carrier-operated noise suppression circuit is used. When the incoming carrier is removed, the plate current of the second detector increases. When this happens the voltage on the grid of the driver section of the double triode tube is reduced to cut-off by means of a neon tube which acts as a constant voltage device. Two other neon tubes are used as bias voltage regulators to compensate for changes in supply voltage.

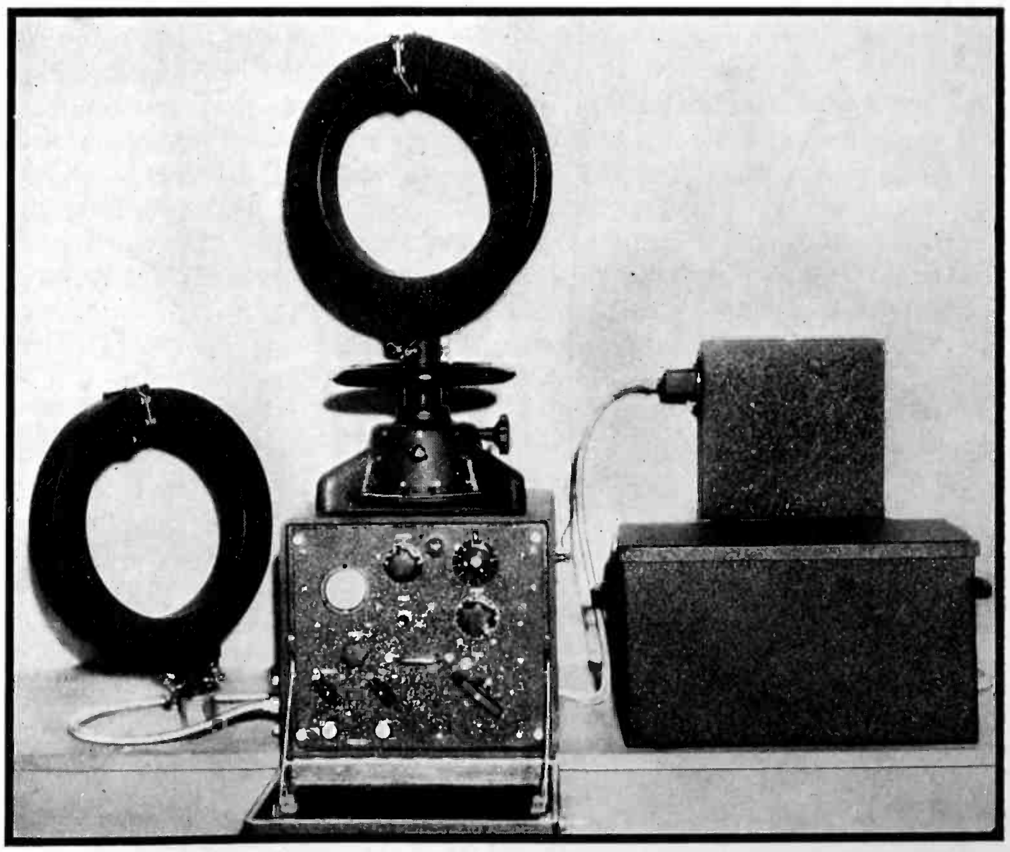
Measuring Loud Speaker Performance

FOLLOWING ARE THE DETAILS of the methods used by the National Physical Laboratories of Teddington, England, in measuring the acoustical output of

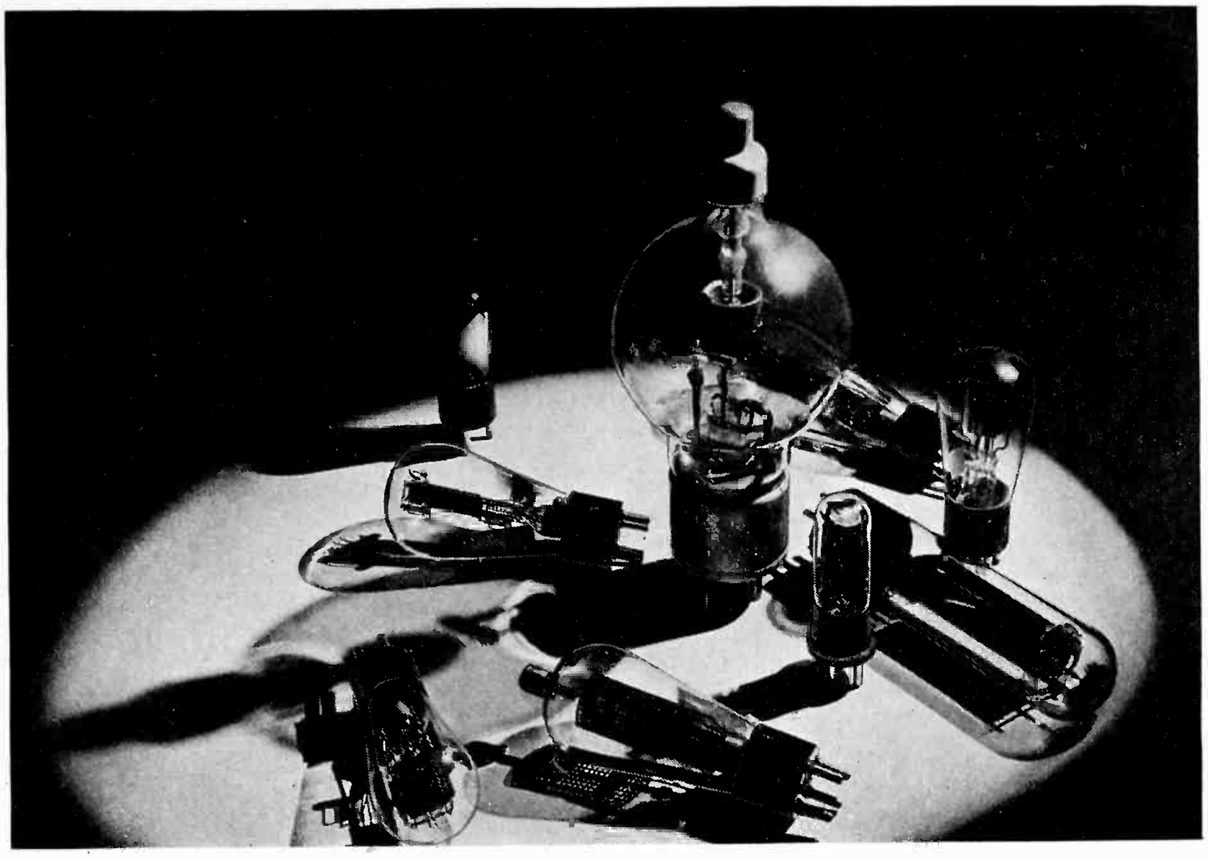


a moving-coil loud speaker. The loud speaker (model 33 Magnavox, manufactured by Benjamin Electric, Ltd., a double voice coil model) was mounted in a rectangular wooden baffle 48 x 63 in. The speaker was mounted midway between the two shorter edges and 17 in. from one of the longer edges. The loud speaker and baffles were mounted on the edge of a high roof pointing away from the mass of the building. The shorter edges of the baffle were horizontal. A low wall 7 ft. behind the speaker and a subsidiary flat roof 18 ft. below it were each covered with sloping sound reflectors. These reflectors were intended to project the reflected sound away from the speaker and away from the sphere of measurement. The microphone was situated at a distance of 6 ft. on the forward axis of the speaker, and a driving e.m.f. of 2 volts r.m.s. was applied across the voice coil of the loud speaker in series with a one ohm resistance. The frequency of the driving voltage was varied from 30 to 10,000 cycles per second and the resulting acoustical sound pressure and variation of sound intensity measured in the usual manner. The diagram shows the results of the measurements. The response was exceptionally uniform, probably because of the double voice-coil construction of the speaker measured.

PORTABLE DIRECTION FINDER FOR COAST GUARD



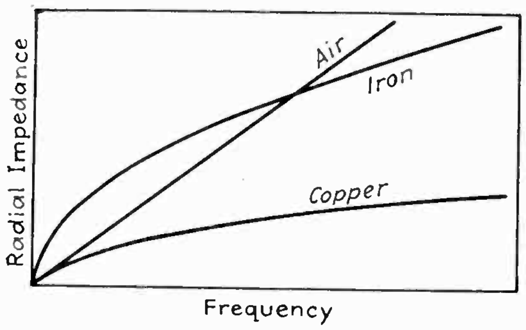
Designed primarily for use in the land radio stations of the U. S. Coast Guard, this new equipment can be moved quickly to boats or motor vehicles if the need arises. It is a "homing" direction finder of the type described in Electronics, October, 1935, page 7



Shielding Problems Treated by Transmission Line Theory

[S. A. SCHELKUNOFF] The problem of the cylindrical shield used in communication lines is comparatively simple in principle, but extremely difficult to express in the specific quantitative form. A method of approach applicable to shields of cylindrical cross section which considerably simplifies the problem makes use of transmission line theory in connection with the radiation of energy from the conductor which is being shielded. It is well known that when energy travels along a wire a certain portion of the energy travels radially away from the wire at right angles. This energy causes cross-talk and interference. The same basic laws govern the transfer of this radial energy as govern the energy travelling along the line.

In the transmission line the energy travelling from the sending end to the receiving end is attenuated continuously by the resistance and leakage of the line. Likewise if the impedance of the line suddenly changes at any point a reflection of energy occurs which still further reduces the energy received at the end of the line. It is pointed out that attenuation and reflection occur likewise in the transfer of energy radially from the wire, and it is the shield which dissipates the radial energy by attenuation and reflections.



In applying this idea, the transmission line is replaced (as can be done without serious error) by a line source midway between the wires. The outward progress of the radial wave originating from the line source can be described by an electric intensity E parallel to the wires and a magnetic intensity H perpendicular both to the wire and to the radius from the line source to the point under consideration. The ratio of E to H may be called the radial impedance. As the radial energy wave travels outward it is attenuated, simply by spreading if it passes through perfect dielectric, or in addition by transformation into heat if it travels through a metallic conductor. In passing through metallic substances the radial wave is attenuated at the rate

$$a = \sqrt{\pi f \mu g}$$

nepers per centimeter, where π is 3.146 μ is the permeability in henries per centimeter, which for copper is 1.257×10^{-8} (the same value as for vacuum), f is the frequency, and g is the conductance, which is 5.80×10^{-5} for copper. At 10,000 cycles the attenuation constant for copper is about 130 db. per centimeter (15 nepers per cm.).

The effectiveness of the shield is due in part to the rapid attenuation in the metal, but also because of the sudden change in radial impedance which occurs between the shield and the adjacent dielectric. Since the radial impedance is a function of frequency for all materials the reflection will be different for different frequencies. But at one frequency the radial impedance of iron, for example, is the same as that for air, so that no reflection occurs.

The theory thus explains the differences between magnetic and non-magnetic shields when operating in fields of low and high frequency. Non-magnetic shields become increasingly effective with increased frequency but this is not true with the magnetic shield which may be most effective at low frequencies. The effectiveness can be estimated by considering the reflections produced at the boundaries between the different metals and dielectrics as well as the attenuation within the body of the shield itself. (*Bell Telephone Laboratories Record*, Vol. 14, No. 7, March 1936, page 229.)

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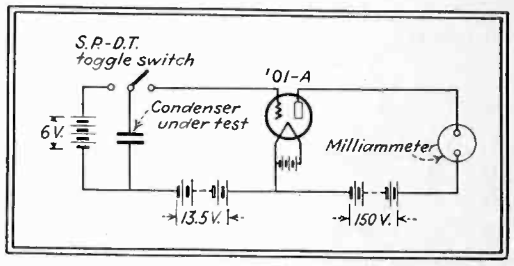
Electron Devices Used in the Spark Plug Industry

FOR THE FOLLOWING information on the use of electronic devices in connection with spark plug manufacture and testing, we are indebted to Mr. H. C. Frost, research engineer of the Defiance Spark Plugs, Inc., Toledo, Ohio. In testing spark plugs for insulation and leakage characteristics, the following method is used. A d-c voltage of 750 volts is applied across the spark plug in series with a microammeter, and the current (usually 10 to 600 microamps.) is used to measure the leakage which must be kept within specified limits. Under certain tests the spark plug may become short circuited and in that event the heavy current through the microammeter would severely damage it unless protective measures are taken. The diagram shown in the figure is an electronic circuit breaker which disconnects the instrument when an excess of current flows.

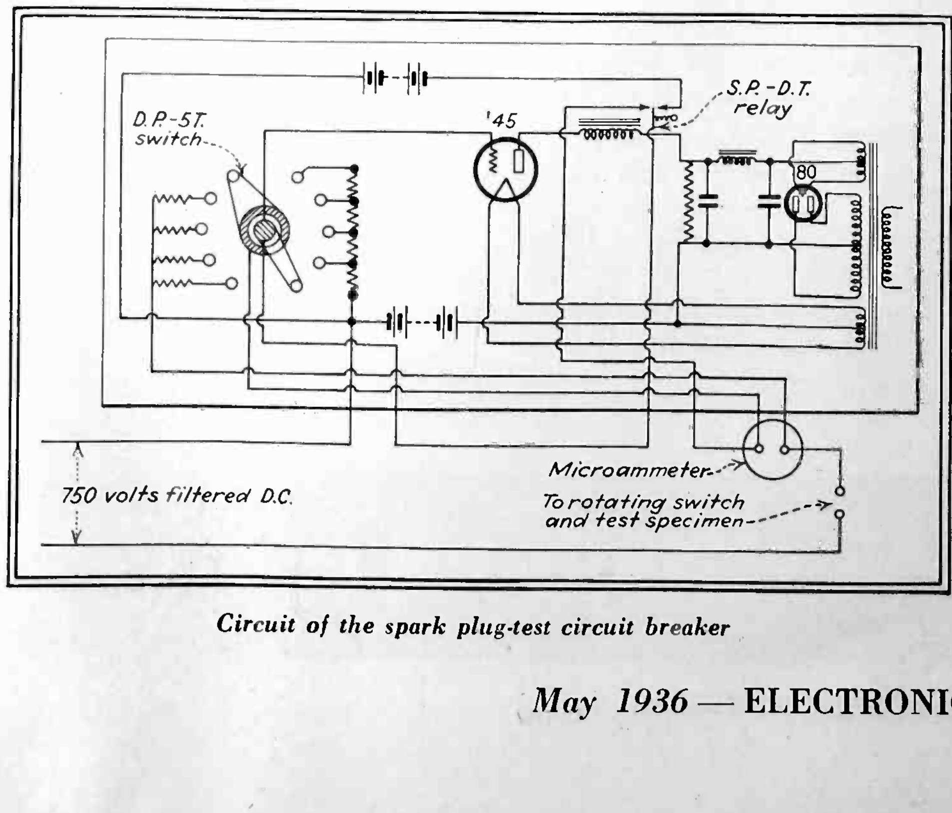
The value at which the circuit breaker operates is predetermined by the size of a resistor which is in series with the supply voltage line and which is controlled by the double-pole, five-point switch. The voltage drop occurring across these resistors is applied to the grid of the type 45 tube, whose plate current is thereby caused to open a relay when the current becomes excessive.

A second tube circuit used by this company is a condenser leakage tester,



used for testing automobile ignition condensers. The condenser is charged to 6 volts and applied in series with a battery to the grid of a type OIA tube, so that the leakage across the condenser influences the plate current reading. The quality of the condenser is determined by the time required for the plate current to assume its normal value after the charged condenser has been connected across the grid circuit.

Other applications of electronic devices include the use of a vacuum tube voltmeter and cathode ray oscilloscope which is used for checking the sparking voltage of spark plugs under various conditions of operation. In the latter application, in order to measure the high voltages in an ignition system, a voltage divider having a continuously variable ratio, between 2 and 132, is used to apply the proper voltage to the deflection plates of the oscilloscope.



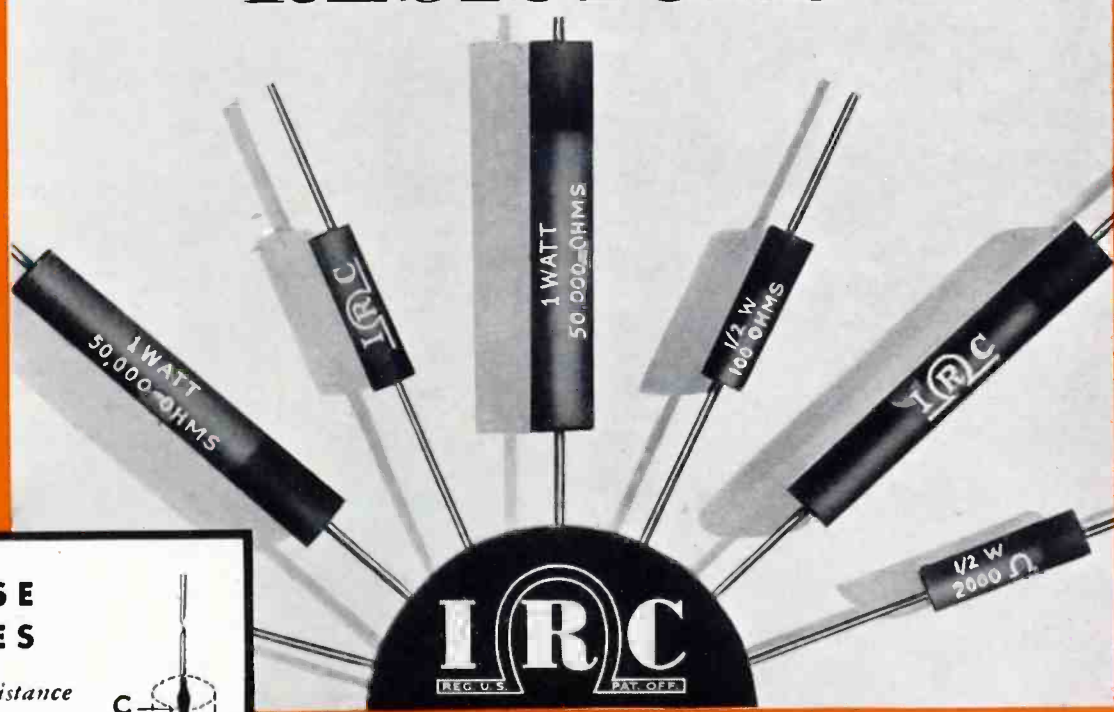
Circuit of the spark plug-test circuit breaker

Pioneered in 1934

Tremendously Popular in 1935

STANDARD PRACTICE in 1936

IRC INSULATED RESISTORS



✓ CHECK THESE ADVANTAGES

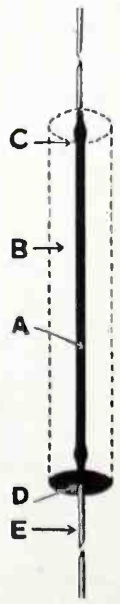
A. *Famous Metallized resistance principle.*

B. *Heavy casing of insulating material moulded around Metallized Filament Resistance Element, sealing it from moisture and protecting it against shorting other parts.*

C. *Positive integral contact obtained by bonding wire lead to resistance element.*

D. *Moisture-Proof. Sealed throughout.*

E. *Highly tinned end leads for quick, easy soldering.*



IRC engineers are responsible for the creative research and practical development work that produced the *original insulated resistors.*

The success of "IRC" has forced competition into the making of insulated units. But—IRC *Metallized* INSULATED Resistors—the *first* in the field—remain the *foremost* in the field today.

The International Resistance Company took the first step and produced the *last word* in insulated resistors. When further progress is made you may look to the *originators of insulated resistors* to make it!

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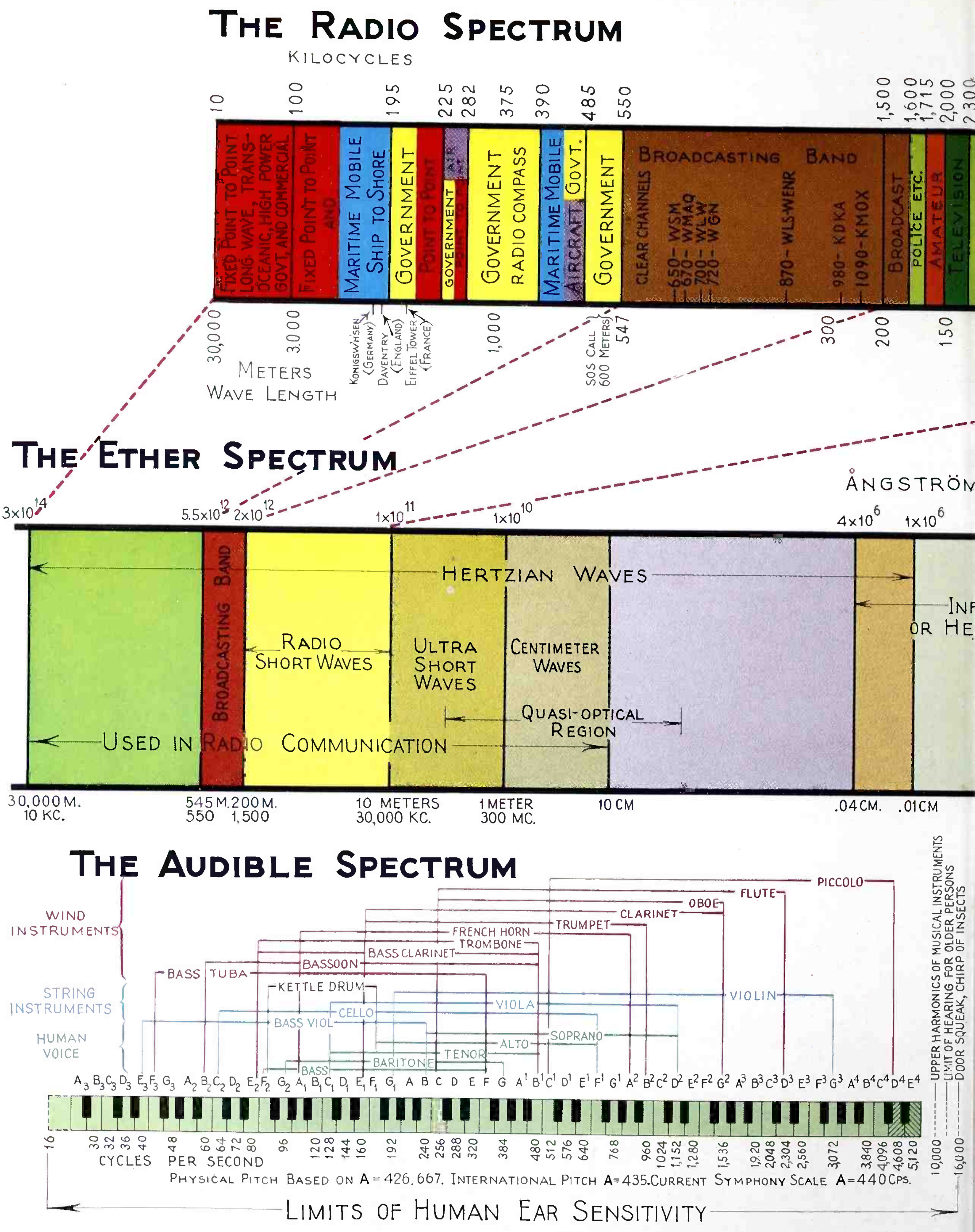
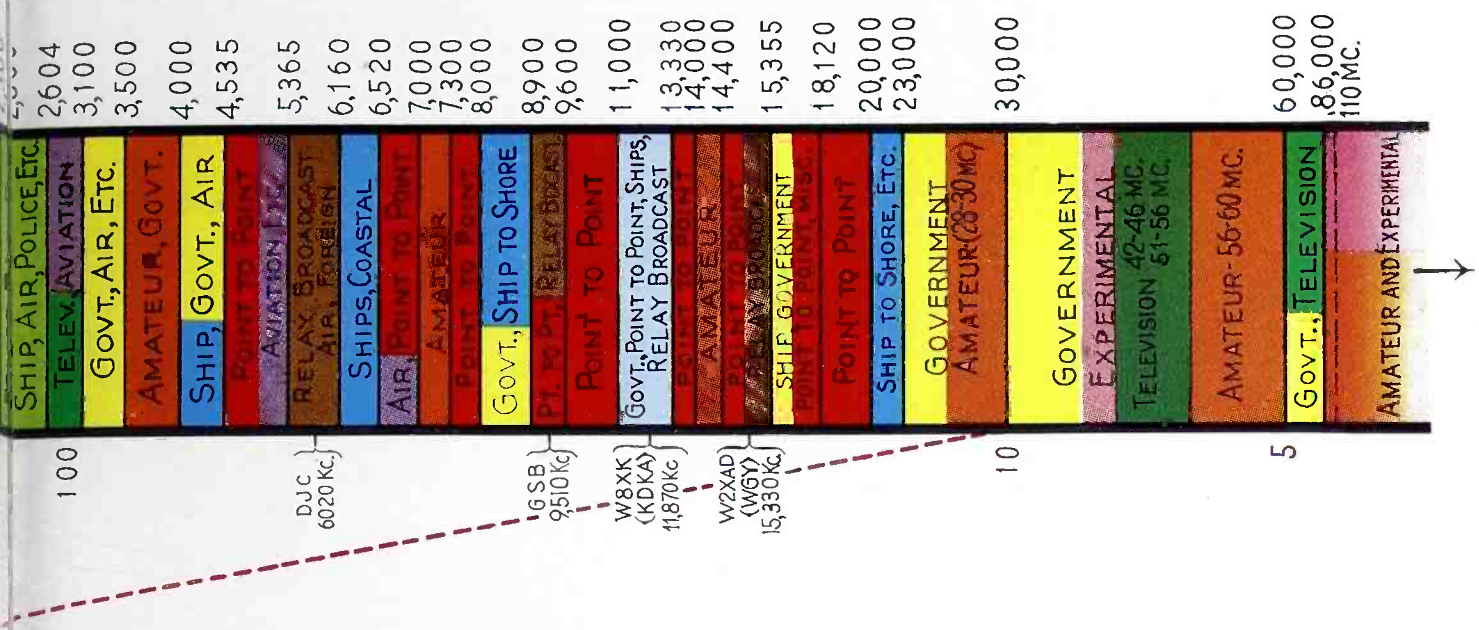
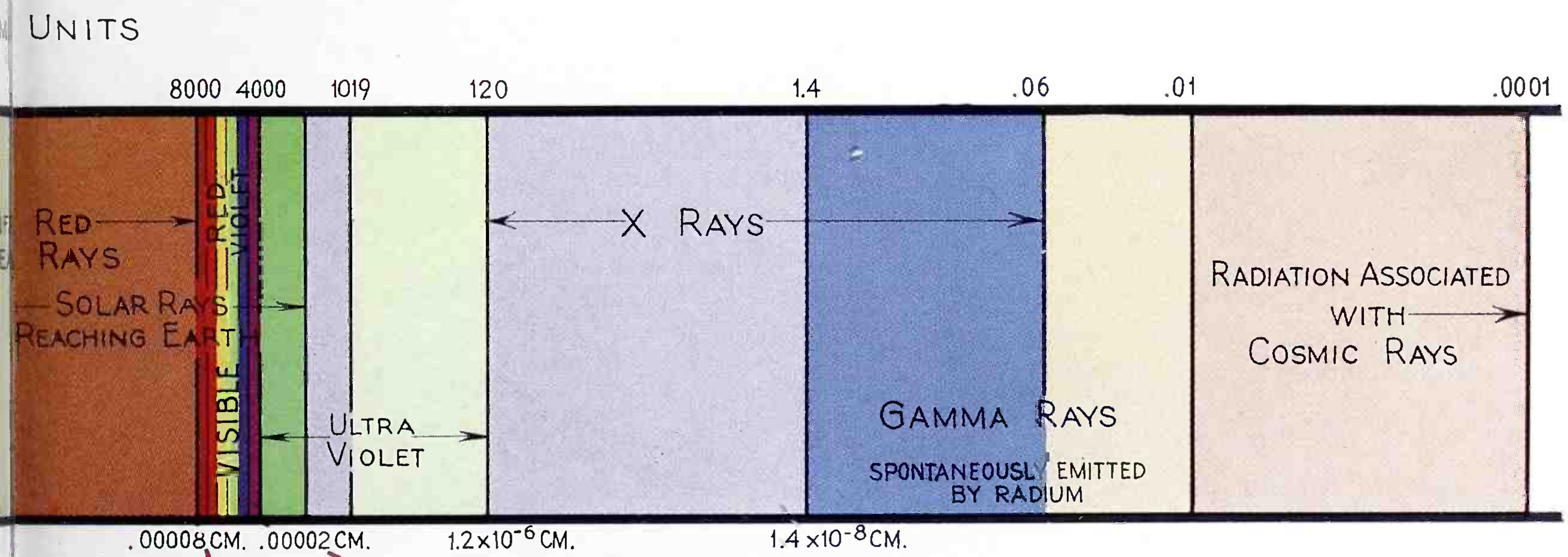
CANADA ENGLAND FRANCE GERMANY ITALY DENMARK AUSTRALIA

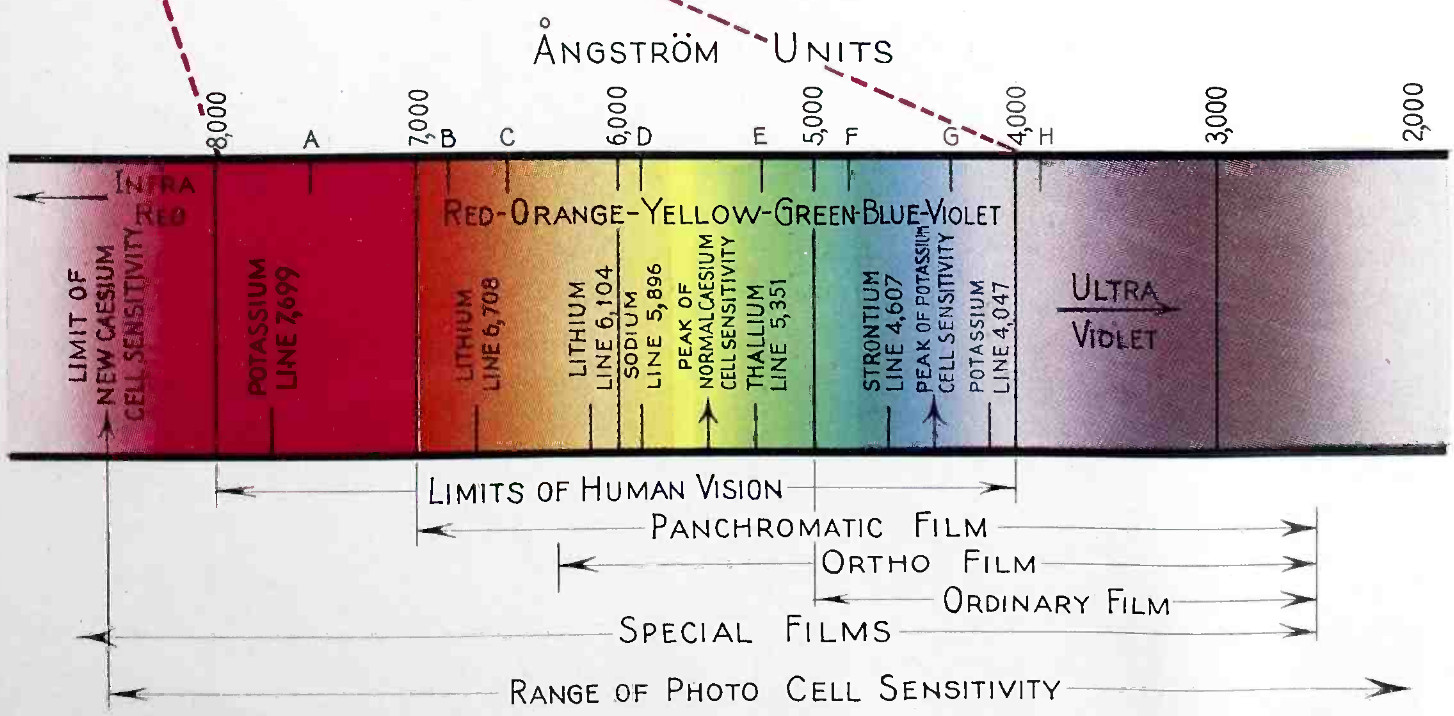
SPECIFY IRC RESISTORS FOR ALL RADIO AND ELECTRICAL EQUIPMENT


THE RADIO SPECTRUM
KILOCYCLES
10
100
195
225
282
375
390
485
550
1,500
1,600
1,715
2,000
FIXED POINT TO POINT LONG WAVE, TRANS-OCEANIC, HIGH POWER GOVT. AND COMMERCIAL
FIXED POINT TO POINT AND
MARITIME MOBILE SHIP TO SHORE
GOVERNMENT
POINT TO POINT
GOVERNMENT
AIR
GOVERNMENT RADIO COMPASS
MARITIME MOBILE AIRCRAFT
GOVT.
GOVERNMENT
BROADCASTING BAND
CLEAR CHANNELS
650 - WSM
670 - WMAQ
700 - WLW
720 - WGN
870 - WLS-WENR
980 - KDKA
1090 - KMOX
BROADCAST
POLICE ETC.
AMATEUR
TELEVISION
30,000
3,000
METERS
WAVE LENGTH
KONIGSWUSTERHAUSEN (GERMANY)
DAVENTRY (ENGLAND)
EIFFEL TOWER (FRANCE)
1,000
SOS CALL 600 METERS
547
300
200
150
THE ETHER SPECTRUM
ÅNGSTRÖM
3x10^14
5.5x10^12
2x10^12
1x10^11
1x10^10
4x10^6
1x10^6
HERTZIAN WAVES
BROADCASTING BAND
RADIO SHORT WAVES
ULTRA SHORT WAVES
CENTIMETER WAVES
QUASI-OPTICAL REGION
USED IN RADIO COMMUNICATION
INF
OR HE
30,000 M.
10 KC.
545 M.
550
200 M.
1,500
10 METERS
30,000 KC.
1 METER
300 MC.
10 CM
.04 CM.
.01 CM
THE AUDIBLE SPECTRUM
WIND INSTRUMENTS
STRING INSTRUMENTS
HUMAN VOICE
PICCOLO
FLUTE
OBOE
CLARINET
TRUMPET
FRENCH HORN
TROMBONE
BASS CLARINET
BASSOON
BASS TUBA
KETTLE DRUM
VIOLA
VIOLIN
CELLO
BASS VIOL
SOPRANO
ALTO
TENOR
BARITONE
BASS
UPPER HARMONICS OF MUSICAL INSTRUMENTS
LIMIT OF HEARING FOR OLDER PERSONS
DOOR SQUEAK, CHIRP OF INSECTS
16
30
32
36
40
48
60
64
72
80
96
120
128
144
160
192
240
256
288
320
384
480
512
576
640
768
960
1024
1,152
1,280
1,536
1,920
2048
2,304
2,560
3072
3,840
4096
4,608
5,120
10,000
16,000
CYCLES PER SECOND
PHYSICAL PITCH BASED ON A = 426.667. INTERNATIONAL PITCH A = 435. CURRENT SYMPHONY SCALE A = 440 CPS.
LIMITS OF HUMAN EAR SENSITIVITY





The Photo-Electric Spectrum



to RADIO ENGINEERS
CONTINENTAL-DIAMOND OFFERS
a Specialized Service

WHEN insulating problems arise—when choice of a suitable material is in question—when you endeavor to further lower fabrication or assembly costs—you will find Continental-Diamond Engineers desirous and capable of assisting in numerous ways.

We make many types of electrical insulating materials—can therefore recommend without bias suitable proved and accepted insulation—in size, form and grade for fabrication at minimum cost and with little waste.

Make full use of this specialized service—consult with us whenever occasion demands—let us show how Continental-Diamond products, engineering skill, experience and fabricating facilities may help you improve product quality or reduce production costs, or both.

DILOPHANE
THE NEW
DIAL MATERIAL

In Dilophane we offer a dial material with vastly improved characteristics—that prints readily and beautifully, with sharp, clearly defined figures—non-inflammable—translucent—mechanically strong—permanent in form—available in colors—a material that resists warpage or shrinkage—is easily fabricated and costs little or no more to buy and use than ordinary dial materials.

DILECTO
LOW POWER LOSS
INSULATING MATERIAL

Dilecto XPLW is a laminated phenolic material, developed especially for radio. It is a phenomenally low power loss insulation and maintains this property even under high temperature and high humidity conditions—has good machining qualities—is readily fabricated. A super radio insulation which many manufacturers find far superior to any other laminated plastic material. Ask for test data and samples for your own test purposes.

VULCOID
NON HYGROSCOPIC
INSULATING MATERIAL

Vulcoid, another product of Continental-Diamond research, is a non-hygroscopic form of vulcanized fibre, combining the mechanical qualities of fibre with much better dielectric strength and the ability to retain permanently, under varying atmospheric conditions, the form and dimensions into which it is machined or formed. It is a comparatively low cost material.

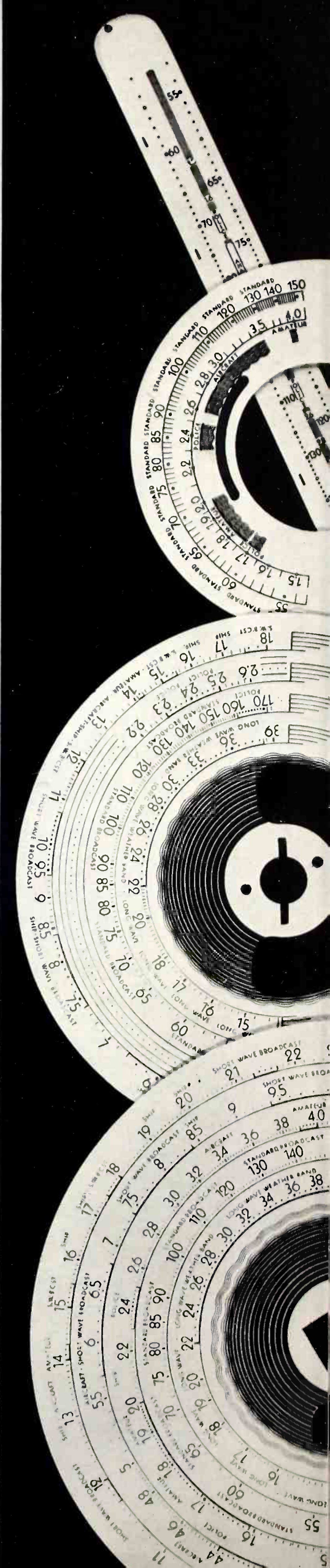
VULCANIZED FIBRE
GENERAL PURPOSE
INSULATING MATERIAL

Diamond Vulcanized Fibre is a product of years of experience. It is made from carefully selected materials, manufactured with especially developed equipment and methods. We believe you will find, as many users have, Diamond Vulcanized is the best insulating fibre money can buy.

There are catalogs on each of the above Continental-Diamond products—send for them. And when we can help with Specialized Radio Engineering Service please feel free to ask—this service is maintained for your benefit.

CONTINENTAL DIAMOND FIBRE COMPANY

CONTINENTAL-DIAMOND
FIBRE COMPANY
NEWARK, DELAWARE



THE ELECTRON ART

DETAILS of a public address automatic gain control system, a German version of the beam deflection tube, an ultra-high frequency wavemeter, and a 100-300 megacycle receiver using concentric lines as interstage coupling.

Automatic Public Address Amplifier Volume Level Control

BY HEINZ BOUCKE

[FUNKTECHNISCHE MONATSHEFTE, January 1936, P. 31-32]. It is often desired to adjust the volume of P.A. systems so as to overcome temporary audience interference (such as hand clapping, etc.). The great disadvantage of manual volume control lies in the unavoidable time lag between the perception of interference and the volume increase adjustment, and again between a suddenly lowered noise level and the corresponding turning down of the volume. Acoustical experts are able to consider only an average noise level in their calculations and other means must be found to overcome these disturbing factors.

An interesting automatic compensating device has been suggested for this purpose particularly for use in sound film theatres. The device consists of a microphone, suspended, as shown, in a favorable location with relation to the loudspeaker. Two control voltages are generated as indicated on the diagram by *M RG.*, and *R.RG.* Their resultant is the compensating voltage which is brought to the grid of the amplifier as control bias voltage.

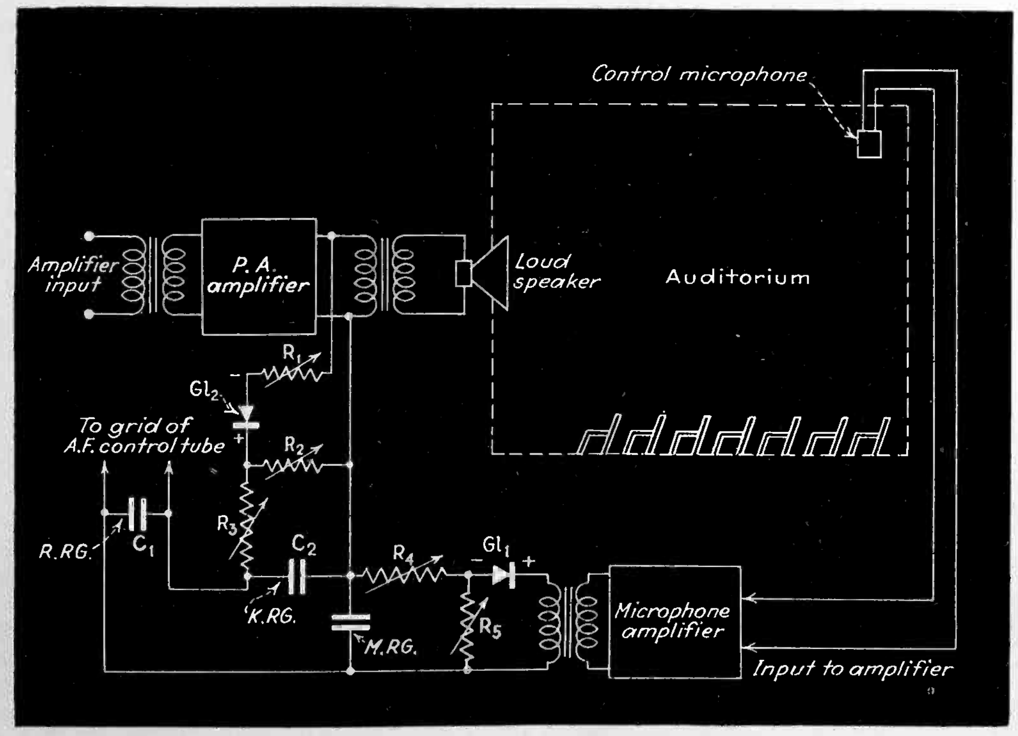
In the diagram *K.RG.*, the control voltage coming from the amplifier should be chosen somewhat larger than the *M.RG.*, which is to be compensated. Since in practice it may be difficult to keep the two control mechanisms fully in step with one another, *K.RG.* should in no case be smaller than *M.RG.*

If a time delay constant of about ½ to 1 second is chosen, by an adjustment of R_1-R_5, a microphone of lesser quality may be used, because then linear and nonlinear distortion may be neglected. The time constant must be in proportion to the distance between speaker and microphone so that the two compensating voltages remain in symmetry.

If distortion is to be avoided, the resultant control voltage *R.RG.* should be brought to the very first step of the pre-amplifier as variable grid bias.

With this device it is possible to bring the average volume level to a point agreeable to the listener and *below* the usual fixed level. Other applications are found in connection with P.A. systems of overflow meetings or of sport events, as well as for factories, where the noise level varies constantly.

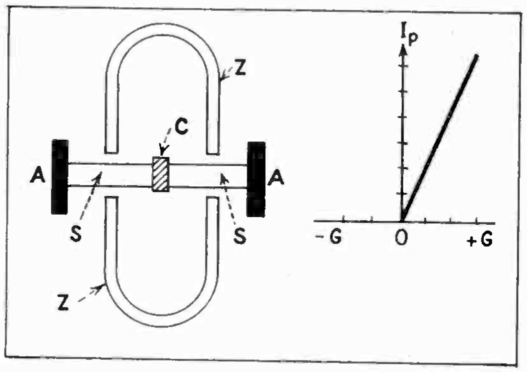
In broadcast receivers too this device in modified form has its possibilities as eliminator of home made interference from talkative listeners!



Circuit of Boucke's automatic gain control

A "Different" Amplifier Tube

[FUNKTECHNISCHE MONATSHEFTE, January 1936, 11-12]. An interesting new amplifier is now being developed in Germany, whose operating principles are similar to those of the cathode ray tube. (See also pages 14 and 46 *Electronics*, March 1936). In the adjoining diagram, C is a cathode located centrally within the cylinder Z, which



is slotted at the points S, as shown. The plates are A (for anode). The cathode, as usual is negative with respect to the plates. Since the cylinder is kept negative with respect to the cathode, any variation of its potential changes only the density, but not the form, of the electron bundles between cathode and plates. The resulting "plus" straight line curve of this tube recommends it as an ideal amplifier or as a rectifier. It is said to have an internal resistance of only 200 ohms.

• • •

A Wave Meter for Decimeter Waves

[LOTHAR ROHDE, Laboratory for Industrial Physics, Munich]. When working with wave-lengths between 30 cm. and 600 cm. it becomes necessary to ascertain the presence of oscillations in the desired range or to make sure that the wave-length remains constant. Lecher wires are not very convenient for this purpose, and it is simpler to use tuned circuits which have been calibrated with the aid of Lecher wires. Four tuned circuits consisting of a loop of wire and a two plate condenser adjusted by means of a micrometer screw which may be read to 0.001 mm. cover the range 30-500 cm. if given the following dimensions, the wire used having a diameter of 4 mm. in each case:

Range 30 to 60 cm.: loop 25 mm. diam., plates 8 mm. diam.

50 to 100 cm.: loop 35 mm. diam., plates 10 mm. diam.

90 to 210 cm.: loop 35 mm. diam., cylindrical condenser.

A Low Cost Wooden Mast

By V. J. Andrew and A. M. McGregor.

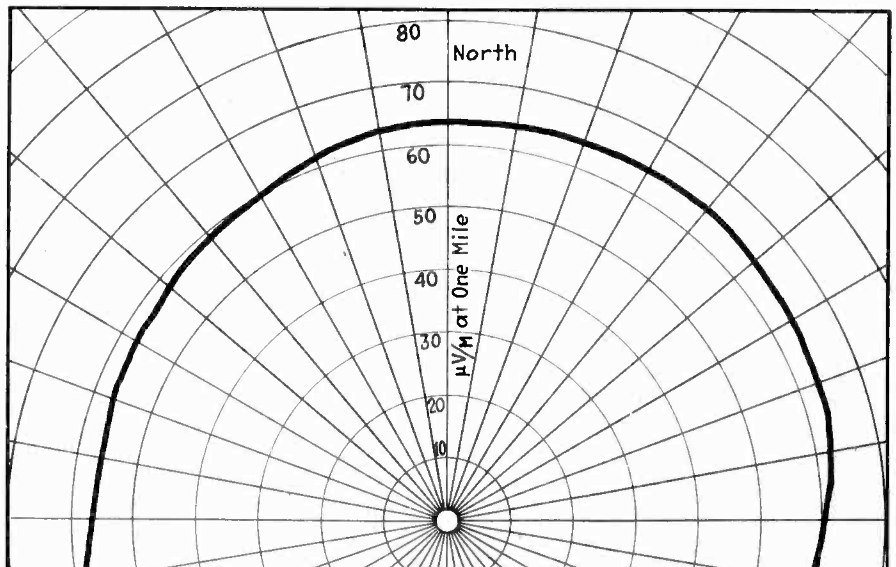
Station WJBC in Bloomington, Illinois, has recently installed a vertical radiator designed by the station personnel. It consists of a 160 foot guyed wood mast supporting the wire which serves as radiator.

The construction consists of four timbers bolted together to form a single pole. At the base each of the timbers are 6" x 6", forming a 12" x 12" pole. Each timber is 20' long, but they are mismatched so one of them ends every 5'. The structure is reduced at two points so that the top consists of four 4" x 4" pieces. Three sets of three guys each are used, and the base is set two feet in the ground. In one direction all of the guys come to an anchorage 85' from the base, and in the other directions the distance is somewhat greater. Buried railroad ties are used for anchorages.

The separate pieces were bored for the bolts while they were on the ground, and then were lifted in place by a rope passing through a pulley temporarily attached to the top of the preceding piece. The cost of the wood used was about $100.00, and the services of a steeplejack about $95.00.

The radiator proper is a wire about three feet from the mast which attaches to a basket-like top capacity in the form of a hemisphere of five foot radius. It is doubtful whether a capacity as small as this adds very materially to the performance. The ground system consists of radial wires from 175 to 200 feet long, buried 2 or 3 inches deep. The mast is provided with wooden cross arms for steps, and safely supports a man.

The field strength pattern at one mile is shown. The average field strength, 62.5 millivolts per meter, is remarkably high for a 100 watt station, doubtless due jointly to an effective radiator and to an unusually fine location.



One-mile field pattern at WJBC

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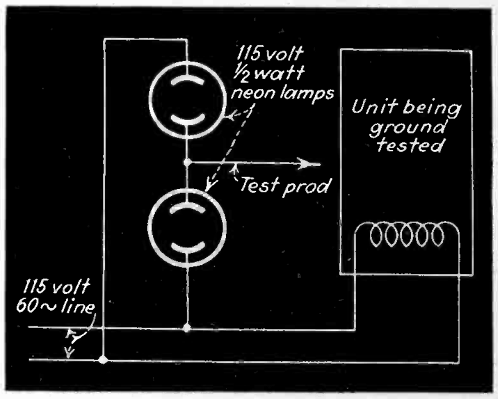
Neon Indicator Test Reveals Grounds

The accompanying diagram shows the connections of a neon-tube leakage indicator, which may be used to test production units for the presence of faulty insulation and grounds. According to John F. Foster of Dayton, Ohio, who supplied the information, the neon lamps used are of the half-watt size and must not light at a voltage lower than 75 volts. When used in connection with a 115 volt 60 cycle line, as shown, it is possible to detect a leakage to ground of one million ohms. Two lamps are used in series across the line so that both sides of the line may be checked without reversing the line plug, and with the appliance switch on or off. The use of two lamps also eliminates any capacity effect produced by the use of alternating current. If the unit under test is grounded, one of the two lamps will light, and the approximate position of the short in the winding may be found since the lamp which lights is connected to the side of the line farthest away from the ground.



For more sensitive tests, a single neon lamp of the same type may be used in series with a 50,000 ohm one watt resistor on a 500 volt d-c line. With such an arrangement, leakage resistances of the order of 5,000,000 or 6,000,000 ohms can be detected with ease.

• • •

British Highway Safety Studied with Electronic Instruments

Among the chief electronic developments in Great Britain during the past few months have been experiments in connection with cathode ray tubes and instruments for investigating street lighting. The number of road deaths has been viewed very seriously during the past year or two and as a step to reduce them the lighting in many main roads has been brought more up to date. High pressure mercury vapor lamps have become common and research is going on to try and produce low wattage units of this type. The best, so far having an efficiency of about 50 lumens per watt.

However, whether an illumination layout is good from a safety point of view depends on the brightness and reflectivity of the road surface and various instruments have been devised to measure these rather elusive factors. Reflectivity the easier of the two, is generally measured by a comparison or substitution method using photo cells. Brightness has been measured by two instruments operating on entirely different principles. In one, a silvered spot on a plain piece of glass is caused to disappear to the eye when an optical system is altered. The brightness being obtained from a calibration chart.

The other instrument is really a

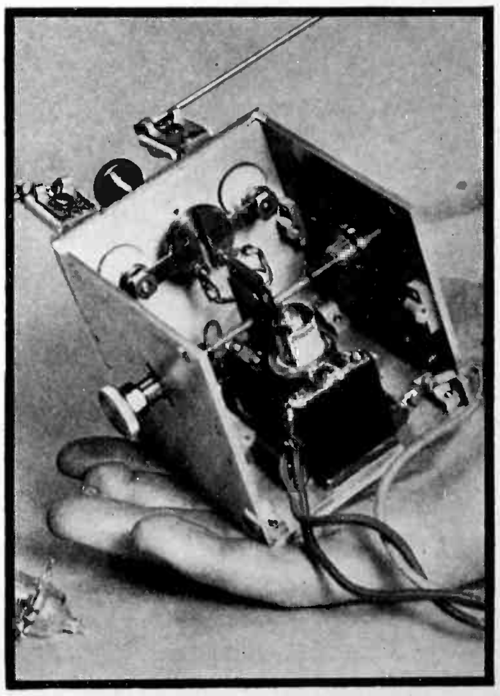

ECW 87

densitometer and should be considered in two parts. First of all a photographic plate is exposed but is divided into two halves. One half is an ordinary photograph of the road surface under test and the other a photograph of an optical wedge with a known background brightness.

In the densitometer proper, a beam of light about 2 mm. in diameter is passed through the plate and on to a photo cell. The areas of equal density on the road photograph and the wedge photograph being found in terms of the photo cell current and are balanced against each other by means of a potentiometer arrangement. A pantograph is attached to the apparatus and it is possible to trace contours of equal brightness on an enlarged print from the plate itself. Various foot candle meters have also been developed and improved for street lighting investigation, many of them employing the barrier layer photo cells.

A rather interesting link between the lighting researches and cathode ray tubes has also been made. It takes the form of an instrument to show the polar diagram of a lamp directly on the screen of a cathode ray tube. A mirror is rotated about the centre of the lamp to be examined and the light at various angles reflected on to a stationary photo cell, the cell current being amplified and then passed through a potentiometer. The rectangular coordinates for the oscillograph tube are obtained by mechanical contacts operating on the potentiometer circuit. The polar diagram is seen in the usual way on the oscillograph screen and the method is a vast improvement on the older method of observation and curve plotting.

NBC'S ONE-METER TRANSMITTER



This 0.2 watt, 300 mc. transmitter was developed to aid announcers in "foot-loose" broadcast pickups. A single acorn tube is used

Radio Controlled Lighthouse Functions Entirely Without Keeper

ACCORDING TO AN ANNOUNCEMENT from the Bureau of Lighthouses, Department of Commerce, a fully equipped lighthouse is now in commission at Peshtigo Reef in Green Bay, Lake Michigan, but no keeper is required to keep the equipment in order, or to operate it. The lighthouse has in addition to a powerful beam an electrically operated bell and a compressed air fog signal, all of which are remotely controlled by radio from a neighboring lighthouse eight miles away at Sherwood Point. Although no keeper remains in attendance, occasional visits are made to service the equipment and provision is made for staying at the station if necessary. In order to insure reliability of operation, practically every piece of apparatus in the installation has been provided in duplicate and provisions have been made for quick substitution of one for the other whenever the necessity arises.

In operation the light keeper at Sherwood Point observes weather conditions and starts his radio transmitter on approach of fog. By snapping a switch he starts the fog signal at Peshtigo Reef. When the fog clears the horn is stopped similarly. A gas-engine generator is provided at Sherwood Point for power supply for the control equipment should the regular power service fail. When the fog horn is in operation, a return-circuit radio telephone transmitter at the Peshtigo Reef station is automatically placed in operation. The keeper at Sherwood Point can thus hear the operation of the machinery and the blasts from the fog signal. In addition the two-way telephone system provides communication during servicing visits.

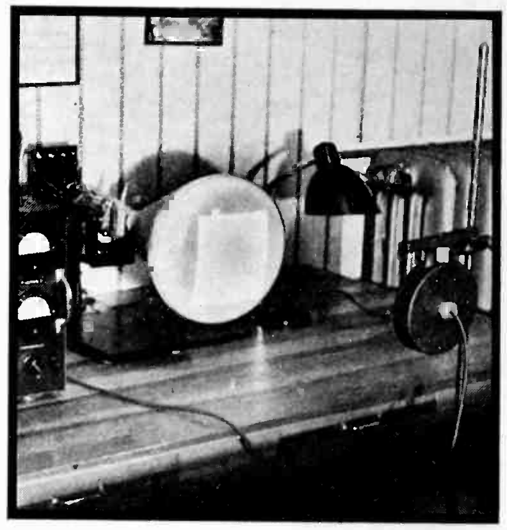
• • •

Frequency Recorder Used in Radio Listener Survey

A MECHANICAL METHOD of recording the frequencies to which a radio receiver is turned over a period of several weeks, by which the relative popularity of various radio programs may be judged, has been devised by Professors Robert F. Elder and L. F. Woodruff, of the Massachusetts Institute of Technology. The device contains a metering clock which records the days, hours, and minutes of listening, while a recording pencil, geared to the tuning dial of the receiver, records the frequency to which the receiver is tuned at any given time. A group of 1,000 homes in the Boston area were tested by this method. The results showed that the average family listened consistently from 3½ to 3¾ hours per day, and that Sunday evenings command the widest audience.

Measuring the Characteristics of Cathode Ray Tubes

THE ILLUSTRATION shows an interesting device, developed in the laboratory of Manfred von Ardenne, with which all the essential characteristics of cathode ray tubes, as used in measuring devices or in television, may be determined in a few minutes. With the aid of the barrier layer photo cell, shown at the right in the illustration, the device makes possible the measurement of the characteristic curve of the strength of the fluorescent light, at the anode potentials required in general practice. At the same time are also measured both the ray potential, and



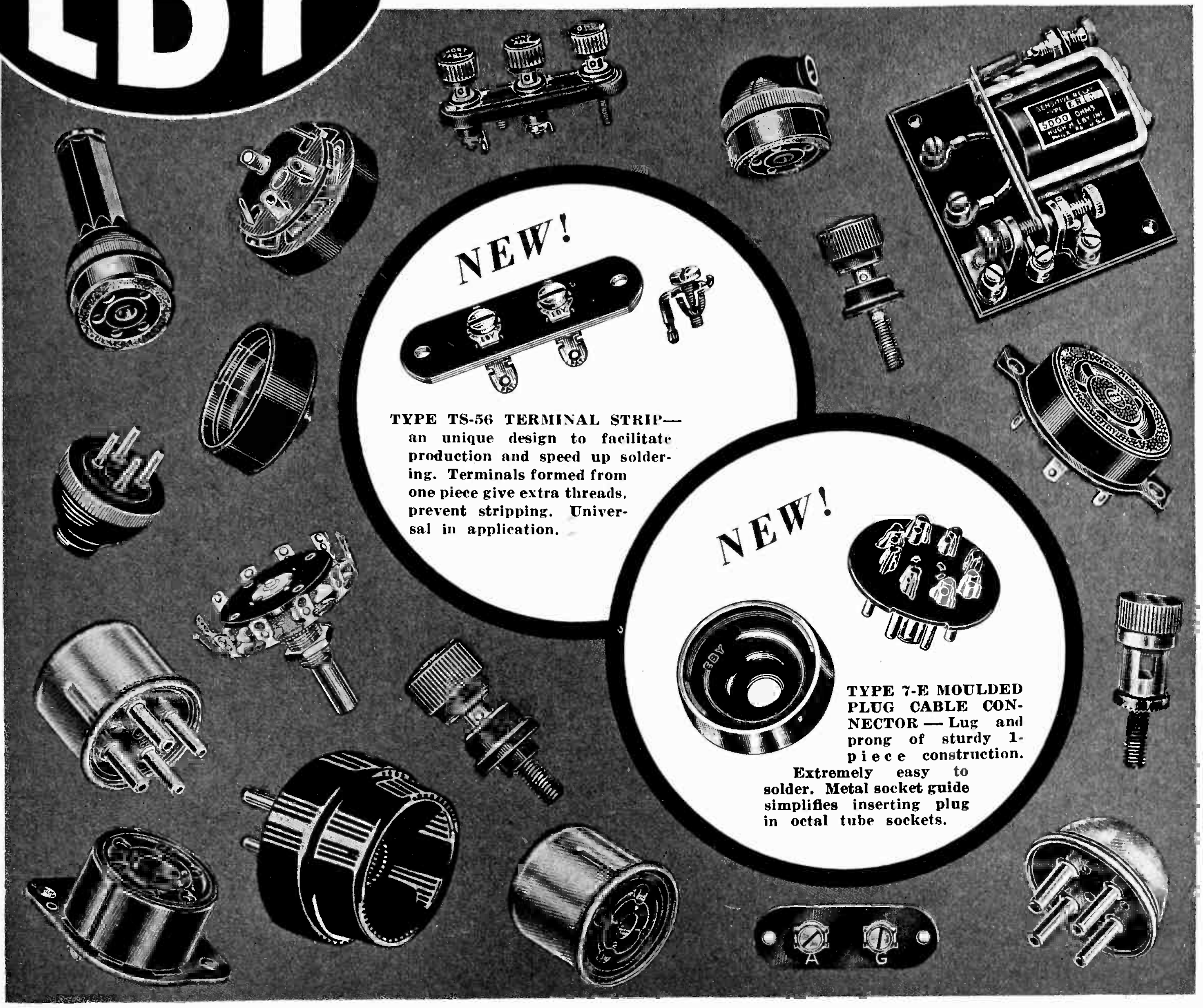
the lens electrode current which is dependent upon the control electrode potential. One may furthermore determine or control the dot sharpness, the corresponding potential for the lens electrode, sensitivity to deflection, the vacuum factor and conditions influencing saturation at the light screen.

• • •

Phototube to Facilitate Handling Visitors at Texas Centennial Exposition

WHEN THE Texas Centennial Exposition opens its gates in Dallas on June 6, phototubes will check the total number of visitors passing through the entrance gates and throughout the duration of the exposition. Each entrance turnstile will be equipped with a phototube counter connected by wire with the finance office of the Administration Building, where the officers of the exposition may check attendance figures continually. Any discrepancy between gate receipts and the number of persons visiting the exposition between specified hours can thereby be readily revealed. The unusual lighting effects which are planned for the exposition will likewise be tube controlled by the saturated reactor method, with full automatic control.

EBY PRESENTS . . . . .



√ QUALITY √ DURABILITY
√ SIMPLIFIED PRODUCTION

Here are radio components that live *up* to a reputation—not just *on* it.

From the new Terminal Strips and the new Type 7-E 8-prong Plug Cable Connectors with their many outstanding features, you will find Eby parts designed in full keeping with today's more exacting radio production requirements—and you will find full EBY QUALITY built into every one of them.

Eby Engineers will welcome the opportunity to assist in adapting standard units to your needs—or in making special parts to specifications. Samples and prices gladly sent.

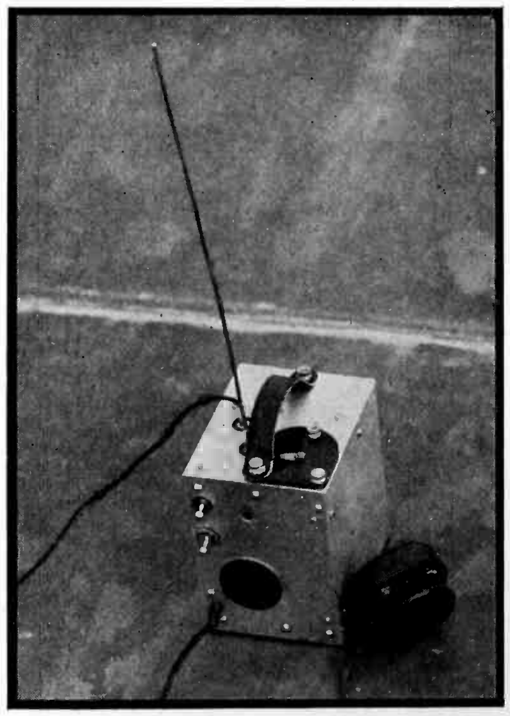
Write for our new 1936 catalog describing our complete line of Switches, Terminal Strips, Speaker Plugs, Shielded Cable Plugs, Cable Connectors, Binding Posts, Moulded Sockets, Knobs and Dials, Electric Eyes and Relays.

HUGH H. EBY, Inc. 2066 Hunting Park Ave., Philadelphia, Pa.

Coaxial Cable Used on German Television Circuit

ACCORDING TO A REPORT from the Electrical Division of the Department of Commerce, a new coaxial television cable has been installed by Siemens and Halske between Berlin and Leipzig, in Germany. Construction of the cable is as follows: The inner copper wire, which is 5 millimeters in diameter, is kept in place by a spiral of insulating material known as "styroflex" which is a transparent flexible material of paper thickness. The spiral is surrounded by a "styroflex" sleeve on top of which is a sleeve of spiral wound flat copper bands held together with copper foil, over which is a linen sleeve finally covered with a lead jacket. The frequency band capable of being handled by the cable is 4,000 kilocycles, of which only 500 kilocycles is now being used for television for a 180-line, 25-frame picture. Later it is believed that a 2,000 kilocycle band suitable for 400-line, 25-frame pictures will be used. A new type of cable called "symmetrische" has been designed by the same company and it is claimed to be equivalent if not superior to the coaxial type of cable. The "symmetrische" cable contains two wires in one core, one of which handles the return circuit instead of using the spiral wound copper sleeve as is done in the coaxial system.

3-POUND TRANSCEIVER



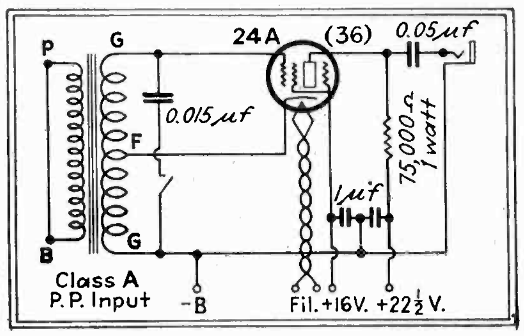
This amateur-built transceiver is complete with batteries in a 3"x3"x5" case. Note the receiver and mike mounted back-to-back. A set of batteries gives 1/10 watt for 50 hours; 3 mile range with ½ wave antenna

An Electron-coupled a-f Oscillator

By T. H. Stahl, Sr.

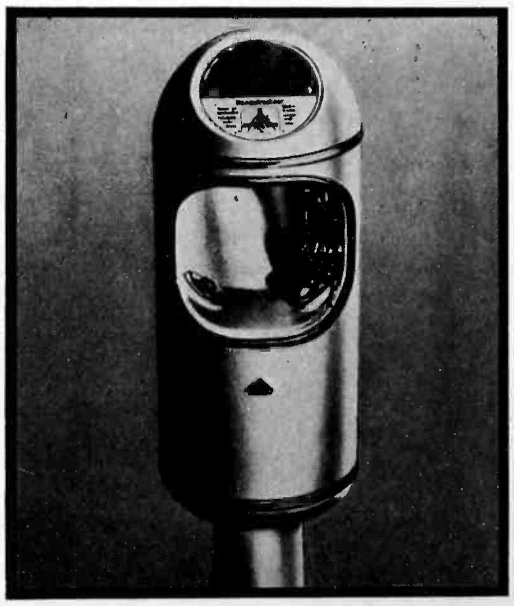
For a large part of laboratory work a single frequency oscillator will take the place of a large and expensive beat frequency oscillator. An electron coupled a-f oscillator has the advantage of requiring only a single tube and very low B supply.

The schematic circuit is shown. Constants given were found suitable for use with a type 24 tube. For work



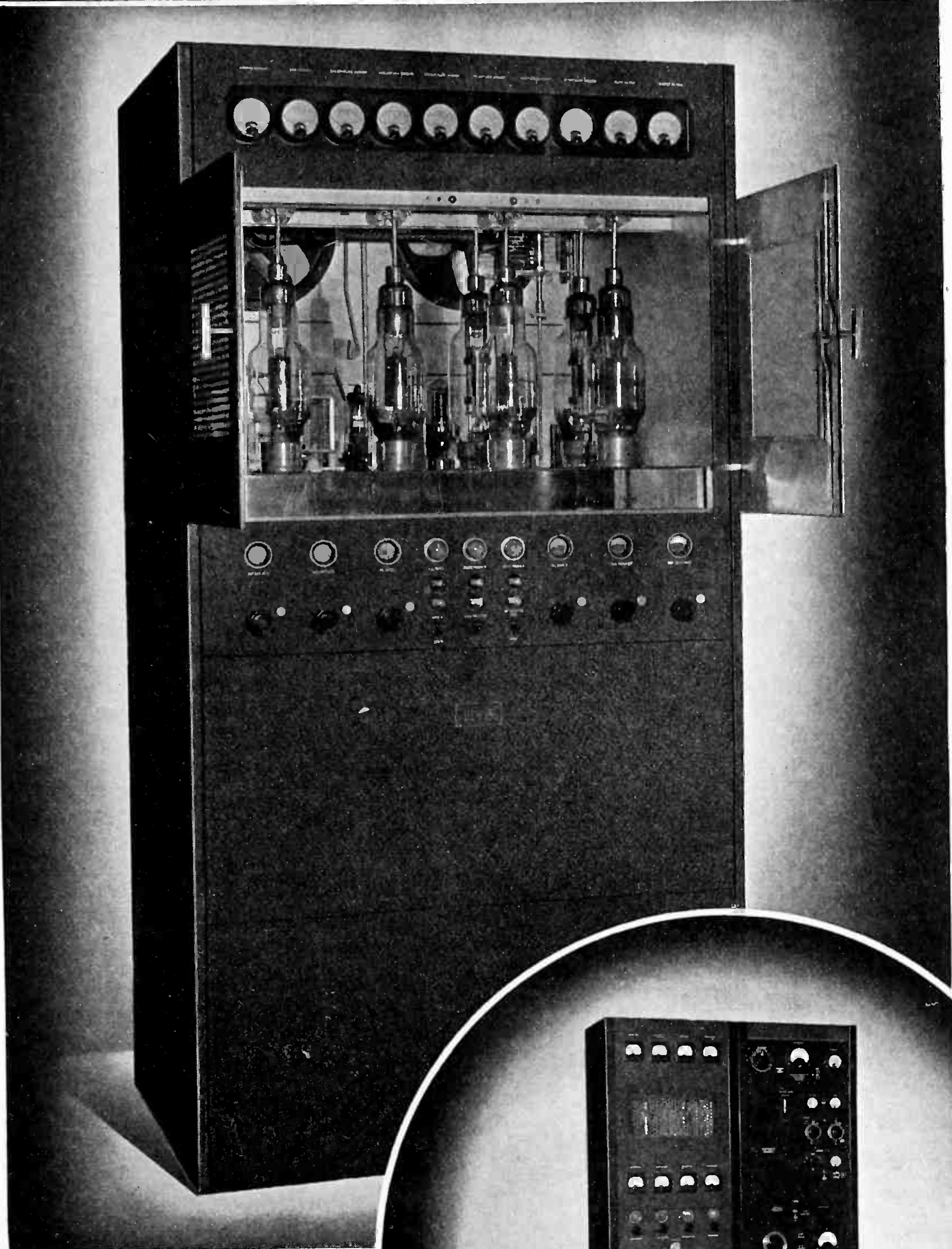
in which there might be danger of a-c heater supply introducing error a 36 with d-c heater supply may be substituted. Constants given produced approximately 1070 cycles output and a 0.015 μf condenser tuned it to 420 cycles. Higher output can be obtained by raising the plate supply voltages. Shorting the primary reduces the inductance and increases the frequency of oscillation. A few of the uses of ths unit are: audio voltage for modulation measurements, amplifier gain tests, bridge measurements, etc.

PHOTOTUBE CONTROLS HAND-DRIER



This German hot-air drier, similar to those used in this country, is fitted with a photoelectric control which turns on the air-blast automatically

GOOD ENGINEERING PRACTICE



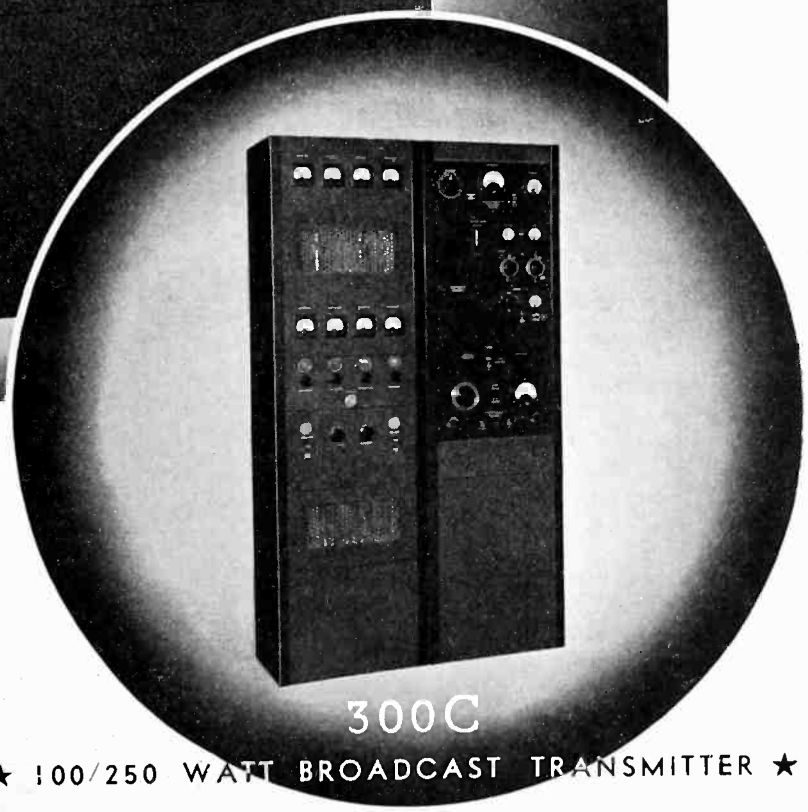
20C 1000 WATT

BROADCAST
TRANSMITTER

THE COLLINS RADIO COMPANY manufactures every type of radio transmitting equipment. COLLINS microphones, speech input systems, transmitters and antenna matching units are all properly coordinated to assure efficient and reliable performance.

Each COLLINS broadcast transmitter installation meets every requirement of the Federal Communications Commission in connection with "good engineering practice."

Full Technical Details Covering Radio Transmitting Equipment Mailed on Request to Interested Broadcasters



300C

★ 100/250 WATT BROADCAST TRANSMITTER ★

COLLINS RADIO COMPANY

CEDAR RAPIDS, IOWA ★ NEW YORK, 11 West Forty-Second Street

MANUFACTURING REVIEW

News

Dr. E. F. Lowry, recently appointed Director of Research and Development for Continental Electric Company

✦ **Stromberg Carlson Telephone Manufacturing Co.**, in a recent financial report, showed a net profit of $46,654 for 1935, after taxes, depreciation and other charges.

✦ **In the annual report** of the Radio Corporation of America, David Sarnoff said that field tests at the television broadcasting station on the Empire State Building would be started on June 29. These tests, according to Mr. Sarnoff, will require from twelve to fifteen months.

✦ **Reorganization.** Word has been received by wire to the effect that on April 17 Judge Philip Sullivan of the District Court of the United States, Northern District of Illinois, approved the reorganization plan of the General Household Utilities Company, well known manufacturers of radio receivers in Marion, Indiana.

✦ **DeJur-Amsco Corporation** have moved their factory and offices from 95 Morton Street, New York City, to Shelton, Connecticut, where operations are now in full swing.

✦ **Callite Products Company**, 39th St., Union City, N. J., announces the appointment of **Dr. C. S. Brainin** as manager of its newly formed department for the manufacture of a complete line of "Calliflex" thermostatic bimetals. Dr. Brainin has been on the research staff of the Baker Platinum Works, of Newark, N. J. **Mr. Mark Lincoln**, a previous associate of Dr. Brainin, has been appointed factory superintendent in charge of bimetal production.

✦ **Harold J. McCreary** has been appointed chief engineer of the Leich Electric Company, Genoa, Illinois. Mr. McCreary has been active in the communication field for many years. His most recent work has been in connection with cathode ray television transmission.

✦ **Thad R. Goldsborough**, registered patent attorney, has opened an office for private practice, specializing in the field of electronics. He is located in Suite 201-205, McLachlen Building, Washington, D. C. Mr. Goldsborough operates in a consulting capacity in connection with patent and trade mark soliciting, validity, title and infringement searches, patent sale and license negotiations, and patent cases.

New Products

Studio Speech Input Equipment

Remler Company, Ltd., 2101 Bryant Street, San Francisco, California, announces their Model 70-A studio speech input equipment. Operation of this system is accomplished at the control turret. The six-position mixer uses six, three-position key switches to be placed in any position on either channel thus permitting an audition to be run simultaneously with the program. The channels are identified on each position by indicator lamps. A transmission line switch is used which connects the input on the transmitter line to the studio line or to a remote studio or chain broadcast line.

An all-wave, high-fidelity, six tube superheterodyne radio tuner is incorporated in the 70-A Speech Input Equipment. Of special interest is its high-fidelity circuit band-spread which permits response up to 5,000 c.p.s. at normal position and response up to 8,000 c.p.s. at high fidelity position. An illuminated meter type tuning indicator is used to insure accurate tuning. The complete system operates from a 110 to 125 volts a.c. line and requires 405 watts.

High Frequency Chokes

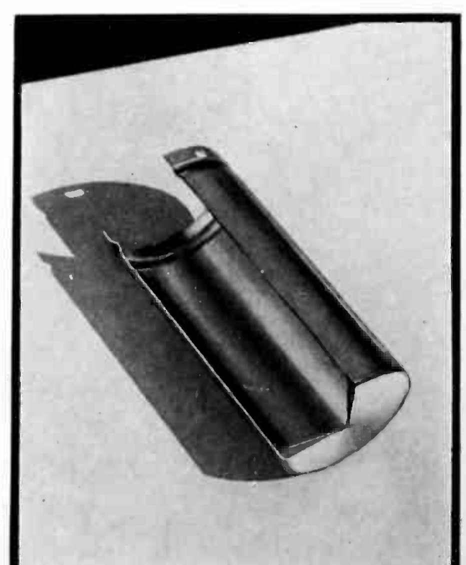
Ohmite Manufacturing Company, 4835 West Flournoy Street, Chicago, Illinois, has developed a new line of plate chokes, all of which are capable of carrying 1,000 milliamperes without overload. There are four different chokes in this line, with specifications as follows: Z-1—60,000 kc. (5 meters); Z-2, 28,000—14,000 kc. (10-20 meters); Z-3, 14,000 to 7,000 kc. (20-40 meters); and Z-4 14,000—1,800 kc. (20-160 meters). These chokes are wound on porcelain tubes and the windings insulated to hold each turn in place and to protect the wire from moisture.

Low Capacity Trimmer

The F. W. Sickles Company, 300 Main St., Springfield, Massachusetts offers a new low-capacity trimmer known as the LX, made now in various capacities and gangs. The triple assembly has provisions for mounting to a coil form, providing practical and compact means for assembly. The power factor at 26 mc. is .050, and at 15 megacycles is .033.

Extruded Zinc Housings

General Extrusion Company, Hillside, New Jersey, in cooperation with



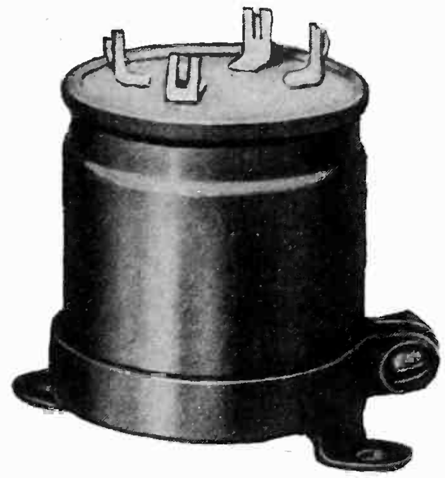
the New Jersey Zinc Company, has developed a new auto radio B voltage supplier housing, extruded in zinc. The heavy base of the housing prevents vibration from being set up.

Pertinent Data

Frequency range. . 20 to 20,000 cycles
Operating levels. . . . . . —80 to +6 dB
Shielding. . . . . Magnetic and static
Average unit weight. . . . . 3¼ oz.
Cubic content . . . . 2¼ cu. in.
Diameter of case. . . . . 1⅜ in.
Height of case. . . . . 1½ in.
Type mounting . . . . Reversible
No. of standard designs. 35

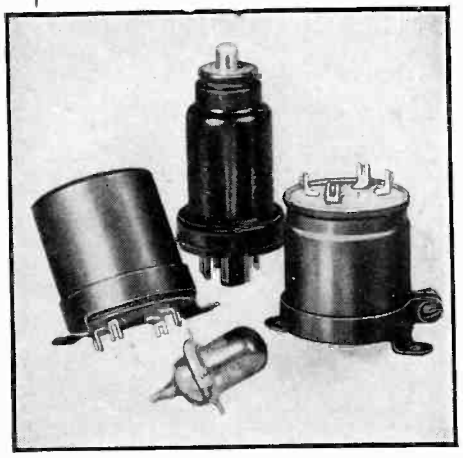
Types available—

Line-to-grid	Plate-to-line
Mixing	Line-matching
Interstage	Audio Reactors



ACTUAL SIZE

Showing AmerTran Midgets (with mounting brackets in two positions) in comparison with all-metal and acorn tubes.



New "MIDGET"

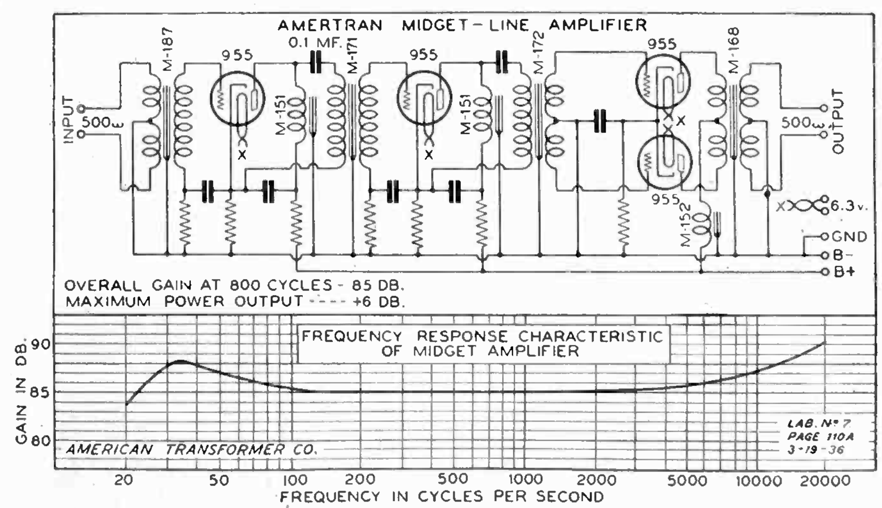
AUDIO TRANSFORMERS BY

AMERTRAN

Smallest Available High Quality Transformers for Wide-Band Sound Reproduction in Amplifiers for Portable, Broadcast and Aircraft Service

Drastic reduction in both size and weight of low-level (+6 dB output) amplifiers is possible as a result of AmerTran's latest laboratory development—Midget Audio Components. These are high-quality audio transformers and reactors suitable for use in broadcasting and recording equipment, and are available from stock for all usual applications, including mixing, line-to-grid, interstage, plate-to-line, and reactor types. A Midget filter reactor and small plate-filament transformer are also offered as companion equipment so that complete apparatus may be assembled.

Three-stage amplifier utilizing acorn tubes and AmerTran Midget components throughout with curve indicating gain and frequency characteristic obtained.



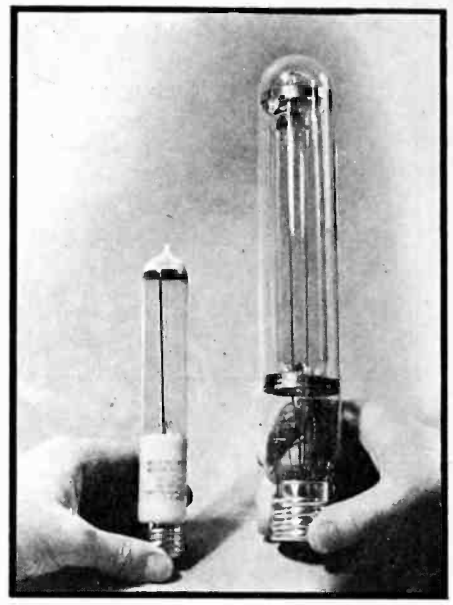
May we send you complete information on AmerTran Midget Audio Components? Ask for Bulletin 1003.

TRANSFORMERS

Manufactured Since 1901 by— AMERICAN TRANSFORMER COMPANY
172 Emmet St. . . . . Newark, N. J.

Mercury Vapor Lamp

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY announces a 250 watt high intensity mercury vapor lamp. This lamp is about one-third the size of the present 400 watt design. It has an efficiency of about 30 lumens per watt, produces 7,500 lumens of light



of distinctive color, for an average life of 2,000 hours, has a medium screw base, an overall length of 8 inches and can be burned in any position. Because of its single T-9, clear glass bulb, as contrasted to the double bulb of the 400 watt design, it is susceptible to drafts and must therefore be operated in enclosing globes to assure maximum output of light. W. E. & M. Co., East Pittsburgh, Pennsylvania.

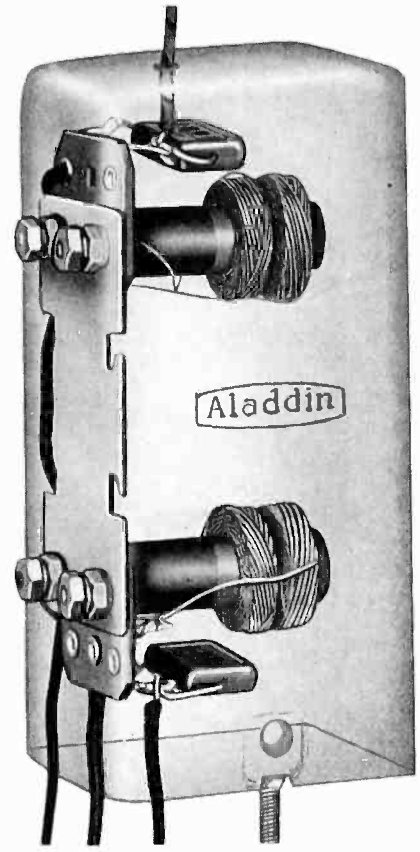
Speakers

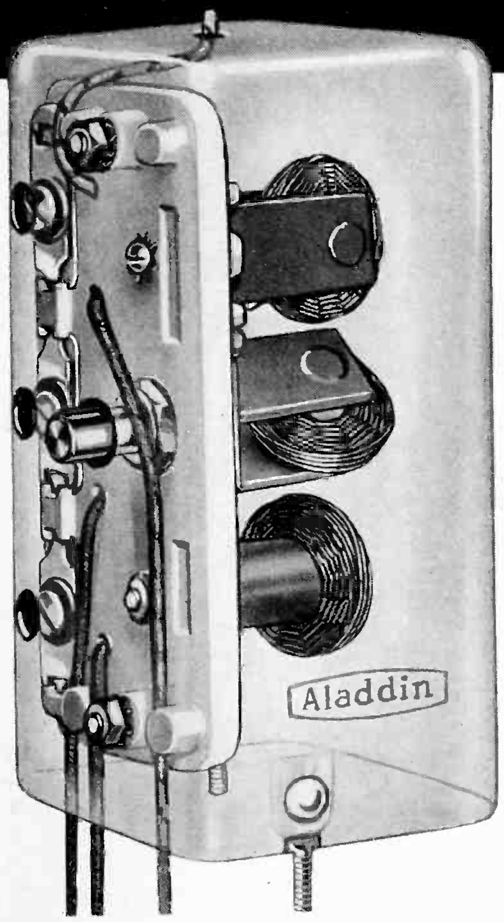
THE ARLAB MANUFACTURING COMPANY, INC., 1250 North Paulina Street, Chicago, Illinois, announce their new line of "Kinetic" speakers, using the new Alnico magnetic alloy. These speakers are of the laminated armature construction and the magnets use about ¼ of an ounce of this alloy. The 5 in. speaker weighs ⅞ lb. and lists at $3 each; the 6 in. 1⅛ lb., listing at $3.50 and the 8½ in. size 1½ lb. listing at $5 each.

Sound System

SOUND APPARATUS COMPANY, 150 West 42nd Street, New York City, announces reproducing systems built to order at reasonable rates. One such system includes a dynamic reproducer type R5, with a flat response curve, free from resonance and other variations over a wide frequency range, plus a suitable low frequency equalizer and a set of three low-pass filters. These cut off very sharply 4, 6 and 8 kilocycles and are a distinct improvement over the average tone control employed on phonograph reproducers.

NEW distinctive Aladdin Polyiron Transformers

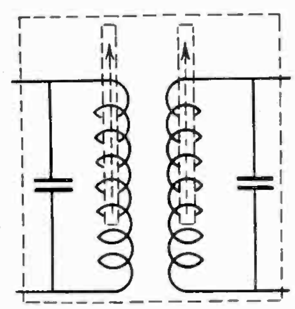




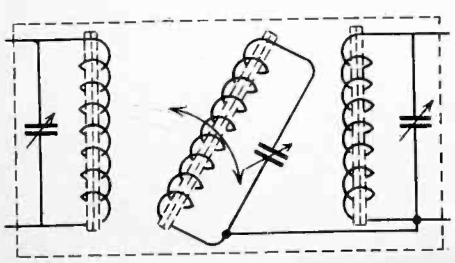
Characteristic of Aladdin engineering are two new and different i-f transformers having features, made possible by the use of Polyiron, which are far in advance of all previous i-f transformer designs!

In Type P, permeability adjustment replaces the usual capacity trimmers in an advanced design i-f transformer. Fixed sealed condensers offer stability of alignment and freedom from mechanical shifts causing capacity changes. The adjustable Polyiron cores in primary and secondary coils provide the necessary tuning range, high gain, and narrow band width.

Type D is a 3-circuit capacity trimmed continuous flat top band expansion i-f transformer in which the center inductor may be rotated with respect to the other two inductors, varying the selectivity without appreciable loss in gain or departure from a flat top, sharp cut-off characteristic! High fidelity or split channel selectivity is thus at the option of the users! To you who are interested in outstanding achievement in your 1937 line, concentration of thought and effort on these Aladdin Polyiron components will make that achievement possible. Feature *Selective Band Expansion* in your best 1937 deluxe receiver designs!



Type P



Type D

These devices are manufactured under one or more of the following U. S. Letters Patents:
1887380, 1940228, 1978568, 1978599, 1978600, 1982689, 1982690, 1997453, 2002500, 2005203, 2018626, 2028534, 2032580, 2032914, 2035439.
Other patents pending.

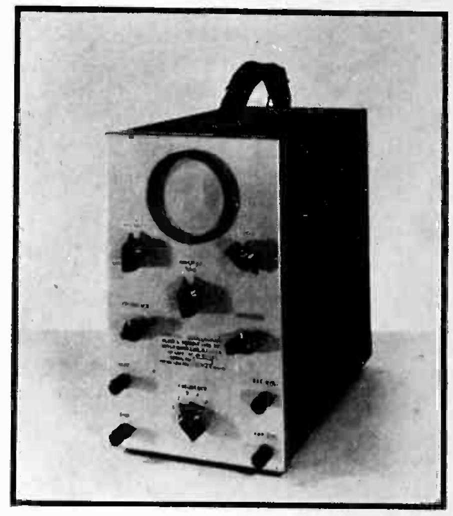
Aladdin

Aladdin Radio Industries, Inc., 466 West Superior Street, Chicago, Illinois

Licencee of Johnson Laboratories, Inc.

Oscillograph

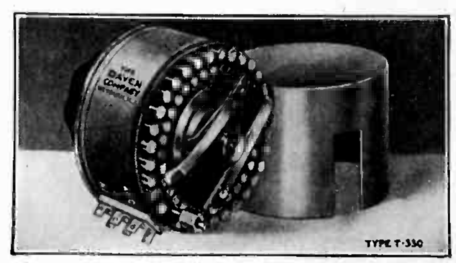
ALLEN B. DUMONT LABORATORIES, INC., Upper Montclair, New Jersey, announces a new cathode ray oscillograph, known as type 154. It has a linear sweep circuit range of 10 to



1,000,000 cycles using a condenser discharge circuit. It uses a pentode constant current regulator; has an amplifier with a voltage gain of 100 between 10 and 25,000 cycles, and 25 at 1,000,000 cycles. D-c or very high frequency patterns may be measured. It lists at $74.50, with tubes.

"T" Attenuator

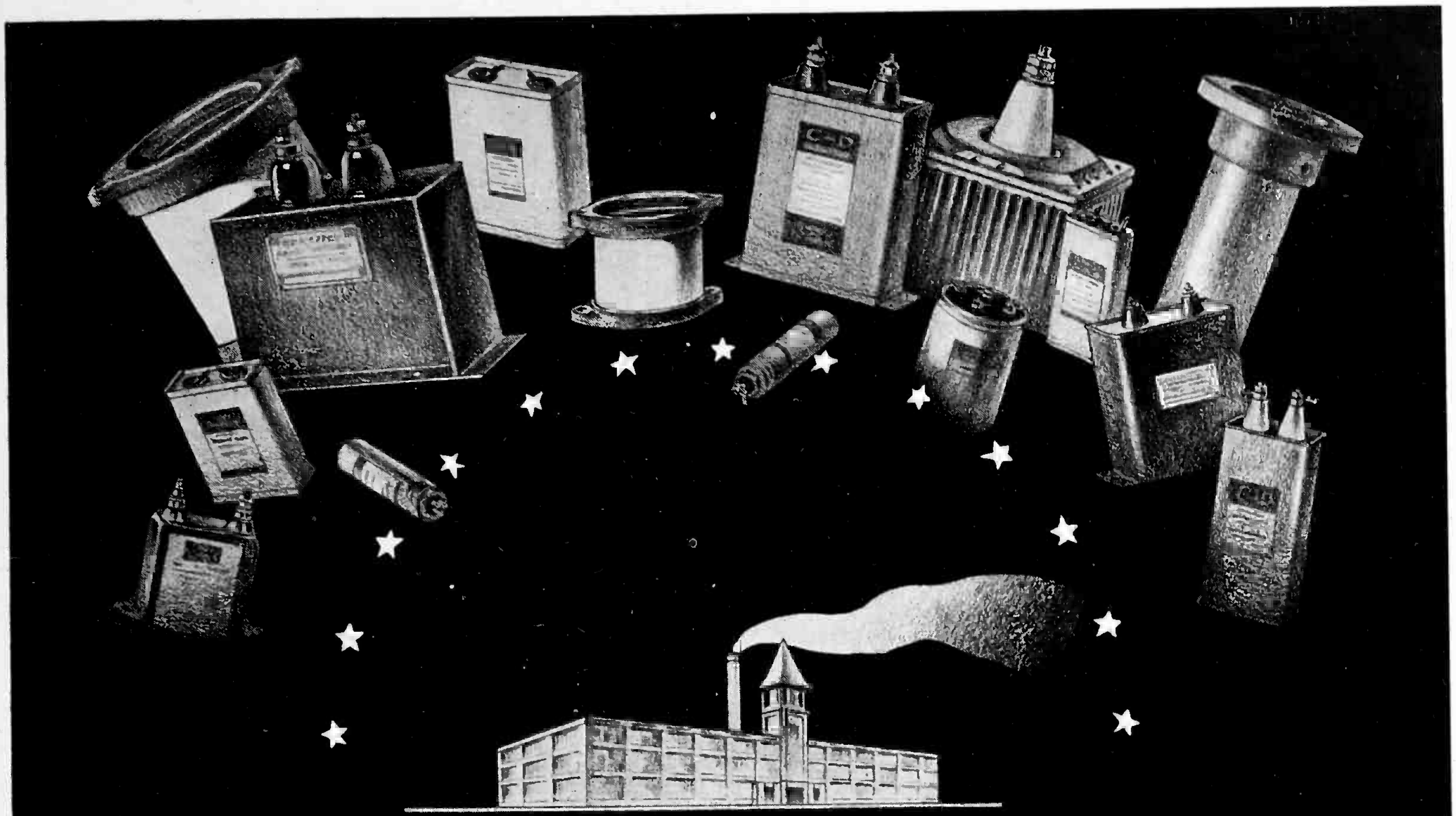
THE DAVEN COMPANY, 158 Summit Street, Newark, New Jersey, announce the availability of a high quality popular-priced 30-step "T" network. This unit, "T-330," is applicable to low level mixing, has zero insertion loss, constant input and output impedance at all settings of the dial, wide attenuation range, and extremely low



switch noise level. Its wiping type, multi-leaf switch require low but constant torque at all settings.

The attenuator is offered in all impedances from 30 to 600 ohms with attenuation of 1.5 db per step. The loss per step is increased on the last few contacts. Unequal input and output impedances designed for minimum loss may be obtained upon request.

This unit is interchangeable electrically and mechanically with the popular ladder type attenuators. The size is only $2\frac{11}{16}$" in diameter, by $2\frac{1}{16}$" back of panel space. The net weight is 12 ounces.



CITED FOR DISTINGUISHED PERFORMANCE IN THE RADIO INDUSTRY

CORNELL-DUBILIER CONDENSERS

NO citation could be more impressive than the acceptance of Cornell-Dubilier condensers by the radio engineering fraternity. In the electronic field and in the field of physio-therapy, in broadcasting, and in high tension systems, in radio receivers and in special applications for the many phases of the radio engineering art, engineers have come to the realization that C-D condensers serve their purpose best.

The experience of twenty-six years in the manufacture of condensers. The engineering and research facilities of the world's largest condenser manufacturing plant. Continuous inspection and test of raw materials. Careful supervision and control of production methods. Unceasing modernization and improvement of equipment and machinery. These are factors behind the dependability, advanced design and economy of Cornell-Dubilier condensers.

DYKANOL • PAPER • MICA • WET & DRY ELECTROLYTICS

Available in the most complete capacity and voltage range. Special Catalog No. 127 for radio and industrial engineers now available. Send for your copy today.

VISIT WITH US AT THE I. R. E. CONVENTION • HOTEL STATLER, CLEVELAND, OHIO

CORNELL-DUBILIER CORPORATION

4380 BRONX BOULEVARD NEW YORK, N.Y.

Transformers

FERRANTI ELECTRIC, INC., 130 West 42nd St., New York, N. Y., announces a complete line of high fidelity audio transformers and reactors, known as Super High Fidelity, Series A. These

units have a frequency response of within 1 db. from 30 to 12,000 cycles, according to the manufacturer, and employ the core type construction which renders them entirely free from hum and pickup. Each unit is fitted with electrostatic shields between windings and is designed for extremely low insertion loss. The weights and dimensions of the line of transformers are as follows: weight, 2 lb.; width, 2¾ in.; depth, 2⅛ in.; height, 2⅞ in.; mounting, 2⅛ x 1⅝ in.

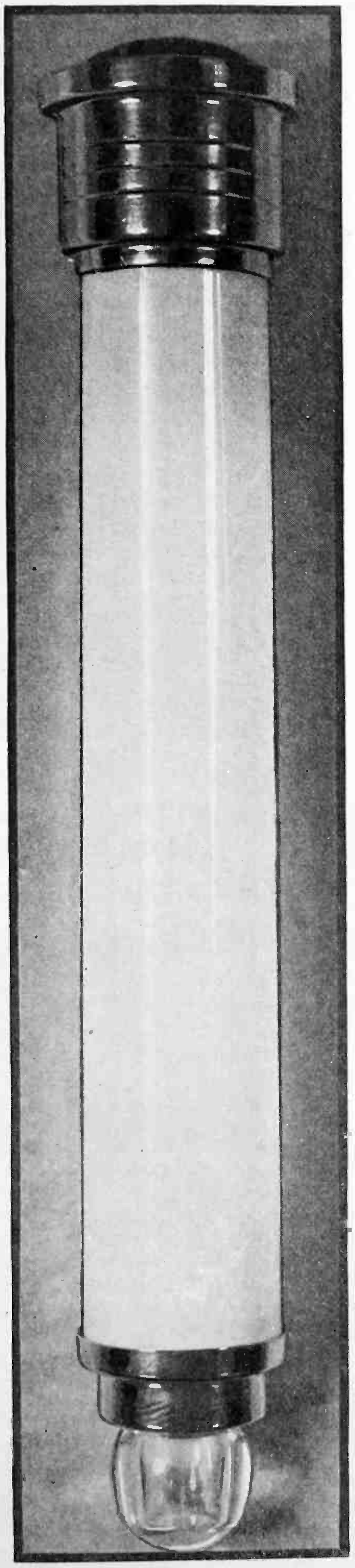
Speakers

THE OXFORD-TARTAK RADIO CORPORATION, 915 West Van Buren Street, Chicago, Illinois, recently developed a new series of 6, 8 and 11 inch electro-dynamic replacement speakers. This speaker incorporates features which make for improvement in tone quality and also permits a quick easy change of field coil, if necessary, to secure the proper combination of transformer and field "for the job" when needed. This company also announces a new Exponential Horn which improves reproduction and projective power for sound truck, auditorium and public address jobs. The horn is constructed of patented fabricated acoustic material, and is weatherproof and waterproof. It is reinforced with steel bands to make it durable and is designed for use with electro-dynamic cone type trumpet unit. The back cover is so designed as to give a minimum of back pressure. This horn lists at $25. Response and characteristics curves will be furnished by the manufacturer upon request.

TRANSLUCENT SHEETS·

not Brittle-

FOR LIGHTING FIXTURES



Translucent Formica — a recent development of the Formica laboratories — now makes available a translucent sheet in white, colors and certain patterns that is not fragile. It will stand a lot of grief without cracking and will never shatter. For lighting effects where a fragile material is not desirable this sheet opens up new possibilities. It has already been used for such purposes as translucent panels on illuminated counters and bars, signs, louvers and many similar purposes. The sheet is available in white, orange red, blue and green. It may be had with an opaque face in any Formica color which can be sandblasted away to form letters or designs. It can also be had with an opaque face and colored translucent back, so that when the front is sandblasted away the transmitted light will be in color.

We shall be glad to send samples and data to any one interested.

THE FORMICA INSULATION CO.
4638 Spring Grove Ave. • Cincinnati, O.

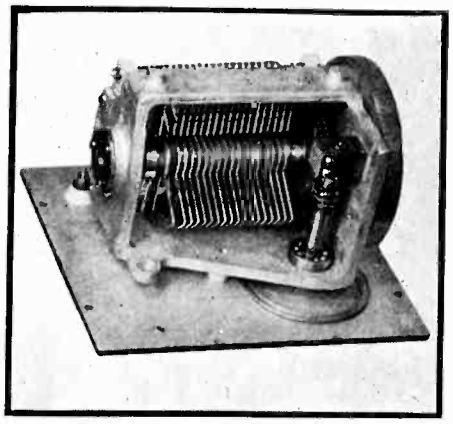
Fixture designed by Paul H. Goodell, Cincinnati, Ohio.

FORMICA

FOR FURNITURE & FIXTURES

Precision Condenser

General Radio Company, 30 State St., Cambridge, Massachusetts, announces a worm-driven air condenser of interest to engineers. Type 722 is constructed with stability of capacitance as the chief requirement. Two mounted



models are available. Type 722-H maximum capacity of 1,400 $\mu\mu$f and Type 722-F with a maximum capacity of 500 $\mu\mu$f. The overall characteristics of the Type 722 are similar to those of the older type 222. Prices include a capacitance calibration table giving the capacity for 26 points to 1 $\mu\mu$f or 0.1 per cent.

Sand and Gravel Aggregate

George F. Pettinos, Inc., 1206 Locust Street, Philadelphia, Pennsylvania, announce that they are in a position to offer a special sand and gravel aggregate for concrete foundations subjected to high-frequency currents. This material is especially recommended for tower foundations of high power transmitting stations, since its use eliminates the heating of foundations caused by induction.

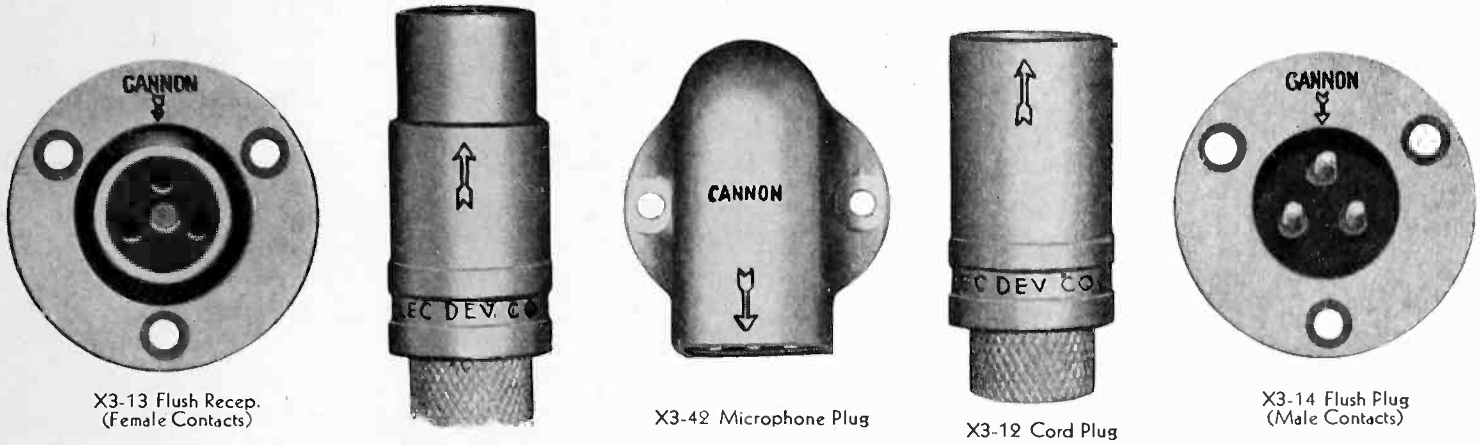
Tubes

The Arcturus Radio Tube Company, Newark, New Jersey, announces the addition of Types 6N6 and 6R7 to its line of Coronet tubes. Type 6N6 is a duplex-triode power output tube, permitting circuit simplicity and efficient operation in public address systems and regular amplifier work. This tube has a good overload characteristic, no grid current being detected even when the tube is overloaded 60 per cent above its rating; 7 watts output can be obtained with a distortion of only 9 per cent. The 6R7 Coronet is a duplex-diode triode, somewhat similar to the type 75, but having a mutual conductance of 1,900 and a μ of 16.

SAVE THIS PAGE FOR CATALOGUE REFERENCE . . .

Now–Midget Plugs with CANNON quality at a Popular Price!

(Each fitting is pictured actual size)



X3-13 Flush Recep. (Female Contacts) — X3-11 Cord Recep. — X3-42 Microphone Plug — X3-12 Cord Plug — X3-14 Flush Plug (Male Contacts)

LIST PRICE . . . $1.00 EACH FITTING

THESE MIDGET JEWELS of the Plug Family are for use on any electronic circuit requiring three conductors or less in any cable from 3/16 in. to 9/32 in. Or, on special order, fittings can be bored to accommodate 5/16 in. cable.

• DESCRIPTION AND SPECIFICATIONS •

Bronze, self-cleaning contacts . . . open-sided, tinned solder lugs. Positive cord grip for 3/16 in. to 9/32 in. round cable. Flush plates 1 3/8 in. diameter; cord fittings 3/4 in. barrel diameter. Weight of fittings: Less than 2 oz. each. Special duraluminum lighter weight units at slightly higher price for air service.

All fittings made in 3 poles only. Standard finish: Cadmium-plated aluminum lacquered. Polished chromium and statuary bronze 15c, net, extra. Special finishes quoted on request.

Discounts vary witn quantities covered by single order.

CANNON ELECTRIC DEVELOPMENT CO.

P. O. BOX 75, STA. A, LOS ANGELES CALIFORNIA. EASTERN SALES OFFICE, 220 FIFTH AVENUE NEW YORK, N. Y.

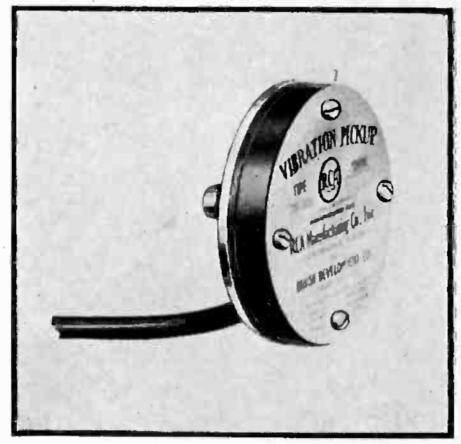
Note: On account of low price, these fittings cannot be combined with other series of CANNON fittings to compute discounts. NEW ACCOUNTS shipped C.O.D. to conserve time pending receipt of banking and three commercial trade references. CREDIT TERMS: 2% 10 days; Net 30 days.

• The Cannon Company builds a group of Cable Fittings in excess of 600 varying from 1 to 34 poles.

CANNON PLUGS

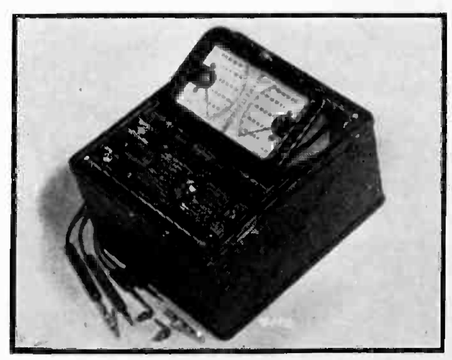
Vibration Pickup

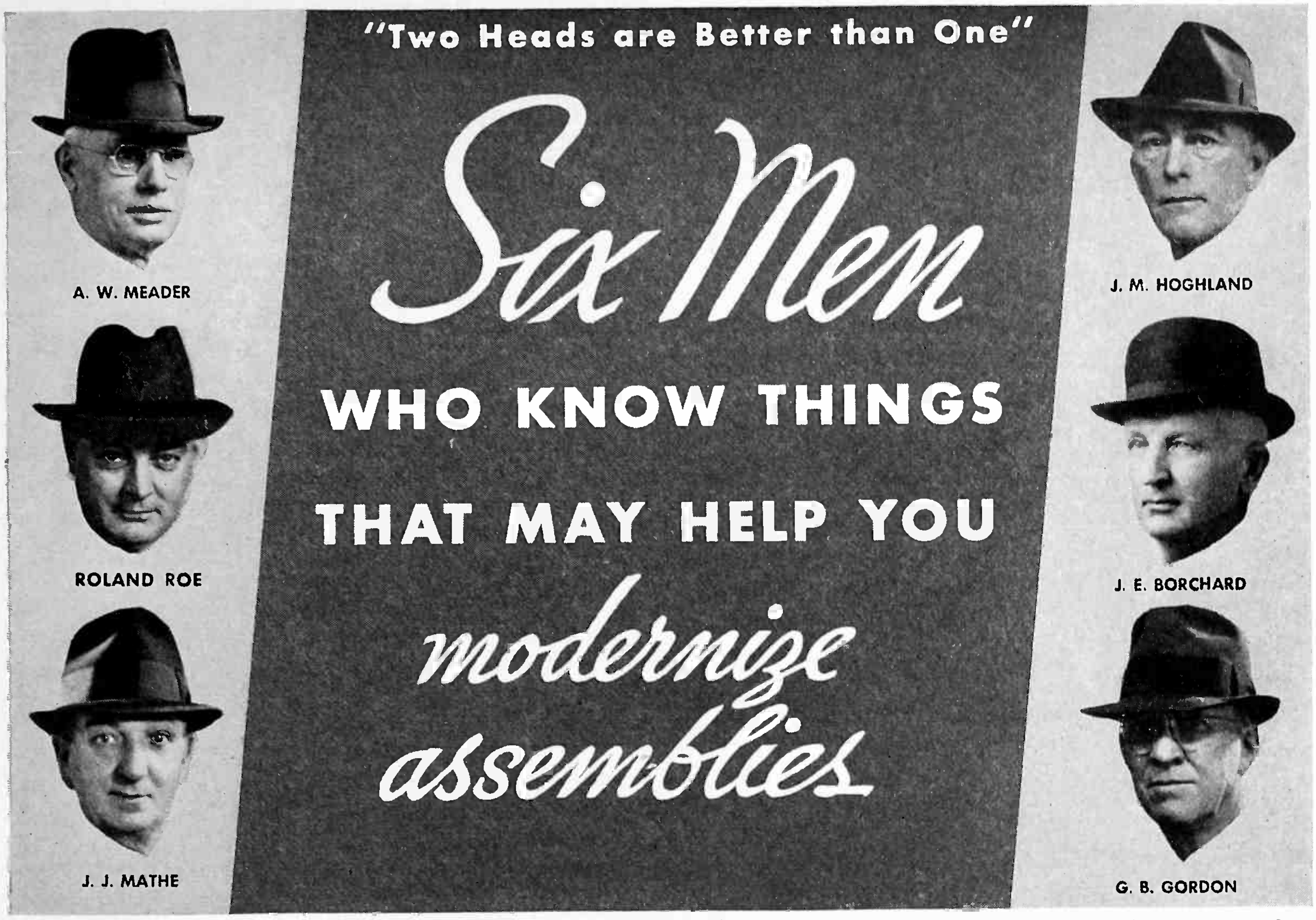
RCA MANUFACTURING COMPANY, INC., Parts Division, Camden, New Jersey, has a new vibration pickup for varied use. By means of this pickup mechanical vibration or motion may be converted into electrical currents of identical characteristics. If this motion is recurrent in character, the resulting electrical current may be presented visually on a cathode ray oscillograph, for study and analysis. This pickup functions through the piezo-electrical properties of a Rochelle Salt crystal and has wide use in mechanical and sound laboratories. This device lists at $20; has an output voltage of 0.25 volts per .001 in. movement at 250 cycles; a frequency range of 10-3,000 cycles, and a vibration axis at right angles to face of pickup.



Volt-Ohm-Milliammeter

THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, Bluffton, Ohio, has developed a new Model 1,200 Triplett Volt-Ohm-Milliammeter. This contains the popular twin instrument having separate a.c. and d.c. movements. One switch quickly selects all instrument readings. This device is easy to operate and is both accurate and convenient. The scale readings are d.c. 10-50-250-500-1,000 volts at 2,000 ohms per volt; 1-10-50-250 M.A.; 1,500 ohms; 1.5 and 3 megohms; a.c. 10-50-250-500-1,000 volts. This instrument lists at $32.50.





Scores of design and production men have found new economies and improvements by employing the specialized knowledge of a PARKER-KALON ASSEMBLY ENGINEER

A few words will tell you what it would mean to invite one of these Parker-Kalon Assembly Engineers to go over your fastening jobs with you:

First, these men are not salesmen, and their services will not obligate you.

Second, you won't be visited by a "know-it-all". These men have years of practical experience and a broad knowledge of general assembly practise that fits them to understand your problems. But they don't pretend to be "experts" in everything!

Third, they do know more about one of the most important ways to modernize assembly work than any general assembly man could know. This knowledge will be placed at your disposal. The Parker-Kalon Assembly Engineer will study your fastening jobs with you, and use his specialized knowledge of the famous Parker-Kalon Hardened Self-tapping Screws to help you locate any practical possibilities for applying them to reduce costs, save operations, simplify design, and strengthen fastenings.

Fourth and most important, there is a 7 to 10 chance that you will uncover economies and benefits which can be obtained without added expense or radical changes. That average has held in hundreds of cases where Parker-Kalon Assembly Engineers have been invited to investigate metal and plastic fastening jobs. These include some of the largest plants in the country. And it is significant that usually the design and production men extended the invitation with a feeling that they "knew about" Self-tapping Screws, but wanted to make sure that they were getting all possible benefits.

Wouldn't it pay you to use the knowledge of one of these six men? If you'll write, we will schedule a visit with you for the Engineer in your territory.

PARKER-KALON CORP., 198 Varick Street, New York

PARKER-KALON *Modern* FASTENING DEVICES

TYPE "Z" HEX CAP A HARDENED SELF-TAPPING SCREW FOR EVERY KIND OF ASSEMBLY TYPE "A" TYPE "U"

Literature

✦ **Volume Control Replacement Guide.** Clarostat Manufacturing Company, Inc., 285 North Sixth St., Brooklyn, N. Y., has recently completed a volume control replacement guide, containing servicing data and specifications covering all known makes of sets.

✦ **Resistors.** Hardwick, Hindle, Inc., 40 Hermon St., Newark, N. J., offer a new catalog of electrical resistance products, known as Bulletin No. 236. In addition to describing the characteristics and ratings of these products the catalog contains nomographs of interest to engineers.

✦ **Rectifier Tubes.** Electrons, Inc., 127 Sussex Ave., Newark, N. J., offer a catalog containing general characteristics, tube data and operating characteristics of their EL Rectifier Tubes.

✦ **Alloys.** Hoskins Manufacturing Company, Detroit, Mich., has just completed a catalog devoted to Chromel resistance and thermo-couple alloys. This catalog contains data and price sheets of Hoskins alloys.

✦ **Radio Telephone Equipment.** A new bulletin recently published by the Western Electric Company illustrates and describes radio-telephone transmitting equipment No. 309-A for use by police departments. The equipment described is suitable for installations to serve metropolitan centers, counties or states.

✦ **Welders.** "Electric Welding Mahines and Welding Tips," a 64-page reference book on resistance welding has just been published by Charles Eisler of the Eisler Engineering Co., 740 So. 13th St., Newark, N. J. This book deals with special welding problems arising in various lines of industry. A copy of this booklet may be had by sending your request to the company at the above address.

✦ **Microphones.** A new catalog of microphones and accessories has been compiled by Shure Brothers, 215 West Huron St., Chicago, Illinois. This catalog deals with price lists and descriptions of microphones. Data sheets are available on items in the catalog and will be sent on request.

✦ **Resistors.** "Yardsticks" a two-color folder issued by the Ohio Carbon Company, 12508 Berea Road, Lakewood, Ohio, gives specifications, test data and prices of Ohiohm carbon resistors for radio sets.

✦ **Transformers.** Ferranti Electric, Inc., 130 West 42d St., New York City, has issued a new transformer bulletin giving a complete listing of the super high fidelity line and the ultra high fidelity line of this company.

PATENTS REVIEW

PATENTS indicate trends. Next year's radio circuits, applications of electron tubes for non-communication purposes, new tube types, new materials, may be discovered by following United States and British inventions.

Electron Tubes and Equipment

Short-wave tubes. Patent Nos. 2,017,-549 and 2,030,187 to Bernard Salzberg, RCA, on tube construction for tubes of the type popularly known as "acorn." See also No. 2,025,075 to A. L. Samuel on short wave tubes, B.T.L., Inc.

Suppression layer photocells. Process of producing cathodes for light sensitive tubes comprising a copper base and a coating of an oxide thereof by coating the base with a thin layer of another metal not belonging to the alkali group of metals and heating the base to cause copper to diffuse into and form an alloy of the other metal. Franz Rother, Paris, France. No. 2,019,096.

Cathode coatings. Method of alloying an alkaline metal with a core metal by disposing and heating a metallic core in an atmosphere containing a gaseous compound of an alkaline metal, decomposing the compound at such temperature for the core that the alkaline metal yielded alloys therewith. H. J. Spanner, Ulrich Doering, Electrons, Inc. No. 2,023,707.

Multi-element tube. A grid structure composed of a helix of which the adjacent grid turns are spaced in relation to each other so that the ratio of the space between any turn to the space between the most widely spaced turns is inversely proportional to a fractional power of the serial number which is assigned to the spaces by serially numbering these spaces in the order of decreasing space width. No. 2,016,760 to H. A. Wheeler, Hazeltine.

Multi-tube circuit. Circuit arrangement for a tube of five grids, cathode and anode. Gunther Jobst, Telefunken. No. 2,015,185.

Relay tube. A photo electrostatic type of tube. H. Nelson, RCA. No. 2,027,751.

Piezo-electric cell. An arrangement for light intensity control purposes comprising a Nicol element, etc. Kurt Klingsporn, Loewe, Berlin. No. 2,024,-737.

Tube testing apparatus. No. 2,025,163 to W. N. Goodwin, Weston; 2,014,379 to C. H. Hockner, Dayton, Ohio; 2,012,045. P. F. Jackson, Radio Products Co.; 2,014,102, J. W. Conklin, RCA, and 2,028,278 to D. K. Gannett, and B. F. Lewis, A.T.&T.Co.

Vibrator. A cathode, an anode, and a tuning fork within an evacuated envelope and an undamped shutter mounted on a tine of the tuning fork, and interposed in the path between the cathode and anode to interrupt space current. P. F. Scofield, Heintz & Kaufman. No. 2,011,951.

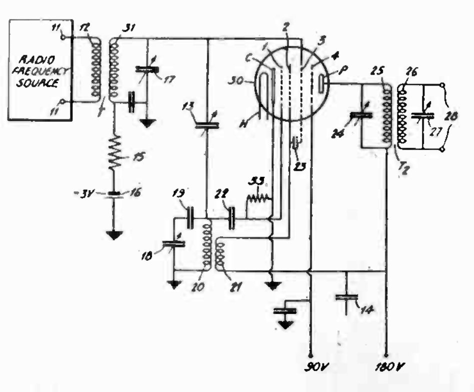
Receiving Circuits

Generator. A constant frequency oscillator. B. J. Witt, RCA. No. 2,034,735.

Ultra-short wave receiver. No. 2,030,-872 to H. E. Hollmann, Telefunken, Germany, and 2,031,103 to R. W. George, RCA.

Crystal receiving system. A push-pull amplifier fed from an antenna circuit has in the grid center tap of the input transformer a connection to an r-f amplifier also coupled to the antenna and equipped with piezo-electric crystals which filter and greatly amplify the carrier component with respect to the side-band components. G. L. Beers, RCA. No. 2,034,647.

Frequency converter. A tube having an oscillator section and a signal amplifying section with undesired capacity



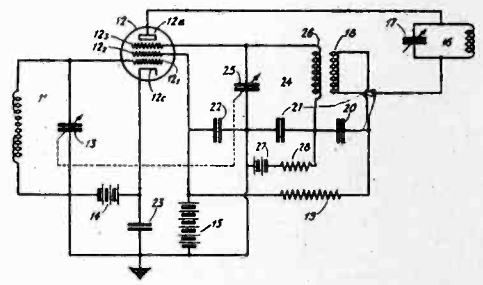
coupling between the sections and means for neutralizing the effect of this coupling. W. A. Harris, RCA. No. 2,033,986.

Diode rectifier. The input circuit is connected to the anode and to ground. Between cathode and ground is a resistance shunted by a condenser in series with an inductance. The condenser shunts the resistance and inductance in serires. P. O. Farnham, RCA. No. 2,034,511.

Detector oscillator. A self-biased autodyne first detector circuit comprising a multi-element tube including diode plates. The voltage fed to the rectifying circuit from the local oscillator circuit is greater than the voltage fed back from the local oscillator to the grid of the tube by an amount which is normally sufficient to insure a marginal bias on the grid of the tube for the signals to occupy to thereby preclude grid current. David Grimes and W. S. Barden, RCA. No. 2,034,513.

Short wave receiver. A tube having a divided cylindrical anode, an antenna system having as many energy collecting arms as there are sections to the anode, and a resistor between the direct current source and the anode sections for so adjusting the potential gradient in the zone of electronic emission the receiver is tuned to the frequency of an incoming wave. H. E. Hollmann, Telefunken, Germany. No. 2,033,937.

Oscillator modulator. A multi-element tube circuit including a source of high positive potential connected to a



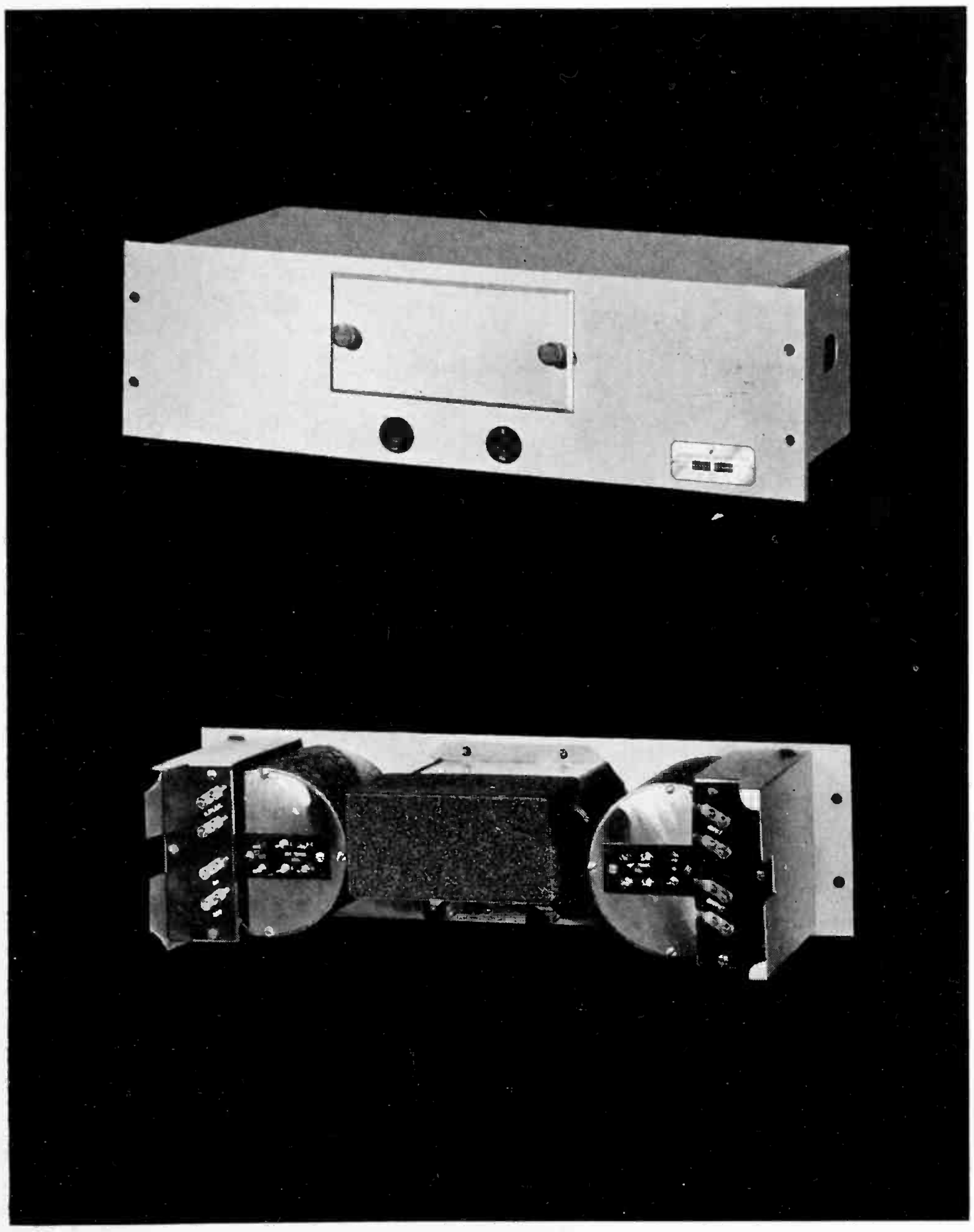
fifth electrode for isolating the input circuit from the oscillation currents, the potential of this fifth electrode being the highest voltage in the tube, and means for providing a uniform output from the oscillation circuit as the circuits are tuned through a frequency band. H. A. Wheeler, Hazeltine Corp. No. 2,034,013.

Image suppression. Method involving the use of a tapped input coil with r-f amplifier preceding the first detector. Jacob Yolles, RCA. No. 2,027,949.

Power supply system. Circuit adapted to utilize either a-c or d-c sources involving a mechanical rectifier, a thermionic rectifier and a transformer switching means for energizing either of the rectifiers. Nicholas Raskhodoff, United American Bosch Corp. No. 2,021,380.

Automatic tone control. Circuit whereby the fidelity and amplification of signals reproduced is controlled by the average amplitude of the carrier wave. H. M. Lewis, Hazeltine Corp. No. 2,028,511.

AN IMPROVED HIGH-FIDELITY LOW LEVEL MICROPHONE PRE-AMPLIFIER

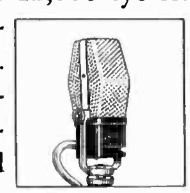


Dynamic and Velocity types of microphones have been universally accepted by discriminating broadcast engineers as standard for high-fidelity transmission. Characteristic of these microphones is their low level output which necessitates a high gain pre-amplifier with an extremely low noise and distortion level. The AR-83 Pre-amplifier by "Techna" has been designed to meet this rigid requirement.

Strictly adhering to a policy of quantity production with the latest types of high-speed precision machinery, we are able to offer equipment built to uncompromising laboratory standards at a reasonable price.

AR-83 SPECIFICATIONS

Circuit: Two high gain resistance coupled stages. Input: 30 and 250 ohms. Output: 50, 200 and 250 ohms. Output Level: —40 db. Gain: 42 db. Voltage Requirements: 180-250 volts DC and 6.3 volts AC or DC. Frequency Response: ±1 db., 30 to 12,000 cycles. Precision DeLuxe High-Fidelity Transformers. Dural Panels, Brush Finished or to match customers equipment. Panel Size: 5¼″ x 19″.



Net Price, $67.50.

EXAMINATION OFFER

We offer to send, at your request, the AR-83 Pre-amplifier for a six day examination period. Railway Express will hold the C.O.D. charges for the entire period, returning same if the equipment is returned. Return charges are guaranteed by us.

P-84 POWER SUPPLY

Supplies 200 volts of perfectly filtered plate potential and 6.3 volt AC filament for up to six AR-83 Pre-amplifiers.

Net Price, $58.00

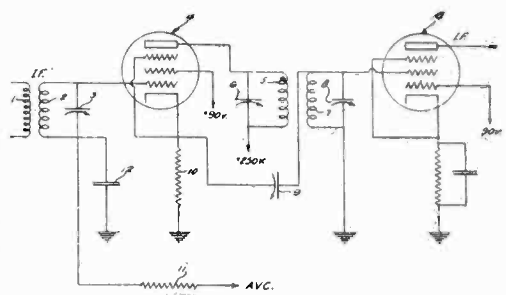
TECHNA

TECHNA CORPORATION

CABLE ADDRESS "TECHNA" 926 HOWARD STREET, SAN FRANCISCO BELL TELETYPE "SF 329"

Noise gate. A radio receiver provided with an automatic volume control network, a combined noise gate and tuning indicator composed of a cathode ray tube, one of the electrodes being connected to a point of fixed potential and the other electrode being connected through an impedence so that an electron beam within the tube is deflected in accordance with variations in received signal intensity. John F. Dreyer and R. T. Orth, RCA. No. 2,034,565.

Selectivity control. Circuit using feedback of energy whereby the band-pass characteristics of an amplifier may be altered in accordance with the intensity level of substantially any signal capable of affecting the receiver. L. F. Curtis, United American Bosch. No. 2,033,330. See also No. 2,029,523 to Curtis on a tone compensated volume control circuit.



Automatic volume control circuits. No. 2,031,238 to L. E. Thompson. No. 2,029,033 to L. M. Perkins. No. 2,028,859 to L. E. Barton. No. 2,028,359 to H. A. Snow. No. 2,026,357 to L. M. Perkins, all assigned to RCA. No. 2,027,939 to Rudolf Urtel and Karl Steimel, Telefunken, Germany. No. 2,032,117 to George Corbett, Tampa, Fla. No. 2,030,913 to H. F. Elliott, Palo Alto, Calif., and reissue No. 19,857 to P. O. Farnham, RCA.

Program control and remote control circuits. No. 2,029,909 to J. L. Cassell, Wired Radio, Inc. No. 2,029,461, C. E. Brush, Chicago, assigned to E. H. Scott. No. 2,031,075 to G. B. Scheibell, New York, N. Y., and No. 2,031,074. No. 2,031,555, A. S. Blatterman, Asbury Park, N. J., method of remote controlling a receiver by means of signals over an electric power supply line. No. 2,035,612 to O. P. Liebreich, New York, N. Y., and No. 2,034,708 to B. O. Browne, Bell Telephone Laboratories, Inc.

Variable-selectivity circuit. A fixed-frequency amplifier including pairs of coupled resonant circuits, each of the pairs comprising two ferro-magnetic-cored inductors, one inductor in each pair being rotatable and mounted at an oblique angle to its axis of rotation, and means for rotating the inductors in unison to vary the selectivity. Alfred Crossley, Johnson Laboratories. No. 2,028,534. See also 2,032,914, diode system, Crossley and Meinema, Johnson Laboratories.

6B5-6N6

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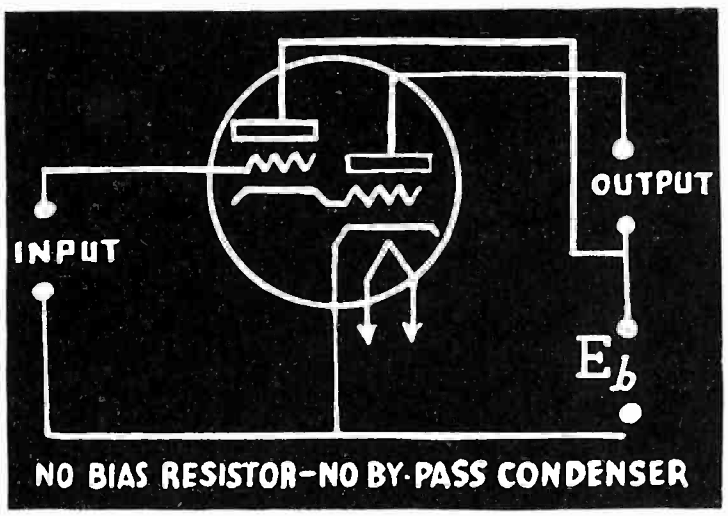

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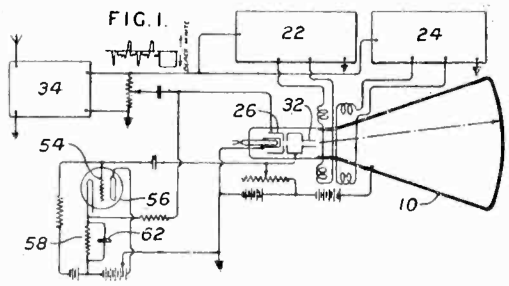
British Patents

Television

Receiver system. A system in which the d-c components of the picture signals are automatically reinserted at



the receiver. H. A. Iams, Marconi Co. No. 439,547.

Synchronizing. Synchronizing signals are produced by the rapid discharge of a condenser through a grid-controlled gas-discharge tube, the discharge of which is controlled by a periodic voltage derived from the scanning system. No. 439,146.

Light-valves. A light-valve comprises a medium traversed by high frequency mechanical waves, so that the medium acts as a diffraction grating upon reflected or transmitted light. Preferably, the central beam is utilized as the controlled beam. The medium may be a solid, a liquid or a gas for transmitted light or mercury or a membrane for reflected light. Scophony, Ltd., London. No. 439,236.

Radio Receiver Circuits

Multi-purpose receiver. A switching method for operating a receiver with high selectivity or as a single sideband receiver with high fidelity. Marconi Co. No. 439,528.

Interference reducer. To reduce disturbances in a receiving set an automatic regulating device is provided having little inertia and the action of which is delayed until the amplitude of the disturbing voltage is larger than the maximum admissible signal amplitude. The predetector stages feed three diodes, the third of which controls a preliminary stage through an inductance-capacity filter with a time constant of five-thousandth to one two-thousandth of a second. Philips. No, 439,859.

Automatic tuning. A relay or other device is actuated by a gas-filled discharge tube and a condenser charged in the anode circuit of the tube and discharged in the control grid circuit is used to maintain the tube in conducting condition for a given period. Associated Electrical Industries, Ltd. No. 440,282.

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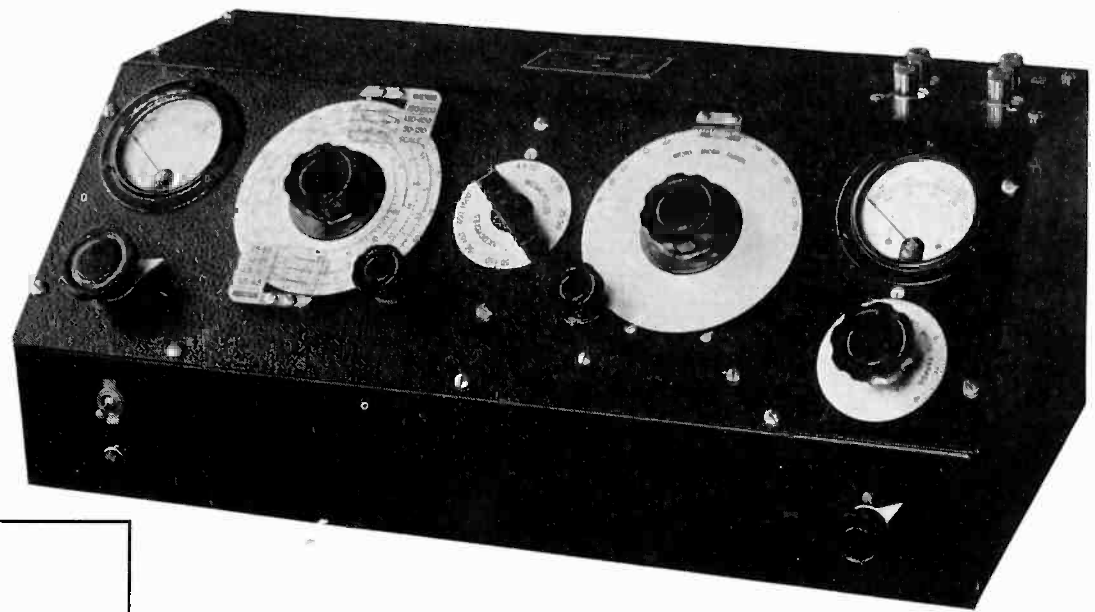

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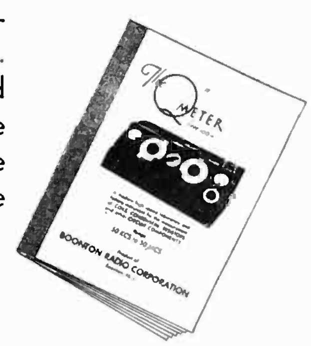

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Japan and Manchukuo
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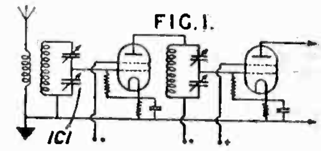
BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY

Scratch filter. A filter for eliminating needle scratch and other high-frequency disturbances from a loud-speaker circuit is designed to produce less effect upon loud than upon weak signals. Thus a rejector circuit composed of an inductance, condenser, etc. which is anti-resonant at a high frequency such as 5000 cycles per sec. may be shunted by a pair copper-oxide or other rectifiers, which offer a higher impedance to weak than to strong currents. GE Co. No. 440,199.

Input circuit. In a tuned high-frequency amplifier the grid is tapped down on the capacitative branch of the input circuit so that the impedance between the control grid and cathode is

FIG. 1.



small relative to the reactance of the capacitative impedance in series therewith. Marconi Co. No. 440,333.

Volume control. Variations in the impedance of a tube having a negative feed-back coupling between its anode and grid circuits are used to control the output of an amplifier in accordance with the volume of signals received. J. W. Whiteley, Middlesex. No. 440,337.

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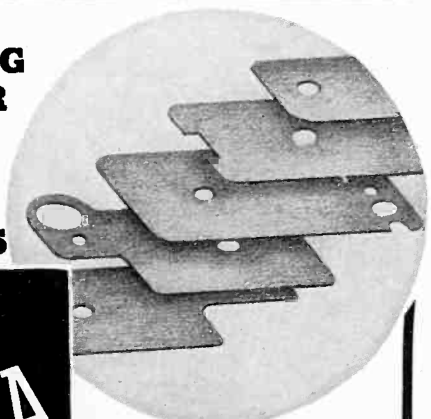

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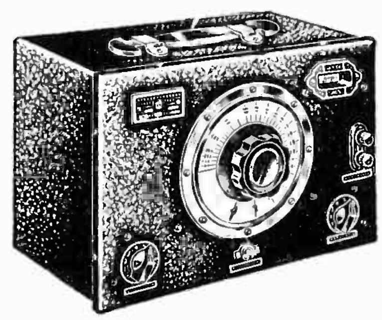

MODEL OB, extended frequency range beat-note audio oscillator, 20 cycles to 15,000 cycles. Less than 1 db. variation of output and not to exceed 2% distortion content. Hand calibrated with Cathode-ray oscillograph. Output 5 volts at 500 ohms. Matching transformers for higher and lower levels. Net price complete with tubes..$112.50

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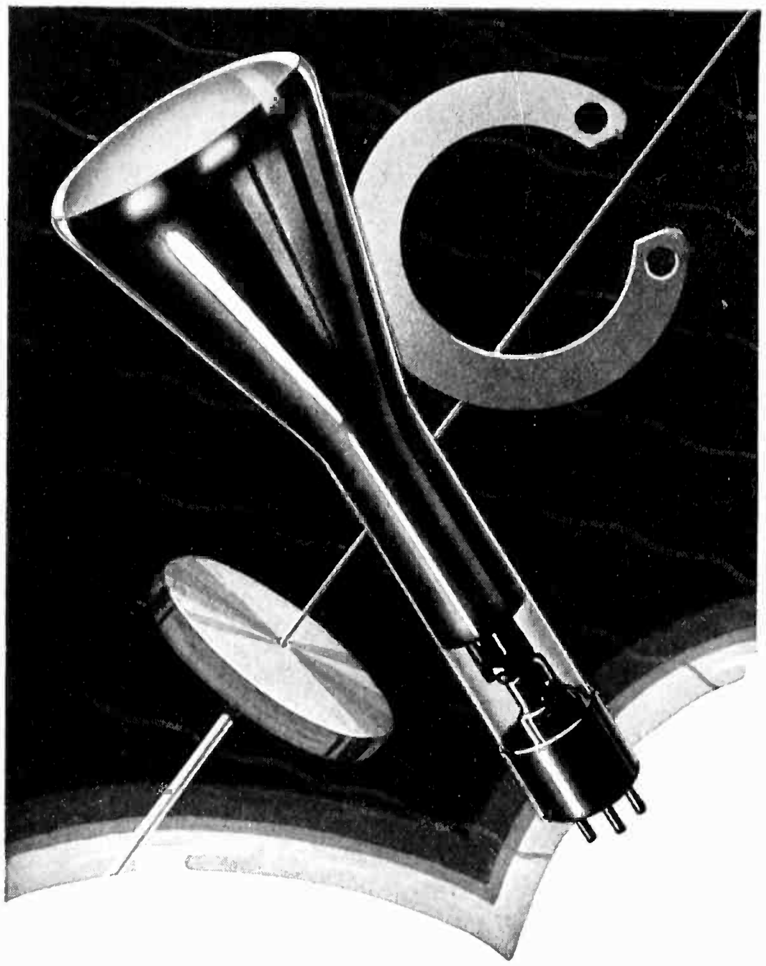
Dial lamp circuit. The dial lamp is connected in the anode circuit of an indirectly-heated cathode low-frequency amplifying tube. The receiver is of universal type, the loud speaker current passing through the dial lamp. The voltage drop across the lamps is used as part of the grid bias of a tube. E. K. Cole. No. 437,569.

Tuning indicator. In a superheterodyne receiver resonance with the incoming signal is indicated by the use of one or more lightly damped resonance circuits coupled to the intermediate frequency amplifier and connected to a tube in the direct current circuit of which a lamp or the like is provided. Philips. No. 438,255.



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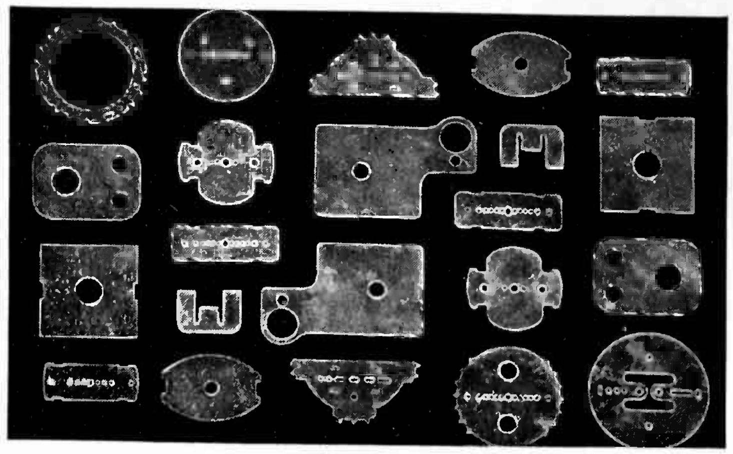

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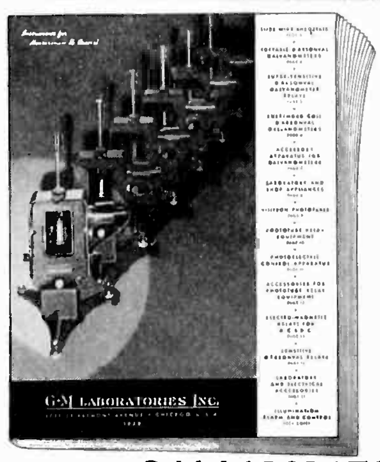

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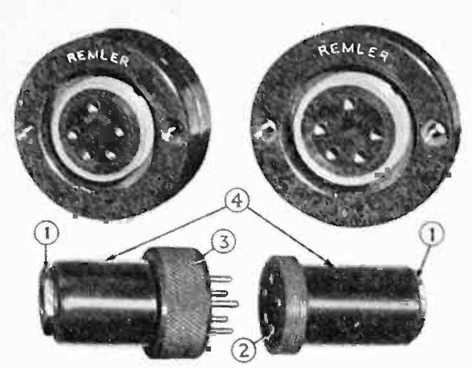

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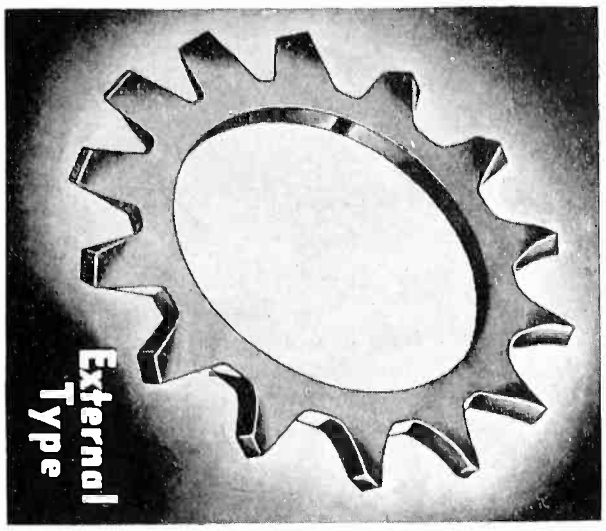

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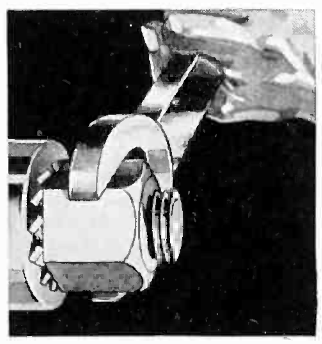

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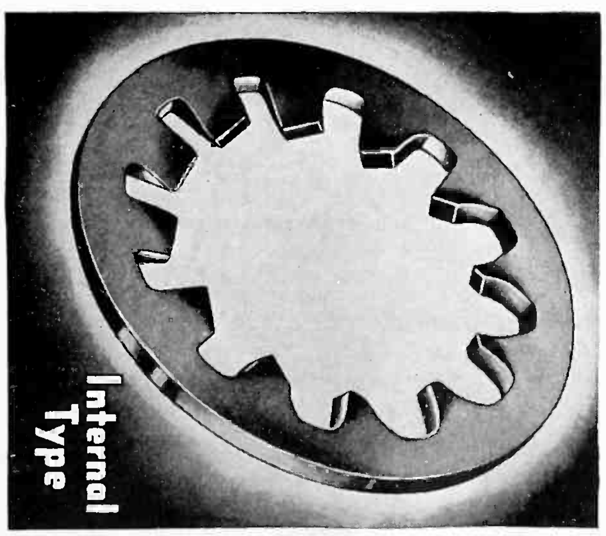

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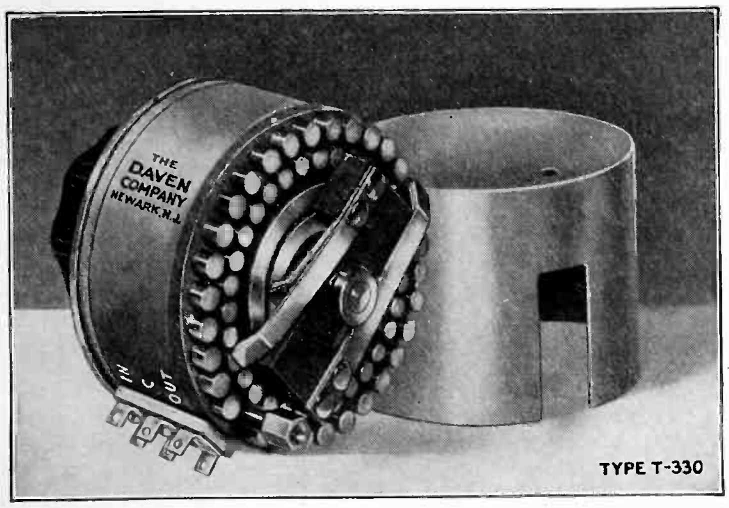

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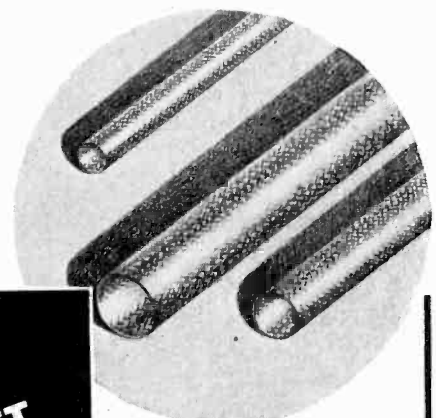

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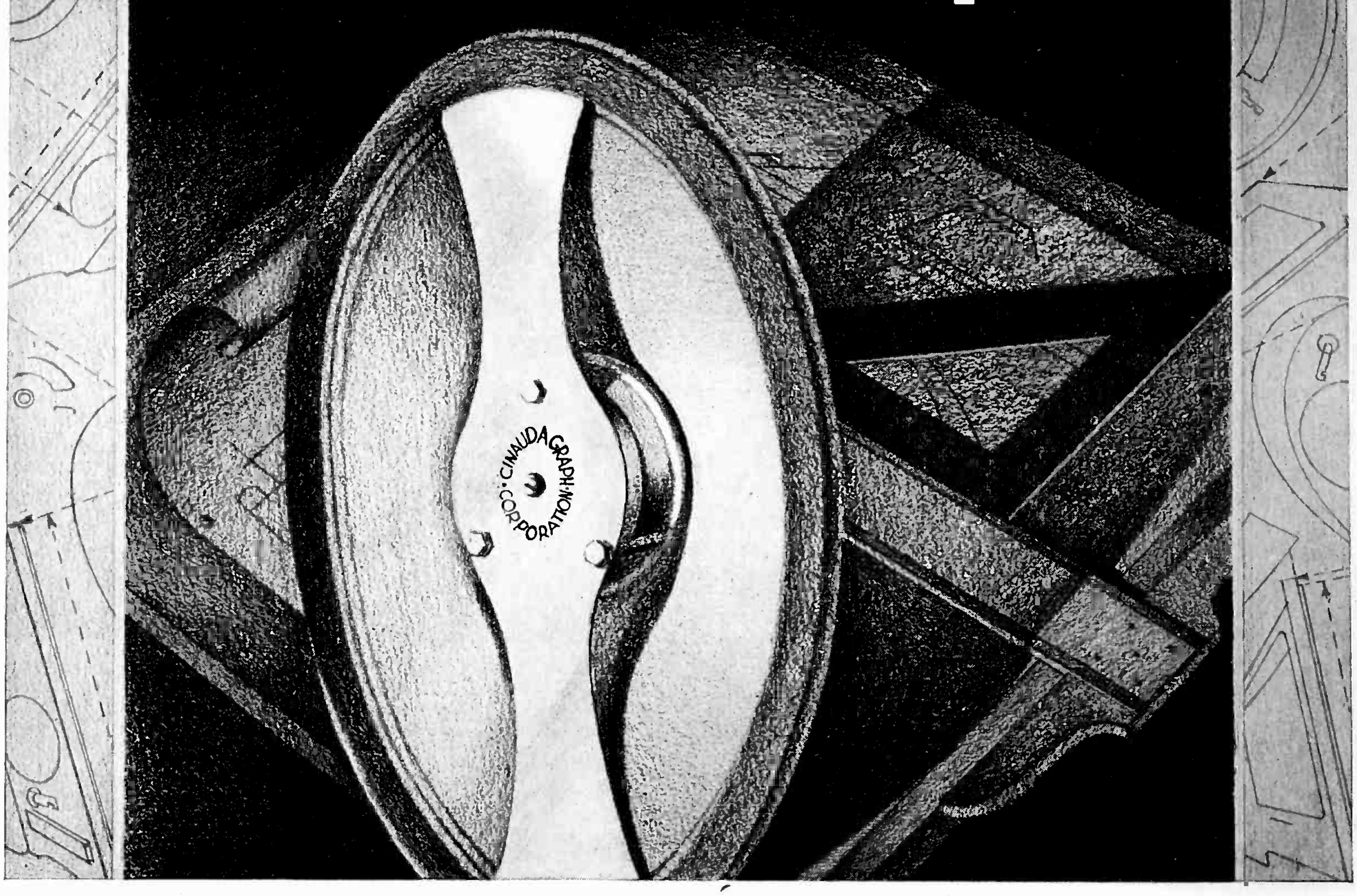

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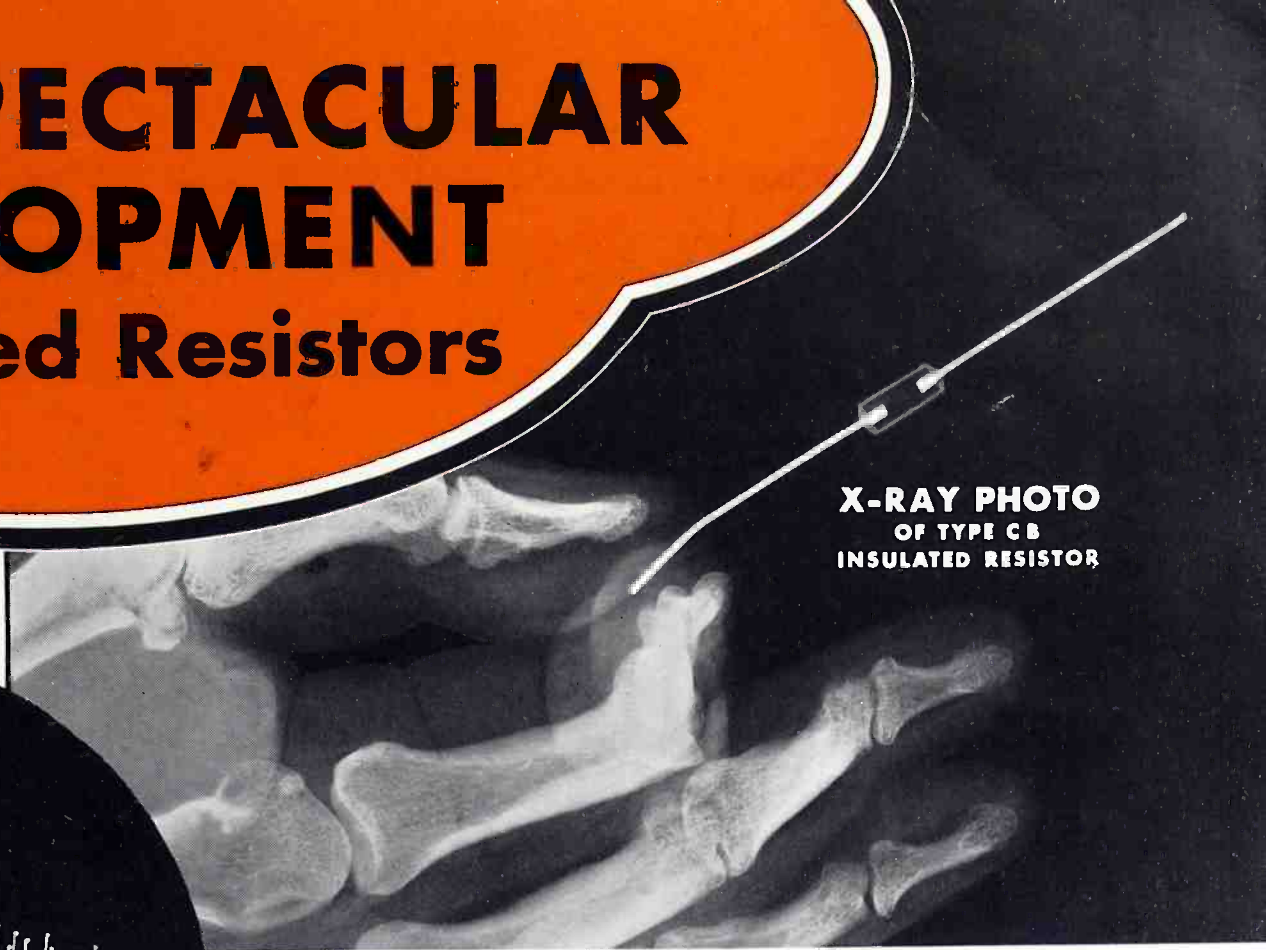
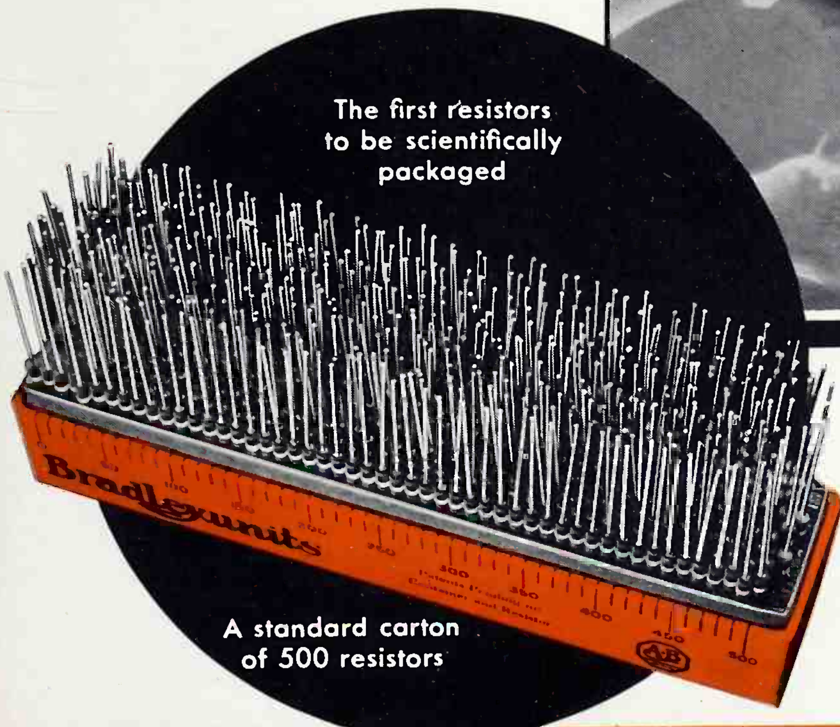
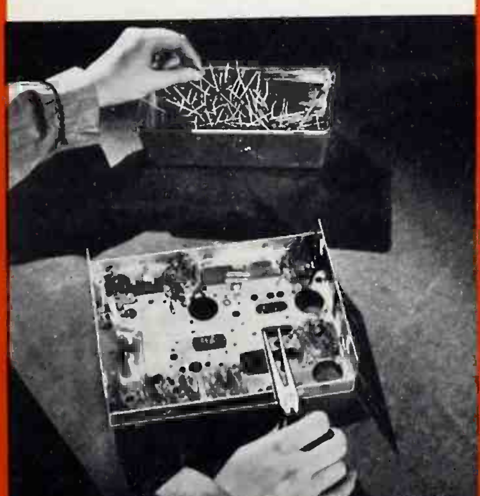




TWO NEW RESISTORS which offer outstanding advantages to all radio manufacturers . . .

THE NEW WAY—Scientific packaging eliminates resistor fumbling and speeds up the production of radio equipment.



THE OLD WAY—Jumbled resistor stocks cause delays in production lines and introduce soldering troubles.

TYPE E SOLID MOLDED RESISTOR (Non-Insulated) with straight-line leads molded into the resistor. No sprayed-copper connections—no soldered joints—no inductive, coiled lead ends around the resistor. Leads are specially tempered to prevent sharp bends at the resistor. Rating, 1/3 watt.

TYPE CB MOLDED INSULATED RESISTOR has each and every advantage of the Type E resistor, plus molded bakelite insulation. Rating, 1/2 watt.

SCIENTIFIC PACKAGING. The new Allen-Bradley indexed carton—graduated to provide an instant inventory of resistors in storerooms or production lines. Delays, due to counting and weighing of resistors, are eliminated.

Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee, Wis.

ALLEN-BRADLEY

PIONEERS IN RADIO RESISTOR ENGINEERING