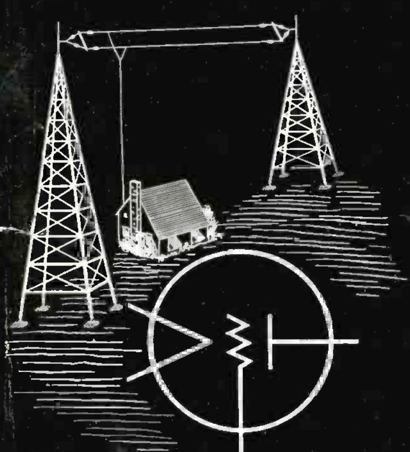
FEBRUARY, 1934

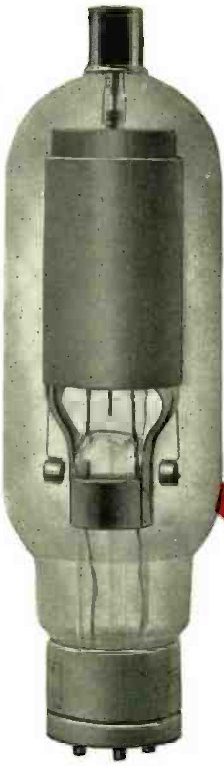
Radio Engineering



VOL. XIV NO. 2

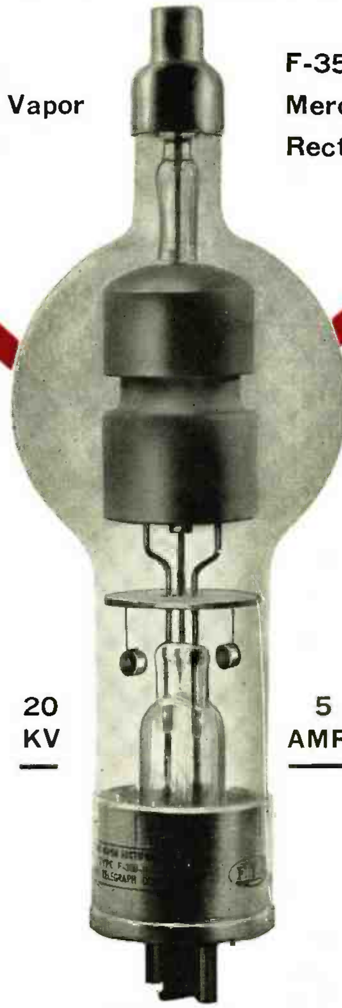
The Journal of the Radio and Allied Industries

Power Rectifiers
of
SVEA METAL
by
FEDERAL TELEGRAPH CO.



15 KV
3 AMP.

F-375-A
Mercury Vapor
Rectifier

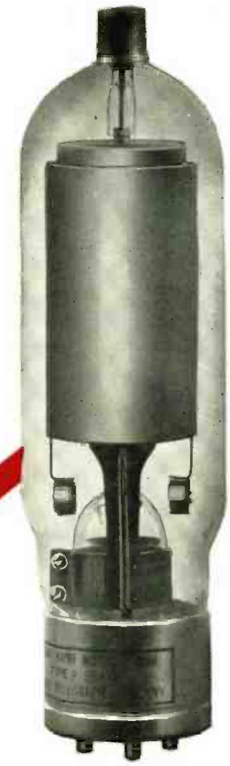


20 KV

5 AMP.

F-369-A

F-353-A
Mercury Vapor
Rectifier



10 KV
2.5 AMP.

Ruggedness
Longer Life

Progressive research and production engineers of the Federal Telegraph Company have been alert to the advantages of quality and economy offered by this new material. These are actual photographs of three husky mercury vapor rectifiers containing SVEA METAL.

These types are not influenced by extraneous modulated or unmodulated R.F. fields because they are completely shielded. Blackening of the tube which decreases operating efficiency is practically eliminated by the shielded construction.

Uniformity
Efficiency

The rugged plates and careful design show what is being done to insure sturdy reliable rectifiers of long life, uniformity and dependability.

SVEA METAL is ideal not only for rectifier and receiving tubes but also for transmitter tubes, television tubes, crater lamps, neon electrodes and all electronic devices where uniformity of temper and structure, freedom from occluded gases, high heat resistance, good conductivity, lightness in weight and ease of forming and welding are important factors.

SVEA METAL

Swedish Iron & Steel Corporation

17 Battery Place — New York City

NRA MEMBER U.S. WE DO OUR PART

For more than a quarter of a century suppliers of high grade metals to the foremost electrical equipment manufacturers.

Here is your

Reliable Source of Supply

for Auto Radio Remote Control Flexible Shafts

S. S. WHITE Contributions to Auto Radio Development

Originators of 43-wire, .150" diam. flexible shaft (No. 150L53) for remote control of auto radio. Shaft has low torsional deflection in either direction of rotation.

Originators of square swaged ends (S. S. W. patent).

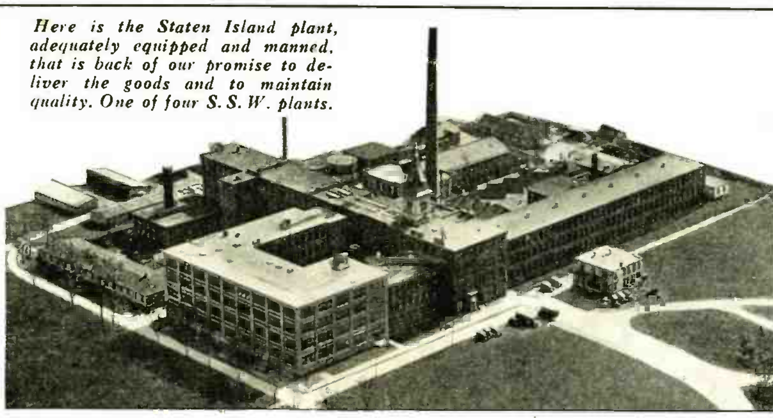
Originators of octagonal swaged ends (S. S. W. patent).

Originators of small outside diam. (.255") metallic casing for auto radio application. Neat, flexible, sturdy.

Originators of enlarged casing end (S. S. W. patent). Eliminates end fittings.

S. S. WHITE has the facilities, the equipment, the organization and the resources to meet all demands for remote control flexible shafts and casings and to meet them without sacrifice of quality.

With S. S. WHITE as your source of supply you are protected against hold-ups of production when demand is at its peak, and against a falling off in quality. Use S. S. WHITE Shafts and Casings and be assured of *deliveries to specification and to schedule.*



Here is the Staten Island plant, adequately equipped and manned, that is back of our promise to deliver the goods and to maintain quality. One of four S. S. W. plants.

WRITE for SAMPLES

Samples of S. S. W. Auto Radio Remote Control Flexible Shaft No. 150L53 and Flexible Metallic Casing No. 170A1 will be sent on request to Auto Radio Set Manufacturers and Manufacturers of separate controls. Quotations on specific requirements will also be furnished for the asking.

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INDUSTRIAL DIVISION
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RADIO ENGINEERING

Reg. U. S. Patent Office

Editor
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Member
Audit Bureau of Circulations

Associate Editor
RAY D. RETTENMEYER

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CONTENTS

DEPARTMENTS

Dr. J. H. Morecroft

DR. J. H. MORECROFT, past president of the Institute of Radio Engineers, professor of Electrical Engineering at Columbia University, died at Pasadena, California, on January 26. In recent years Dr. Morecroft had spent a part of each year on a citrus fruit development which he had acquired in California.

Dr. Morecroft had been closely identified with radio engineering and radio education since 1910. In 1912 and later he was associated with E. H. Armstrong in connection with the development of regenerative radio reception and with the improvement of radio reception systems which followed.

His two published works on Radio Communication have been widely recognized as standard text books on this subject.

In 1924, Dr. Morecroft was elected president of the Institute of Radio Engineers, his energetic administration of the affairs of the Institute giving a new impetus to the growth of that organization.

At the time of his death he was fifty three years of age.

BRYAN S. DAVIS
President

JAS. A. WALKER
Secretary

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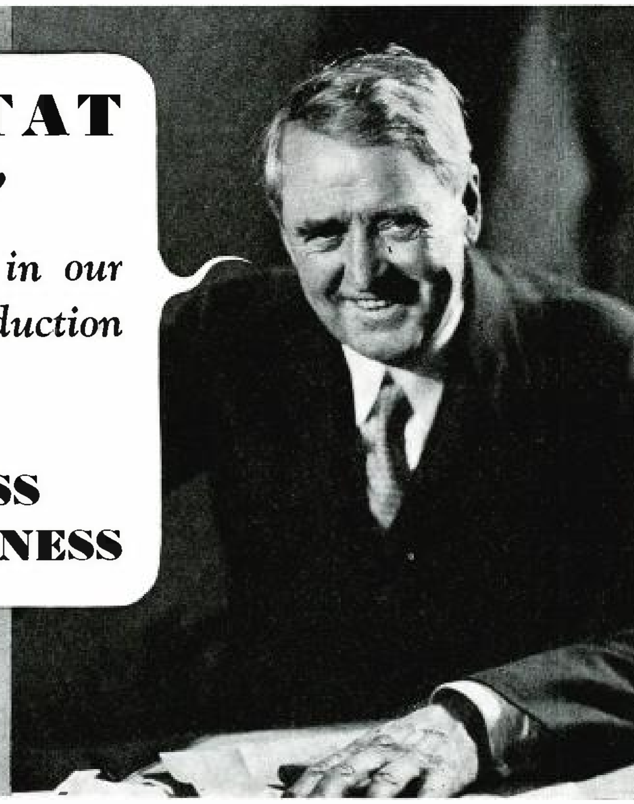
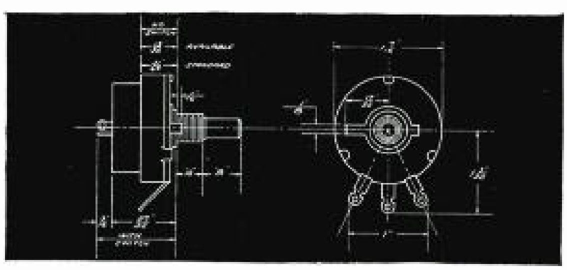
Series "33"

have been adapted in our standard control production because of their

RELIABILITY
RUGGEDNESS
COMPACTNESS



For auto and midget radios



Drawing portrays three separate controls.

(1) Series 33—without switch—shallow model—depth 13/32".
(2) Series 33—without switch—standard model—depth 31/64".
(3) Series 133—with power switch—depth 27/32".
Standard dimensions of bushings and shafts are: "A"=⅜" x 32 thd. ⅜" long. "B"=.248"—.249" dia. x ⅝" long.
Bushing and shaft insulated although available grounded if requested.

WHILE permitting considerable saving in space, this control retains all the reliability and factor of safety found in Clarostat controls. It is available in all usual requirements, both mechanical and electrical. It is in production ready to service the production lines of current demand. WRITE FOR SAMPLES.

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We solicit inquiries on mass production or special resistor problems, for radio, sound, communication or industrial application.

NEW CONTROL REPLACEMENT GUIDE UPON REQUEST

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285 North 6th Street **Brooklyn, N. Y.**

"AD-A-SWITCH" was originated by Clarostat

EDITORIAL

HIGH FIDELITY

CONSIDERATION WAS GIVEN the high-fidelity receiver at a meeting on February 3 of the Joint RMA-NAB-IRE Committee on Broadcast Reception. Attending the conference were leading engineers representing the broadcasting and manufacturing camps of the radio industry.

Chairman Arthur T. Murray of the RMA Set Division, has named the special committee, comprising W. Roy McCanne of Rochester, as chairman, and James M. Skinner of Philadelphia, and Captain William Sparks of Jackson, Michigan.

At the time of this writing, the report of the conference is still in the stages of preparation. Until its release, the points of discussion and the outcome of transmitter-receiver characteristic proposals can be only matters for speculation.

No doubt it will be some time before definite action can be taken on the alteration of broadcast transmitter frequency characteristics, etc.—if any action at all is taken—and until then the receiver engineer cannot set limits in his receiver design. But, no matter the outcome of the conference, a number of broadcasters are laying down signals in areas of dense population, whose frequency characteristics pass the present limits of many broadcast receivers in both the low- and high-priced field.

A receiver covering a wide band of audio frequencies; say, from 40 to 5000 or 6000 cycles, and having a low degree of frequency distortion, has one property which could be of advantage from the regulatory viewpoint; this type of receiver has a tendency to "show up" broadcasters suffering from modulation ills or narrow frequency bands. Were thousands of such receivers put in use, the "circulations" of broadcasters might undergo a considerable shift, the really good stations deriving the benefit—even, possibly, if their program material were of a lower order.

Most broadcast-station owners have long ago become aware of the importance of listener service, and know it to be good business to keep their transmitters up to snuff. These same owners will be just as anxious to further improve their transmitters when, as, and if a parallel improvement is made in broadcast receivers.

The subject is retroactive no matter how viewed: The set manufacturer would likewise benefit by the move, as improved characteristics at both ends of the service would increase the obsolescence of radio receivers in present use, including many only a year or two old.

How far broadcasters and manufacturers may care to go in an increase in fidelity is dependent, we believe, more on the engineering considerations than on any matters of economics or financing. Too wide a range might make the matter of noise an engineering problem in itself, not to forget the difficulties arising from broadcasters building up the high frequencies too near to the limits of their channels. In any event, both broadcasters and set manufacturers would benefit by the introduction of "high fidelity" even though at first the response were not quite so high as some would wish. A gradual increase over a period of years may be the most satisfactory way of handling the matter.

There appears to be little doubt that the public will react favorably to any improvement made in broadcast-receiver response. The listener, once a rather perplexing "sound degenerate," has been awakened to his condition by the poor quality of the majority of midget receivers. His ears are now acute, and he has unquestionably become sound conscious. This new-born partiality may well over-ride his earlier desire for sensitivity—though he will continue to view with awe the receiver that will pull in distance without an aerial.

A CHRONOLOGICAL HISTORY

of electrical communication

—*telegraph, telephone and radio*

This history began with the January 1, 1932, issue of RADIO ENGINEERING. The items are numbered chronologically, beginning at 2000 B.C., and will be continued down to modern times. The history records important dates, discoveries, inventions, necrology and statistics, with numerous contemporary chronological tie-in references to events in associated scientific development. The material was compiled by Donald McNicol.

PART XXVI

1902 (*Continued*)

(1033) 3,620 central electric light and power stations in the United States report a total gross income of $85,700,605; 30,326 employees and $20,646,692 paid in wages.

(1034) The Pacific Wireless Telegraph Company establishes communication between San Pedro, California and Santa Catalina Island.

(1035) At the annual meeting in Toronto of the Great North Western Telegraph Company, directors and officers are elected as follows: H. P. Dwight, president; Adam Brown, vice-president; George D. Perry, secretary-treasurer and superintendent of supplies; A. C. McConnell, auditor. Directors: H. N. Baird, R. C. Clowry, Richard Fuller, James Hedley, A. S. Irving, W. C. Matthews and William McDougall.

(1036) The American District Telegraph Company is incorporated in New Jersey, to take over the various A.D.T. companies throughout the country. The Western Union Telegraph Company controls the new organization.

(1037) The Marconi Wireless Telegraph Company builds a high power station at Glace Bay, Nova Scotia.

(1038) The Marconi Wireless Telegraph Company of Canada organized November 1. A station for long distance working is established on Cape Breton.

(1039) The Marconi Wireless Telegraph Company of America is organized in New York.

(1040) John W. Mackay dies and is succeeded as president of the Commercial Cable Company and Postal Telegraph-Cable Company by his son, Clarence H. Mackay.

(1041) For the year, 987 electric railways report gross income of $250,526,642; 140,769 employees, and $88,210,165 paid in wages.

1903 (1042) The International Telegraph Conference is held at London, England.

(1043) On March 30, what is said to be the first transatlantic radio complete message is received by and printed in the London *Times*.

(1044) Lord Kelvin receives the first award of the John Fritz medal in recognition of his inventions in submarine telegraph apparatus.

(1045) The Decker primary battery cell invented, employing graphite and zinc elements with a sodium bichromate depolarizer.

(1046) An automatic telephone exchange is installed at Grand Rapids, Mich.

(1047) The Siemens-Halske rapid printing telegraph system, using the photographic method of recording, is tried experimentally.

(1048) Poulsen, of Denmark, obtains (June 19) a United States patent (No. 789,449) covering the invention of a hydrogen-arc transmitter for radio signaling.

(1049) The Commercial Pacific Cable is opened for service between San Francisco, Calif., and Manila, P. I., July 4.

(1050) A 5,000 K.W. turbine is installed at the Fisk St. Station, Chicago, of the Commonwealth Edison Co., the first steam turbo-generator exceeding 500 K.W. placed in service by a central station company.

(1051) The first International Conference to consider questions relating to wireless signaling is held in Berlin, Germany, August 4.

(1052) A telegraphers' fast-sending tournament is held in Philadelphia, Penna., October 30-31.

(1053) Aurora borealis electrical disturbances affect telegraph and telephone lines between Chicago and the East, and lines across Canada. Without regular line battery being applied, grounded lines show induced potentials varying from 425 volts positive to 225 volts negative, between the hours of 12:15 a.m. and 9:15 a.m., October 31.

(1054) The first induction motor employed in the steel industry in the United States is placed in service at Joliet, Ills., for the Illinois Steel Company.

(1055) Underground cable conduits made of fiber are introduced in service.

(1056) The Nernst electric lamp is introduced commercially.

(1057) Bion J. Arnold is elected president of the A.I.E.E.

(1058) B. G. Lamme, in the United States, brings out improved single phase electric railway motors.

(1059) The Moore gaseous-conductor tube lamp is commercially employed in the United States.

(1060) A German-American transatlantic cable is laid from Emden, Germany, to New York, by way of the Azores.

(1061) John Stone, of New York, is granted a number of patents covering improvements in wireless telegraph systems.

(1062) Harry Shoemaker, in the United States, is granted a number of patents covering wireless telegraph inventions.

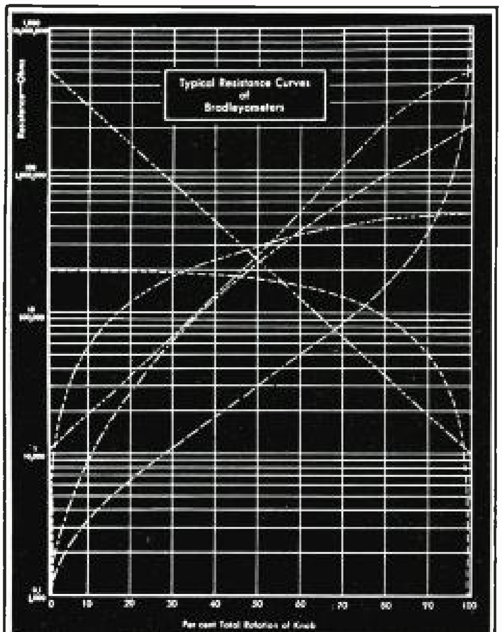
(1063) Wireless telegraph communication is established by officers of the United States Signal Corps, between Safety Harbor and St. Michaels, Alaska, a distance of 107 miles, November 5.

(1064) At the end of this year there are in operation in the United States 29,000 miles of electric railway equipped with 60,000 motor cars and 12,000 trailers.

(1065) Statistics for the year 1902 show that in the United States there are 4,151 telephone companies, and twenty-five telegraph companies (systems). There were in operation 4,850,486 miles of telephone wire and 1,318,350 miles of telegraph wire. Of the employees 64,628 were in telephone service and 26,798 in the commercial telegraph service. The telephone companies had a total revenue of $86,825,536 and the telegraph companies $40,930,038. Aside from interest on bonds the telephone companies' expenses were $61,652,823 and the telegraph companies' $28,998,884. In dividends the telephone companies paid $14,982,719 and the telegraph companies $6,256,693.

(1066) David L. Lindquist invents an alternating-current electromagnet.

(*To be continued*)



Quality

• in Flexibility

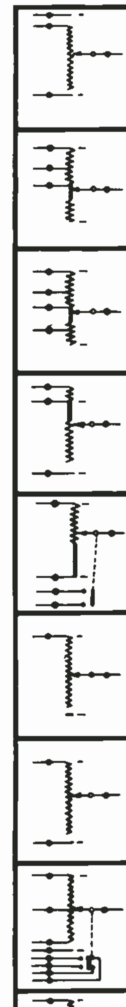
The Bradleyometer, by virtue of its unique resistor element which is not obtainable in any other control, can be supplied with practically any resistance-rotation curve for over 100 different connection combinations.

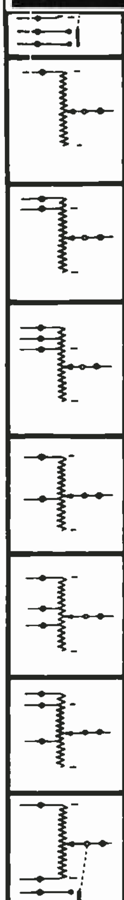
• in Performance

The design of the resistor element together with the precision manufacturing methods used in its construction result in an output of Bradleyometers of unequaled uniformity. This, in turn, assures a continuous output of radio receivers of optimum performance.

• in Workmanship

Carefully selected raw materials, precision manufacturing methods, and continuous checking of production processes guarantee long life and de luxe performance for all Bradleyometers.





Volume Control De Luxe

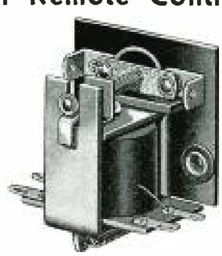
The Bradleyometer, now available in over 100 circuit combinations, represents the highest attainment in variable resistors for volume control, tone control, and automatic tone correction with volume control. Allen-Bradley engineers, foremost in the field of radio resistor design, have pioneered in the development of this volume control de luxe.

The slight extra cost of the Bradleyometer adds immeasurably to the quality of the receiver. Make your receivers outstanding in performance by using the Bradleyometer—the Volume Control De Luxe. Let Allen-Bradley engineers send you performance data, today.

Allen-Bradley Co., 126 W. Greenfield Ave., Milwaukee, Wis.

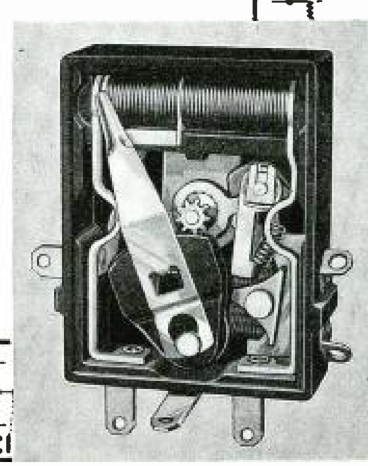
A-B

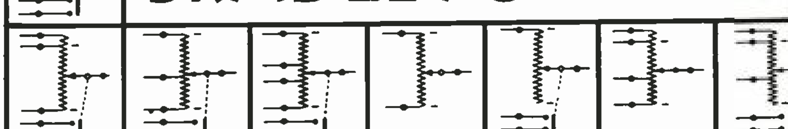
A Quiet A. C. Relay for Remote Control



Allen-Bradley scores another triumph in this new quiet A. C. remote control relay for radio receivers. When operated by remote control, this relay connects or disconnects the main power pack circuit of the receiver. Send for specifications and prices today.

BRADLEYOMETER





RADIO ENGINEERING

Reg. U. S. Patent Office

FOR FEBRUARY, 1934

RECEIVER DESIGN TRENDS

HIGH-FIDELITY, REMOTE TUNING AND SELF-ADJUSTING CIRCUITS WILL LEAD

By M. L. MUHLEMAN
EDITOR

A NEW CLOCK has a streamlined Bakelite casing. It reflects the modern trend toward the elimination of corners, projections and fancified art work conspicuous in most of life's adornments for the past century or two

Designers of the modern school, who specialize in the simplicity of the art of the Greeks on the one hand, and the ultra-modern rotundity of lines on the other hand, continue to place a radio receiver in the category of a still object and have, therefore, refrained from adding Mae West curves to the cabinets.

The trend in radio cabinet design is distinctly in line with the post-modern school, which is a conservative form of the hard angles of the modern craze of a few years back. It may be said, then, that the trend in design is in line with a definite simplicity in the dealing with surfaces, but without the elimination of corners. That is, receiver cabinets will continue to have high wind resistance.

● The demand for receivers with improved tonal quality is bringing forth many improvements in circuit design, and likewise bringing about the resurrection of earlier tubes and amplification systems.

TUNING INDICATORS

Receivers in the higher price brackets have been sporting tuning indicators. Unquestionably they have been a necessity for, without such visual conformation of resonance, users cannot be expected to tune properly and obtain the sort of reception every member of the radio field is most anxious they should have.

The tuning indicator has helped to preserve our good name, and will continue to do so in many receivers to be brought out this year. It may be a shadow tuning meter, with a dark area contracting as the tuner reaches the point of resonance, or a neon column rising and falling as the receiver travels through successive resonance points. If of the neon type, many engineers may well take advantage of Mr. J. F. Dreyer's fourth element and let the tube serve the double purposes of tuning indicator and noise gate.

THE NOISE GATE

The "Noise Gate and Flashograph" circuit is shown in Fig. 1. This arrangement is being used by Fada and Belmont in a few of their 1934 receiver models. The elements. A, B, and C, are used to provide the light column which travels up along the element C. The fourth element, D, which has a portion of its length insulated by a glass sleeve, forms the noise-suppression circuit and releases the first audio tube with a high degree of rapidity.

The tuning-indicator portion of the neon tube operates from the plate current of the r-f, i-f tubes in the usual manner. When the light column reaches the level of the exposed portion of element D, there is a discharge from C to D which develops a voltage across the resistor R-4. Since the a-f tube is normally biased to the point of cut-off in this circuit, the voltage developed across resistor R-4 will offset a portion of the a-f grid bias and release the tube for amplification.

It is the opinion of many that tuning indicators work a hardship on the set owner. It places upon him the responsibility of proper tuning, whereas the opinion is that this responsibility should rest with the receiver.

AUTOMATIC CHANNEL CONTROL

The answer to this problem would appear to be automatic channel control, but in the past such systems have been far from foolproof due to such conditions as oscillator drift and improperly aligned i-f circuits. Nevertheless, the

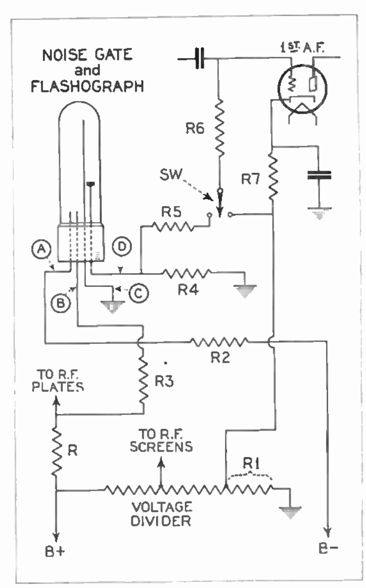


Fig. 1. The neon tube functions as a tuning indicator and as an a-f amplifier cut-off during between-station intervals.

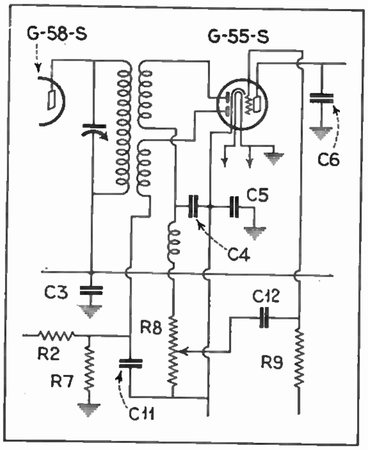


Fig. 2. Diode detector and AVC actions are separated by the use of a double secondary winding on the intermediate-frequency transformer.

present trend is toward this form of automatic control, and the previous shortcomings of channel control are being rubbed out.

The 1934 Stromberg-Carlson receivers employ a thermostatic condenser in shunt with the tuned oscillator circuit which takes care of frequency drift in this circuit. The absence of drift and the practice of peaking the intermediate stages through the use of oscillographs provides the necessary accuracy for the use of a channel control system.

In circuits employing delayed automatic volume control or channel control systems, the actions must be divorced from the diode element used for detection. Philco has been using separate tubes for detector diode, AVC diode, and QAVC tube. Stromberg-Carlson has consolidated matters a bit by using a 2B7 for the amplified AVC circuit, the pentode section of the tube feeding the amplified signal voltage to the AVC diodes of the same tube. Majestic has indicated a well-developed sense of economy, and uses the same tube for detection and delayed AVC by the expedient of employing separate secondary windings on the last i-f transformer, as shown in Fig. 2. The lower secondary feeds the AVC diode. The functioning of the delayed AVC is therefore independent from that of the detector diode. The delayed action is obtained by placing a negative bias on the AVC diode. Rectifying action is therefore delayed until the signal voltage is sufficient to overcome the bias.

A similar arrangement, with double secondary windings, is used in the Maestic Model 800, but separate, type 4-S tubes, are used for detection and AVC.

Delayed AVC is particularly important in auto receivers if their inherent sensitivity is to be realized in actual practice. It stands to reason that AVC is a necessity in these receivers with signal fields constantly altering when the car is in movement. The delayed feature takes care of the excessively weak signals which ordinarily would fall below the reception level of a receiver using straight AVC. In some early receivers delayed action is obtained in a common diode detector circuit, with a resultant distortion at certain signal strengths. More thought has been given to this in present auto receivers, and design is now much along the lines found in the higher-priced a-c receivers.

REMOTE TUNING SYSTEMS

Among the newer conveniences may be listed the three distinct classes of remote tuning and volume control systems. Early models were little more than cigar-box receivers used in conjunction with isolated speakers in comparatively large cabinets to provide the desirable baffle area.

The present trend is towards a break-up of the receiver and amplifier into two units. The first types are typified by the sketch A of Fig. 3. The "Remote Tuning and Volume-Control" turns out to be . . . a radio receiver, minus its speaker. The percentage of convenience in this case is directly proportional to the size of the remote unit—on this basis; if the unit is purposely made small, it suffers as a receiver and amplifier. The user is blessed with a physical convenience, but suffers in respect to the quality of reproduction. If the unit is large, its convenience has been lowered, unless by chance it is a cleverly-contrived lazy fellow and classed as a piece of furniture as much as a desk or a traveling bar.

● Convenience is being stressed in the new receivers. All-wave reception, delayed automatic volume control, and remote tuning units are increasing the obsolescence factor of old sets as well as bringing in new buyers.

The second types are typified by the sketch B of Fig. 3. In this case the audio amplifier has been placed in the cabinet with the speaker, and the remote unit houses only the r-f, i-f, and detection system, which is coupled to the speaker cabinet by means of an a-f transmission line. This method reduces the necessary space required in the remote unit, as indicated by the dotted lines or, conversely, leaves more space in the remote unit cabinet for the receiver units which then need not be crowded. It places the a-f amplifier and power supply chassis in the speaker cabinet which is reasonably a roomy affair to start with.

The third types are typified by the sketch C of Fig. 3. In this case the remote unit contains only the r-f tube and the mixer-oscillator. The output of the mixer is piped to the speaker cabinet through an i-f transmission line where is located a single chassis containing the i-f amplifier, second detector, automatic volume control, a-f amplifier, and power-supply unit. The space required in the remote unit is reduced to such an extent that the cabinet may be reduced in size without overcrowding the components. Moreover, the chassis in the speaker cabinet, though of greater proportions, is not cramped for space.

The arrangement indicated in sketch C is gaining great favor and has already blossomed out in a number of commercial receivers.

VOLUME AND TONE CONTROLS

The subject of volume controls is of considerable interest. To be covered properly, it must be treated together with tone controls.

With the advent of the diode detector in broadcast receivers, the volume control graduated from its usual position in the antenna-cathode circuit of the pre-selector tube, into the control-grid circuit of the a-f tube immediately following the diode detector. The purpose of this movement was, of course, twofold; first, it is undesirable to reduce a signal voltage at the input of a diode detector below a certain limit. If the signal voltage on the diode is too low, the diode no longer functions as a true linear rectifier, and distortion occurs. Second, if sufficient signal voltage is impressed on the diode to insure linear detection, the rectified voltage in the diode load circuit would, in many cases, overload the grid of the first a-f tube, causing grid current to flow and producing second harmonic distortion.

With the volume control in the grid circuit, the signal input to the diode may be high, for under these conditions the signal voltage to the control-grid of the a-f tube is controllable.

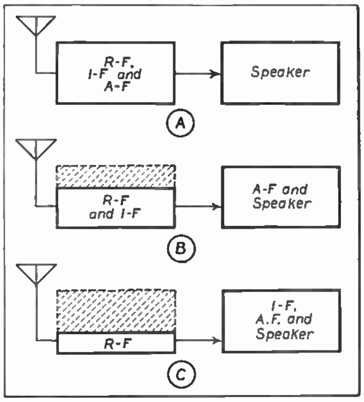


Fig. 3. Remote tuning and volume control units take three forms. Space is saved by including only the r-f and mixer-oscillator in the control cabinet.

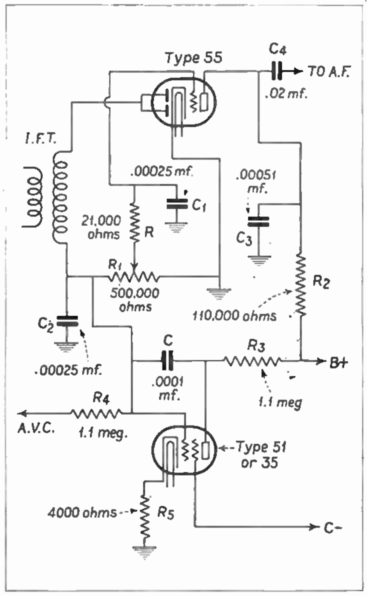


Fig. 4. An automatic tone-control and noise-suppression circuit. A change in the mutual conductance of the type 35 tube by the AVC voltage, alters the dynamic capacity of the condenser C.

In a few receivers this practice is not carried out, but precautions are taken in the form of diode biasing of the a-f control grid, and a current-limiting resistor in the plate circuit. Moreover, sufficient a-f gain is used following the first a-f tube to discourage the user from "pushing" the receiver to obtain more volume.

In one receiver where diode biasing is used, a compensated volume control system is employed in the a-f feed circuit between the first and second (push-pull) a-f stages. In a receiver somewhat of a similar type, the compensated control is located in the control-grid circuit of the first a-f tube. These compensated systems are quite common by this time and probably will continue to be extensively used.

EFFECT OF TONE CONTROLS

The compensated volume control has proven a disguised convenience to the average set owner, unless he had foreknowledge of its existence in his receiver and some understanding of its operation. But, then, most radio blessings of this sort are received unconsciously by the public. And, as with compensated volume control, inadvertent recognition is given the engineering fraternity when the set owner remarks that his receiver sounds better with the "loud knob" turned down.

Yet the improved low-level response may quite often be offset by the tone control. If the average set owner is not tone deaf, at least he is treated as if he were. Consider the man with a modern receiver, having exceptionally good frequency response, and equipped with compensated tone control and in addition a separate tone control for cutting out the high-frequency passages. When this man first uses the receiver he will instinctively set the tone control for the "lows" and follow up by reducing the volume of the receiver to a point where the program is a soft background of thumps and twitter to break the monotony of silence or bridge talk.

With high-frequency attenuation and low-frequency gain in the compensated tone control, plus further high-frequency attenuation in the tone control, the receiver's value as a good reproducer has been almost completely annexed.

Forgetting for the moment the value of the tone control as a reducer of stray noises, it appears that it has worked a form of black magic on the ears of the people. The difficulty seems to be that the ear has a peculiar adaptability to familiar sounds and that this adaptability robs it of the power of distinction between good and bad—much in the same manner that a dog appears to be incapable of realizing that his master may be the worst sort of rotter.

The result is two-faced; firstly, most people have become not only used, but very much attached, to "radio music" devoid of "highs", and secondly, people very seldom like the sound of their neighbor's radio, even though the neighbor's set may be superior. Still, the very same people will complain that a radio receiver is not true to the original.

If it is the fault of the ear—and it appears to be—the ear will have to be trained by force. The perfect answer would be, "Tut-tut, no tone control!" Fortunately, this is not necessary.

● Tone control systems are in for a revision. The introduction of automatic tone control will make high-fidelity receivers practical for the home by eliminating manual tone controls which permit serious frequency cutting.

AUTOMATIC TONE CONTROL

The answer will show up this year in the form of automatic tone control, or ATC. This will take away from the set owner the responsibility of training his own ears, yet provide the desirable features of the compensated tone control—plus an extra one of its own—and at the same time eliminate the drawbacks of the individual tone control.

Automatic tone control is used in the Stewart-Warner Model 110 Chassis. The circuit, with extraneous connections omitted, is shown in Fig. 4. Briefly, the lower, type 35 or 51, tube has its control grid tied in to the negative side of the diode load circuit, which also provides the AVC bias. This tube operates as a variable capacity across the output circuit of the diode, the capacity increasing with a *decrease* of signal. If the signal received is strong, the total capacity shunting the diode output is the capacity of condenser C plus the inter-element capacity of the tone-control tube. This total capacity is about average for the diode load resistor shunt and in consequence there is no appreciable attenuation of the frequency band in this part of the circuit when a strong signal is being received. However, when the signal is weak the "dynamic" capacity of condenser C rises to a high value (with a minimum signal the dynamic value of C will rise 50 to 60 times its static value). The result is an increase in the attenuation of high frequencies, with the actual cut-off extending to as low as 800 cycles or so.

The scheme is based on the fact that the input capacity of a tube varies with its mutual conductance, and is governed by the grid-to-plate capacity. If, then, the grid-plate capacity of a variable-mu tube is supplemented by a static capacity, large values of input capacity can be obtained—in the case under discussion about .006 mfd peak when using a moderate value of static capacity.

This automatic tone control works hand-in-hand with the automatic volume control, and because of the high shunt capacities developed, may be used effectively as the intercarrier noise suppressor as well. Under these circuit conditions, the amount of noise removed is dependent on the strength of the signal, with the greatest removal at minimum signal. For this reason the swish which occurs at the fringe of a channel is entirely removed.

Its value as an automatic tone control rests not in the fact that high frequencies could be attenuated were there a volume control preceding the diode detector, but rather in the fact that the full quality of a strong signal—with volume controlled in a circuit following the diode—cannot be tampered with by the set owner.

SECOND ATC ARRANGEMENT

Another ATC arrangement is shown in Fig. 5. This system is based on the

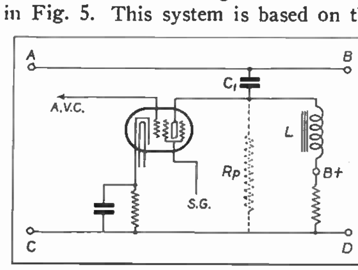


Fig. 5. Another form of automatic tone control, based on a change in the value of Rp with a change in grid voltage.

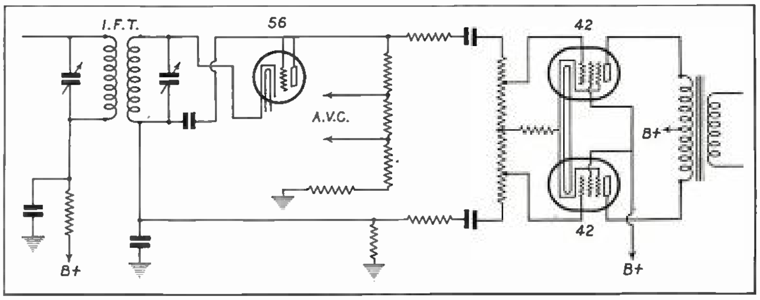


Fig. 7. A diode feeding a pair of 42's in a resistance-coupled push-pull circuit, used by Crosley in 1932. Will this type of circuit return with ATC, AVC, and iron-core i-f transformers?

variation in the plate resistance of the tube with a variation in grid bias. A-B and C-D represent the a-f feed circuit. In the plate circuit of the tube is a very high impedance, L, and from the upper a-f line to the plate, a condenser C-1, of about .01 mfd. If the grid is tied into the negative end of the diode circuit and the signal voltage is high, the consequent grid bias will also be high. Under these conditions both Rp and the impedance L have extremely high values and the condenser C-1 is ineffective as a bypass. However, if the signal voltage is low, the grid bias is also low. The value of Rp therefore drops, and the condenser C-1 becomes effective as a bypass, though still ineffective with respect to L, whose value is practically constant. The amount of bypass or effectiveness of the capacity C-1 varies with signal strength.

A similar circuit arrangement is effective in producing parallel resonance, and by the judicious selection of capacity and inductance values it is possible to attenuate the higher frequencies without reducing the lower frequencies.

HIGH FIDELITY

Most of the emphasis for some time to come will be placed on high fidelity. The movement has already begun, as evidenced by the opening up of i-f bands and the equalization of frequency distortion by the use of distorted resonance curves. Two manufacturers at least have receivers with i-f systems which will pass a band up to 6000 cycles. Single speakers capable of handling 40 to 8000 cycles have been developed.

About 6000 cycles seems to be a good stopping point for receivers, as reports indicate very little improvement above this figure. Moreover, as much as 5 per cent distortion becomes very apparent around 8000 cycles.

The matter of background noise also becomes an important factor at such high frequencies, not due to the extent into the high end, but rather because of the addition of a band 2000 or 3000 cycles wide—of questionable utility—whose total noise content is about equal to the total noise in the present band covered. Thus, if the frequency band were increased from, say, 4000 cycles to 8000 cycles, the noise content will have doubled.

RETURN TO TRIODES

In any event, the trend is toward a wider band and as a forerunner to this we find many manufacturers returning to the use of type 45 triodes in single or parallel push-pull in the power stage—or the use of pentode tubes connected as triodes. These arrangements are favored over circuits employing 2A3 triodes, which appear to have met with only partial success. This tube, like the type 53, operates in that region between Class A and Class B. Circuit and component design require particular attention.

Two manufacturers have turned to the use of type 42 tubes as triodes in Class A Prime push-pull circuits, and obtain approximately the same undistorted power output as delivered by a pair of 2A3's in the usual Class A circuit.

Class B is on the wane and it is a question whether Class A Prime will stick for long, as numerous manufacturers are being charmed by the possibility of resistance-coupled push-pull as

(*Continued on page* 24)

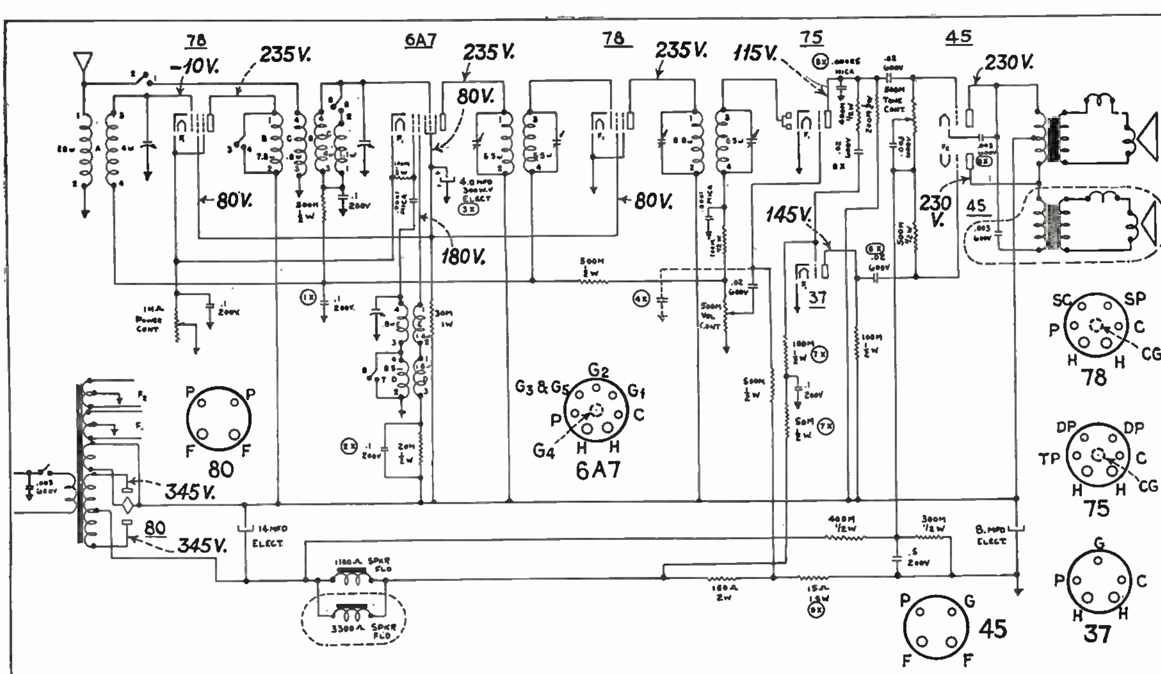


Fig. 6. The Sears-Roebuck Silvertone Model 1708 receiver, which uses two 45's in resistance-coupled push-pull. True push-pull action is obtained by the use of a phase changing tube which provides an equal voltage, but opposite in value, for the grid of the lower 45 tube.

OUTPUT POWER and Harmonic Distortion

BY D. C. ESPLEY, M.ENG., A.M.I.E.E.
AND D. A. OLIVER, B.Sc.

GENERAL ELECTRIC COMPANY, LTD., WEMBLEY, ENGLAND

● The relation of harmonic outputs of pentodes to such factors as load resistance. The authors discredit the impression that pentodes suffer from large percentages of third-harmonic distortion

A FEW YEARS ago the necessary information essential to ensure the correct operation of different makes of power valve or tube was lacking, and it was customary to pay attention to the value of the power which could be continuously dissipated by the anode of the tube. Its importance will not be questioned for, if this figure is appreciably exceeded, the tube fails due to overheating or its life is greatly shortened, while on the other hand an appreciably lower anode dissipation results in reduced output and practical inefficiency.

ELECTRICAL CONSIDERATIONS

It is the purpose of this article to comment on a few of the many other factors which, sooner or later, modern set designers are bound to take into account. In practice it is well known that the actual power supplied to the input winding of a loudspeaker load is considerably less than, and bears no simple relation to, the steady anode dissipation. Some basis is therefore desirable on which power tubes can be compared irrespective of loudspeaker efficiency, loudspeaker input impedance and coupling arrangements, in order that tubes of a similar type can be reliably compared and their merits accurately assessed.

Most readers are familiar with the anode-current, anode-voltage characteristic curves taken for round values of grid bias and with the conception of resistance load lines. Several articles have appeared in the technical press explaining these matters, but, for completeness, it is convenient to restate that the maximum possible electrical output power which can be drawn from a power tube occurs when the loudspeaker winding is replaced by a resistance having a particular value. In order to distinguish between the steady and varying components of the current in the anode circuit it is convenient to imagine the resistance coupled to the tube by an ideal transformer and then the way is clear to consider the power tubes under discussion as separate entities.

The simple equivalent circuit diagram for a triode is shown in Fig. 1 and a typical set of characteristics for a pentode with different load lines, corresponding to different values of resistance R, is given in Fig. 2. The method is general and can be applied to either triode or pentode characteristics. It will be observed that these load lines lie below the course of the steady anode dissipation hyperbola, but run close to it to ensure efficient running.

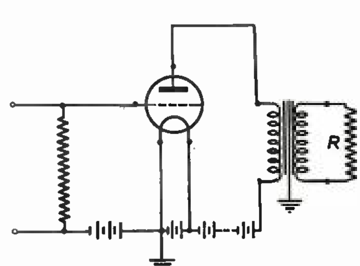


Fig. 1. Triode with resistance load; transformer assumed perfect.

PENTODE CHARACTERISTICS

Consider tubes operating under these simplified, pure resistance load conditions. Then it is apparent from Fig. 2 that for some values of the load resistance the positive and negative loops of the anode current wave for a sinusoidal variation in grid voltage will be unequal on account of the differences in the lengths OA, OB. By a well-known mathematical theorem, a distorted anode current wave can be regarded as the sum of a series of pure sine wave components added in particular phases. Thus the anode current can be regarded as consisting of a major or fundamental pure sine wave of the same frequency as the alternating voltage applied to the grid, and a number of considerably smaller waves (unless the distortion is excessive) having particular amplitudes and frequencies, twice, three times, four times, etc., that of the fundamental. These double and higher frequency components are termed the second, third, fourth harmonics, etc., and when reproduced by the loudspeaker in other circumstances are spurious, unwanted contributions to the overall complex reproduction.

There are occasions when harmonics produced in one part of the system can neutralize those produced in another, but normally the introduction of harmonics is deleterious and there is general agreement in this view.

It is evident that a mere statement of the maximum available power output of a tube into a resistance load is not a sufficient criterion of performance. A number of limitations have to be imposed either from considerations of the design of the tube itself or of its associated circuits. The static working point on the anode-current, anode-voltage characteristic curves should not, in general, lie outside the hyperbola which represents the rated anode watts dissipation. However, the whole of the range within this curve is not available for the working point, as at high voltages the tube may suffer bombardment of the electrodes by positive ions, and at high currents the drain on the filament, or cathode, may approach the condition in which saturation of the emission of electrons begins to have an adverse effect. In practice the working point will lie well between the two extremes and in what follows the maker's recommended point will be taken as a basis.

TABLE I

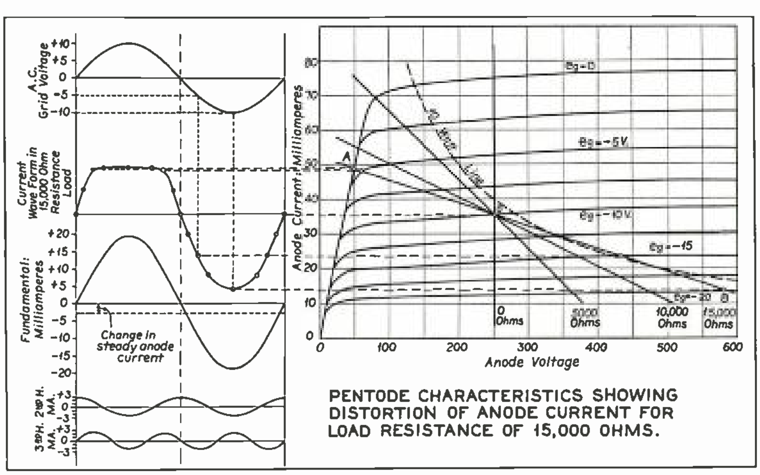
The percentage harmonic distortion in the modern 4-volt pentode of Fig. 2 showing the effect of load resistance and output power variations.

Watts Output	5,000 Ohms Load					10,000 Ohms Load					15,000 Ohms Load				
	2nd	3rd	4th	5th	Distortion Factor %	2nd	3rd	4th	5th	Distortion Factor %	2nd	3rd	4th	5th	Distortion Factor %
0.5	5.8	0.4	0.8	0.1	5.8	4.2	0.4	0.2	0.1	4.2	3.4	0.8	0.5	0	3.5
0.75	6.4	0.5	0.7	0.3	6.4	4.5	0.7	0.5	0.1	4.5	2.8	1.4	1.0	0	3.3
1.00	7.1	0.1	0.3	0.4	7.1	4.3	1.2	0.9	0.2	4.5	2.0	2.0	1.4	0.1	3.2
1.25	7.8	0.7	0.1	0.3	7.8	3.8	1.7	1.2	0.2	4.3	1.0	2.8	2.0	0.1	3.6
1.50	8.6	0.8	0.3	0	8.6	3.2	2.3	1.6	0.2	4.3	1.0	4.0	2.6	0.2	4.9
1.75	9.4	0.7	0.5	0.4	9.4	2.2	3.3	2.0	0.3	4.5	3.7	5.5	3.2	0.4	7.4
2.0	10.2	0.5	0.7	0.8	10.2	1.2	4.4	2.4	0.4	5.2	6.2	7.2	3.5	0.4	10.2

LIMITED GRID VOLTAGE

The maximum voltage which can be applied to the grid is usually limited by the design of the input circuit and in many cases it is arranged that the maximum allowable positive peak is just insufficient to cause the tube to run into grid current, although this voltage cannot always be utilized due to considerations which follow. This is especially important where the input circuit has a high impedance, in which case violent distortion can occur with the passage of even a small grid current. The arrangement of the Class B amplifier is somewhat different and may be considered as a special case which is outside the scope of this article. However, provided that the particular conditions determining the allowable grid swing are satisfied, the present general remarks will apply.

Even on the above assumptions the power which the tube is capable of handling cannot yet be stated. We have not up to the present decided what value of load resistance should be coupled to the anode circuit, and the amplitude of the applied grid voltage also remains to be fixed. A figure for the maximum tolerable harmonic content, defined on an agreed basis, provides the required additional data but the value to adopt is not universally agreed and is a matter for careful specification. The tolerable value of harmonic content will be derived eventually from the results of subjective tests. Methods are available for the calculation of the separate harmonic currents which appear in the load for a sine wave of grid voltage and these can be conveniently given as percentages of the amplitude of the fundamental current. In the case of triode tubes it is found that the even harmonics are predominant and the percentage of second harmonic is often stated as the limiting factor. Some measure of agreement is gradually being evolved and a value of 5 per cent is often quoted as a tolerable figure. Pentode tubes behave differently from triodes in that the second, third and higher harmonics vary greatly with change of load resistance and grid input voltage so that some other condition is clearly desirable.



PENTODE CHARACTERISTICS SHOWING DISTORTION OF ANODE CURRENT FOR LOAD RESISTANCE OF 15,000 OHMS.

Fig. 2. Pentode characteristics analyzed for various values of load resistance, with all harmonics up to the fifth calculated for any applied voltage up to a value representing a swing from the working point to zero grid volts. See Table I above.

DISTORTION FACTOR

A "Distortion Factor" has been suggested and this is simply the ratio of the r.m.s. value of all the harmonic currents to the r.m.s. value of the fundamental current, and is defined by $\sqrt{I_2 + I_3 + I_4 + \ldots\ldots}/I_1$, where I_1, I_2, I_3, etc., are r.m.s. values. Again 5 per cent has been quoted as a convenient figure. Any value for either the percentage "Distortion Factor," or the percentage of any particular harmonic, will serve as a basis of comparison but it is desirable to adopt a value which has been found to correspond to a maximum allowable distortion of the sound radiated from the loudspeaker. An aural test is ultimately essential, but already a preliminary investigation tends to show that in some cases the higher harmonics produce an apparently greater amount of sound distortion than do equal amplitudes of either the second or third harmonics. This, of course, complicates the issue and while the "Distortion Factor" may provide a better criterion than a figure for the percentage of any particular harmonic, it seems likely that soon a more highly specified factor will be necessary which will give a better guide to the expected distortion in the reproduction of sound.

Assuming then that some value of the harmonic content has been set as a practical limit, a number of load lines can be drawn through the working point on the anode current, anode voltage characteristic and for various values of grid voltage swing, both the power output and the harmonic content can be obtained. There will be some value of the load resistance which, combined with a value of grid voltage swing, will provide the maximum power output with the harmonic figure just within the agreed maximum. The tube operating conditions are then completely speci-

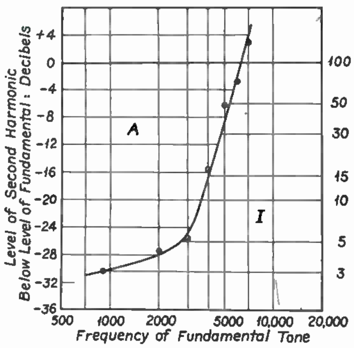


Fig. 4. Amount of just-perceptible second harmonic. "A" is the audible region, and "I" the inaudible region.

fied, but it will be recognized at once that much of the foregoing process is often omitted and results obtained which cannot in general represent the tube performance.

The characteristics of a typical modern pentode power tube, of which Fig. 2 is a somewhat simplified drawing, have been analyzed in detail for various values of load resistance. All harmonics up to the fifth were calculated for any applied voltage up to a value representing a swing from the working point to zero grid volts. Some of the results are tabulated in Table I and the component currents in the distorted anode current wave form are plotted in Fig. 2 to give a clearer mental picture of the process taking place which shows a particularly bad case of distortion resulting from the use of too high a value of load resistance. Of course, a reduction of the input voltage by one half would considerably reduce the harmonic content but the power output would be small and the arrangement inefficient.

MAXIMUM LOAD VALUE

The maximum value of load resistance to be coupled to the anode circuit of a pentode tube is sometimes stated in its specification, but although this seems obvious from a consideration of Fig. 2 some ambiguity remains as to the best value to adopt. With zero load the second harmonic is usually excessive, but as the load resistance is increased this harmonic rapidly diminishes to zero and then becomes greater as the load is further increased. Over this range the third harmonic rises slowly from a small value and then rapidly increases as the load line passes through the "knee" of the characteristic curves. Table I shows this, and Fig. 3 illustrates the point further by including the values of "Distortion Factor" and power output plotted against load resistance for the tube of Fig. 2.

It will be seen that a statement of the maximum permissible load resistance is incomplete as, actually, to give a minimum "Distortion Factor" a definite optimum load is required. This only applies to the value of grid voltage swing adopted, namely 10 volts peak, but a series of "Distortion Factor" curves could be plotted easily for a number of voltage swings. The circuit designer then knows exactly what to expect of the tube as a component and a basis for intercomparing power has therefore been arrived at. In other words, having specified the "Distortion Factor," the maximum power available from a tube is obtained directly.

Confusion sometimes arises regarding the exact definition of the power output, as the term may include either the power output of pure fundamental frequency, or the total power of this fundamental together with all the various harmonics. The answer is that in nearly every practical case the two powers as defined have nearly the same value. For example, the difference between them when the "Distortion Factor" is 10 per cent amounts to an error of only 0.5 per cent.

The case of the pentode has been chosen deliberately as representing a difficult example. Sufficient has been shown in Table I and Fig. 3 to discredit the widespread idea that the pentode suffers mainly from a large percentage of third harmonic. In fact the second harmonic is usually the largest. In many cases it is only when pentodes are compared with triodes in the push-pull arrangement (removing all even harmonics in the balanced case) that pentodes show up to disadvantage.

Many departures are often made from the optimum conditions in a practical arrangement using this tube, the worst of which is probably that of coupling a variable impedance load, such as a loudspeaker, to the anode circuit. Even so, some judgment is required to effect the best average matching. The triode is easier of treatment as the characteristics are not subject to such violent changes of curvature in certain regions.

The general conclusion is that the specified output ratings of two tubes, triodes or pentodes, do not necessarily represent their relative performances fairly under working conditions unless the same interpretations are applied to each rating from the point of view of harmonic content. Either of two identical tubes could be rated slightly higher than the other and the user would then tend to discriminate between them until he realized that they were not being compared on a common basis.

ACOUSTICAL CONSIDERATIONS

In so far as the power tube and loudspeaker are a means only to the end of amplifying and reproducing speech and music, it is important to know what percentage of any particular harmonic is just perceptible by ear. A discussion of the aural effects of the introduction of spurious harmonic frequencies into the reproduction, and their interaction with those frequencies which are rightly present, would necessarily become highly involved. For example, the masking of certain tones by others of different frequency in the presence of the main body of the reproduction would have to be taken into account and the complicated effects associated with the non-linear rectifying action of the ear in connection with the combination, and beat frequencies could not be overlooked.

In the face of such complexity a simplified case will therefore be dealt with and the amount ascertained of second harmonic which sounding simultaneously with its fundamental, assumed of unit strength, will just suffice to enable a change in the quality of the

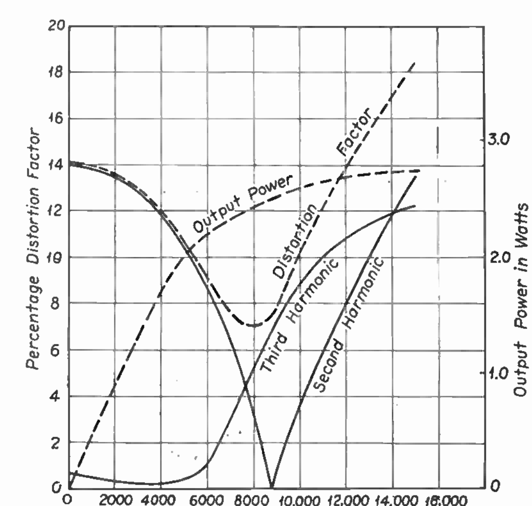


Fig. 3. Performance of modern 4-volt pentode tube with maximum permissible voltage applied to the grid (swing of 10 volts peak from a steady bias of 10 volts). Ea and Esg equal 250 volts.

pure fundamental tone to be detected. There appears to be a scarcity of data on this subject but some valuable measurements were carried out a few years ago by the B. B. C. and mentioned in a lecture by R. P. G. Denman.[1] These have been made the basis of Fig. 4 in which is given for a limited range of frequency the power level in decibels of the second harmonic relative to the level of the fundamental of half the frequency such that the presence of the second harmonic is just perceptible. Alternatively it can be said that if the level of the second harmonic for its respective fundamental frequency is on or below the line drawn in Fig. 4 then the strength of the fundamental is sufficient to mask the presence of the second harmonic without any apparent loss in the purity of the sound from the loudspeaker.

Even with the simplification already made it is necessary to point out that Fig. 4 needs revision if weak fundamental tones are being considered as then the threshold sensitivity of the ear becomes an additional controlling factor. It was not stated at what intensity level of fundamental tone the original observations were made and, therefore, an interpretation of the results cannot safely be taken much farther. Nevertheless, an indication is given from the percentage scale on the right side of Fig. 4 that a minimum value of 5 per cent for harmonic content is not an unreasonable measure to adopt for sensibly perfect reproduction.

RESISTANCE LOAD

When the more practical case of an inductive load in the anode circuit of a power tube is considered, it would appear that, when using tubes giving 5 per cent or less of harmonic distortion on an optimum pure resistance load, a much larger harmonic content will normally be found in these new circumstances. An harmonic distortion comparison for two power tubes having pure resistance loads is necessarily a rather hypothetical case, and while satisfactory for comparing tubes, it does not follow that the results so obtained are applicable under ordinary working conditions, unless the respective loads are free from reactance.

Another matter receiving attention at the present time is the precise alternating current power output of the tube. Some tubes are estimated as giving a few tenths of a watt greater output than similiar tubes of a different make and the question arises as to what significance should be attached to such differences. Table II is an attempt to answer this question. In the first column the values of output power corresponding to Table I are taken, and in the second column the power level in decibels above or below unit power level is given. This column is simply $10 \log_{10} \frac{W_1}{W_0}$, or $10 \log_{10} W_1$, as $W_0 = 1$.

TABLE II

W	db above or below 1 watt level	Difference in level db.	Number of just perceptible steps in interval for 1,000 cycle sec. pure tone: 40 phon level	60 phon level	80 phon level
0.5	—3.0				
0.75	—1.3	+1.7	2	4	4
1.0	0	+1.3	1	3	3
1.25	+1.0	+1.0	1	2	2
1.50	+1.8	+0.8	1	2	2
1.75	+2.4	+0.6	1	1	1
2.0	+3.0	+0.6	1	1	1
2.25	+3.5	+0.5	0	1	1
2.5	+4.0	+0.5	0	1	1

In the third column the successive change in level in decibels is tabulated for each successive ¼ watt increase in power.

Now, interpret these results in terms of their aural effects. To fix ideas we require some scale for assessing loudness and for this purpose we shall take a just perceptible step in the scale of intensity as being a measure of the loudness change. The magnitude of this effect varies with the frequency and intensity of the note to which we are listening and therefore we choose a 1,000 cycle per second note as a standard. The actual intensity, or noise level, in an ordinary room, of the sound reaching the ear for a given power output depends largely upon the efficiency of the loudspeaker and the size and absorbing power of the room.

THE "PHON"

Assuming that the volume from the loudspeaker is under control it is evident that in a particular room we shall, for a given volume control setting, listen to the reproduction at a given level of intensity. Let this level of intensity be measured in terms of the equivalent loudness of a 1,000 cycle per second pure tone, specified by the level in decibels above the level of the threshold of audibility, at 1,000 cycles per second. This scale of loudness has been called the "phon" scale and the loudness in phons is numerically equal to the number of decibels, as just defined. This scale, whatever may be its shortcomings as a proportional scale of loudness, is very useful as an acoustical intensity measuring yard. For example, the National Physical Laboratory have found that loud radio music has a noise value of about 75 phon, loud radio speech 60 phon, and ordinary conversation at three feet distance, 50 phon.

TUBE RATINGS

Now refer back to Table II and examine the last three columns. There have been given for equivalent noise levels of 40, 60 and 80 phons, the number of just perceptible steps for a 1,000 cycle pure tone corresponding to each successive increment of ¼ watt in electrical power to the loudspeaker. Table II shows the significance in terms of loudness to be attached to a ¼ watt increase or decrease in electrical power for different initial power levels and for different intensity levels at the ear of the listener. It is interesting to note that a 10 per cent increase in tube output power at an electrical level of 2 watts and an aural level of 40 phon, is not even detectable, but at higher levels it can be just appreciated. Clearly then, for tubes giving an output power of this order, differences in rating of 0.1 or 0.2 watt, even when precisely established, have little or no importance and in cases where greater overall set sensitivity is required it is probably better to select a more sensitive loudspeaker than to make relatively expensive improvements by increasing the electrical input power to the loudspeaker.

[1] *Journ. Roy. Soc. Arts, London. LXXVII* (1929) 668.

AUTO INTERFERENCE SUPPRESSION ADVISED

PROBLEMS in developing automotive radio were presented at the annual meeting of the Society of Automotive Engineers at the Book-Cadillac Hotel in Detroit on January 22, by Virgil M. Graham of Rochester, N. Y., chairman of RMA engineering.

Suppression of interference in automotive radio was an objective stressed in Mr. Graham's paper:

"The radio engineer would feel that he was not giving good counsel if he failed to urge the use of better operating characteristics and features of automobile radio so as to be in keeping with the car improvements.

"In the home electrical appliance field there is a situation to which the automotive condition may well become analogous. Within the last few years the manufacturers of such appliances, vacuum cleaners, mixing machines, hair dryers, et cetera, have been forced by the public to design their devices to prevent radio interference. Now, more and more purchasers of such equipment are asking to be sure that it is non-interfering."

Type 800 Data

Characteristics of the Type 800 tube and its application as a Class B modulator for low-priced units.

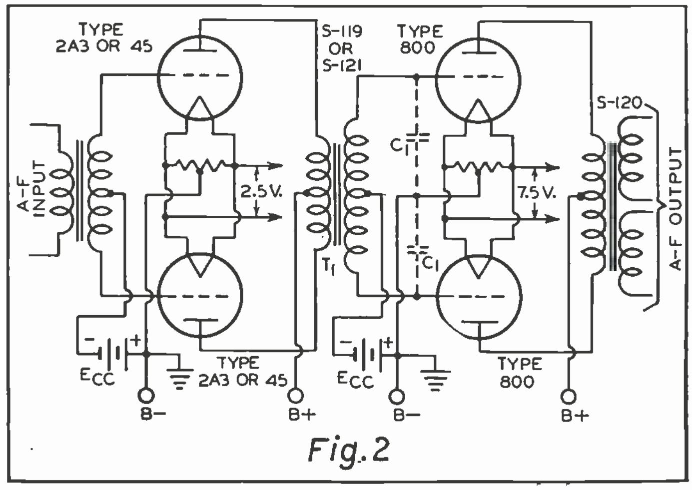


Fig. 2

Two type 800 tubes in a typical Class B circuit. Component design data is given in the text.

ONE TRIODE designed to be used as a radio-frequency power amplifier or oscillator is the RCA-800, which can also be used as a Class B audio-frequency amplifier where a large power output is desired. By the use of two tubes, 100 watts of audio power can be obtained.

VALUES AND OPERATION

The following data, supplied by the Engineering Department of RCA Radiotron Co., Inc., are for Class B operation with plate voltages of 750, 1000, and 1250 volts being given, as well as the optimum plate-to-plate loads and transformer ratios for each case of operating voltage. The two 800's are in a Class B output stage.

Fig. 1 shows the change in audio level and output volts for frequencies from 30 to 10,000 cycles for the 1000-volt condition of Table I.

These fidelity characteristics are based on the circuit of Fig. 2. This is a typical circuit diagram for a Class B audio amplifier. The source for the grid bias should be one with a good voltage regulation. An excellent source for this bias is a small-capacity storage battery, since the amplifier action is generally such as to keep the battery charged, or a rectifier with a good voltage regulation may be used. A dry battery, however, should not be used as it tends to polarize when the grid current is drawn. It may, also, have too high an internal resistance.

TABLE I

Driver Tubes, Two 2A3's; Plate Volts, 250; Grid Volts, —45

Plate Volts	Grid-Bias Volts	Driver Transformer Ratio* Pri. to ½ Sec.	Plate-to-Plate Load Ohms	Plate Input Power (2 Tubes) Watts	Total Power Output Watts	Total Distortion Per Cent
750	—50	1.75 :1.0	6400	160	90	7.3
1000	—55	2.0 :1.0	12500	160	100	7.0
1250	—70	2.0 :1.0	21000	160	106	7.0

TABLE II

Driver Tubes, Two 45's; Plate Volts, 275; Grid Volts, —56.

1000	—55	2.16 :1.0	12500	160	100	7.9

**For approximately 80% peak-power efficiency.*

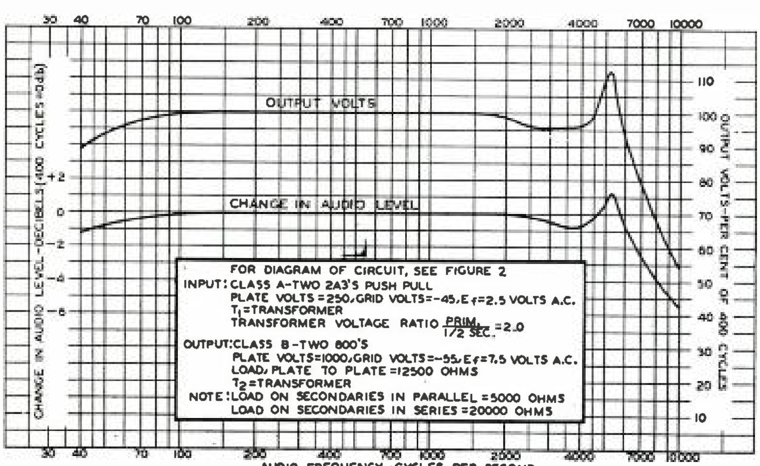


Fig. 1

Fidelity curves of the type 800 tube used in the Class B circuit of Fig. 2.

TRANSFORMER DESIGN CHARACTERISTICS

The modulation transformer should be designed to carry direct current, and the secondary windings of such a transformer should provide a plate-to-plate load on the 800's of 12,500 ohms when they are series connected and shunted by 20,000 ohms, or when they are parallel connected and shunted by 5000 ohms. The transformer should have an air gap to carry 100 ma. d-c for the two secondaries connected in series, or 200 ma. for the parallel connection of the secondaries. Naturally, the air gap becomes unnecessary for a secondary load without direct current, and hence a smaller transformer of the same efficiency may be employed. A transformer for loudspeaker operation should be designed from the plate-to-plate loads given in the table, and should have the same primary inductance and the same space distribution of windings as the modulation transformer, but it should not have an air gap.

OPERATION CHARACTERISTICS

In the following, let us first consider the three cases under Table 1 with 2A3's in the input. In the first case, for a driver-signal voltage (r. m. s.) per tube of 30 volts, the grid milliamperes will be about 14 per tube, dropping to almost zero at 5 volts for the driver signal. The power output (two tubes) varies from zero to 85 watts at 30 volts, and the plate milliamperes vary from 18 milliamperes at 2.5 volts to 103 milliamperes at 30 volts. At 30 volts, the total harmonics are approximately 6.9 percent, 4.4 percent at 17.5 volts, 4.2 percent at 10 volts, and 1.4 percent at 3.5 volts.

(*Continued on page* 24)

A New Method of

By S. S. EGERT AND S. BAGNO

WIRELESS EGERT ENGINEERING, INC.

● A system of measuring distortion which makes use of a phase-changing device in connection with a gain indicator and vacuum-tube voltmeter

DUE TO THE ever increasing demand for greater fidelity in reproduction, the radio engineer has constantly been at work in an effort to manufacture radio receivers which will produce good quality reception. During the course of this development there have been numerous setbacks due to such things as depressions, the overzealous desire to produce equipment which would merely sell (and not satisfy) the public, the inability to obtain reasonably-priced equipment in order to record the much needed information to overcome these inherent faults, etc.

EFFECTS OF DISTORTION

As we all know, there are many types of distortion which can find their way into a radio receiver. Their forms and characters are so numerous that for perfect understanding it would necessitate a long study in problems of distortion alone. It is not the intention of the authors to try to go into this matter very deeply, as it would require studied information and observations which would necessitate recordings much too lengthy for the space limitations herein granted. We do, however, wish to present first a very general picture of the effects of distortion upon voice and music reproduction. It is also our intention herein to illustrate a very simple method of determining the amount of over-all distortion in a radio receiver, in the hope that by means of this, better radio receivers will soon be built.

For speech reception, various types of distortion may have a counter-balancing effect on the output reproduction of a radio receiver. For instance, the introduction of certain harmonic distortions actually help the articulation of speech, as, due to their non-linearity, the weak consonant sounds of speech are made stronger in comparison with the vowel sounds. Articulation may be defined as a recognition for understandability of speech. On the other hand, distortion due to overloading of the tubes of a receiver, or improper biasing, has a very detrimental effect on speech.

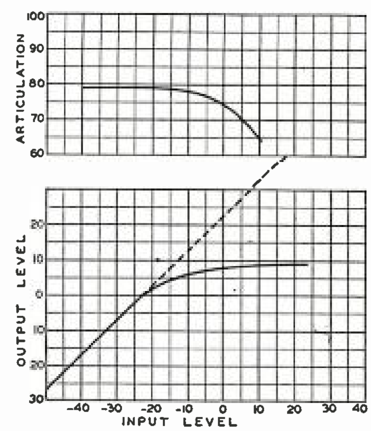


Fig. 1. Effect of overloading upon the articulation of speech.

(Courtesy of D. Van Nostrand Co., Inc.)

With music reproduction all types of harmonics are detrimental, as the richness of musical tones are dependent on the harmonics emitting from the instruments themselves and any added harmonic values only tend to destroy the original quality.

Fig. 1 (Reference: "Speech and Hearing," by Fletcher; Chapter VI, page 292) shows a curve of the effect of overloading upon the articulation of speech. When the input level into the vacuum tube used in this curve was 20 decibels, the output of the circuit reached its capacity.

SPEECH AND MUSIC

For higher levels, the output for speech energy is no longer proportional to the input. It can be seen, however, that the articulation of speech decreases only from 79 to 77 units as the input level increases 15 db above its overload point, or up to —5 db, as indicated by the curve. For higher levels the articulation drops off rapidly.

On the other hand, the effect of overloading when music is reproduced is very much more marked than upon the

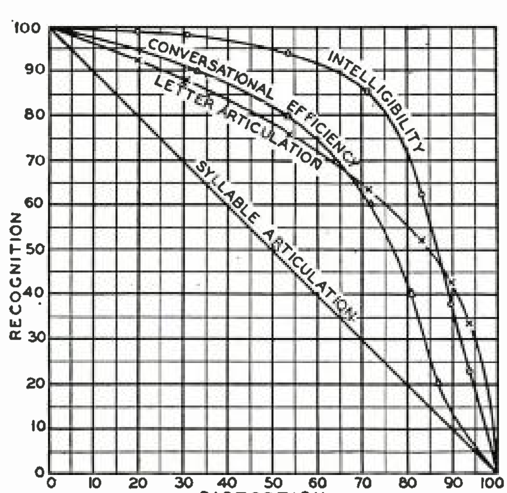


Fig. 2. Curves showing the relation between distortion and recognition. The intelligibility curve is referred to in the article.

(Courtesy of D. Van Nostrand Co., Inc.)

Measuring Distortion

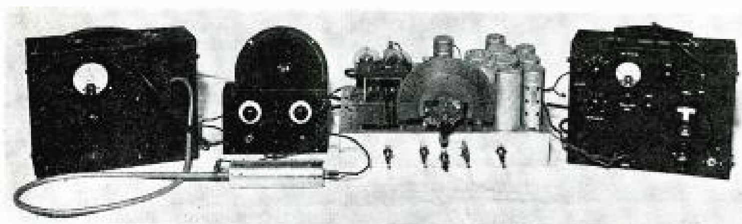


Fig. 4. The layout of the equipment. From left to right are: vacuum-tube voltmeter, distortion analyzer and gain indicator, receiver under test, signal generator.

reception of speech. Tests made with music indicate that when the input was increased more than 5 db above the overload point; that is, for input levels higher than —15 db on the scales shown in Fig. 1, the reproduced music was noticeably affected and distorted.

The above-mentioned facts can be readily shown upon observing the curve shown in Fig. 2. Here the reader will see a curve indicating the results of recognition of speech against distortion. (Reference: "Speech and Hearing," by Fletcher; Chapter III, page 266).

The term applied lately to our so-called cigar-box "speech receivers" can be readily appreciated here also. Regardless of the enormous amount of distortion inherent in small receivers, the reproduction which emits from their miniature speakers still allows the hearer to understand what the speaker is talking about. It can be seen from the curve that distortions even up to 20 units correspond to less than 1 percent change in the intelligibility, and also even up to distortions as high as 80 units there is still the possibility of 70 percent intelligibility.

On the other hand, from extensive arbitrary tests, it has been shown that when distortions as low as 5 percent are introduced when music is reproduced, the quality of the reception is hampered according to the opinion of a great majority of the listeners.

HARMONIC CONTENTS OF RECEIVERS

Since the Federal Radio Commission requires that all broadcast stations have a harmonic content which is no greater than 10 percent (at 100 percent modulation) of the original modulated signals propagated by the antenna, it is most advisable that the inherent distortion in receivers be kept as low as possible. The ordinary broadcast receivers of the semi-portable type, on the average, usually have harmonic contents which are in the neighborhood of 10 to 15 percent. A careful original design can reduce this figure to a great extent, and it has been proven that with a slight bit of extra experimentation harmonic contents can be reduced to figures as low as 3 and 4 percent when a 30 percent modulated signal is fed into the antenna of a broadcast receiver.

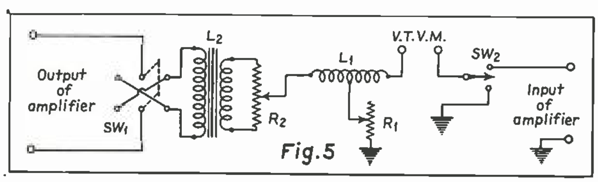
For general work the above-mentioned standard of a 30 percent modulated signal giving a 3-to-4 percent factor of distortion is satisfactory, and is a figure which presents a standard to which manufacturers can work for and still maintain competitive prices. Among the higher price receivers, on the other hand, a much higher degree of fidelity can be obtained. Employing the duo-diode linear detectors it should be possible to obtain these low harmonic contents even when modulations as high as 80 percent are employed in the tests. Higher percentage of modulation are particularly advantageous for the recorgnition of percussion instruments.

Fig. 3 shows the general set-up employed for measuring the harmonic content, and the individual units employed are shown in the illustration of Fig. 4. As can be seen, aside from the receiver under test, there are three individual instruments employed; 1, a harmonic analyzer and gain indicator; 2, a vacuum-tube voltmeter; 3, a standard signal generator. Before illustrating the procedure of the test, the individual operation of each instrument will be explained.

GAIN INDICATOR AND DISTORTION ANALYZER

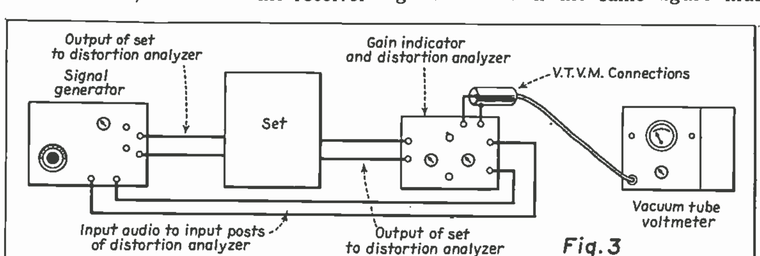
A diagram of the gain indicator and distortion analyzer is shown in Fig. 5. This particular instrument is an extremely handy unit which performs just what its name implies. The input audio signal to be fed through an amplifier or a receiver is also fed into the input posts, as indicated in Fig. 5. The output of the amplifier is then fed into the output posts as indicated in the diagram. A vacuum-tube voltmeter is then connected on to the posts as indicated. The original audio signal is then generated, and the potentiometer R-2 is varied until a null point or minimum indication is noticed on the vacuum-tube voltmeter. What is done here is a process of merely reducing the output signal of the amplifier to a point where it becomes equal to the input voltage of the amplifier. If the pointer of the potentiometer is calibrated directly in gain, it then becomes possible to read gain directly with this instrument.

Connections for the gain indicator and distortion analyzer, as used in the tests.



PHASE-CHANGING DEVICE

Aside from this, another highly important feature is incorporated in the unit in the form of the inductance L-1 and resistance R-1. An analysis of just how this phase-changing device operates is illustrated in Fig. 6. The vector diagram shown in the same figure illus-



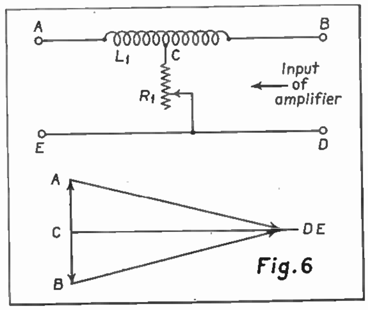
Complete set-up of the equipment as illustrated in Fig. 4. The connections to the set are common to two terminals.

trates the voltages set up across the individual components L-1 and R-1. Here it can be seen that the inductance L-1 is center-tapped. As the incoming signal enters into the device, equal and opposite voltages are set up on either side of the mid-point of L-1. Then by varying the resistance R-1, the resultant phase angles generated (AE outgoing and BD incoming) can be changed through almost 180 degrees.

My means of the phase-reversing switch SW-1, as shown in Fig. 5, it is possible to obtain phase rotations ranging through almost 360 degrees.

The instrument then operates as follows. After the original hook-up is made to the input, output, and vacuum-tube voltmeter posts, the gain indicator R-2 is varied until a null point is reached in the vacuum-tube voltmeter. The phase rotator R-1 is then varied until a lower null point is reached. The operator then should go back to R-2 for a slight readjustment, and then again to R-1 for another readjustment. This procedure is kept up until there is an absolute null in the fundamental and only the harmonics are apparent.

As can be seen from the vector diagram, due to the fact that AE is always equal to BD, the harmonics are never attenuated regardless of their frequency. Readings on the vacuum-tube voltmeter should then be taken for both positions of switch SW-2. When the switch is down the voltmeter will indicate the input voltage of the amplifier, and when the switch is up, the vacuum-



Circuit of the phase changer, and vector diagram. The inductance L-1 is center-tapped and equal and opposite voltages are set up on either side of the mid-point. Varying the resistance R-1 permits a changing of phase angles through almost 180 degrees.

tube voltmeter will indicate only the harmonic content, due to the fact that the fundamental frequencies are balanced out.

THE VACUUM-TUBE VOLTMETER

The vacuum-tube voltmeter shown is a newly developed instrument which is capable of reading full-scale voltages of 2/10 of 1 volt a-c when a 15-microampere meter is employed as an indicator. The instrument used in this test uses a 200-microampere meter and is capable of recording full-scale voltages of 1 volt a-c.

The signal generator employed is capable of supplying modulations varying up to 90 percent, and therefore is an ideal instrument to use for the test.

RECORDING HARMONIC CONTENT

In order to record the harmonic content in a receiver, the signal of the standard signal generator was fed directly into the antenna posts of a radio receiver, as shown in Fig. 3. The modulated audio voltage which was fed into the receiver was taken off separately and fed into the input posts of the gain indicator and harmonic analyzer. The output of the radio receiver was then fed into the output posts of the gain indicator and distortion analyzer. The vacuum-tube voltmeter was then connected on its designated posts. During the test, the radio-frequency signal of the signal generator was held constant and the percentage modulation of the generator was varied from zero to 60 percent. The receiver employed was of the medium priced class and used a C-bias detector. The procedure covered above in the description of the gain indicator and distortion analyzer was then followed. Switch SW-2 was first turned up and then down. Using as symbols, X for distortion or harmonic content, and Y for the level of the incoming signal, the readings were incorporated in the formula as follows, using the values given below:

$$\frac{X}{Y} = \text{percentage harmonic content}$$

10% modulation at 5% harmonic content
20% modulation at 5% harmonic content
30% modulation at 8% harmonic content
40% modulation at 11% harmonic content
50% modulation at 16% harmonic content
60% modulation at 22% harmonic content

SEVEN NBC STATIONS BOOST POWER

SEVEN OF THE network stations of the National Broadcasting Company have, within the past several months, been granted power increases. The stations, with old and new powers, and the dates when this increase went into effect, are given below:

WBZ (Boston) 50,000 watts from 25,000 watts, December 23, 1933.

WHAM (Rochester) 50,000 watts from 25,000 watts, January 6, 1934.

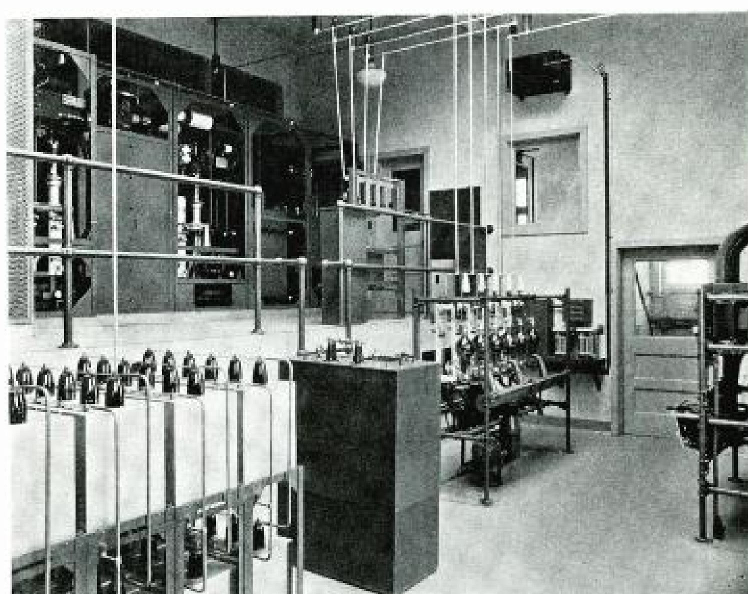
KVOO (Tulsa) 25,000 watts from 5,000 watts, November 11, 1933.

WFI & WLIT (Philadelphia) 1,000 watts from 500 watts, December 18, 1933.

WSAI (Cincinnati) 1,000 watts (night) from 500 watts, 2,500 watts (day) from 1,000 watts, August 24, 1933.

WTAG (Worcester) 500 watts (night) from 250 wats, November 14, 1933.

At the right is a view of the transmitter equipment of WHAM, Rochester. The installation of this 50,000-watt unit was made by the Western Electric Company. The 17,000-volt mercury vapor rectifier units and filter, and rear of the low and intermediate stages are shown.



Interior of a portion of the new transmitting room at WHAM, Rochester, with mercury rectifier units in the foreground and low and intermediate power stages in background. The power used is now 50,000 watts.

ANGLO-FRENCH Micro-Ray Link

By A. G. CLAVIER and L. C. GALLANT

FROM JANUARY 1934 "ELECTRICAL COMMUNICATIONS"

● Technical description of the new telephonic and teleprinter ultra-short wave link between Lympne and St. Inglevert, which uses a wave length of 17.4 cm. The tower is shown on the front cover.

THE BRITISH AND FRENCH Air ministries recently decided to establish a micro-ray communication system between the aerodromes of Lympne and St. Inglevert. It represents the shortest wavelength radio telephony link in regular commercial exploitation today and may be considered as heralding an era in which the practical advantages of privacy, efficiency and reliability of these wavelengths will be exploited to the full.

The link is used to send teleprinter messages across the channel in order to signal the passage of aeroplanes over the Straits of Dover. While the present equipment provides for only one-way teleprinter communication, provision has been made to extend it to two-way teleprinter communication as well as, eventually, to duplex telephony.

The distance between the two terminal stations is about 38.2 miles and the sites have been so chosen that the line between the terminal stations is clear of obstacles, the electro-optical equipment being installed on suitable steel towers, as illustrated on the cover of this issue.

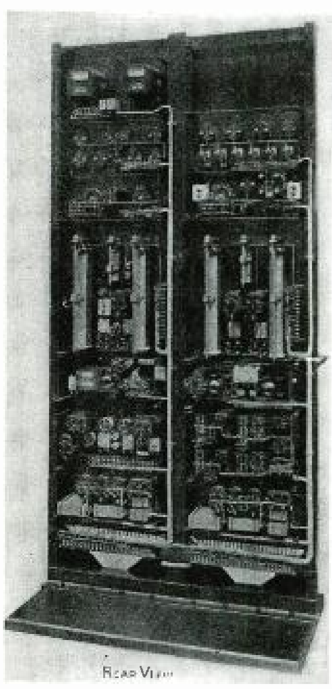


Fig. 3. Rear view of the bays which control all normal transmitter and receiver functions, and the teleprinter "creed".

The equipment of each terminal station may be described as follows:

(a) Electro-optical systems (transmitter and receiver units).
(b) Micro-ray tubes and circuits.
(c) Transmitter and receiver control bays.
(d) Power supply.
(e) Teleprinter desk and switchboard.

ELECTRO-OPTICAL SYSTEMS

The antenna and reflector assemblies for transmitter and receiver are similar in construction. The main reflector is paraboloidal—12.5 feet in diameter and is spun out of an aluminum sheet about 0.234 inch in thickness. At the periphery of this reflector—an aluminum ring is riveted, which serves to keep the reflector rigid and undistorted. A spherical reflector 3 wavelengths (the wavelength used being 17.4 cm.) in diameter faces the large reflector to which it is attached by three radial wooden members.

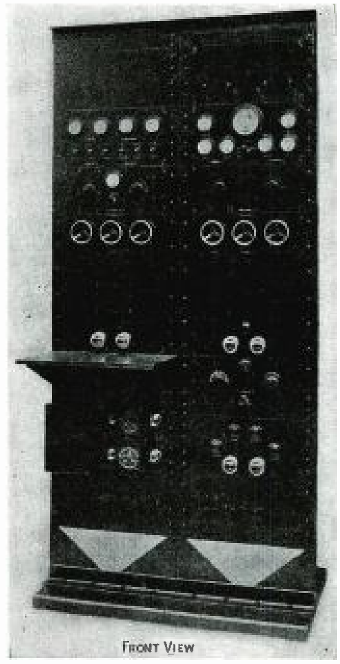


Fig. 4. Front view of the control bays.

The antenna, which is of the half-wave type, is placed at the focus of the paraboloidal reflector, which coincides with the center of the spherical reflector.

The focus of the paraboloidal reflector is situated in the aperture plane of said reflector, this being the condition for optimum working for a given outside diameter. The radiation emitted from the antenna on the transmitting side is concentrated into a very sharp beam by means of the main paraboloidal reflector. The spherical reflector is used to reflect the direct forward radiation of the antenna back to the paraboloidal reflector, thus increasing the gain of the total electro-optical system. The gain of the paraboloidal reflector alone is of the order of 28 db, and it becomes 33 db when the spherical reflector is added to the system. Of course, the same gain is obtained on the receiving side where the electro-optical system concentrates the incoming wave toward the receiving antenna.

The antenna is fed by a specially designed concentric transmission line, the external surface of the outer tube being tapered and of great rigidity in order that the antenna should not appreciably move on windy days. The inner member is insulated by means of micalex spacers located at voltage nodes in order to keep the loss as low as possible. The only difference between the transmitter and receiver assemblies is that the former includes an auxiliary antenna and short transmission line which is used to feed a radiation indicator.

THE MICRO-RAY TUBE

At the rear of the large reflector is located the housing for the micro-radion tube, shown in Fig. 1. It is mounted in an ordinary socket, but the lead-in wires to the oscillating electrode of the tube are adjustable in relation to the transmission line. This adjustment is provided in order to tune the oscillatory circuit of the micro-radion tube on site, using data obtained from the laboratory tests and furnished with each particular tube. The oscillatory circuit is connected to the tubular transmission line through small high-frequency condensers so that no d-c voltage is applied to the transmission line and antenna.

The tubular transmisison line comprises a movable part, the length of which is equal to three-fourths of the wavelength used. This serves to match the impedance of the antenna to the internal impedance of the tube, thus giving optimum working conditions.

All surfaces conducting high-frequency currents are gilded by a galvanic process in order to prevent corrosion. As for the other metallic parts, they are painted with a special weather-resisting paint as a protection against the unfavorable weather conditions which prevail near the sea coast.

On the transmission side, the auxiliary transmission line is connected to a thermo-couple and an associated galvanometer situated in the control room and acting as a radiation indicator. A support with terminals has been arranged inside the tube housing to hold the galvanometer when, for instance, tuning up the circuit or for checking purposes. When the tube is oscillating, the adjustment of the auxiliary line for maximum deflection of the galvanometer shows on what wavelength the tube is oscillating, and also whether it gives its correct output.

In order to adjust the transmitting tube to the desired wavelength, the thermo-couple line is adjusted to a given setting known from previous calibration and the main transmission line is then adjusted for maximum deflection of the radiation indicator.

The reflector assemblies and the tube housing are installed on a platform supported by a steel tower in order to avoid all obstacles in the path of the beam between the two terminal stations. Such a system is shown on the front cover. The tube housing is watertight and is covered by a semi-circular shelter of aluminum sheet intended for the protection of the operator and apparatus if it is required to change the tube during bad weather conditions.

CIRCUIT ANALYSIS

The St. Inglevert installation includes both teleprinter and telephonic facilities. In this case use is made of batteries to supply the necessary voltages, and the power equipment of the complete terminal consists of the following:

(a) A 340-volt battery to supply the voltage to the oscillating electrodes of the micro-radion tube, with tapping at 130 volts for the plate circuits of the auxiliary amplifiers and oscillators.

(b) A 60-volt battery used to bias the reflecting electrodes of the micro-radion tubes.

(c) A 12-volt battery divisible into two 6-volt units for the filament circuits of the tubes.

The speech originating in the ordinary type of microphone is passed through a band-pass filter and a voltage limiter. Though these devices might be omitted for a straight forward telephone channel, they have been in-

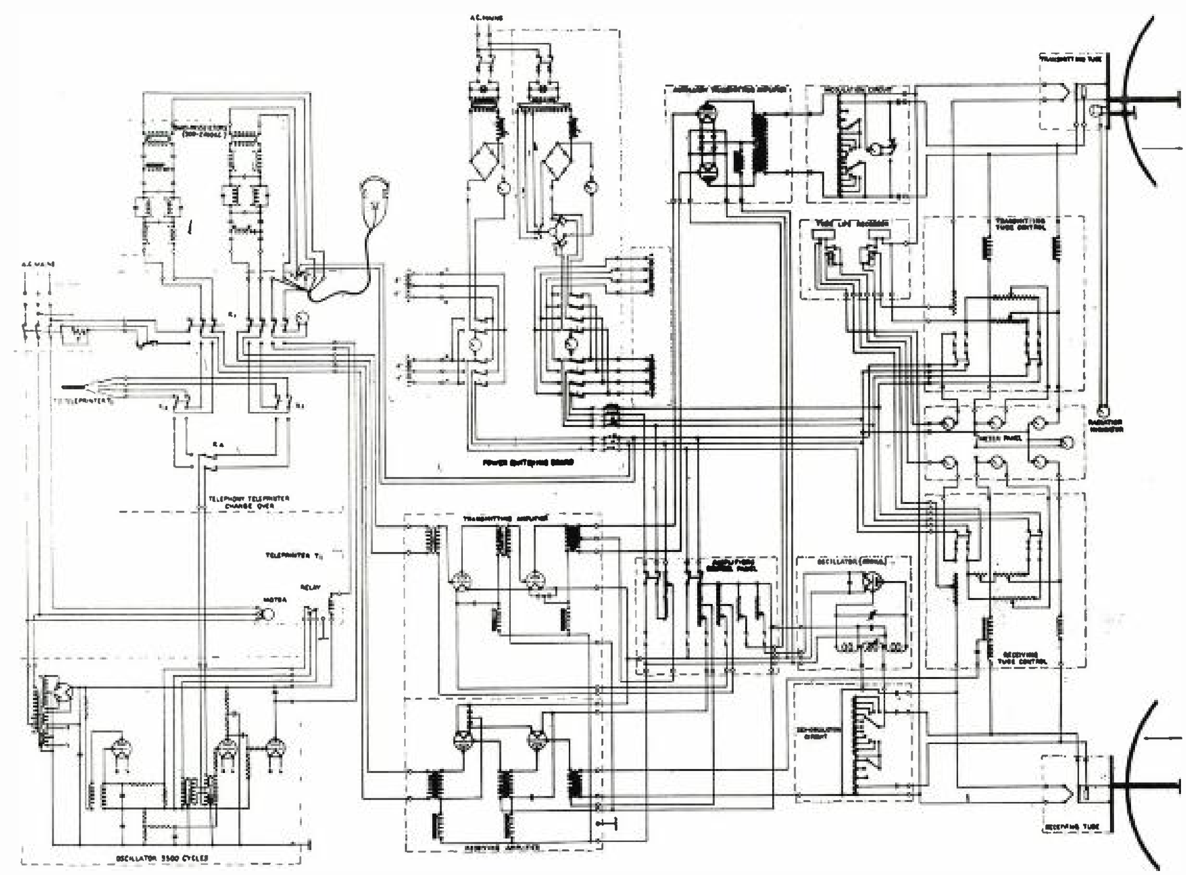


Fig. 2. Detailed schematic of the complete micro-ray system, including reflectors.

cluded in case the system is connected to the telephone land line or in case it becomes desirable to superpose the telephonic channel and the teleprinter channel in the micro-ray cross-channel link.

The modulation which may be speech or 3,500-cycle signals coming from the teleprinter unit is then increased in amplitude by means of amplifiers. The first unit is an ordinary transformer-coupled, two-tube amplifier of the repeater type with attenuators for gain control, and the second is a push-pull output stage, the tubes employed being one 4101 D, one 4102 D, and two 4019 A. Signals coming from the amplifier are then applied to a voltage divider which supplies the modulation of the electrodes of the micro-radion tube in a proper ratio.

Signals coming in from the distant micro-ray terminal are picked up by a receiving reflector, focused on the receiving antenna and demodulated by means of the micro-ray tube. In order to stabilize this demodulation process an auxiliary oscillator applies a 500-kc voltage to both electrodes of the receiving tube in a definite ratio which is determined from the constant-frequency curve of the tube in the same way as the corresponding ratio for the modulation on the transmitting side. This is very helpful in rendering the adjustment less critical.

The demodulated signal is then fed into a receiver amplifier and gain control and thereafter either passes through a panel bandpass filter and is sent into an ordinary telephone receiver, or is transmitted to the teleprinter equipment for a second demodulation.

The detailed schematic of the complete micro-ray system will be found in Fig. 2.

THE CONTROL BAYS

Front and rear views of the bays are shown in Figs. 3 and 4. Referring to Fig. 3; on the left bay, starting from the top, we find:

1. Meter panel to control all voltages applied to the anode circuits of the amplifiers and oscillators as well as the bias voltage for the grids, also the anode and filament currents.
2. Modulation panel comprising the switches for the potentiometer resistances, and a voltmeter showing the modulating voltages applied to the oscillating and reflecting electrodes of the transmitting micro-radion tube.
3. Tube control panel (transmitter) on which potentiometer hand-wheels can be seen which serve to adjust the d-c voltages for the tube electrodes. On this panel are also located the two rotating switches in the main battery supply.
4. Auxiliary amplifier panel used on the transmitting side.
5. Low-frequency amplifiers, two stages being used for transmission and two for reception. This panel comprises a gain control arrangement on each amplifier.
6. Band-pass filter panel (240 to 2,600 cycles) for the transmitting side.
7. Terminal strip.

On the right bay in Fig. 3, starting from the top, we find:

1. Tube-life recorder panel for the micro-radion tubes. These recorders are fed by the filament batteries across a relay operated by the filament current of the corresponding micro-radio tube.
2. Tube meter panel with suitable meters to measure the voltages and currents relating to the micro-radion tubes.
3. The 500-kc. voltage divider to adjust 500-kc. modulation on receiving tube electrodes and to obtain better stability for receiving adjustments.
4. Receiving-tube control panel with potentiometer hand-wheels and vernier adjustment for the receiving electrode bias voltage; also the main switches on the battery feeders.
5. The 500-kc. oscillator with frequency and coupling adjustments.
6. Amplifier control panel with rheostats to adjust the bias voltages and filament currents of the amplifier tubes. This panel includes a general switch for the d-c supply to the amplifiers.
7. Band-pass filter panel (240-2,600 cycles) for the receiving side.
8. Terminal strip.

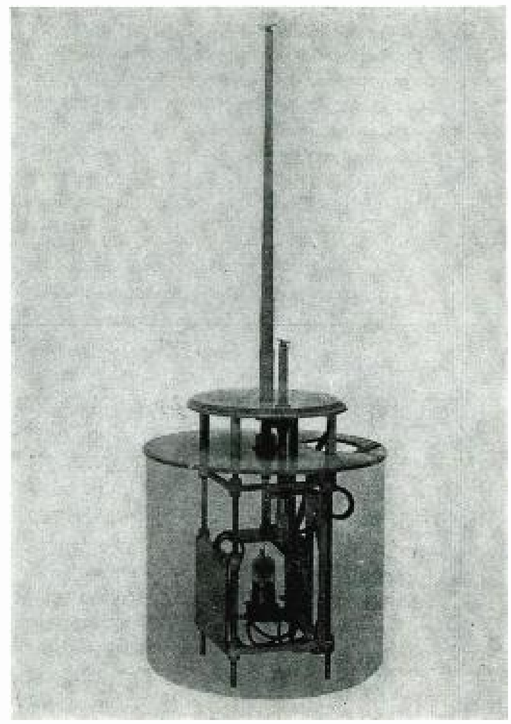


Fig. 1. A view of the micro-ray tube and its housing.

POWER-SUPPLY EQUIPMENT

As mentioned above, the power supply equipment is constituted, on the St. Inglevert side, by: (1) A 340-volt battery with midpoint tapping. (2) A 60-volt battery; and (3) a 12-volt battery with mid-point tapping.

At Lympne it had been thought advisable to use a motor alternator with suitable speed regulation to correct the variation of the mains supply. The alternator feeds the rectifiers from which the high-tension power supply to the tubes is obtained.

TELEPHONY AND TELEPRINTER EQUIPMENT

Standard microphones and receivers are used, and duplex-operation is obtained with the possibility of connecting the micro-ray link to the land line if ultimately required.

The teleprinters are of the 3A Creed type used in conjunction with a single-current voice-frequency equipment. The transmitting contacts of the teleprinter control the flow of voice-frequency current to the input side of the modulation equipment. Signals being transmitted also operate the receiver side of the voice-frequency unit and give a home record of the message. A 3,500-cycle frequency has been chosen in case of future simultaneous working of the telephonic channel.

Voice-frequency signals received from the micro-ray receiving equipment are amplified by means of voice-frequency equipment and after demodulation these signals are sent to the teleprinter magnet, the detected current output being 20 milliamperes for correct operation. The voice-frequency unit is fed from the a-c mains. It does not require adjustment if tubes are changed. The only adjustment necessary when putting an equipment into service is the connection of the supply mains to the correct tapping on the power transformer. The signal distortion is very small and the circuit includes a device to maintain the detected current approximately constant for a wide variation of signal strength.

TELEPRINTER TERMINALS

The St. Inglevert station has been equipped either for telephonic or teleprinter operation; moreover, the French Administration decided to install two teleprinters, one located in the micro-ray building and the other in the Administration building situated about half a mile away. Each teleprinter is able to transmit while the other is being used for reception.

On the Lympne side only simplex teleprinter operation has been installed for the moment, but the equipment could easily be extended later to provide the same facilities as on the French side.

The Anglo-French Micro-Ray link between Lympne and St. Inglevert was inaugurated the latter part of January, 1934.

WHITHER BROADCASTING?

MR. E. L. NELSON who has been a helpful and constructive member of the Broadcast Committee of the I.R.E., at a recent forum meeting propounded the question: "Whither Broadcasting?" Reasons which would prompt engineers who have been identified with broadcasting from the beginning to speculate upon probable trends, may vary according to individual habits of thinking.

The simpler question: "Why Broadcasting?" may be answered by observing that broadcasting as of the present time in the United States is carried on as a commercial enterprise, reasons for its existence being the same as those accounting for any other commercial venture.

The more challenging question: "Whither Broadcasting?" cannot be fully answered by guessing at the probable immediate future of commercial broadcast undertakings.

Airplane services are commercial ventures, but these are heavily subsidized by the Government, the reason for this being that in order to have a sufficient number of pilots and planes for war needs, should such need materialize in the future, it is necessary in peace time to maintain in service a much greater number of planes than there is justifiable commercial need for.

The radio broadcast situation in Europe at the present time parallels somewhat the airplane situation in the United States. In Europe radio chaos has continued for some years—a veritable Babel of tongues. Frontiers have been bombarded and over-run in the war of kilowatts. Diplomats have been quoted as stating that radio broadcasting in Continental Europe has become the greatest hate propagating medium the world has ever known. Communist speakers in Moscow and Nazi speakers in Berlin, on the air simultaneously, seek to drown each other out in the ear-phones and loudspeakers of the Continent.

The Pact of Lucerne, to which twenty-eight countries in Europe, Africa and Asia Minor are signatories, was signed in May, 1933. An attempt to put it into effect was begun on January 14, 1934, but the fact that Holland, Greece, Lithuania, Finland, Poland and Sweden refuse to be governed by the frequency, power and time determinations of the Pact renders it doubtful that neighborly conventions have a favorable chance.

The Russian Soviet station RW1 is said to have five times the power limit established by the Lucerne agreement. When this station is on the air broadcast stations in France and England have great difficulty reaching the receivers of their own nationals.

Whither Broadcasting! In the United States more than one-half of the homes in the country being equipped with radio receivers, licensed broadcast stations are the centers from which is sent out whatever is intended to attract attention of persons listening. The sponsored entertainment program is in the nature of a vehicle that carries the publicity of the sponsor, as the literary entertainment in the fiction weekly is the vehicle that carries the publicity of advertisers, who indirectly pay the costs, into the homes of those who pay a nickel or a dime for the publication.

The excellent entertainment of sponsored broadcasts has brought about a very widespread distribution of radio receivers. System broadcasting — transmission plus reception — constitutes a service in being which at any moment might become an essential agency of the national Government, without in the mean time costing the Government a penny.

No doubt, in the minds of those who devote thought to the various possibilities of broadcasting, unusual proposals appear. It has become well established that radiophone broadcasting is a powerful instrumentality for the dissemination of propaganda, of political viewpoints, and for lobbying by selfish interests. This, of course, was anticipated when the Federal Radio Commission was created by law, the national Government, quite rightly, seeking to retain a measure of control over the service until such time as its proper place in the scheme of things should be established.

The present situation in Europe presents a convincing picture of what can happen when broadcasting is politically controlled by those in governmental office from time to time.

Every receiver owner has realized that broadcasting constitutes an excellent modern means of distributing news, at least of national and international origin. But, in the United States radio being still, quite rightly, a commercial enterprise, the policy of "Live and Let Live" as between industries and services, is followed. An agreement between broadcast interests and news gathering agencies has been made which closely restricts the frequency and extent of news bulletins which may be sent out by radio.

So far as the inventors and the engineers whose genius brought this great art into being are concerned, their lot is not unlike that set forth in more than one Biblical parable.

SHIPPING PROBLEMS **ELIMINATED** BY **RAILWAY EXPRESS**

No matter what you want to ship, Railway Express will answer your shipping problems. At your convenience and at your very door, in principal cities and towns, a Railway Express truck will call and take your shipments away to be rushed to the consignee at passenger train speed. Whether it be one shipment or five hundred—it makes no difference to Railway Express. Absolute safety and careful handling during transit are assured throughout. We give a receipt on collection and take a receipt at delivery—a twofold guarantee of safety and swiftness.

Railway Express service is inexpensive, too, and saves you much in convenience, worry and time. Telephone your local Railway Express agent who will be glad to give you information, rates, and service.

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Flexo-Terminal
the only single suppressor that fits
ALL CARS
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Equip your auto sets . . . with this universal suppressor

Reduce sales resistance with the Continental FLEXO-TERMINAL Suppressor. The spring bronze terminal can be bent easily for vertical or horizontal installation on any car. Thus the need for numerous types to fit all cars is obviated.

The Carborite resistance element is accurate and permanent. A heavy bakelite molding assures protection from mechanical injury and deterioration.

The new Continental molded bakelite suppressors are available also in all usual terminal styles. Write for samples and prices.

Compact Resistors to Simplify Auto-Radio Design

Extreme mechanical strength, plus the exclusive Continental copper-spray terminal bond that eliminates troublesome end-caps, make these tiny resistors perfectly adapted for the most severe automotive set applications. Write or wire for samples to meet your specifications.

Continental Engineering Service

Modern radio design is steadily departing from established practice. Continental engineering facilities are always available to cooperate in your development work. This wealth of experience, accumulated through years of specialization on resistor problems, is at your service.

WRITE OR WIRE FOR SAMPLES AND PRICES

CONTINENTAL CARBON Inc.

13904 LORAIN AVE. • CLEVELAND, OHIO
Canadian factory • Toronto, Ontario

Receiver Design Trends

(*Continued from page* 10)

employing phase inverters to obtain true push-pull action with the resistance coupling arrangement.

RESISTANCE PUSH-PULL

The arrangement in the Sears Roebuck Silvertone Model 1708 receiver is shown in Fig. 6. It will be seen that a portion of the output of the type 75 triode is placed on the grid of the type 37 phase changer tube. The plate circuit of the phase changer is coupled to the grid of the lower 45 tube through the .02-mfd blocking condenser. By the proper selection of resistance and voltage values, the voltage on the grid of the lower 45 tube is made equal to the voltage on the upper 45 tube. Since the signal voltage for the lower tube is fed through the 37 tube, it is opposite in phase to the voltage on the upper power tube.

The magazine *Radio World* has recently given considerable space to the details of a circuit arrangement employing a diode directly resistance coupled to a pair of power pentodes in push-pull. The same circuit was used by Crosley in the Model 130 receiver, released in June of 1932. It is shown in Fig. 7. The arrangement is not only very interesting, but leads one to wonder if it may not return this year or next along with iron-core i-f transformers.

A glance at this circuit will show its practicality. Advantage is taken of the equal and opposite values of voltage existing at one and the other ends of the diode load resistor. The grids of the two power pentodes may therefore be coupled to the ends of the diode load resistor. Blocking condensers and grid resistors are used so that the power tubes may be biased in the usual manner.

This arrangement calls for a receiver with a high gain. But the use of iron-core i-f transformers, in conjunction with tubes such as the 58 or 78, might make the arrangement satisfactory for swinging a pair of power triodes.

The charm of resistance coupling is somewhat reduced when scanned from the viewpoint of high fidelity, as the circuits are difficult to balance above 4000 cycles. Nevertheless, the difficulty may well be reduced to a negligible quantity in a short space of time.

HIGH-FREQUENCY SPEAKERS

We doubt if there is a single manufacturer who isn't playing with tweeters, or high-frequency speaker units. Dynamic units of this type, used either with or without low- and high-pass filters and a good dynamic cone, do wonders to a receiver with a wide frequency band.

Thirty centrally located controls on the operator's control unit of WLW's new 500-kilowatt broadcast transmitter plant give complete automatic operation or any desired degree of manual control. The operation of the various circuits is indicated by 35 lights. The station, described in the January issue of RADIO ENGINEERING, was designed and built for the Crosley Radio Corporation by the RCA-Victor, Westinghouse and General Electric companies.

Some of the tweeter diaphragms suffer when overloaded, producing a rather unpleasant monkey chatter. One manufacturer is getting around this very nicely by a unique manner of increasing the load of the air column. In practically all cases it seems that a variable shunt resistance is required across the voice coil in order that some semblance of balance between high- and low-frequencies may be reached. Too much of the high is nerve-wracking, too little spoils the effect. Moreover, the angle of projection is said to be rather important, with favor going to the small horn pointing ceilingward, rather than parallel to the floor.

The crystal tweeters require no filters, we understand, and can be connected directly in parallel with the voice coil of the dynamic cone speaker.

Type 800 Data

(*Continued from page* 15)

In the second case, the grid milliamperes vary from about zero at 7.5 volts, to 10 milliamperes at 30 volts. The power output varies from zero to 100 watts at 28.5 volts, while the plate milliamperes are 15.5 at 2.5 volts, and 80 milliamperes at 30 volts. At 5 volts the total harmonics are 1.4 percent, at 10 volts 2.5 percent and 4.5 percent at 15 volts. Then 5 percent at 20 volts, and 7.8 percent at 30 volts.

In the third case, the grid milliamperes at 10 volts are about zero and 6.5 at 29 volts. The power output increases from zero to 112 watts at 28.5 volts, and the plate milliamperes increase from 15.5 at 2.5 volts, to 64 at 28.5 volts. The total harmonics at 5 volts are 1.8 percent, 2.5 percent at 12.5 volts, and 7.6 percent at 28.5 volts.

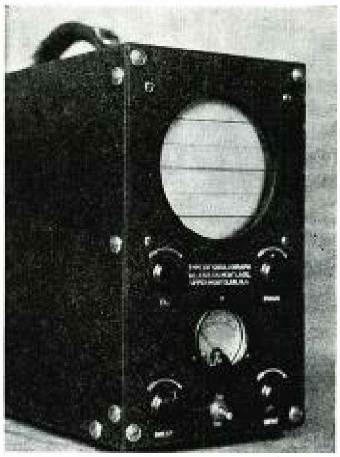
Considering the case in Table II, the grid milliamperes are zero at about 10 volts and reach 10 milliamperes at 39.5 volts. The plate milliamperes at 2.5 volts are 15, and 81 milliamperes at 39.5 volts, and the power output at 39.5 volts reaches 107.5 watts. The percent total harmonics at 5 volts is 0.7, and 0.8 at 12.5 volts. It is 4 percent at 17.5 volts, 5 percent at 27.5 volts, and 8 percent at 39.5 volts.

CORRECTION

IN THE article, "Checking Up On 1933" on page 9 of the January issue of RADIO ENGINEERING, it was stated that the ultra-short wave oscillator tube designed for use as an "electronic oscillator" provided one watt at frequencies of 70,000,000 cycles per second. This, after all, is not an ultra-short wave in the true sense.

The frequency should have been given as 700,000,000 cycles per second rather than the figure stated.

OSCILLOGRAPH FOR MODULATION DETERMINATIONS



★ The unit consists of type 54 DuMont cathode ray tube with a high intensity screen, a power supply which furnishes the voltages necessary for the operation of the cathode ray tube, a sweep circuit and the necessary controls and binding posts. An engraved glass is mounted in front of the cathode ray tube and marked with suitable lines so that the percentage modulation may readily be observed. The unit is entirely self contained and operates from the A-C line.

Type 137 Oscillograph
Price $165.00 Complete

*In addition to this unit, a number of other cathode ray oscillographs are available, as well as a complete line of cathode ray tubes.

ALLEN B. DuMONT LABORATORIES
UPPER MONTCLAIR, N. J.

GOAT SHIELDS

now adopted by 62 manufacturers!

Because these modern form-fitting shields cost much less than old-fashioned "can" shields.

Because their use permits other important manufacturing economies through reduction of chassis and overall set dimensions.

New sets are now distinguished from old models by the fact that GOAT form-fitting tube shields are used — especially on auto radios, portables and compacts.

Write for samples.

GOAT RADIO TUBE PARTS, Inc.
314 DEAN ST. BROOKLYN, N. Y.

with ELECTRICAL SHEET PROBLEMS

THE "old-timers" in radio manufacturing will remember ARMCO'S early creation of special electrical steel sheets. It solved many perplexing problems and helped lift the industry to new heights of service and profit ● That, however, was only the beginning. For thirty years we have gone on improving ARMCO ELECTRICAL Steel Sheets . . . . adapting them to changing needs and new products . . . working closely with manufacturers to increase efficiency and reduce costs ● Another reason why ARMCO is qualified to help you is this: *ARMCO Electrical Sheets are manufactured in a special plant devoted to these sheets alone.* The costly equipment is modern and highly specialized; the workers have been long trained in this separate branch of sheet making; and the metallurgical laboratories concentrate exclusively on the control and improvement of electrical steel sheets ● Whatever your problem of the moment may be, we can help you produce the results you seek. Without committing yourself in any way, just call in an experienced ARMCO Engineer.

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ARMCO means GOOD STEEL

NEWS OF THE INDUSTRY

NATIONAL CARBON "AIR CELL" RECEIVER CAMPAIGN

Backed by a national farm radio contest for cash prizes totaling $6,750, two-page advertising in seventeen national and state farm papers, and volume production in the factories of eighteen leading set manufacturers the new Air Cell receiver makes its entrance this month into rural territories from coast to coast.

The contest is sponsored by National Carbon Company, Inc., and heralds the most extensive campaign for new radio territory in the history of air reception. It is directed at the 10,000,000 homes which, according to the U. S. Department of Commerce, are without any electric service. For the best letters from farm paper readers on "What Air Cell Radio Means to Me"—letters of one sentence or 100 words—winners will receive 383 prizes, with the first three $1,000, $500 and $250.

The Farm Radio Contest marks the greatest opportunity ever presented to dealers in this vast rural market. Into a majority of this territory the Government is now pouring $350,000,000 of Hog and Grain Control money.

•

WARNER NAMED VICE-PRESIDENT OF RADIOTRON-CUNNINGHAM

Appointment of J. C. Warner to be Vice-President and General Manager of RCA Radiotron Co., Inc. and E. T. Cunningham, Inc., has been announced by E. T. Cunningham, President. Mr. Warner has held the post of Vice-President in charge of engineering since December, 1932.

RITTER AND SCHMIT PROMOTED

Mr. Warner announced the appointment of E. W. Ritter to the position of Manager of the Research and Development Laboratory, effective February 1.

He appointed D. F. Schmit Division Engineer in charge of the Engineering Division of the Laboratory, incorporating the Development, Application, Commercial and Standardizing Sections.

Previous to his appointment as Vice-President in 1932 Mr. Warner had been in charge of the Research and Development Laboratory. He was born in Freeport, Illinois, and holds a B. A. degree from Washburn College, an M.A. degree from the University of Kansas, and an M.S. degree in Electrical Engineering from Union College. He was a member of the Signal Corps during the war, taught physics at the University of Kansas, and was Assistant Physicist in the Bureau of Standards. From 1920 to 1931, he was engaged in research work and vacuum tube engineering for the General Electric Company.

•

BAKER NOW RCA-VICTOR VICE-PRESIDENT

E. T. Cunningham, President of the RCA-Victor Company, on January 25, announced the appointment of W. R. G. Baker, as Vice-President and General Manager.

It was also announced that E. A. Nicholas, Vice-President in charge of sales of the RCA-Victor Company, has tendered his resignation.

THORDARSON APPOINTS NEW EXECUTIVES

C. H. Thordarson, president of the Thordarson Electric Manufacturing Company, 500 West Huron Street, Chicago, Illinois, has just announced an expanded program for 1934 involving important personnel changes in the Thordarson organization.

A new line of transformers is announced for radio manufacturers; an improved line of replacement transformers for radio servicemen is featured in the new 1934 catalog; and a new line of transmitter and amplifier transformers is also announced for radio amateurs.

An important change in personnel is indicated by the appointment of Donald MacGregor who becomes treasurer and general manager of the company. Mr. MacGregor comes to the Thordarson organization with a broad executive experience in the financial and commercial management of radio and electrical manufacturing plants. In his new capacity, he will coordinate Thordarson manufacturing, sales, and administrative activities. Mr. MacGregor is prominent in radio manufacturing circles, having served as treasurer and director of the Radio Manufacturers' Association.

C. P. Cushway has been engaged as general sales manager to handle the sale of Thordarson equipment to the radio and electrical industries. Mr. Cushway is widely known for his activities in the manufacture and merchandising of radio equipment and electric refrigerators.

Russell Lund, advertising manager of Thordarson for the past six years, will be chief sales engineer in which capacity his broad technical knowledge will be utilized in serving manufacturers requiring special engineering service in the application of Thordarson equipment.

•

GILBY DOUBLES PLANT FACILITIES

Mr. R. Bauer, Treasurer of the Walter Gilby Alloy Company, Inc., announces the removal of their offices to 222 Verona Ave., Newark, N. J., and the acquisition of the entire building adjacent to their former plant. Present facilities are just double former space and the plant is working full time.

•

SYLVANIA MOVES CHICAGO OFFICE

The Chicago office of Hygrade Sylvania Corporation has moved from its former location at 445 Lake Shore Drive, to 612 North Michigan Avenue. The warehouse, however, is still maintained at the former address. All products of the corporation—Hygrade Lamp Bulbs, Sylvania Radio Tubes and Equipment are represented in the Chicago office.

•

COBURN JOINS NATIONAL UNION

National Union Radio Corporation, of New York, has announced the appointment of Reuben M. Coburn as sales analyst with headquarters at the National Union, 400 Madison Avenue, New York City address.

Mr. Coburn brings to the post a wealth of experience gained through many years of activity in the radio industry. He was called from the Retail Dealer field by Kolster Radio Corporation who appointed him as Metropolitan District Sales Manager. With this company he played an important part in producing an outstanding rise in sales during 1927 and 1928. Later as General Sales Manager for the Sterling Radio & Electric Company, he handled distribution of Majestic Receivers in the Metropolitan District. Freed-Eisemann Radio Corporation then commanded his services as Metropolitan District Sales Manager after which he established a fine sales record for the Ware Manufacturing Corporation as Manager of Sales.

•

CANDOHM REFERENCE CHARTS

The Muter Company, 1255 South Michigan Ave., Chicago, Ill., have prepared highly practical Voltage-Drop and Watt Charts, and technical details on Candohm fixed resistors.

The Voltage-Drop Chart is a very useful one giving the voltage drop for different values of currents at different resistances. The Watt Chart gives the values of power in watts and current in milliamperes for different values of resistance. In the latter chart the decimal point has been placed and thus supplements the use of a slide-rule and eliminates possible error.

In both charts, the milliamperes are given in intervals of 5 from 5 to 100, in intervals of 20 from 100 to 500, and from 500 to 1,000 in intervals of 100; and the resistances are separated by values of 50 from 50 to 100, by 100 between 100 and 1.000, and by 1,000 between 1,000 and 10,000 ohms.

A copy of this folder will be sent free on request.

•

NEW PARKER-KALON CATALOG

A catalog is now available from the Parker-Kalon Corporation, 200 Varick St., New York, giving a complete list of data on their self-tapping sheet-metal screws, cap screws, punches, drive screws, screw nails, masonry nails, and thumb screws.

The new catalog contains much information that the previous catalog lacked, and includes some very interesting data on the use of self-tapping sheet-metal screws.

Four new products are covered. These are: the Hex Head Hardened Self-Tapping Cap Screws, Type "Z" Non-Corrosive Self-Tapping Sheet-Metal Screws made of stainless steel, Cold-Forged Wing Nuts, and Cold-Forged Thumb Screws.

Copies of this new catalog will be sent to any design engineer or production official on request.

•

I. R. E. AND I. S. R. U. JOINT MEETING

Arrangements have been made between these two organizations for a joint meeting in Washington, D. C., annually in the spring. The first joint meeting will be held this year on Friday, April 27. It will be devoted to the presentation of papers on the more fundamental aspects of radio problems. It is though that this meeting may become an important annual feature of the week which attracts to Washington every year an increasingly large number of scientists and scientific societies. Dr. J. H. Dellinger is vice-chairman of the American Section, International Scientific Radio Union

NEW PRODUCTS

GEN-E-MOTOR ROTARY AUTO-RADIO PLATE SUPPLY

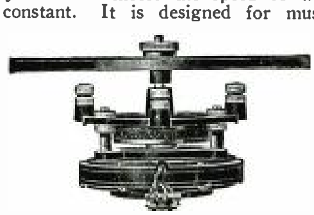
The Pioneer Gen-E-Motor Corporation, of 1160 Chatham Court, Chicago, Illinois, has just announced a new rotary power supply device for auto-radio receivers. It is said that this is the smallest power supply unit that has ever been offered to manufacturers, regardless of type.

Of like importance is the fact that its output voltage is unidirectional and flat except for a commutator ripple that is only several percent of the total voltage. Thus the filtering problem is simple, requiring small condenser cost and assuring a very smooth voltage that allows excellent audio reproduction, it is stated.

●

"SAJA" SYNCHRONOUS MOTORS

The "Saja" Type B-S motor, manufactured by the Sound Apparatus Company, 400 East 81 Street, New York, N. Y., is a synchronous motor the speed of which is constant. It is designed for musical



recordings, and consists of a cast-iron turntable resting on a vibration filter which insulates the turntable from the motor. The following specifications are given:

Speed .... 78 r.p.m.
Torque .... 85.6 oz. in.
Height .... 5.25 in.
Weight .... 21 lbs.
Current .... 110 v., a-c, 60 cys.
Power Consumption .. 33 watts
Turntable .... 12 in. heavy size

It is equipped with a rubber pad and clamping screw, adjustable to any feeding mechanism.

The Type 33 1/3 motor produced by this company has a speed of 33 1/3 r.p.m., a torque of 220 oz. in., and a 16-inch extra heavy turntable.

The Type V motor, which is for reproducing only, has a speed of 78 r.p.m., a torque of 17.3 oz. in., and is equipped with a 12-inch velveteen-covered turntable. The Type V motor, unlike the others, may be used on either 110 or 250 volts, a-c, 60 cycles.

●

BRUSH BERYLLIUM OXIDE

The Brush Beryllium Company of Cleveland, Ohio, offer to the vacuum tube engineers a 99.9% pure Beryllium Oxide, purported to be the best available single refractory and insulating substance.

The material must form strong parts; it should have sufficient resistance while hot to prevent electrical leakage between the two filaments; its heat conductivity should be high; and there should be little or no chemical reaction between the hot filament and the insulator.

The following properties are given for pure Beryllium Oxide:

Exceptional strength.

Resistance to thermal shock of the same order as fused silica.

Lowest electrical conductance at high temperature of any of the refractory substances.

Ability to operate indefinitely in contact with a tungsten filament at 2000°C.

Low specific gravity (3.0).

Low coefficient of linear expansion (7.5×10^{-6}).

Melting point of pure Beryllium Oxide is 2570°C.

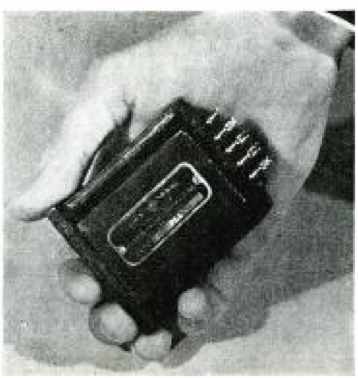
●

KENYON REMOTE PICKUP EQUIPMENT

The past year has brought about numerous changes in the design of portable remote pickup equipment. Many of these changes have been forced by the widespread use of the newer types of microphones which have improved frequency response but extremely low output levels. Other changes have been forced by the increasing number of outside pickup jobs which necessitate either more equipment, or more readily transported equipment, which will cut the time lost between pickups to a minimum.

To meet the demand for transformers for this type of equipment, Kenyon Transformer Co., Inc., has announced a new line of portable transformers which, they state, meet the exacting requirements of suitability for low-level and high-fidelity work in addition to being small in size and light in weight.

The line includes parallel-feed chokes, mixing, input, interstage and output transformers which are designed for use with the different tubes more commonly used in portable equipment. The line-matching input and output transformers have balanced 500-ohm windings with taps for a



200-ohm balanced connection. These windings can also be connected to give other impedances; i. e., 50, 125, 250 or 333 ohms. Input and output transformers have a complete electrostatic shield between the low and the high winding. This shield is grounded to the transformer core and a connection brought out to the terminal board. The core is completely insulated from the case. Balanced windings are tested for resistance, inductance and capacity balance. Interstage transformers are designed to allow the passage of the plate current, although if extreme low-frequency response is required, the use of parallel-feed chokes is recommended.

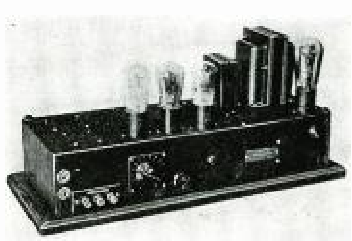
Use is made of the latest alloys for core material, different alloys being used for the different transformers depending on their intended use. These transformers have a new type of impregnation and sealing which makes them proof against failure due to adverse climatic conditions, it is stated.

The transformers are potted in aluminum cases which are similar in appearance to the Kenyon Laboratory Standard Line. The base size is 2⅛" x 2¾"; height of pot, 3"; height over terminals, 3½"; mounting dimensions. 1¾" x 2 5/16." The average weight is 20 ounces.

●

GATES A-300 A-C REMOTE AMPLIFIER

The A-300 remote unit, manufactured by the Gates Radio and Supply Co., Quincy, Ill., uses three UY 227 tubes in the amplifier circuit, the last audio stage being push-pull. A type 80 is used as the rectifier tube and is shown in the accompanying figure along with its power trans-



former. It is said that sufficient audio output is provided with this combination to handle a telephone line from 35 to 50 miles in length, and that with the push-pull output stage it is nearly impossible to overload it even when crowding the microphone. The amplifier, which is 19 in. long, 7 in. deep, and 9¼ in. high, is finished in black wrinkle.

This amplifier is designed to operate from a 110-volt, 60-cycle line, and thus no batteries are required for the operation of the unit itself or for the carbon microphone button current. The microphone connection, as well as the gain control, are shown in the illustration.

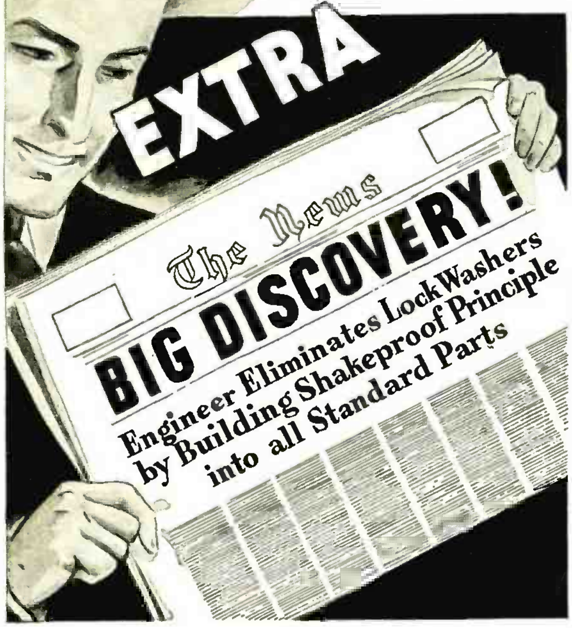
●

ALLEN ENGINEERING DATA BOOK

The Allen Manufacturing Co., Hartford, Conn., have available for distribution an engineering data book on Allen hollow set screws and socket head cap screws. giving the holding power, the recommended size of set screws, and the recommended tightening force of cap screws.

INDEX TO ADVERTISERS

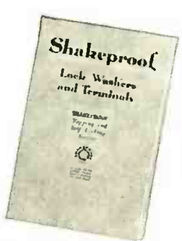
SHAKEPROOF



Improve your product
this money-Saving way

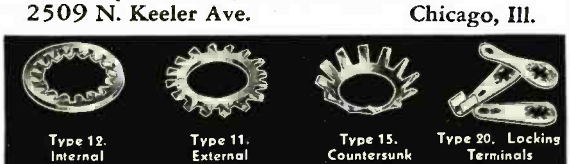
HERE'S an idea that deserves the attention of every designing engineer. The adaptability of the Shakeproof principle makes it possible to build this positive locking method right into any standard part. This means you have the powerful twisted teeth of Shakeproof biting into both work and nut surfaces and, at the same time, no separate lock washers are required. Thus you are providing the greatest possible protection against vibration and also saving time and money on the production line. Let us show you how this new idea can be applied to your product—write for complete information today!

"It's the Twisted Teeth that LOCK"



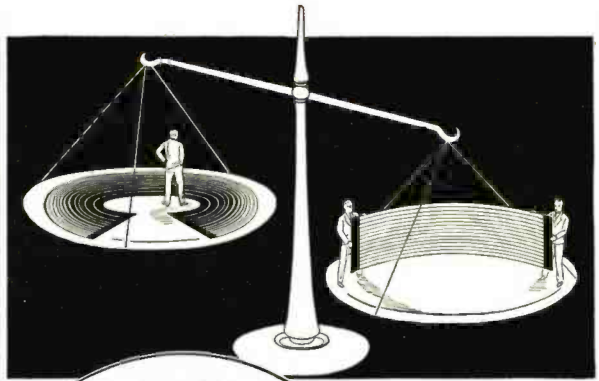
Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

SHAKEPROOF
Lock Washer Company
(Division of Illinois Tool Works)
2509 N. Keeler Ave. Chicago, Ill.

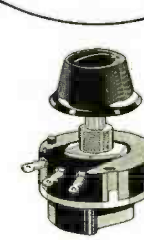


Type 12. Internal | Type 11. External | Type 15. Countersunk | Type 20. Locking Terminals

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



THE *new* OUTWEIGHS THE OLD

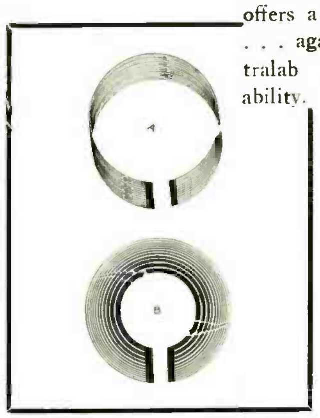


The new Centralab Radiohm permits smoother attenuation because of the greater effective length of the resistance strip employed.

The current path in the new Radiohm is more than twice as long as that in an old-style annular control of equal outside diameter. Current short cuts that might cause jumpy control are eliminated in the new Radiohm.

The new Centralab Volume Control Guide Now Ready at Your Jobber

Since smooth control depends upon gradual resistance change the "doubled" length of current path in the new RADIOHM offers a still finer performance . . . again demonstrating Centralab superiority and reliability.



Resistor A used in the new Radiohm, has the same path across its entire width, giving greater effective area for good volume control.

Resistor B of annular shape, has long been the standard type. Current concentrates around the INNER edge, i. e.: the shortest path.

Central Radio Laboratories
MILWAUKEE, WIS.

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Radio Tubes

A uniform quality product with a dependable long life . . .

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The Ken-Rad Corporation
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Division of Ken-Rad Tube and Lamp Corporation

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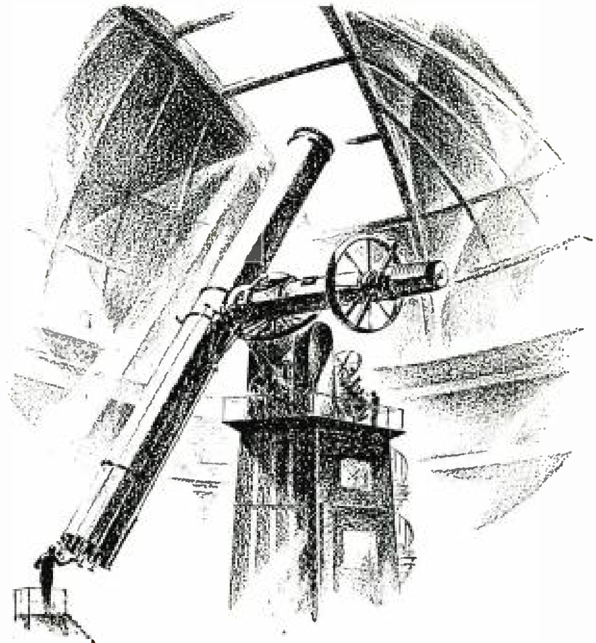

VISION

● For centuries, man looked upward to the stars for new worlds of knowledge. Today radio science offers a realm of research equally broad and rich!

Engineers of the Hygrade Sylvania Corporation hold a leading position in the exploration of this new field. Hygrade Sylvania first pioneered in the development of the new and more efficient 6.3 volt tubes. And recently, this company established a complete new plant for similar development work in the allied fields of broadcasting and electronics.

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Set manufacturers are invited to write for engineering consultation on circuit and design problems. The facilities of Hygrade Sylvania are placed at your disposal without cost or obligation. Sylvania engineers stand ready always to cooperate in the manufacturer's own plant or in Hygrade Sylvania's complete Circuit Laboratories. Hygrade Sylvania Corporation, Emporium, Penna.

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