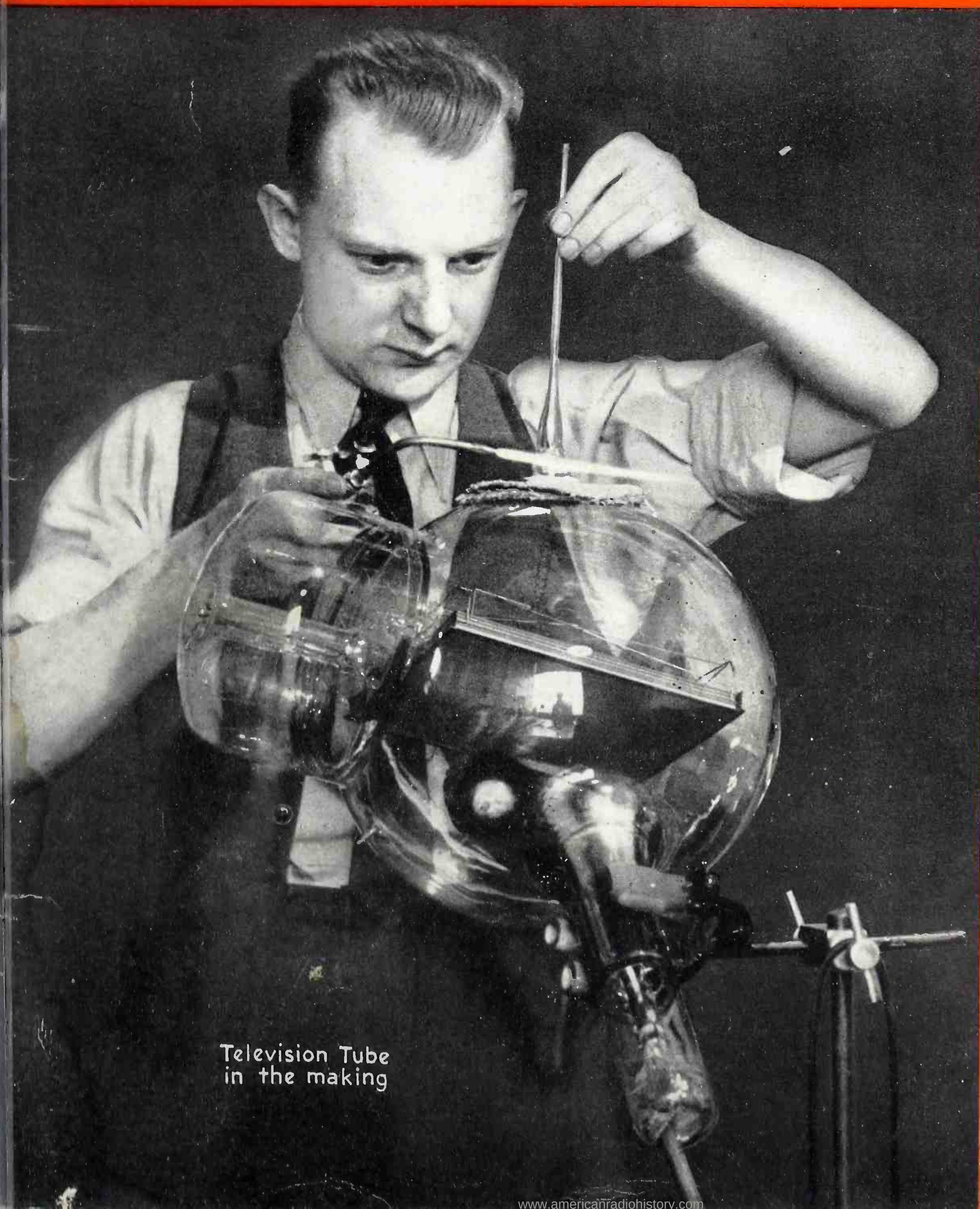
electronics

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



DECEMBER
1936

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McGRAW-HILL
PUBLISHING
COMPANY, INC.

MERRY CHRISTMAS

To our good friends in the radio industry we wish a joyful holiday season and increasing prosperity in the year to come.

H. C. Stackpole

STACKPOLE CARBON COMPANY
ST. MARYS, PA.

HAPPY NEW YEAR

ELECTRONICS

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

Contents • December 1936

COVER: *Karl Schumann, glassblower at the Philco Plant, putting the finishing touches on a television camera tube, photographed by S. F. Essig, also of Philco.*

•

DEPARTMENTS

Volume 9 . . . Number 11

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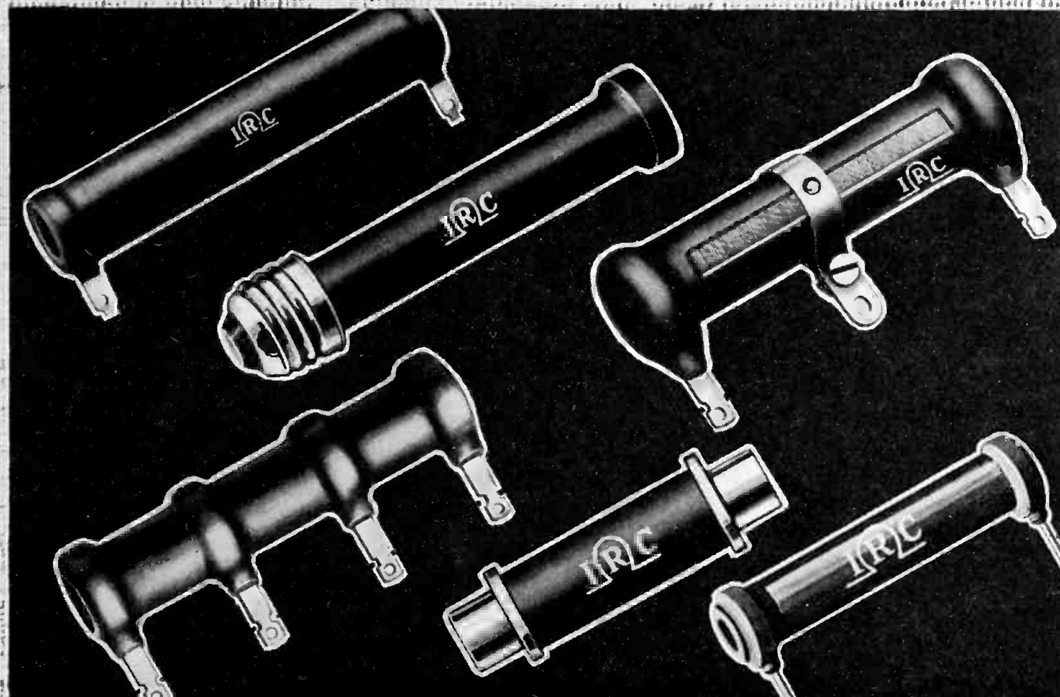

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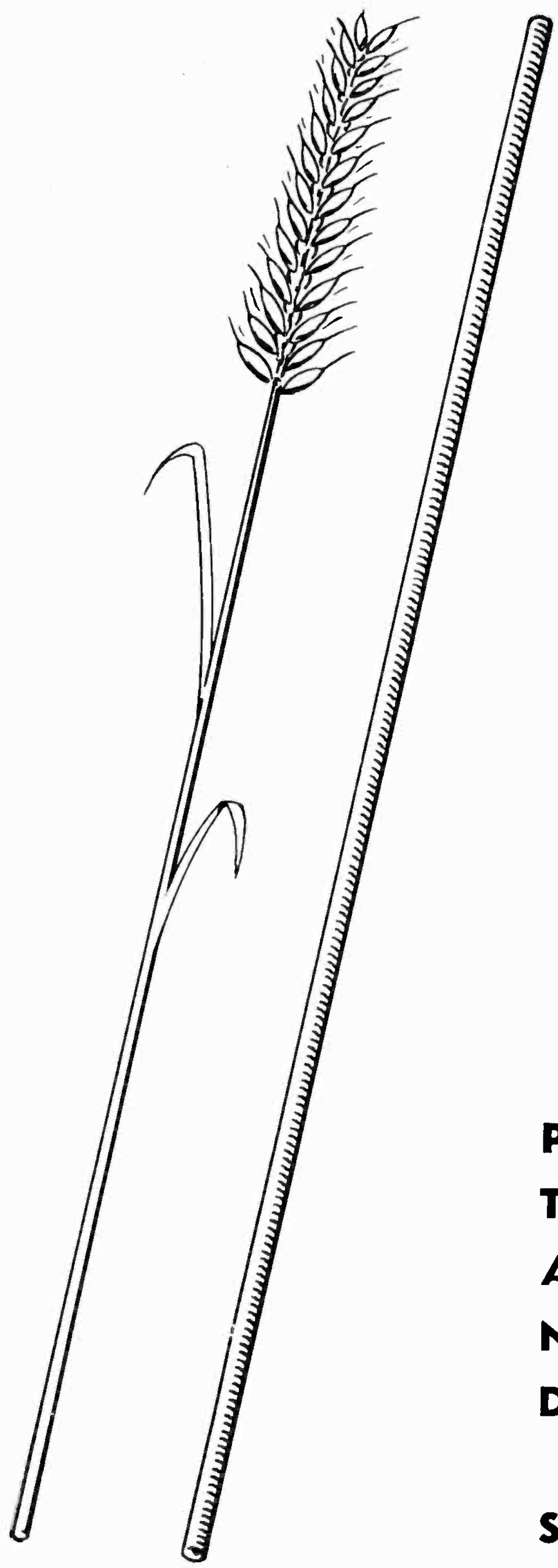

PRODUCTION OF SMALL, FINE, SEAMLESS TUBING IS A PASSION WITH THE MEN WHO ARE THE SUPERIOR TUBE COMPANY OF NORRISTOWN, PENNA. (25 MILES FROM PHILADELPHIA, 100 MILES FROM NEW YORK CITY.)

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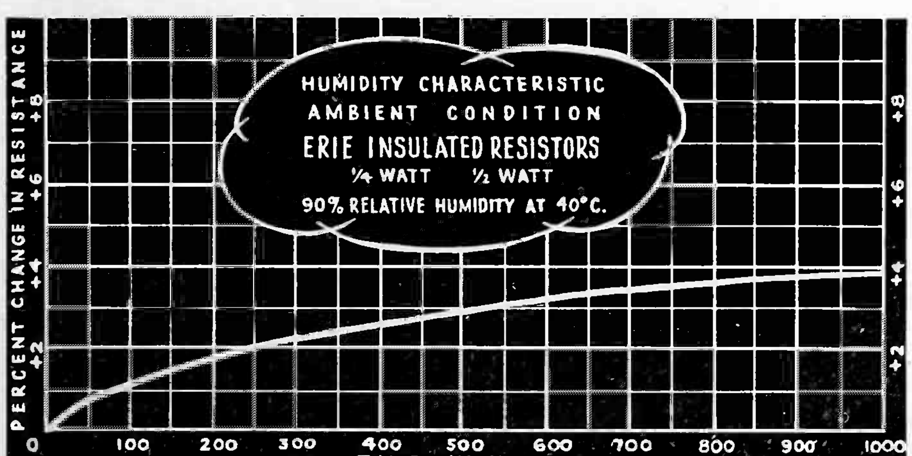
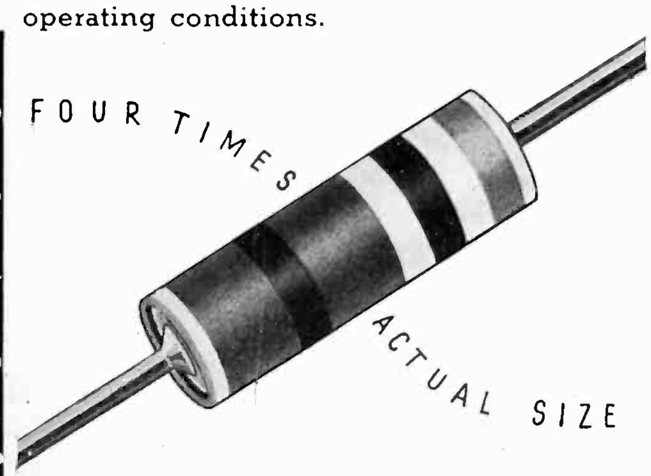
You can depend on Erie Resistors for trouble-free performance under severe operating conditions.





CARBON RESISTORS AND SUPPRESSORS

ERIE RESISTOR CORPORATION

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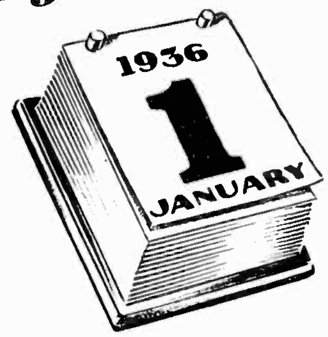
In January . . .



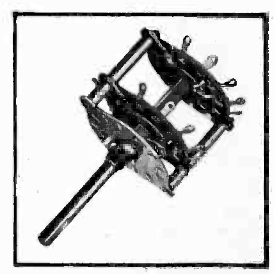
MALLORY-YAXLEY said—
"In 1936 we will continue the good job—anticipating requirements and making continuous advances"

In December . . .

MALLORY-YAXLEY
Present Proof of Maintained Leadership

During 1936 Mallory-Yaxley introduced the Mallory Precision Vibrator. . . a development which provided small size, higher contact pressure, hair-line precision—and was accorded an enthusiastic reception by the radio engineering profession generally.

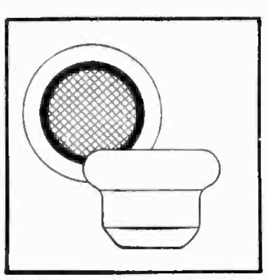
During 1936 Mallory-Yaxley announced Yaxley 3100 Type Switches for short wave, tone control and tap applications . . . and opened a new era of small size, compactness, extreme circuit flexibility, low capacity and low resistance.



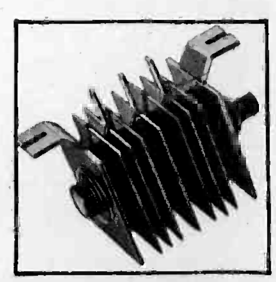
During 1936 Mallory-Yaxley offered in the Yaxley line, the most complete line of all wave switches ever available — meeting the most exacting demands of the simplest or most complicated circuits.

During 1936 Mallory-Yaxley presented Mallory Standard Dry Electrolytic Capacitors so designed and constructed to effect immediate, remarkable and wide-spread savings in material cost, production time, and chassis space.

During 1936 Mallory-Yaxley published the first complete authoritative Dry Electrolytic Capacitor Data Book that ever came off a press— nothing was omitted — nothing overlooked.



During 1936 Mallory Grid Bias Cells were used in more receivers by more manufacturers than ever before—further demonstrating the advantages of Mallory-Yaxley engineering in providing superior characteristics, advanced design and unusual flexibility.



During 1936 Dry Disc Rectifiers produced by Mallory-Yaxley won a greatly increased nation-wide acceptance . . . being used in many new applications in which they proved the value of small size, rugged construction, great flexibility and unfailing service.

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ELECTRONICS

DECEMBER
1936

KEITH HENNEY
Editor

Crosstalk

► **NOBEL PRIZE** . . . In awarding the Nobel prize in physics to Dr. Carl David Anderson for his discovery of the positron, an event of unusual scientific interest was commemorated. The positron is a positive electron. Now it has been pleasant to think of the electron as always negative and although it was a bit annoying to find this electron sometimes acting like a material particle with predictable characteristics, and at other times like a wave with true Huygenian qualities, it still was more or less definite, something to hang onto.

Professor Dirac came along and said that there was another of these scientific building blocks which resembled an "electrical hole." Dr. Anderson found it on one of the many plates he had exposed; and he found that it had negative energy and other characteristics which are really upsetting to those of us who have sort of settled down to the negative electron.

Our photo, by the way, shows Drs. Millikan and Anderson, the latter a student of the famous measurer of the electron's charge.

► **OLD STUFF** . . . Newspapers again fall for the report that television abroad has reached the point where large pictures are thrown on a screen from a very small, very bright cathode ray tube. A lens is used; and the impression is that this is everyday home television.

This is old stuff. Demonstrations of this system were made in this country, long ago. One of the engineers who has seen all in Europe states that an f2 lens is used. Now a well corrected 5 cm. lens of this speed costs about $150, which is quite a burden for a television receiver to assume. And no one will vouchsafe a reasonable life on a cathode ray tube of the brilliance mentioned in this foreign propaganda.

► **TECHNIQUE** . . . While on this subject of television, a year-end summary might not be out of place. Demonstrations have been held by all those actively engaged in the art, several of them within the last few months. Thus pictures have been seen by technical people, and by the laymen (newspaper reporters) as well. Technical experts are amazed; newspaper reporters are blase. And it seems to us that the television people can learn more from the reporters than from engineers.

Drs. Millikan and Anderson, Nobel prize winners 1923 and 1936

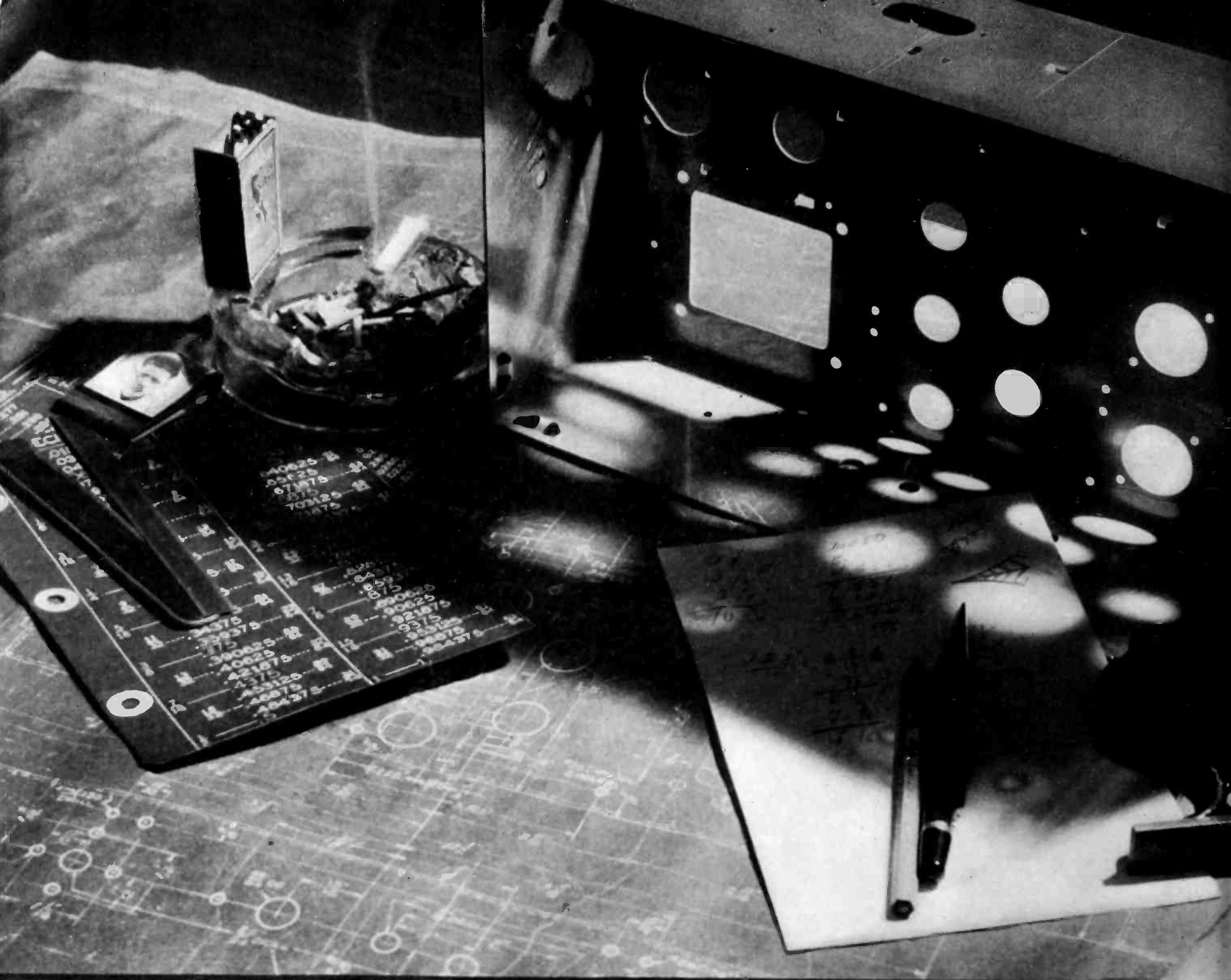
Reporters state that the first demonstration (no matter who made it) was the best; thereafter it becomes a matter of the show. What did they see? Therefore if the camera man, or the fellow manipulating the lights or the monitor engineer does not handle his end of the pick-up properly, the show is no good. If there is bad distortion due to faulty camera work, or bad electron beam control, or if a shaft of light gets into the lens (like pointing your camera at the sun) the reporter feels that the art has not progressed.

Will the green and black images satisfy the purchaser? Will 441 lines spread over 8 by 10 inches make him feel his $500 has been well spent? It depends upon those who stage and control the show. For example the Philco demonstration was fair enough, but in retrospect rather dull until Boake Carter finished his message and then looking into the lens suggested that someone at Chief Engineer Grimditch's house give him a ring on the 'phone. Mr. Carter recognized the voice at our end of the wire, and in the give and take of the ensuing conversation the whole show took on life — we lost contact with radio and television — we were in on something intrinsically entertaining.

The fire department scene at Camden and certain portions of the NBC demonstration emphasize that a program of surpassing interest is going to be necessary to separate the looker-in from the cold fact that he is looking at a rather small tinted picture which gets to him by methods he can appreciate.

At present the trade need not feel that television sets are imminent enough to steal the market away from a good radio. And the engineers need not worry that their work is done — there must be a lot of improvement before the big market is ready for these new luxuries of the electron. And these improvements will have to be carved out of very solid rock, in our estimation.

► **CHASTENED** . . . Called for not including Hygrade Sylvania among those tube companies which issue technical bulletins, we hasten to admit that we have read and learned from "Modulation Capabilities of Infinite Impedance Detectors" and "Input Capacitances of Tubes at Audio Frequencies" to mention only two of the recent papers.



CHECK!

Here is everything necessary for checking a radio receiver chassis base except the checker. Apparently called away from his work, he left it for the photographer — Ken Henderson of Stromberg Carlson Telephone Manufacturing Company

Radio Engineers Look Ahead

Record attendance at Fall meeting hears papers on television, automatic selectivity control, noise limiting circuits, loud speaker measurements and improvements, allocation problems, etc. A review of the Rochester papers

WITH a total registration of 450, nearly one hundred more than in 1935, the annual Fall Meeting of the I.R.E. came to a close on November 18th with its reputation for interesting papers and argumentative discussions well preserved. The fifteen papers presented were aimed primarily at radio-set engineers, according to the usual custom at Rochester meetings. Among the topics discussed were: loudspeaker and other acoustic problems with special reference to the use of labyrinths and similar acoustic networks; television from the commercial, technical and regulatory points of view; radio circuits including feed-back amplifiers, high frequency receivers, and highly interesting systems for controlling selectivity automatically; u-h-f current measurements, shot-effect tube noise; and general papers on radio tubes, the FCC, and on the relation of receiver characteristics to station allocation.

The convention program included also the annual Rochester Banquet and a trip to view the cyclotron (atomic bombarder) at the University of Rochester. A large number of manufacturers' exhibits were on display. These exhibits contained many of the newer types of radio components and testing equipment. One concern showed the action of a power-supply vibrator by viewing it under stroboscopic light; another the use of a cathode ray oscillograph for measuring pressure in conjunction with a piezo-electric pick-up; another demonstrated transmission and reception of supersonic waves.

The following report of the convention papers has been prepared by the editors from notes taken in the technical sessions. Some of the papers may be reported in full in the Proceedings of the I.R.E. and others will be found in *Electronics* in later issues. H. F. Mayer's paper, for example, on automatic selectivity control is presented elsewhere in this issue.

Loudspeaker Acoustics and Measurements

The meeting opened with a paper by S. V. Perry of RCA Victor on "Equipment and Methods used in Routine Measurements of Loud Speaker Response". Mr. Perry reviewed briefly the progress in this work from the manual methods of reading loudspeaker response, through the semi-automatic methods (see Frontispiece, *Electronics*, November 1936), to the fully automatic method in which a beam of light traces the pressure-response curve photographically. To obtain consistent results, the effect of standing waves produced by the loudspeaker in the room must be reduced. This may be done by placing the pick-up microphone close to the loudspeaker, by moving the microphone through the standing wave, or by varying the frequency impressed on the speaker (warble-tone method). Of these the first two were described. The close-up method is used in measuring the characteristics of individual loudspeakers; the moving microphone method for measuring loudspeakers mounted in receiver cabinets.

RCA uses two types of microphones for pick-up work. One is a specially constructed shallow-cavity condenser microphone (whose pre-amplifier uses an acorn triode, thus greatly reducing the size of the assembly). This condenser unit is used for all frequencies from the extreme lows up to about 10,000 cps, but not higher. The other is a special ribbon-velocity microphone having an electro-magnet field, which is not used below 100 cps, but which goes on up to about 20,000. Each microphone has its associated compensated amplifier.

In checking the speakers, the voice coil is fed with about 0.1 volt-amperes, which is approximately normal use for the home. The impedance of the voice coil is measured under these conditions by a substitution method, over the frequency range. The nominal impedance is that value existing, usually near 400 cycles, where the impedance does not change markedly with frequency. It was pointed out that pressure response curves are principally valuable for comparing speakers measured under the same conditions, but do not indicate absolute performance.

U-h-f Current Measurements

John Miller of the Weston Electrical Instrument Corporation presented a paper on "Current Measurements at Ultra-high Frequencies." He pointed out that while the thermal meters are universally used for high frequency measurement, the hot-wire type has become nearly obsolete because ambient temperature compensations are so difficult. The thermocouple type of meter, however, may be properly compensated. When it is desired to calibrate such meters at 100 Mc., however, there is no standard ammeter available for comparison purposes. It is known that thermocouple meters read high at high frequencies, since the skin effect then produces more heat in the heater element per unit of current through it. For the same reading on the meter scale, however, the heating must be the same, hence

$$I^2_{lf} r_{lf} = I^2_{hf} r_{hf}$$

and:

$$I_{hf} = I_{lf} \sqrt{r_{lf}/r_{hf}}$$

The high frequency current can be found from the accurately measurable low-frequency current, therefore, if the ratio of the low-frequency resistance to high frequency resistance is known or can be calculated. In a typical thermocouple meter (11 mil heater wire) this latter ratio at 100 Mc. is 1/2.57, giving an error of about 36 per cent at that frequency. To reduce the error, it is first necessary to get a fairly reliable comparator. This was done by the use of tungsten-filament lamps whose filaments were of small diameter (hence less affected by skin-effect) so that the ratio of resistances was only 1/1.065 Mc. at 100 Mc. giving an error of only 2 or 3 per cent. The tungsten lamps were fed several amperes of current from an 80 Mc. oscillator and their temperature determined by a photoelectric photometer. The same procedure was repeated at 60 cycles. In terms of these data the thermocouple meters were checked and the errors found plotted for convenient correction of the calibration.

To reduce the errors of the thermocouple a new type of heater element consisting of thin-walled platinum-iridium tubing was used, this configuration confining the current to the same path regardless of the frequency. The error found in these thermocouples (in terms of the tungsten lamp "standards") was about 3 to 5 per cent at 100 Mc. as against 50 to 70 per cent error at the same frequency for conventional couples. Further accuracy was deemed unnecessary in view of the other factors which obtain in present-day measurements at ultra-high frequencies.

Cabinets and Loudspeaker "Lows"

The currently popular topic of acoustic networks in radio receiver cabinets was discussed in a paper by Hugh Knowles, chief engineer of the Jensen Radio Manufacturing Company. Mr. Knowles began his paper with a mathematical *tour de force* into the "double source" problem in acoustics, for example the effect on the sound pressure resulting from radiation both from the front and the rear of the cabinet, or from the loudspeaker and an auxiliary acoustic network (labyrinth, series of ports, openings, etc.)

By means of electrical analogs to the acoustic conditions, he showed that the effect of the second source on the reproduction depended not only on phase relations, but to a considerable degree upon the dissipation in the secondary network. For example, a simple acoustic pipe or conduit can be represented electrically by a transmission line with distributed inductance, capacity and resistance. The terminations (short circuit, open circuit, etc.) of the transmission line correspond to an open ended pipe, a rigidly closed pipe, a pipe terminated in an auxiliary diaphragm, etc. In particular if a cabinet with a solidly closed back can be filled with a sufficient absorbing material a considerable strengthening of low frequency response will result. The rear of the cabinet may be only partially closed, with open ports which serve both acoustically and thermally, since ventilation of the chassis is usually necessary. A port may also be used in the front of the cabinet, and if used in connection with an auxiliary acoustic circuit (containing considerable dissipation), the low frequency response is still further improved. In general Mr. Knowles showed that all the cabinet bass-boosters being used by radio manufacturers derive from the same theory, but that they do not all perform in identical fashion, of course, because of the different arrangements used, particularly in relation to dissipative elements.

B. J. Thompson and D. O. North of RCA Radiotron prepared a paper on "Shot-effect Noise in Space-charge-limited Vacuum Tubes." Mr. Thompson, who presented the paper, introduced the subject by saying that tube noise, relatively unimportant in present-day receivers, will undoubtedly play a major role in the design of television receivers and other wide-band equipment. The essence of the paper was a new point of view with regard to the mechanism of shot-effect, an experimental confirmation of the theory, and an indication of the way in which noise may be reduced in positive-grid (screen-grid pentode) tubes.

When all emitted electrons are removed at once and no space-charge forms in the cathode-anode interspace noise components in the cathode current are to be expected from the random emission of electrons, which within a very small space of time will be larger or smaller than in another space of time. If the emission is then limited by space charge, the noise component decreases, until at complete space charge no electrons are removed and the noise component should be zero. At intermediate values of space charge, (according to the Thompson-North view) the noise value is the result of the following circumstances: the potential minimum (due to finite initial velocity) in the cathode-anode space becomes the surface of a "virtual cathode," which then operates like an ordinary cathode under temper-

An important and interesting feature of the annual visit to Rochester is the opportunity to see what new products the manufacturers have to offer ature-limited conditions. If we apply the thermal noise formula (used for temperature-limited noise) to this case, the correct result should be obtained if a factor of 0.6 is used as a multiplier. This has been checked experimentally, the values of the factor ranging from 0.6 to 0.8. The actual mechanism of the effect is pictured as follows: at the potential minimum the space charge varies in a random fashion due to the random emission of electrons. At a certain small element of surface in the virtual cathode a small increase of current may occur, but this is compensated by an equal current flow of electrons back to the emitter, which, however, takes place over a much larger area surrounding the small element in question.

In tubes containing a positive grid the noise in the plate circuit is much larger than that contributed by the cathode. This extra noise comes from the random distribution of current between the screen grid and the plate. If the screen current can be reduced, then the variations are reduced in proportion, and the total plate circuit noise approaches that contributed by the cathode alone. It appears possible by reducing the screen current by suitable design that the noise present may be reduced to about one-half of its present value.

Commander T. A. M. Craven, Chief Engineer of the FCC outlined the necessity of coordinated work between the Commission, the IRE and RMA Engineering Division. He made clear to the engineers that allocation solutions were always compromises of some sort. For example if the broadcast stations are allocated frequencies according to the highest selectivity of modern receivers, audio fidelity would suffer. Equal disadvantages, but in other directions, would occur if stations were placed in the spectrum according to receivers of the lowest selectivity. Commander Craven paid high compliments to the engineering division of RMA for their cooperation in the recent meetings to discover facts which would be useful in future allocation and power problems. There were still questions, however, on which the Commission needed information of the type that engineers could give.

For example what is the desired ratio between wanted and unwanted signals, 10 kc. apart? The second problem on which light is wanted, is that of blanketing. Engineers state that modern sets are not blanketed on a 1-volt input. And yet the Commission gets complaints from localities where the inputs are of the order of one-half this figure.

The third problem is that of the intermediate frequency used in superheterodynes. If proper coordination had taken place some time ago it is probable, according to Mr. Craven, that an international agreement could have been reached setting aside a frequency for no other purpose than for i-f amplifier use. But the trouble is that the set manufacturers themselves are not agreed as to the frequency they want. Before this problem is properly settled in this country the various government departments which have radio services will have to be brought into the picture. It is in this kind of situation where the engineers in the profession can be most useful.

On transmitter problems, the FCC must look to the IRE because of the lack of an organization among manufacturers of this type of apparatus corresponding to the RMA engineering committees.

Radio Tubes Today

Four topics of vital interest to the industry concerned with receiving sets and tubes were discussed by Roger Wise, chief radio engineer of Hygrade Sylvania. First he discussed the position of the tube manufacturer in the industry, commenting on the very high mortality among tube makers since the early days. It is worth noting that there is less concentration of manufacturing now than in the days when there were ten times as many tube plants.

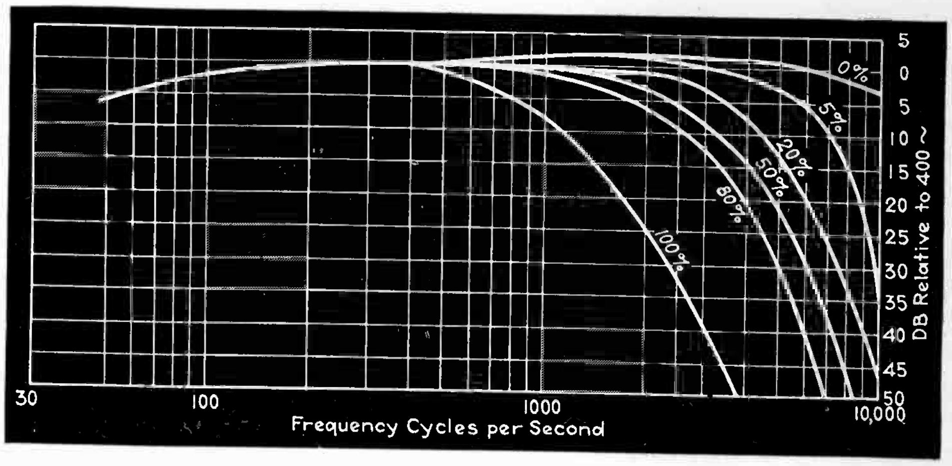
Mr. Wise spoke of the indigestion of the industry caused by the metal tube and of the present diversity of types of tube. In his plant a survey showed that only a few tubes accounted for the greater proportion of production. For example the 78 and 6K7G accounted for 17.6 per cent of the total production for the first 9 months of this year. The 6A7 and 6A8G accounted for 11.3 per cent. Overall, thirty-seven types made up 75 per cent and the remainder of production was made of 78 different tubes. The greater proportion of production should comprise about 16 tubes if the present trend toward octal bases continues.

Out of 52 new type numbers assigned in 1936, 8 were ballast tubes. Of the remaining 44, only 16 were actually new tubes from the tube maker's standpoint. The others presented no problems, being merely new bases on old tubes, changes in heater current or other slight modifications.

On the question of parameter

This year, over 30 manufacturers took space at the Fall meeting, providing a profitable trade show of the components and raw materials manufacturers limits, Mr. Wise pointed out that tubes were now remarkably uniform considering the complexity of structure and the many chances for variation. He showed curves of great interest prepared by Marcus Acheson showing the effect on parameters of slightly displacing the grid from its optimum position in the cathode-anode field.

Problems still existing are those relating to the proper use of the tubes, the set manufacturer often taking into his own hands the maximum voltages and currents at which the tubes were to operate, usually in excess of the limits set by the maker of the tube. The situation of rectifiers is particularly severe because of the occasional breakdown, or deforming, of the first filter condenser. Such breakdown, by causing the plate to emit, sends high-speed electrons to the cathode because of the high voltage existing across the tube under this condition.



Electrical fidelity of 1935 to 1936 sets. Figure on each line gives percentage of sets of greater response than that line. 83 receivers

Acoustical Labyrinth

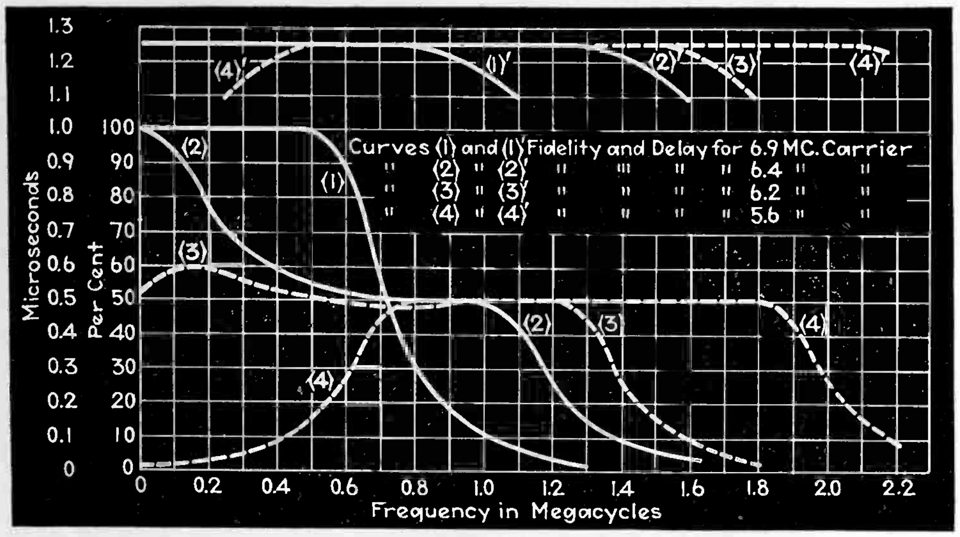
B. J. Olney of Stromberg-Carlson presented new experimental data on the acoustical labyrinth, which was first demonstrated before the Rochester meeting two years ago. He likened the acoustic network of the labyrinth to the electrical analog of the "leaky" telephone line, and showed the peaks of mechanical impedance which occur in such a system. The labyrinth is lined with large amounts of sound-dissipating material; such materials have the property of selective absorption and in general attenuate the high frequencies much more than the lows. The network thus acts as an efficient low frequency resonator but is highly inefficient in the high frequency region. Confining his measurements to frequencies below 1000 cycles, Mr. Olney showed how the system extends the low frequency response and at the same time presents a sharp low-frequency cut-off below the desired region. By its use the resistance component of the air column against which the speaker acts is greatly increased over the value offered to a piston operating in an infinite baffle, and this increased resistance has the effect of increasing greatly the low-frequency radiated power. In addition it has the effect of reflecting a high resistive component through the output transformer to the plate circuit of the output tubes. The damping introduced thereby permits usual operation with pentode and beam-power tubes having high plate circuit impedance without the generation of resonances. In fact, according to the speaker, the labyrinth used with pentodes gives results equal to a straight baffle-mounted speaker operated from low-impedance triodes. The impedance variations throughout the frequency range are reduced also. An unusual set-up was used for measuring these characteristics. As a standard, an un-lined resonant pipe of steel with an adjustable plunger was used, with a microphone at its open end to register air pressures. This system was compared with the pressures produced by the speaker in a baffle, with and without the labyrinth behind it.

Radio Sets Today

A most interesting set of data was shown by D. E. Foster of the RCA License Laboratory. These data were based on the number of sets now in use. Of these 50 percent are 3 years old and 75 percent are 5 years old. Curves showing the selectivity of these receivers were given (see *Electronics*, November 1936 page 13). Assuming that a desirable condition would be where not over 20 per cent of the receivers in use would experience interference and assuming that the desired station produced a signal of 5000 microvolts, the undesired signal could be 1 volt if 50 kc. away; 225 mv. if 30 kc. away; 100 mv. if 20 kc away, and for the adjacent channel, the signal could be 6.75 mv. If stations are on the same channel, if the desired signal is 5 mv. and if the two stations are 50 cycles apart the undesired signal could be 0.25 mv., when 25 cycles apart the undesired signal could be 0.42 millivolts, and if the two stations were on the same frequency and carried the same program the undesired signal could be 1 millivolt.

Nickel Used in Radio

E. M. Wise of the International Nickel Company presented many chemical, physical, and electrical properties of various grades of nickel in comparison with other metals. Nickel used in radio tubes was treated at length, while its application in magnetic alloys, both for shielding (high permeability) and permanent-magnet (high retentivity) uses also received attention. Commercial nickel used for radio uses is usually about 99.5 percent pure and the type of impurity (0.5 per cent) has a great effect upon its suitability for different classes of service. For tube-parts, such as plates, the enclosed gas is of great importance; it is found that the enclosed gas in commercial nickel is about 13 to 28 cubic mm. per gram, as against 100 to 230 cubic mm. per gram for high grade iron. For cathode sleeves, the type of nickel used has a great effect on the overall emission obtained from the cathode coating, the presence of even small amounts of certain impurities greatly increasing its effectiveness. Mention was made of the new permanent magnet materials (*Electronics*, May 1936, page 30) in which iron, nickel, aluminum and cobalt are used, and of the high permeability alloys, such as mumetal, which have excellent magnetic shielding properties. Several examples of



Fidelity and delay characteristics of single-side-band television reception

British cathode-ray-gun shields made of similar material were shown. The use of nickel iron alloys as transformer core material has resulted in extremely small high-fidelity units which weigh only a few ounces, widely used in portable applications.

Television on Suppressed Sidebands

A highly interesting development in television was outlined by D. W. Epstein of the RCA Manufacturing Co., who presented the paper "Sideband Suppression in Television Reception," written by Mr. Epstein and Mr. W. J. Poch. It was found in experimenting with television receivers that a better image often resulted if the circuit was tuned to one side or the other of the carrier, resulting in a partial suppression of one of the sidebands. The increased detail obtainable under this condition was explained in this manner: The bandwidth passed by the receiver was narrower than that transmitted. By detuning, more "highs" were accepted by the receiver, at the expense of signal strength, resulting in a more detailed image with a lower signal-to-noise ratio. Such detuning retained double side-band reception on the low (overall scanning line) frequencies, which were proportionately stronger than the highs. If the receiver band-width is widened in the attempt to accept both transmitted side-bands fully (with on-carrier tuning), the gain per stage decreases in direct proportion to the band-width, necessitating more stages. Hence to make the most economical use of the band-width available at the receiver, single side-band transmission is highly desirable. Likewise the space thus made available in the television band can be put to use by decreasing the width of guard bands, etc.

Messrs. Poch and Epstein examined theoretically and experimentally the effect of single side-band reception on frequency (fidelity) and phase response. The results are shown in the figure. Curve (3) (for a 6.2 Mc. carrier) shows very desirable characteristics. The transmitter and receiver in the experimental set-up were equipped with rejector circuits which lowered the energy transfer in the lower frequency side-band. Among other things it was found that distortion in the second (linear) detector circuit under these conditions did not become serious up to the maximum modulation level of the transmitter (about 80 per cent). Wave-form distortion in a television image due to the presence of second and third harmonics seems, in fact, to be less serious than it is in audible reproduction.

It appears probable that further research along these lines may materially alter the present concepts now current on television-band dimensions, since in the ideal case a given picture can be sent in half the band-width used for the usual double-side-band method.

Television Standards Reviewed

A. F. Murray, Acting Chairman of the RMA Committee on Television Standards, reviewed the recommendations which the RMA made to the FCC at the u-h-f hearings last June. These recommendations were reported in the July 1936 issue of *Electronics* (page 9): they are briefly as follows: A band from 42 to 90 Mc., consisting of television channels each 6 Mc. wide including suitable guard bands; the sound carrier to be higher in frequency than the visual carrier within each channel; negative transmission (decrease in light increases radiated power); a 441 line picture, scanned completely 30 times per second, with a two-to-one interlaced pattern giving 60 field scannings per second; an aspect ratio of 4-to-3; and at least 20 percent of maximum amplitude devoted to synchronizing pulses.

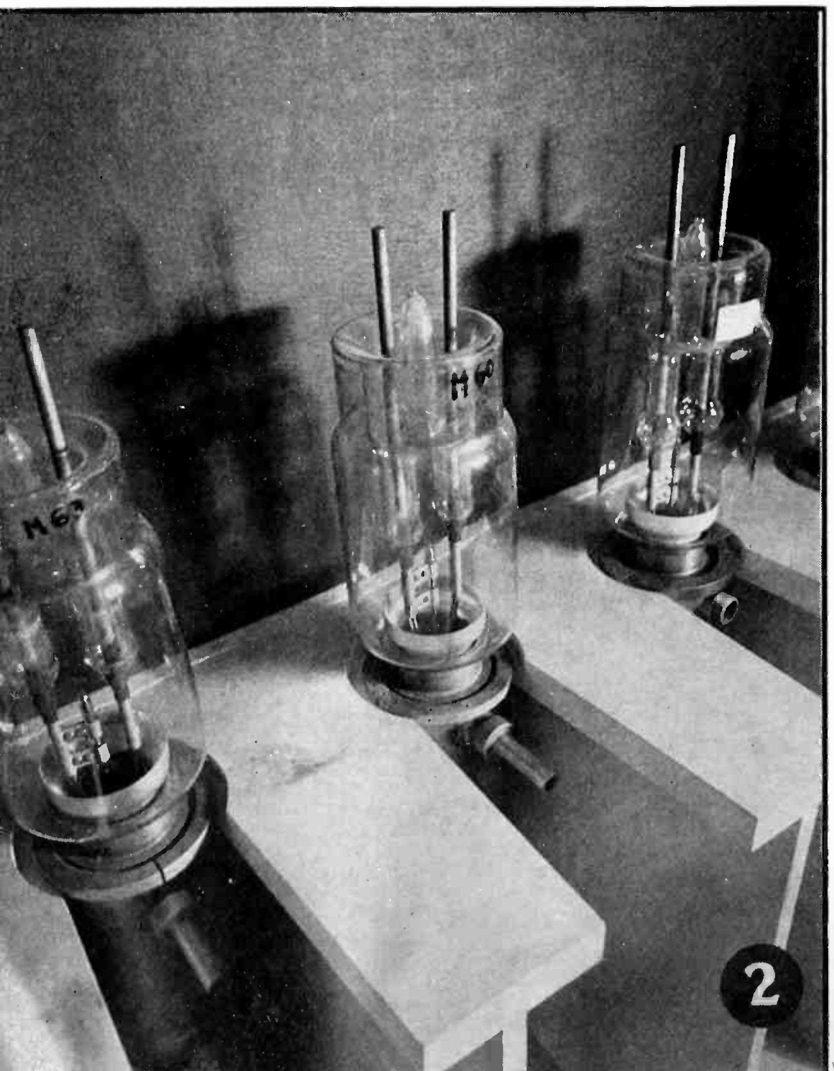
Mr. Murray gave complete explanations of the reasons why each standard was decided upon, and asked that the RMA and the IRE stand behind the committee in supporting the recommendations. He pointed out that the standards were formulated with the possibility of single-sideband transmission in mind, and asked those present to give thought to the problem of designing a powerful transmitter for this mode of operation. As pointed out by Mr. Epstein in his paper (reported below), single-side-band operation would permit a much more economical use of the band-width available in the receiver, while at the same time permitting more stations to occupy space in the television band.

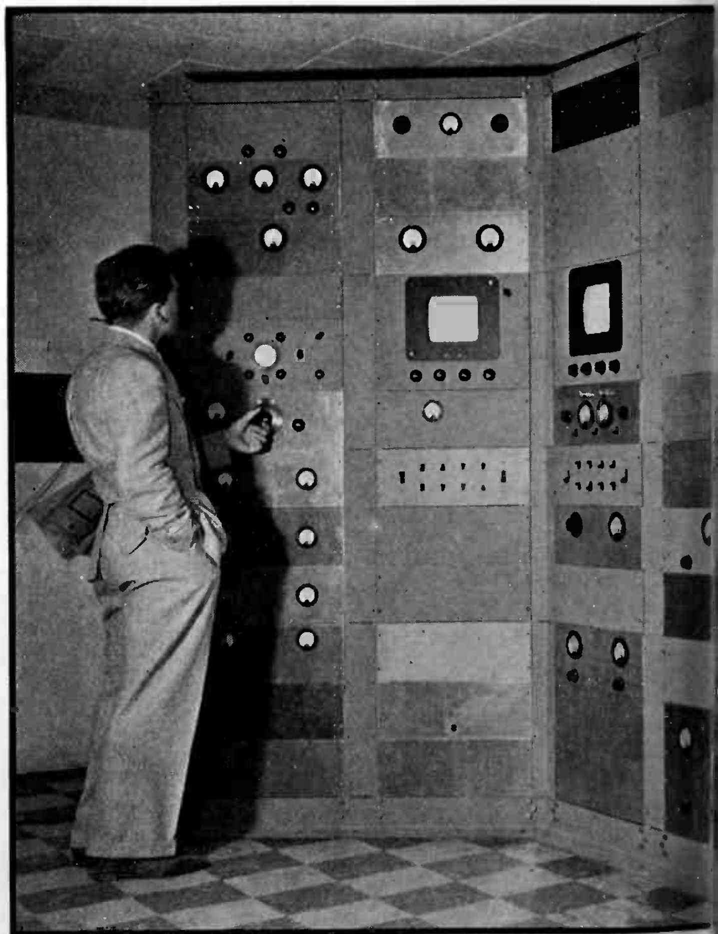
Dr. Goldsmith Analyzes Television's Needs

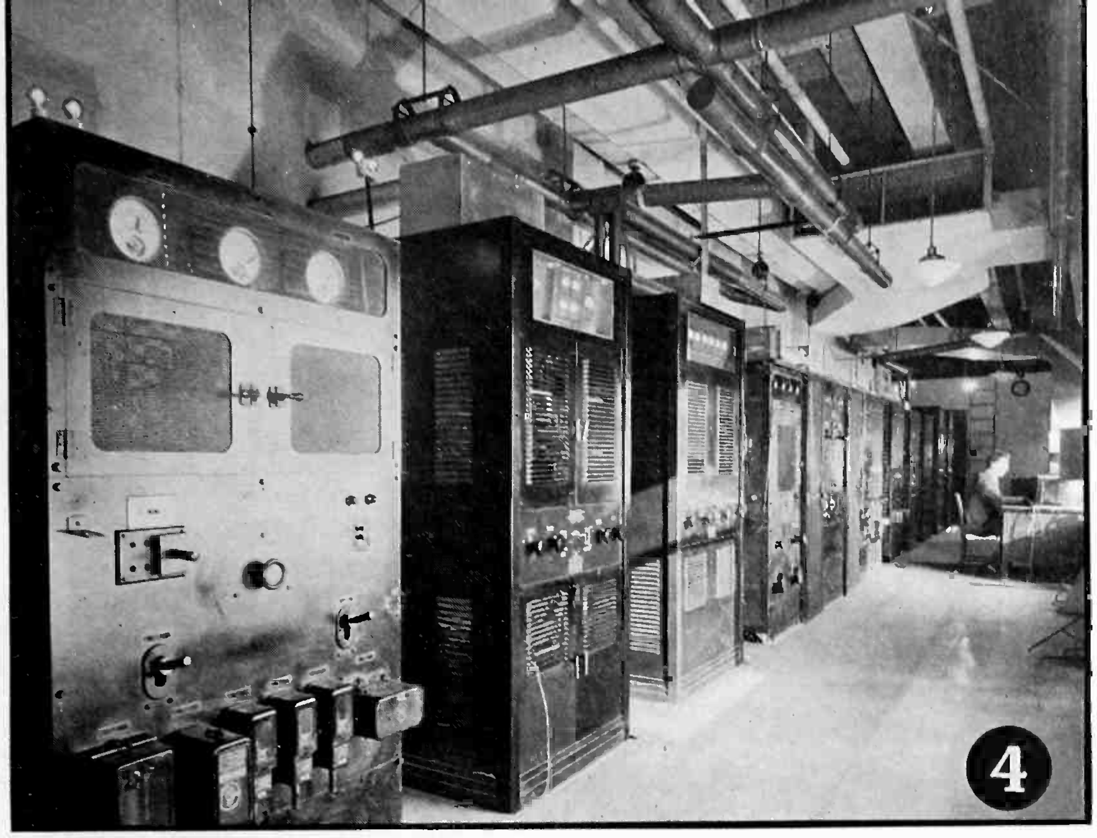
Dr. Alfred N. Goldsmith, whose consulting practice both in radio and sound motion pictures gives him a very broad view of the field, presented "Commercial Television and Its Needs." He outlined six main requirements for successful television: 1. A cooperative and progressive attitude on the part of the government in regulating the art; 2. A sufficient number of television broadcast stations; 3. A program-building organization which can provide interesting material; 4. Sound engineering and manufacturing methods for the production of receivers; 5. A group of home-lookers to view and appreciate the programs provided; 6. Advertisers to support the service through the sponsorship of programs. He emphasized the program-cost-per-listener which, he said, "is the Sphinx at which every broadcaster thoughtfully stares, awaiting

[*Continued on page 36*]

Television at Hand







1 Studio—Lights and cameras are now added to the stage properties of broadcasting. Technique is changed accordingly. Scene made in Farnsworth television laboratories

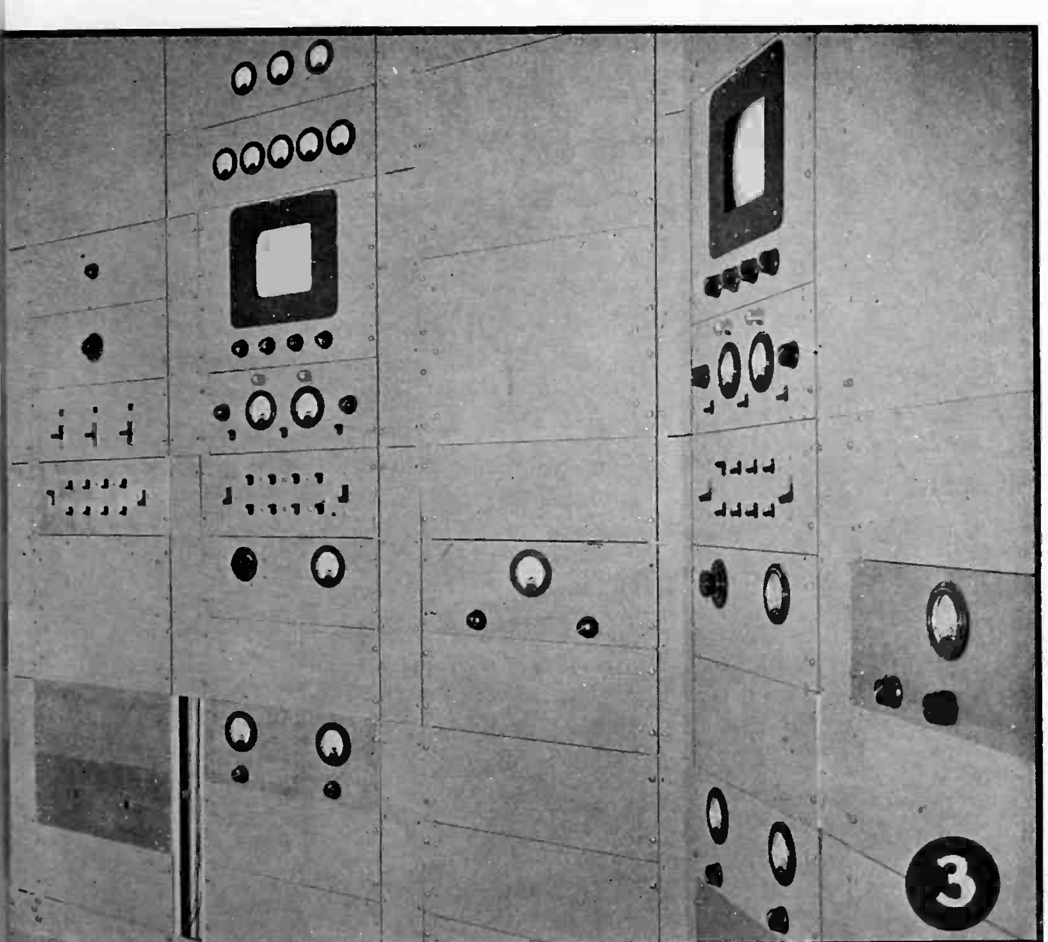
2 Tubes—Water-cooled, high-frequency amplifiers in Empire State building where National Broadcasting Company television field experiments transmissions take the air

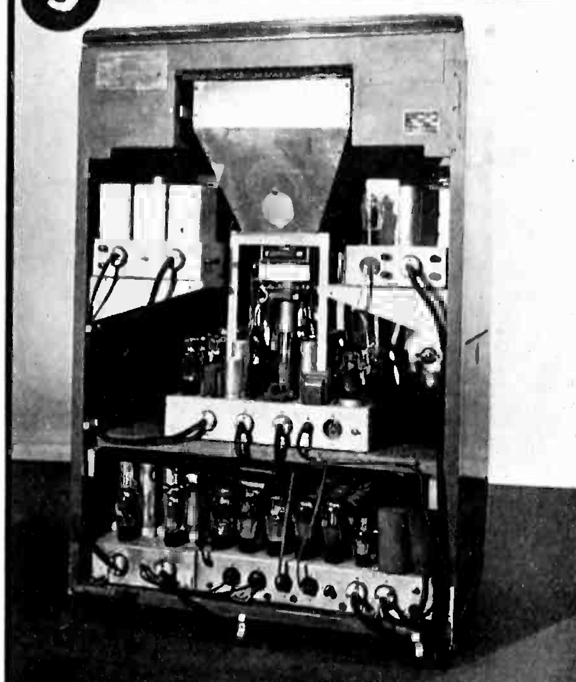
3 Control—Bays of control panels for monitoring video (sight) and audio (sound) channels for three cameras at experimental laboratories of Farnsworth, Philadelphia

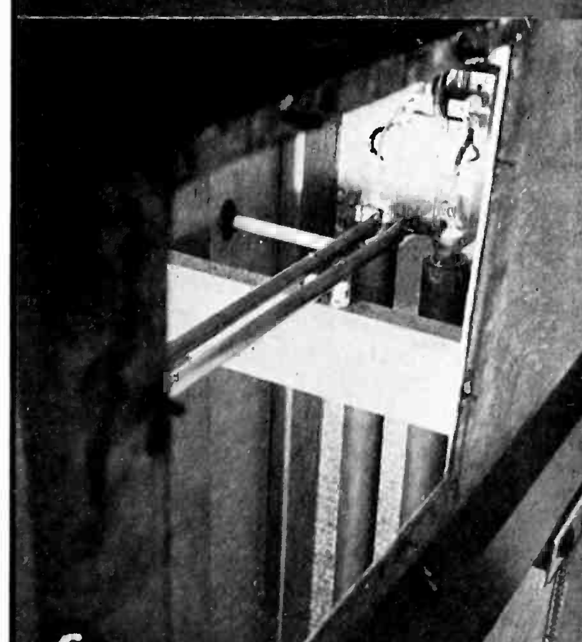
4 Transmitter—NBC Empire State transmitting equipment a quarter-mile above street. Signals arrive by concentric cable from Radio City, go to antenna through concentric line

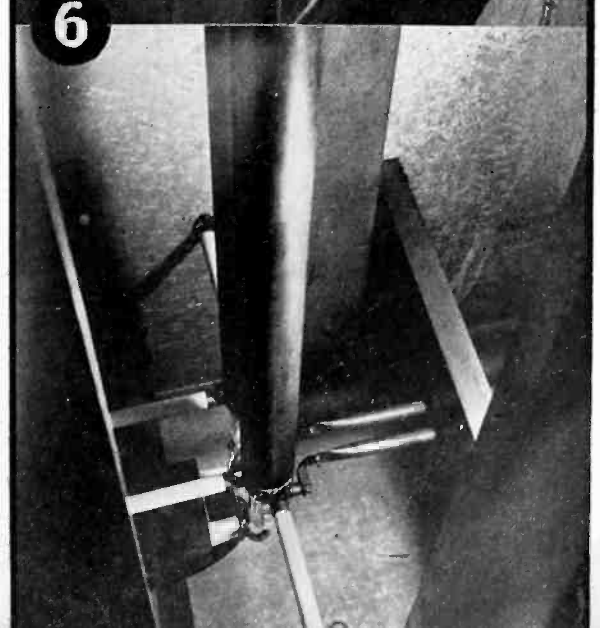
5 Receivers—Views of Philco television receivers. The purchaser buys much equipment, sees his picture in a mirror upon which is reflected the actual cathode-ray tube image

6 Oscillators—At Philadelphia, station W3XE, which is the Philco transmitter, operates on 51 megacycles. The organ-pipe assemblage is the 846-tube oscillator, water-cooled









Terminating Concentric Lines

The theory and practice of coupling the newly popular low-impedance concentric transmission lines to antennas of various characteristics, for maximum reliability and efficiency

By CARL G. DIETSCH
National Broadcasting Co.

THE use of transmission lines, especially those of the concentric tube or coaxial type, affords a convenient and efficient means for conveying radio frequency power. An important element to be considered in the design of such a line, whether it is to convey the power output of a transmitter to its antenna or from one stage to another of any radio frequency system, is the line termination of the circuit. Best results, insofar as reliability and efficiency are concerned, are secured when the termination circuit presents to the output end of the line an impedance equivalent to the characteristic impedance of the line. This impedance, being for all practical purposes equal to $\sqrt{L/C}$, resembles a real quantity in the form of an effective resistance equal to Z_o. Unless the line "looks into" an equivalent impedance to Z_o, stationary waves will form along the line, provided that the length of the line is long compared with the wavelength of the power being transferred as in the case of a line feeding power to an antenna. As a result of these standing waves, high potentials exist across the line in the vicinity of the voltage anti-nodes, which tend to break down the insulation at these points. Although the shielding of a concentric line usually prevents radiation from these waves, the presence of voltage and current anti-nodes tends to produce rather serious dielectric and conductor losses and to prevent a most efficient transfer of power.

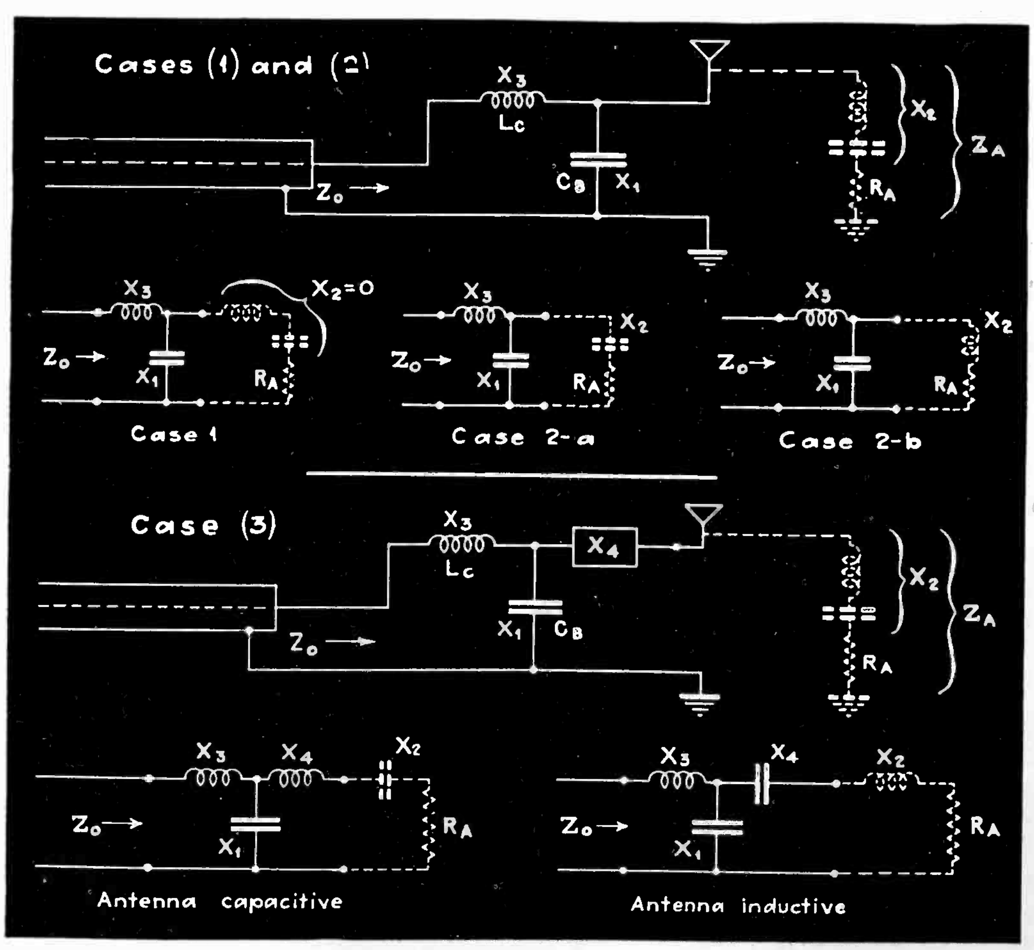


Fig. 1. Connection diagrams and equivalent circuits for terminating concentric lines when antenna is reactive or non-reactive

In a previous paper[1], information is given concerning transmission line terminations for the condition where the characteristic impedance of the transmission line is *greater* than the resistance of the antenna circuit. The reader is referred to this paper for the treatment of this case, and for the simple case where the antenna resistance and characteristic impedance are equal $(Z_o = R_A)$.

The growing use of concentric lines of the low-impedance type, however, has led to cases where the characteristic impedance of the transmission line is *lower* than that of the antenna resistance. It is with these cases that the present paper is concerned. In general there are three cases to consider: (1) when the antenna impedance contains a resistance component only; (2) when the antenna impedance contains a resistance component and a reactive component, either capacitive (2-a) or inductive (2-b); and (3) when the antenna impedance contains resistive and reactive components, the latter being partially compensated by the insertion of an extra reactance of opposite sign. These three cases are considered in order.

Case (1)—Antenna Impedance Purely Resistive

Refer to Fig. 1. The concentric line, characteristic impedance Z_o, is terminated by a network consisting of C_B, L_C, and the antenna impedance Z_A. For case (1) the reactance of the antenna impedance is zero, and $Z_o < Z_A = R_A$. Then the complex impedance Z_L presented to the end of the transmission line is:

$$Z_L = \frac{R_A[X_3 X_1 - X_1(X_3 - X_1))] + j[X_3 X_1^2 + R_A(X_3 - X_1)]}{R_A^2 + X_1^2} \quad \ldots\ldots\ldots\ldots (1)$$

where R_A, X_1 and X_3 are as given in Fig. 1. For proper termination Z_o

1. "Antenna terminations" Carl G. Dietsch. Electronics, Sept. 1935.

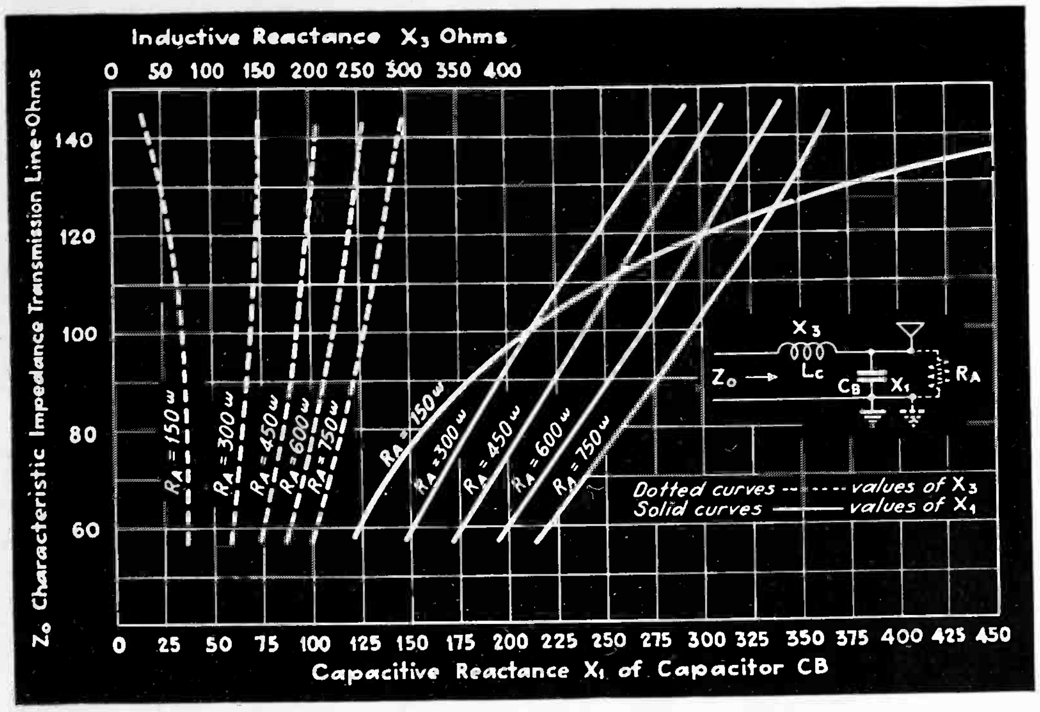


Fig. 2. Values of terminating reactors for Case (1)

must equal Z_L, hence Z_L must be real, and the imaginary term is zero. Then $Z_L = Z_o$ becomes:

$$Z_o = \frac{R_A X_1^2}{R_A^2 + X_1^2} \quad \ldots\ldots\ldots (2)$$

from which X_1, the reactance of condenser C_B, becomes:

$$X_1 = R_A \sqrt{\frac{Z_o}{R_A - Z_o}} \quad \ldots\ldots (3)$$

and X_3 (calculated by equating the j-term to zero), the reactance of inductance L_C, is:

$$X_3 = \frac{R_A^2 X_1}{X_1^2 + R_A^2} \quad \ldots\ldots\ldots (4)$$

Since $C_B = 1/(2\pi f X_1)$ and $L_C = X_3/(2\pi f)$, their values in microfarads and microhenries are then readily calculable from f, the frequency of operation. Figure 2 gives various values of X_1 and X_3 in terms of values of Z_o and R_A.

Case (2-a) — Antenna Impedance with Capacitive Reactance

Refer again to Fig. 1. It will be noted that the equivalent diagram for Case (2-a) is the same as case (1), except that the antenna impedance is now $Z_A = R_A - jX_2$. In this case the complex impedance Z_L presented to the concentric line is:

$$Z_L = \frac{R_A X_1^2 + j(R_A^2(X_3 - X_1) + X_3 X_2^2 + 2 X_1 X_2 X_3 + X_3 X_1^2 - X_2^2 X_1 - X_2 X_1^2)}{R_A^2 + (X_2 + X_1)^2} \quad \ldots\ldots\ldots (5)$$

If the line is to be terminated by a real impedance equal to Z_o, the imaginary part of this equation must be zero, as in case (1). Then $Z_L = Z_o$ becomes:

$$Z_0 = \frac{R_A X_1^2}{R_A^2 + (X_2 + X_1)^2} \quad \ldots\ldots (6)$$

from which:

$$X_1 = \frac{Z_0}{R_A - Z_0} \left\{ X_2 \pm \sqrt{\frac{R_A}{Z_0}(R_A^2 + X_2^2 - Z_0 R_A)} \right\} \quad \ldots\ldots (7)$$

Also, equating the imaginary term to zero, as before:

$$X_3 = \frac{X_1(R_A^2 + X_2 X_1 + X_2^2)}{R_A^2 + (X_1 + X_2)^2} \quad \ldots\ldots (8)$$

Hence, with Z_o, R_A, and X_2 given, X_1 and X_3 can be calculated by the above equations. From the values of X_1 and X_3, L_C and C_B can be calculated, exactly as in Case (1). Values of X_1 and X_3 for various values of R_A and X_2, for the cases where Z_o is 80 and 100 ohms are given in Fig. 3.

Case (2-b) — Antenna Impedance Inductively Reactive

Reference to Fig. 1 for case (2-b) shows that it is the same as Case (1) except that $Z_A = R_A + jX_2$. By a similar process to that used for Case (2-a) we obtain formulas for X_1 and X_3 as follows:

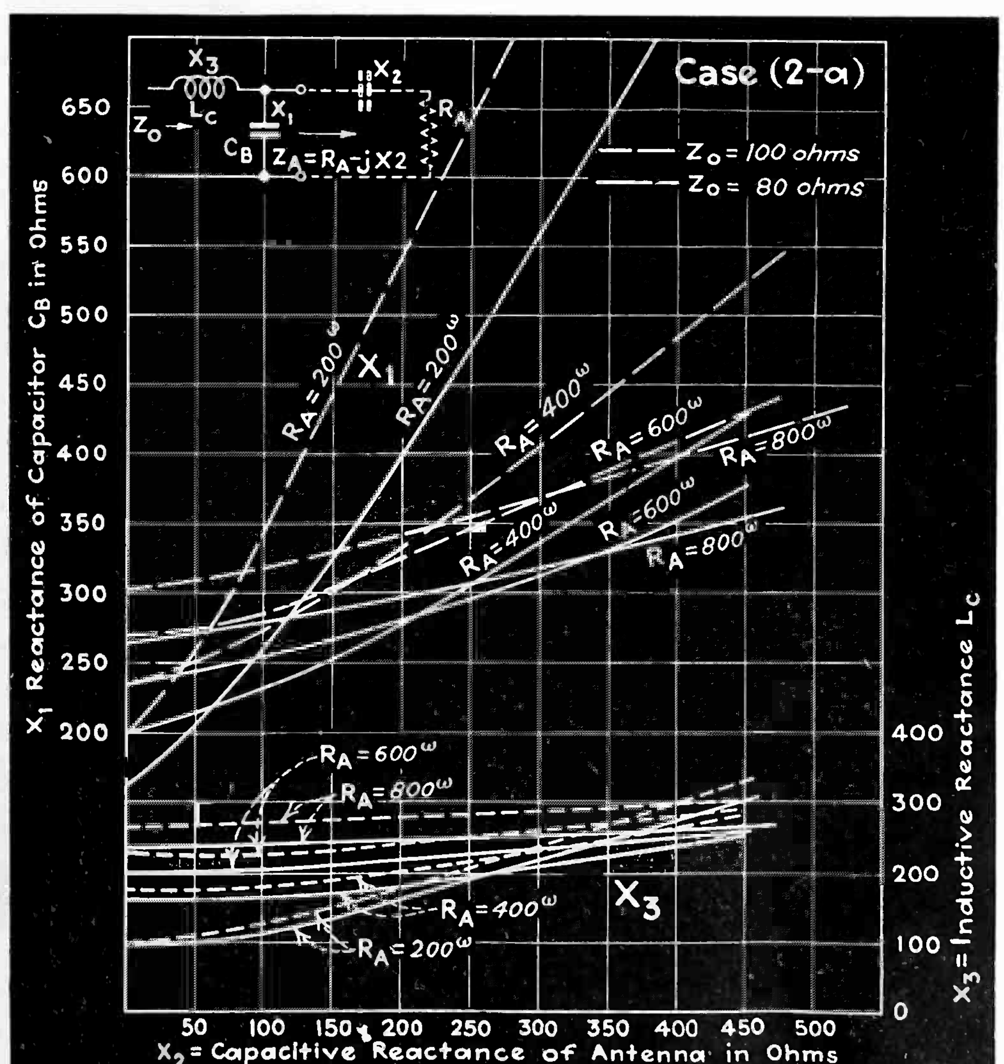
$$X_1 = \frac{Z_0}{R_A - Z_0} \left\{ -X_2 \pm \sqrt{\frac{R_A}{Z_0}(R_A^2 + X_2^2 - Z_0 R_A)} \right\} \quad \ldots\ldots (9)$$

and:

$$X_3 = \frac{X_1(R_A^2 + X_2^2 - X_2 X_1)}{R_A^2 + (X_2 - X_1)^2} \quad \ldots (10)$$

from which L_C and C_B are calculated

Fig. 3. Values of terminating reactors for Case (2-a)



as in the previous cases. Figure 4 shows various values of X_1 and X_3 in terms of R_A and X_2, for Z_o values of 80 and 100 ohms.

Case (3) — Added Reactance to Antenna Impedance

When the transmission line impedance "looks into" a complex antenna impedance, it is possible to simplify the adjustment of the circuit greatly by adding a reactance X_4 as shown in Fig. 1 for Case (3). This reactance X_4 may be either inductive or capacitive, as shown. If the sum of X_1 and X_2 is inductive, then X_4 is made capacitive and vice versa. The value of X_4 is such that the algebraic sum of X_1, X_2 and X_4 is equal to zero. Since X_4 is in series with the antenna impedance, it adds directly with the reactive part of the antenna impedance. The effect of the presence of X_4 can then be taken into account by applying the formulas of case (2-a) or (2-b). It is found by so doing that the values for both X_1 and X_3 are expressed by a very simple equation:

$$X_1 = X_3 = \sqrt{Z_o R_A} \quad \text{......(11)}$$

This occurs only, however, if X_4 is so chosen that:

$$\pm X_4 - X_1 \mp X_2 = 0 \quad \text{......(12)}$$

The reactance X_4 must always have the opposite sign from X_2, as indicated by the plus-or-minus signs in the equation. When X_4 is so chosen, the reactance X_1 and X_3 may be obtained for various value of Z_o and R_A by reference to Fig. 5. Note that these values apply regardless of whether R_A is larger than, equal to, or greater than Z_o.

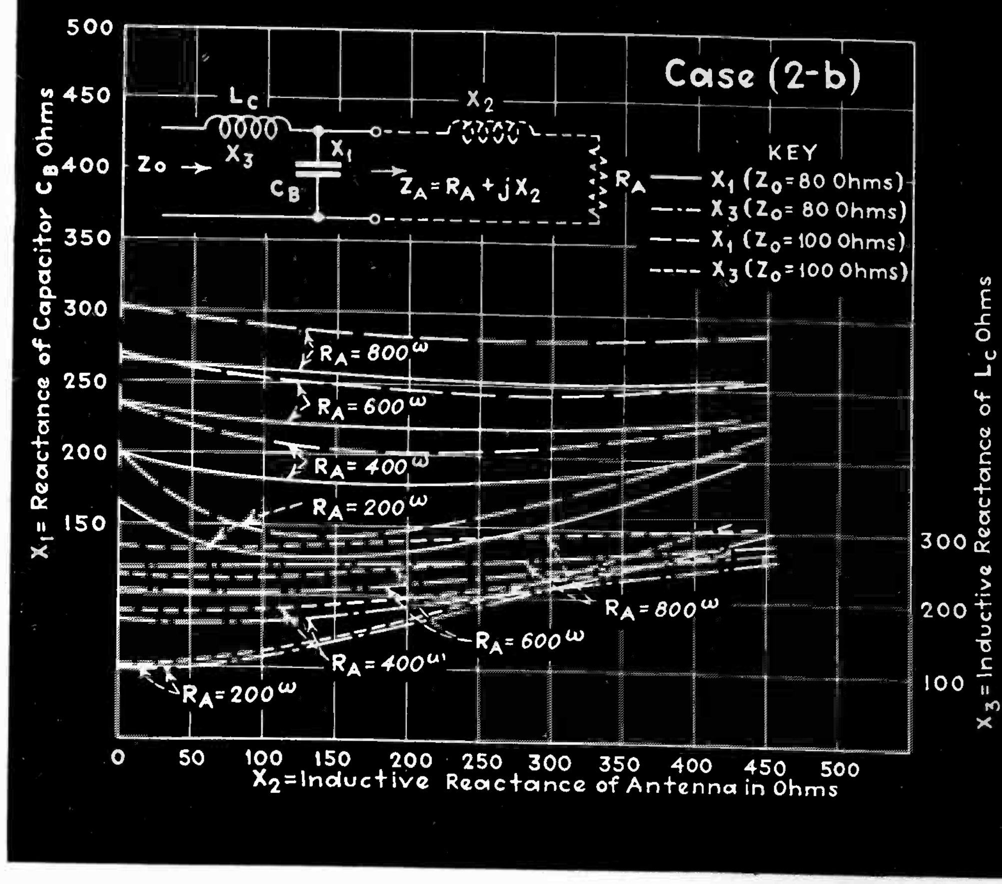


Fig. 4. Values of terminating reactors for Case (2-b), in terms of antenna resistance and reactance

Practical Procedure in Designing Matching Circuits

In making suitable adjustments on the impedance matching circuits to provide a correct termination for a given transmission line characteristic impedance, under Cases (2-a) and (2-b) above, where $R_A > Z_o$, the following procedure is recommended:

1. The transmission line characteristic impedance should be calculated and the results checked by actual measurements if possible either by means of a radio frequency impedance bridge or by the method described in a previous paper.

2. The antenna base resistance should be measured[2] over a frequency band width covering at least 100 kc. each side of the operating frequency. A curve should then be constructed with values of antenna resistance as a function of frequency. A smooth curve drawn through the points of measurements will assist in checking their accuracy.

3. Together with antenna resistance measurements, the antenna reactance should be measured, either by means of a radio frequency impedance bridge or in a manner shown in Fig. 6 over a wide frequency range and a curve constructed with antenna reactance as a function of frequency.

4. With the values of antenna resistance and reactance known, values of capacitance C_B and inductance L_C may be calculated for Case (2-a) or (2-b) as the case may be, and connected into the circuits as shown in Fig. 1.

5. With the transmission line connected, correct termination may be

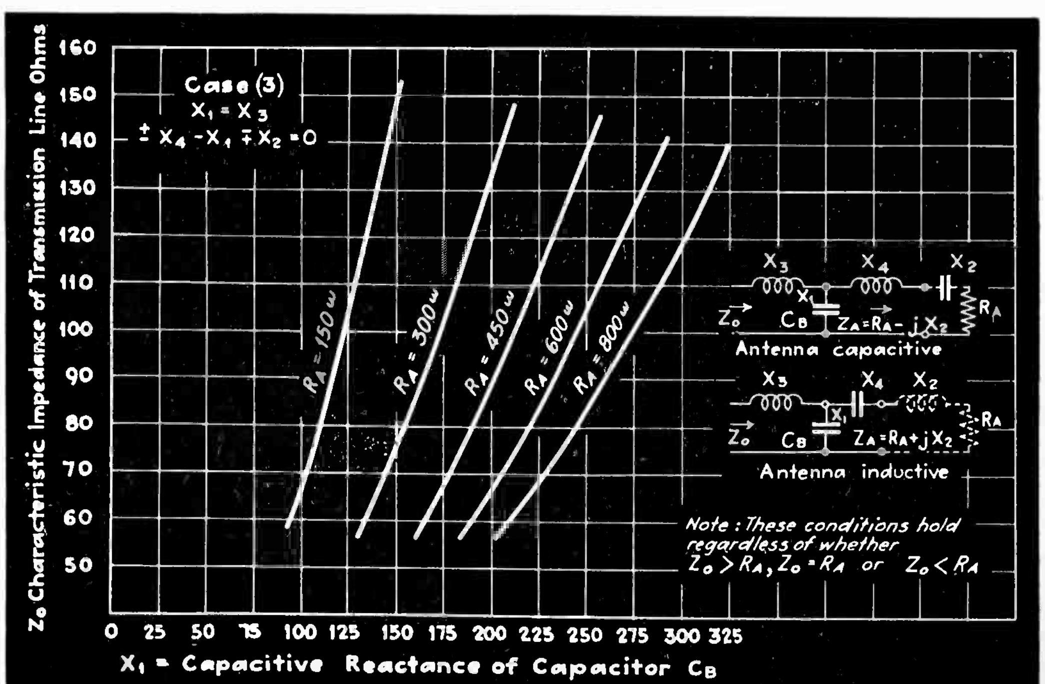


Fig. 5. Values of terminating reactors for Case (3), when antenna reactance is compensated

[2] "Radio Frequency Electrical Measurements", Hugh A. Brown. Pages 177–187. McGraw-Hill Book Co.

CURRENT AND VOLTAGE RELATIONS

CASE	ANTENNA CURRENT I_A	CURRENT THROUGH CAPACITOR C_B $= I_C\left(\frac{Z_A}{Z_A+Z_B}\right) = I_B$	TRANSMISSION LINE CURRENT $= I_A\sqrt{\frac{R_A}{Z_o}} = I_C$	VOLTAGE AT BASE OF ANTENNA $E_A = I_A Z_A$
1	$\sqrt{\frac{W}{R_A}}$	$I_C\left[\frac{R_A^2+jR_AX_1}{R_A^2+X_1^2}\right]$	$\sqrt{\frac{W}{Z_o}}$	$I_A R_A$
2a	$\sqrt{\frac{W}{R_A}}$	$I_C\left[\frac{R_A^2+X_1X_2+X_2^2+jR_AX_1}{R_A^2+(X_2+X_1)^2}\right]$	$\sqrt{\frac{W}{Z_o}}$	$I_A(R_A-jX_2)$
2b	$\sqrt{\frac{W}{R_A}}$	$I_C\left[\frac{R_A^2-X_2X_1+X_2^2+jR_AX_1}{R_A^2+(X_2-X_1)^2}\right]$	$\sqrt{\frac{W}{Z_o}}$	$I_A(R_A+jX_2)$
3 ANTENNA CAPACITIVE	$\sqrt{\frac{W}{R_A}}$	$I_C\left[\frac{R_A+jX_1}{R_A}\right]$	$\sqrt{\frac{W}{Z_o}}$	$I_A(R_A-jX_2)$
3 ANTENNA INDUCTIVE	$\sqrt{\frac{W}{R_A}}$	$I_C\left[\frac{R_A+jX_1}{R_A}\right]$	$\sqrt{\frac{W}{Z_o}}$	$I_A(R_A+jX_2)$

W IS POWER IN WATTS

Fig. 6. Current and voltage relations in terminating circuits

checked by measuring the transmission line currents at the ends, if its length is equal to a quarter wavelength or odd multiples thereof. For a very long line it is good practice to make these measurements at a number of points along the line. The existence of stationary waves of current or voltage of the fundamental frequency along the line are an indication of incorrect termination. In such a case slight adjustments may be necessary in L_C and C_B to correct for stray capacity of leads and tuning equipment or slight errors in measurements. If a radio frequency impedance bridge is available, its measuring terminals may be connected across the input to the matching circuit in place of the transmission line and the termination circuit checked for an effective resistance equivalent to the characteristic impedance of the line without the line attached.

Although Case 3 requires the addition of another piece of apparatus in the form of an inductance or capacity in the antenna lead, which may be rather expensive, the adjustment procedure is less difficult and is as follows:

1. With values of the line characteristic impedance, antenna resistance and reactance obtained by measurement, the value of C_B is calculated from formula (11) which gives the reactance X_1 necessary.

2. With L_C disconnected from C_B, reactance X_4 (inductive or capacitive) is added in the antenna circuit in series with X_1. By means of X_4 the antenna circuit is tuned to resonance as indicated by maximum current through a thermogalvanometer, when the antenna circuit is excited by means of an external oscillator loosely coupled to it.

3. A sufficient value of inductance L_C having a value X_3 equal to X_1 is then connected into the circuit as shown in Fig. 1.

4. The line is then checked for stationary waves, the absence of which indicates a condition of correct termination.

The mechanical properties of long concentric tube transmission lines makes the measurement of current in the center conductor rather difficult. In some cases, removable plugs are placed in the outside tube at various intervals along the line. These plugs, which, when inserted, make the outer tube airtight, permit connections from an anti-resonant circuit across the line. Such an anti-resonant circuit when tuned to the fundamental frequency, presents a very high impedance to the line when bridged across it, and therefore does not effect its characteristic impedance at the fundamental frequency. With low power of about ten watts flowing through the line, the galvanometer reading is an indication of the voltage at the points measured along the line. This method permits measurement for stationary waves of voltage along the line.

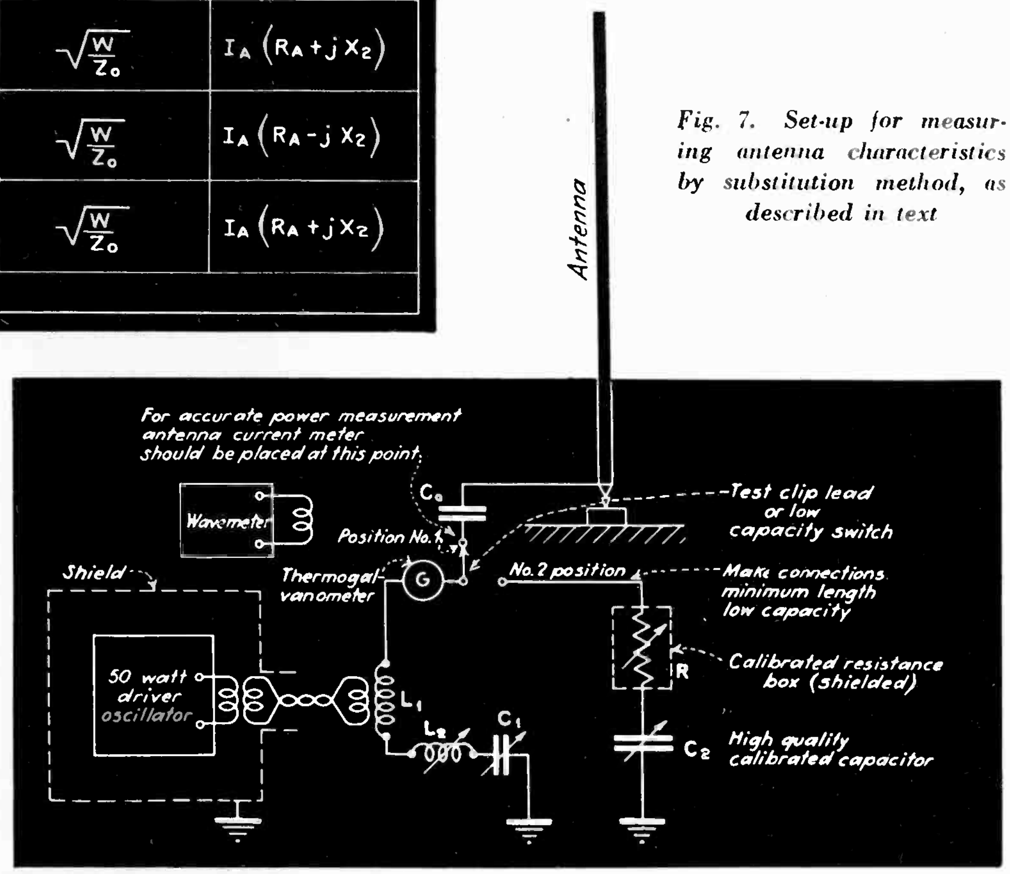


Fig. 7. Set-up for measuring antenna characteristics by substitution method, as described in text

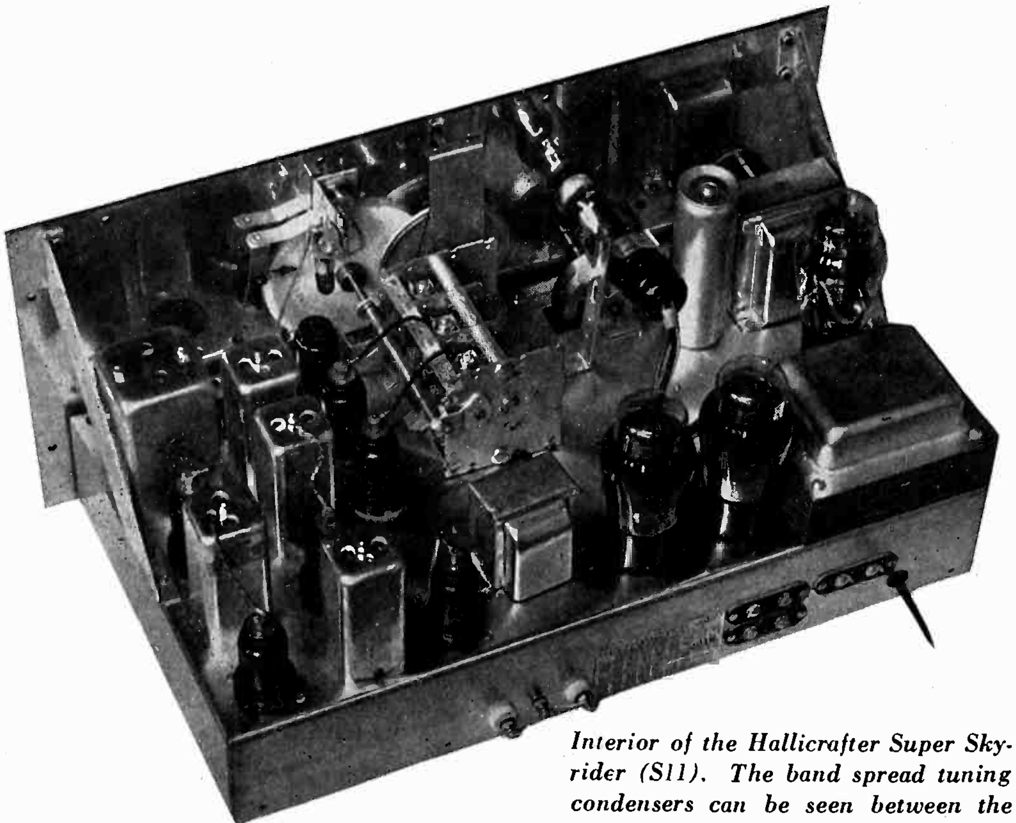
Method Used in Measuring Antenna Characteristics

Refer to Figure 7. The procedure followed is as follows: Value of capacitor C_o (usually about 0.0005 μfd.) is selected to provide sufficient series capacitance reactance to make antenna appear capacitive over frequency range measured. Then with antenna excited by driver oscillator at frequency indicated by wavemeter, and switch at position No. 1 adjust C_1 and L_2 for resonance, as indicated by maximum reading of G. Resistance R is then adjusted until G reading is the same as before. This reading of R is the antenna resistance.

For antenna reactance measurement, the circuit is first calibrated

[Continued on page 36]

Amateur Receivers



Interior of the Hallicrafter Super Skyrider (S11). The band spread tuning condensers can be seen between the main tuning condenser and the row of metal tubes

By BEVERLY DUDLEY
Assistant Editor, ELECTRONICS

IF the broadcasting services of this country utilized the frequency spectrum between 540 kc. and 1,500 kc. as completely as the amateurs utilize their assigned channels, it is safe to say that the interference produced would be so great as to preclude any possibility of intelligible broadcast service. Each broadcast station has assigned for its use a frequency channel 10,000 cycles wide, and the various channels are distributed among the stations in various geographical districts in such a manner that relatively little interference is produced throughout most of the country. Moreover the propagation characteristics of the broadcast band are such that the service area is limited to a relatively small region and interference at a distance from the transmitter is generally unimportant.

In the amateur field the situation is quite different. All told, the amateurs of the world have a total exclusive frequency band of 8,485 kc. split up into sections having different propagation characteristics. Of this total, 1,000 kc. is not yet suitable for any extensive communication services and is primarily the province of a handful of pioneer experimenters and college students. This leaves 7,485 kc. to be divided among the amateurs of which 47,000 are licensed by the United States. If we neglect the foreign amateurs, and assume a "cleared channel" distribution, then each American amateur might expect a frequency band 159 cycles wide. But if we take into account the foreign amateurs (as we must in any practical problem because the transmission characteristics of the higher frequencies are such as to produce interfering signals over widely separated regions) the frequency channel available per amateur station is less than 100 cycles. Under such restrictions phone transmission hasn't a chance. Even a self respecting Morse dot, transmitted at the rate of fifteen words per minute through a channel less than 100 cycles wide, would come out of the process looking somewhat ragged and stoop shouldered. But somehow the amateurs get along—and surprisingly well.

One reason for their ability to get along as well as they do under their crowded conditions is that amateurs have available well built receivers of high sensitivity and selectivity, admirably suited to their requirements. These receivers are complicated and costly and beyond the mechanical abilities and facilities of all but a very few amateurs, so that a few progressive and co-operative manufacturers have supplied the need. These advanced amateur receivers are equal to any stock model receivers and are second to none; they will pick out the desired signal when the amateur bands are so fiercely congested that signals are packed six deep in the standing room; they will produce intelligible speech signals with a spark gap going full blast in the same room containing the receiver. Indeed, some of these receivers are so outstanding in their performance that they are used regularly by police, high frequency broadcasting, airplane, and other commercial services. Yet, they have been primarily built for and sold to amateurs and have been developed with a good deal of amateur technical achievement and operating practice to draw from.

Of course the most advanced type of amateur receiver is expensive and there are many amateurs who are forced to get along with less suitable equipment. Furthermore, not all manufactured receivers covering the high frequency spectrum are suitable for the reception of amateur signals. By amateur receivers of advanced design are meant, in this article, those manufactured receivers specifically intended for use in the amateur bands and incorporating the most advanced technical features which amateur operators have found necessary or desirable.

# of Advanced Design

Combined technical achievements of amateurs and manufacturers result in outstanding amateur receivers. Well built, high sensitivity, superheterodynes with crystal filters, easy tuning, signal indicators, and beat oscillators characterize advanced amateur receivers

The main characteristics of advanced amateur receivers are given in the accompanying table, from which some interesting observations may be made. All of the receivers are of the superheterodyne type, all of them use a separate oscillator for CW reception (this is not listed as it was established *a priori* that some heterodyne oscillator was necessary in order to classify a receiver as amateur equipment), most of the receivers cover the usual broadcast band although the models which are the most truly "commercial type" do not, all of the receivers employ at least one stage of r-f preselection and two stages of i-f amplification, and all but one use a coil switching arrangement, operated from the front panel.

Apparently amateurs are willing to use plenty of tubes to achieve the desired result, for the average number of tubes in the eight receivers listed is eleven. Metal tubes appear to have slightly more usage than glass tubes, and yet glass tubes are found in those receivers which are definitely of the "commercial type".

Presumably on the hypothesis that most amateurs know how to tune a radio receiver, less than half of the receivers are equipped with tuning indicators. However, for those who want them, tuning indicators are available on some receivers. Sometimes these tuning indicators are used in conjunction with panel controls to give some idea of signal strength. In other receivers the signal strength is indicated by means of a meter which is calibrated in R units, decibels (with reference level unstated), or arbitrary units. For the most part these signal level indicators operate from the carrier frequency so that the degree of modulation of the signal as well as the carrier intensity determine the audible result. But even at their worst (which is pretty good at that) these signal level indicators are a vast improvement over the self estimated audibility system which has been in amateur use for years.

The "undistorted power output" —by which we mean the output at five per cent distortion, believe it or not—varies considerably; from 500 milliwatts suitable only for headset operation, to 14 watts which should suit the most hard of hearing ham. And, if one doesn't mind greater distortion, the output can be boosted beyond the values given in the table.

The weights of the receivers are listed as being between 38.5 and 83 pounds, but this is subject to variation, depending upon what associated equipment, such as crystal filters and speakers, is used with the receiver. Finally, we come to the main reason why the most advanced types of receivers are not found in each and every one of the 47,000 American amateur shacks—the prices of these receivers vary from about $90 to almost $500. But for these stiff prices the amateur gets a good looking, substantially built outfit (much better made than he could make himself), with plenty of operating controls conveniently and logically arranged.

Selectivity

The superheterodyne type of receiver is well adapted to providing selectivity which is controlled primarily by the frequency response of the intermediate frequency amplifier and only a small extent by that of the input circuit. For this reason the selectivity remains constant over the entire operating frequency range for a given adjustment of the i-f amplifier circuits. By varying the frequency

CHARACTERISTICS OF AMATEUR RECEIVERS

MODEL	HRO [1]	NC-100 [1]	SP-10 [2]	RME-69 [3]	ACR-175 [4]	AR-60 [4]	S-10 [5]	S-11 [5]
Min. freq. (Mc.)	1.70	0.54	0.54	0.55	0.50	1.50	5.65	0.54
Max. freq. (Mc.)	30.0	30.0	25.0	32.0	60.0	25.0	79.5	38.1
Amateur bands covered	5	5	4	5	6	4	4	5
R-f stages	2	1	2	1	1	2	1	1
I-f stages	2	2	3	2	2	3	2	2
Coil changing system	P. I.	Sw.	Sw.	Sw.	Sw.	Sw.	Sw.	Sw.
No. of tubes †	10	11	16	9	10	11	10	10
Type of tubes	G	M	G	G	M	G	M	M
Tuning indicator	None	6E5	None	None	6E5	None	None	6G5
Crystal filter	Yes	No *	No *	Yes	Yes	Yes	No *	No *
Freq. cal. dial	No	No	Yes	Yes	Yes	No	Yes	Yes
Power output, watts	2.5	10.0	8.0	2.6	2.0	0.5	4.0	14.0
Signal indicator	Meter	6E5	Meter	Meter	6E5			
Consumption, watts	40	105	100	100	110	35	65	125
Weight in pounds	38.5	50	83	50	55.5	80	45	48
Price, in dollars	279.50	175.00‡	380.00‡	198.00	119.50	485.00	99.50‡	89.50‡

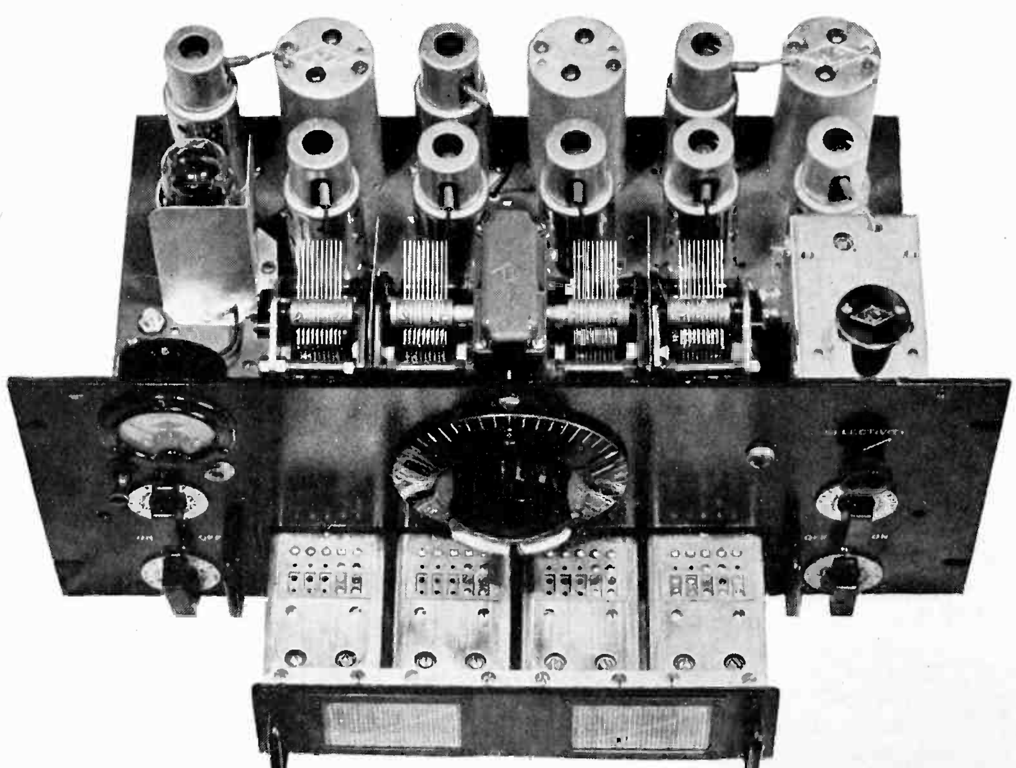
[1] National Co., Malden, Mass.
[2] Hammarlund Mfg. Co., New York City.
[3] Radio Mfg. Engineers, Peoria, Ill.
[4] RCA Mfg. Co., Camden, N. J.
[5] The Hallicrafters, Chicago, Ill.
† Excluding tuning indicators.
* Crystal filters are either optional or may be obtained in other similar models.
‡ Price without crystal filter.

response of the i-f amplifier the receiver selectivity can be controlled easily to suit operating conditions.

For extreme selectivity, the crystal filter is thrown into the circuit by a panel switch. The crystal is usually used in circuits such that the extreme selectivity can be varied somewhat and high attenuation can be obtained for some frequency very close to that of the desired signal. This feature makes it possible to reject one signal within the audio frequency beat range of the desired signal. Although only one signal can be excluded at a time by this process, the ability to reject this signal is, sometimes, a very considerable advantage.

The AR-60 of RCA, with main and band spread tuning dial of unusual construction

Perhaps it is well to point out that the selectivity obtainable with a crystal filter can only be used to maximum advantage when the frequency of both the received carrier and that of the first oscillator are constant. In properly designed, built, and operated crystal controlled transmitters, frequency drift is not an important consideration. However, the first oscillator in the receiver cannot be crystal controlled because of the wide frequency range over which it must tune, so that rigid requirements as to frequency stability are imposed on it. It has also been found that the extreme selectivity of these crystal filter circuits produces a clean cut signal in the headset which is almost a pure tone and fatiguing to copy for any length of time. Although not yet incorporated in commercial receivers, a modulating system in the last i-f amplifier has been devised to overcome this disadvantage.



The calibrated plug-in coil sets of the National HRO fit into the bottom of the panel. The tuning control, actuating the condensers through a worm gear, is the large knob and dial in the center. The crystal filter may be seen at the right, immediately behind the panel

The receivers are also provided with selectivity of the usual air core or iron core type of i-f transformers, and in some of the receivers like the Hammarlund Super Pro and the Hallicrafter Ultra Skyrider, the selectivity of the i-f amplifier can be adjusted at will. This has its advantage primarily in the reception of modulated signals where some compromise must be made between selectivity and fidelity of reproduction.

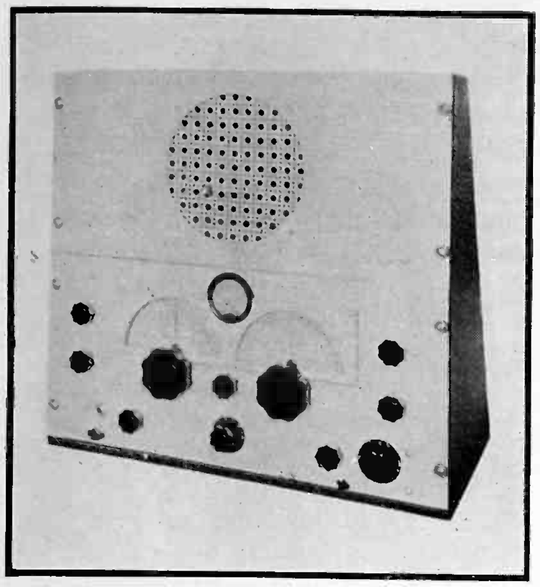
By way of showing the selectivity which is obtainable in typical receivers for advanced amateur use, the following table for two different types of conditions is given.

	Band Width in Kilocycles			
Resonance Voltage Ratio	Crystal Filter Selectivity	No Crystal Filter Sharp*	Average	Broad*
2	0.30	2.8	5.5	14.0
10	1.40	4.6	9.0	21.0
100	4.82	9.0	16.0	26.0
1,000	8.40	13.0	22.0	32.0
10,000	11.00	17.5	29.00	39.0

* Extreme values for typical receiver.

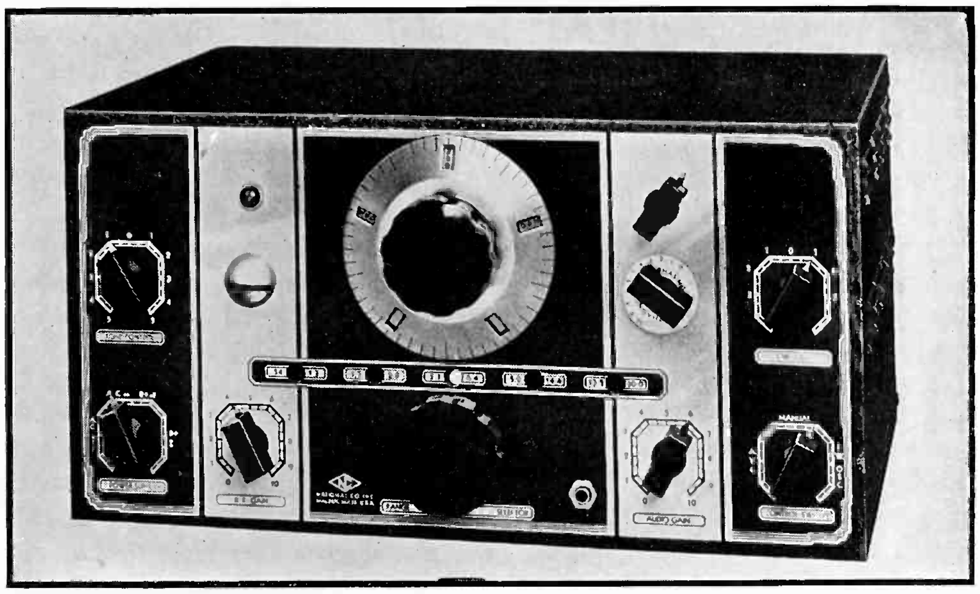
In addition to a selectivity curve similar to that given by the "No crystal filter average" the Ultra Skyrider (S-10) can be adjusted for standby operation to give a wider response than is given in any of the columns above. This receiver has an intermediate frequency of 1,600 kc. whereas the frequency of the i-f amplifier in other receivers is about 460 kc.

The fidelity curves of these receivers is not so important as for the case of broadcast receivers since high quality rendition of musical tones is unimportant.



The RME-69 relay rack mounted receiver in satin finished aluminum, complete with speaker

The Hammarlund Super Pro, with frequency band switch below the meter, and main and band spread tuning knobs conveniently located near the bottom of the panel



The NC-100 receiver in its modernistic dress

With this general introduction, we can pass to a discussion of some of the more interesting and specific design features.

An interesting feature of these receivers is the first oscillator, which is without exception electron coupled. The electron coupling feature tends to provide the isolation between the oscillator and first detector circuits which is required in order that the oscillator will not "lock in" with the carrier frequency.

To reduce to a minimum the harmonics which are present in the output of an electron coupled oscillator, an unusual coupling system is used in the HRO. Since the harmonics are much stronger in the non-tuned plate circuit than they are (compared with the fundamental) in the grid circuit, the first detector is coupled to the tuned grid-cathode circuit of the first oscillator. The output of the oscillator is fed to one of the grids of the detector, and electron coupling is used in the first detector as well as in the first oscillator.

And before we get too far along into the receiver, a word should be said about tuning circuits, for this is a real problem which has a number of headaches in the electrical as well as in the mechanical system. All of the receivers except the popular HRO use switching arrangements operated from the front panel to change from one band to another. In most cases the coils and padding condensers for the preselector stages, first detector and first oscillator are placed at the bottom of the cabinet where they will be least affected by temperature changes as the tubes heat up. At least some of the receivers provide a separate shielded compartment for each LC combination and some of the coupling coils are provided with electrostatic shields. The main tuning controls with their slow motion auxiliaries provide ease of control to such an extent that what was a "band spread" arrangement only a few years ago has come to be regarded as standard equipment.

Most of the receivers cover only one amateur band with each of the frequency ranges with which they are provided. The HRO covers one amateur band at the top and another amateur band at the bottom of each of its interchangeable coil sets. The coils are thoroughly shielded, and since many amateurs operate in only one to two amateur bands with any great regularity, the use of interchangeable coil sets is not considered a handicap.

To assist the reader in spending his $500 for the type of receiver most suited to his purpose, we propose to conclude this article with a brief discussion of the distinctive or exclusive features of the various types of outfits listed in the table.

Individual Receiver Features

The HRO asserts its independence by using plug-in coils, an external filament, grid, and plate supply rectifier and filter, uses a dial with arbitrary calibrations and supplies a calibration curve with each set of coils. Incidentally, practically a linear relation exists between dial reading and frequency, and the dial is a man size affair with an open scale having 500 divisions when rotated through its maximum range of five complete turns. It comes from an old and popular line of ancestor receivers and is undoubtedly among the top with those amateurs to whom expense is a matter secondary to results desired.

The National NC-100, while still suitable as an advanced amateur receiver, is not so exclusively used in amateur circles and has a number of features which tend to mark it as a high frequency receiver for general use. It covers the usual broadcast band as well as all amateur bands up to 30 megacycles. The coils are built in the base of the receiver but are selected by means of a rotary switch on the front of the panel. An electron ray tube is used as a tuning indicator. The NC-100 does not have a dial calibrated directly in frequency but requires a frequency calibration curve. This particular model is supplied without a crystal filter; if you want the crystal selectivity, order model NC-100X.

The Hammarlund Super Pro, S-10, uses more tubes than any of the other receivers listed, and uses as many stages of preselection and i-f amplification as any receiver, if not more. It does not include the 30 Mc. amateur band so those amateurs who "work ten" will have to depend on their super-regenerative outfits. There is a good deal of difficulty in covering a wide frequency band well, and not a little justification in not doing something mediocre. While not included in the present Super Pro, a new model which will make its appearance about the middle of December will contain a sensitivity control calibrated in microvolts, a frequency calibration for the heterodyne oscillator, and a band width indicator switch, also directly calibrated in frequency, which will permit the operator to select the band width most suitable to his operating condition.

The RME-69 has, likewise, its exclusive points of interest. The second detector can be switched to an input pick-up circuit which will make a linear detector and audio amplifier out of the output end of the superhet. This is useful when monitoring local transmitters, for the sensitivity of the monitor is so much less than that of the receiver that the operator can keep check on his transmitter without blowing a voice coil. Another feature—although you will have to go to a modified version of the RME-69 to get it—is the noise silencing auxiliary circuit. Noise silencers can be tremendously effective when interference is bad.

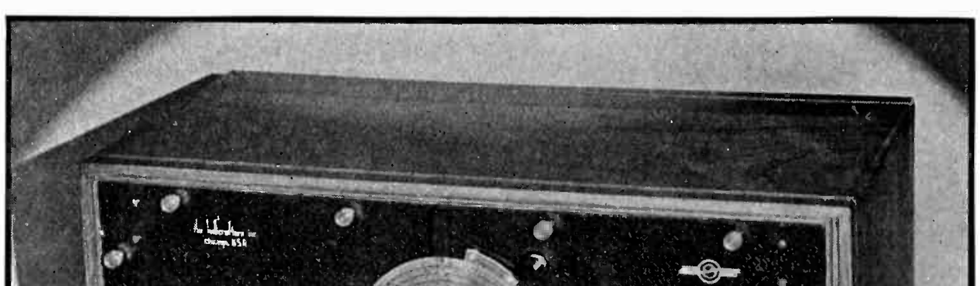
The ACR-175 is, in many respects, a general all around high frequency receiver rather than a purely amateur rig. It has a wider frequency range than most of the receivers and covers one more amateur band than any of the others.

The AR-60, like the HRO, is definitely a communication type of receiver. It does not cover the broadcast band and only four amateur bands. Its power output and audio fidelity curve definitely place it outside the range of those who want a music box, and it goes in for plenty of amplification. One feature which puts this receiver in the communication class, even if the others do not, is the automatic keying relaying contacts provided at the back of the set. These are provided so that the sensitivity of the receiver may be killed when the local transmitter is being keyed, and yet keep the receiver ready for immediate break-in at any time.

The S-10 or Ultra Skyrider is a high frequency receiver suitable for the amateur working "5 and 10", but it does not cover the two lowest frequency amateur bands. With the spread over which the amateur bands are scattered it is almost necessary for the amateur who wants to receive on all bands to have at least two receivers, and the S-10 fills the gap at the higher frequencies.

The Super Skyrider, listed as S-11 in the table covers five amateur bands as well as the broadcast band. Special models are available with noise silencing circuits. The S-11 has a field strength indicator to assist the operator in determining audibility of received signals.

All in all, the receivers described in this article are of the type that does credit to both amateurs and radio manufacturers. They are a long way removed from the NAA type loose couplers and galena crystals with which a lot of amateurs entered the game.



A frequency calibrated dial for those who want it, as well as an arbitrarily divided scale with true vernier, are a part of the Super Skyrider

Putting Public Address to Work

A novel PA system in the plant of the F. W. Sickles Company, makers of coils for radio sets, transmits fire alarm signals, auto call signals, work period time signals, radio programs, phonograph record programs and microphone output

By HOWARD J. BENNER
Chief Engineer, F. W. Sickles Co. Springfield, Mass.

NUMEROUS installations of public address systems have been made in factories, usually for paging purposes, often to furnish music to keep the factory workers happy — or to speed up production. In the installation to be described, however, the apparatus serves many purposes among them the very practical one of acting as a fire-alarm system.

The installation consists of the following units:—

1. Rack and panel assembly
2. 3 fire alarm indicators
3. 4 fire alarm stations
4. 2 master control positions (Fig. 3)
5. 23 dynamic speakers
6. Master clock
7. 3 microphones

Field Supply — 1h

The field supply for the 23 speakers consists of a bank of eight type 83-V tubes working directly from the 110 volt line. The filament supply is taken from a step-down transformer. One hundred and fifty microfarads of capacity are across the d-c output to build the voltage up to 100 volts. Each speaker is supplied with 7 watts of field excitation power. The normal current taken from this unit is approximately one and a half amperes.

Output Amplifiers — 1e-f-g

Each of the three output amplifiers consists of a pair of 6C5 tubes push-pull resistance-coupled, driving a pair of 6L6 beam amplifier tubes class AB. Each amplifier has its own power supply, so that in case one fails, the load can be transferred to one of the two remaining amplifiers while the defective one is being repaired. Each amplifier is capable of delivering 35 watts of audio power with a negligible amount of distortion.

Patch Panel — 1d

The patch panel is a junction point where all input and output circuits terminate. This provides an easy means of disconnecting apparatus that must be repaired without affecting the other units of the rack and panel assembly. The panel also provides a means of transferring loads from one output amplifier to another.

Microphone Input Amplifier — 1c

The microphone input amplifier is used only when one of the three microphones is in use. It consists of three 6C5 tubes, resistance-coupled.

The microphones used at both of the master control positions are of the carbon types. When either of these are in use, one stage of amplification is automatically eliminated. When better quality is desired, a microphone of the velocity type is used. This requires the full amplification of the system, therefore the three stages are used.

Auto-Call—Work Period Time Signal—Fire Alarm Signals—1b

The unit that takes care of the auto-call, work period time signals, and the fire alarm signals is the most complicated assembly of the system. It consists of two audio oscillators, one of which has a frequency of 960 cycles and the other 1200 cycles.

The 1200-cycle oscillator is used for the work period time signals. This is actuated by a master control clock equipped with a tape recorder. At pre-determined times, it transmits an impulse that actuates a relay in the unit. This relay completes a circuit in the oscillator.

The 960-cycle oscillator, when combined with the oscillator used for the time signals, produces a harmonious signal for the auto-call, and although used quite frequently has a very pleasing note that does not disturb the people who must listen to it.

A distinctive signal used for the fire alarm is obtained by using the 1200-cycle oscillator in conjunction with a rotary switch driven by a slow speed motor. The rotary switch inserts pre-determined capacities across the tuned circuit which change the resulting audio sound. The sounds generated by the audio oscillator are the familiar notes of the bugle call.

One noteworthy feature of the fire alarm system is that it is being constantly checked. The oscillator used for the fire alarm signal is used in every time- or auto-call signal. This results in hundreds of checks daily.

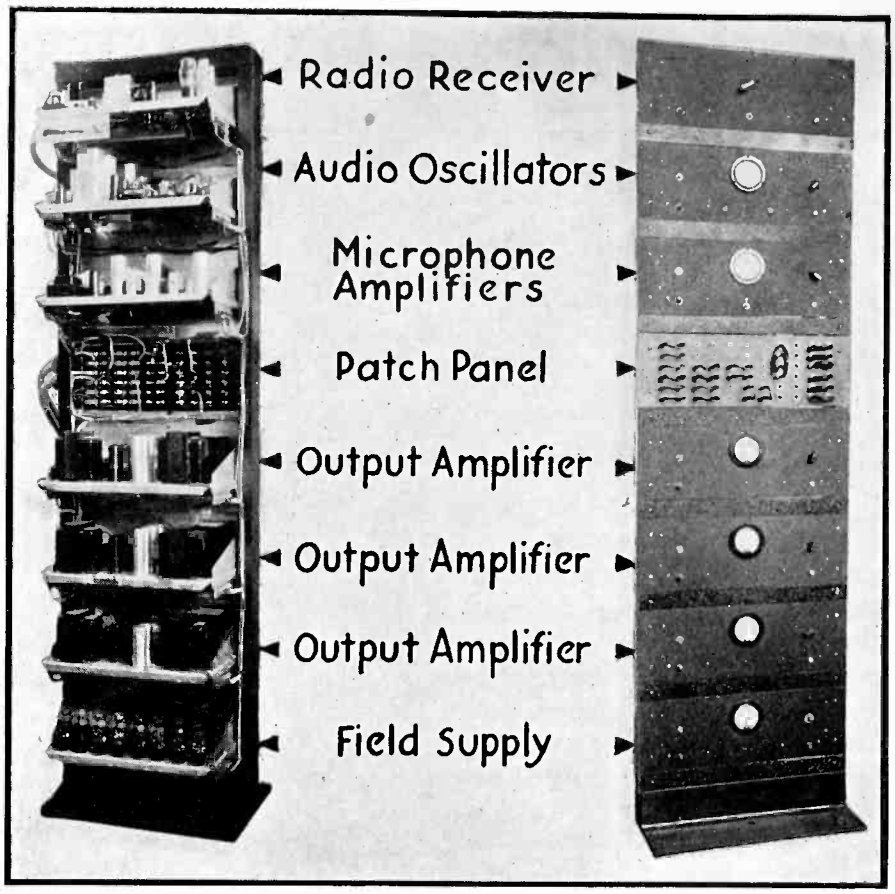
Radio Receiver — 1a

The final unit of the rack and panel assembly is a four-channel pre-tuned radio receiver. The receiver is of the two-stage tuned r-f type with a diode detector and one low-gain audio stage. This design has sufficient selectivity to separate the four local stations. To tune this receiver it is merely necessary to turn a four-position switch to one of the four stations desired. The above method of selection insures perfect tuning and guarantees high fidelity.

Figure 4 shows the schematic diagram. Loss of gain caused by the use of a diode detector is corrected by the use of an iron-core antenna coil with a gain of approximately 50 times.

Frequency selection is obtained by the use of a single set of coils and switching four sets of air condensers. These condensers are set to resonate the tuned circuits to the frequency of the four local stations. Due to variation in signal levels it was found best to use automatic volume control to hold correct levels for the different stations. In this way the program level is set and there is very little use for a manual volume control.

The combined outputs of the input



Front and rear views of the public address system

amplifier, radio, and auto-call time signal and fire-alarm signal units are parallel and fed directly to the input of the output amplifier which are also in parallel. Each of the previously mentioned units is capable of delivering approximately five volts of audio which is sufficient to drive the output amplifiers to maximum output.

Each unit in the rack and panel assembly has its own power supply so that any one can be repaired while the system is in operation without affecting the operation of the others.

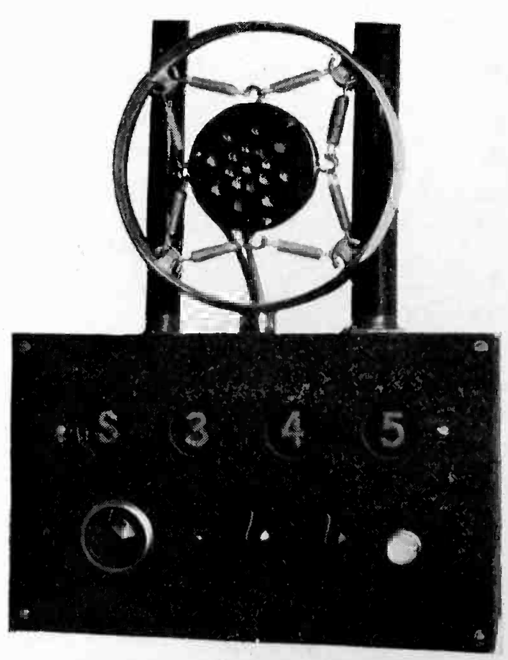
Speaker and Transmission System

There are 23 speakers placed throughout the plant. These speakers are so placed that even in the noisiest portions of the plant, all signals are intelligible. In the offices where the noise level is much lower than that of the factory, volume controls are placed across the voice coils of the speakers to lower the level of the signals.

Each floor of the building has its separate output amplifiers. The output transformer of each amplifier matches a 16-ohm line. All voice coils of the speakers on each floor are in series to properly match the transformer. The reason the voice coil leads were run directly from the output amplifiers was to avoid the losses accumulated in using matching transformers.

Fire-Alarm System

Each floor of the building and the storehouse has a fire alarm station. Each floor also has a signal box which indicates the station from which the alarm was rung. The purpose of this indicator is to advise the members of the organized fire department the location of the alarm so they may report for duty.



Microphone and control panel

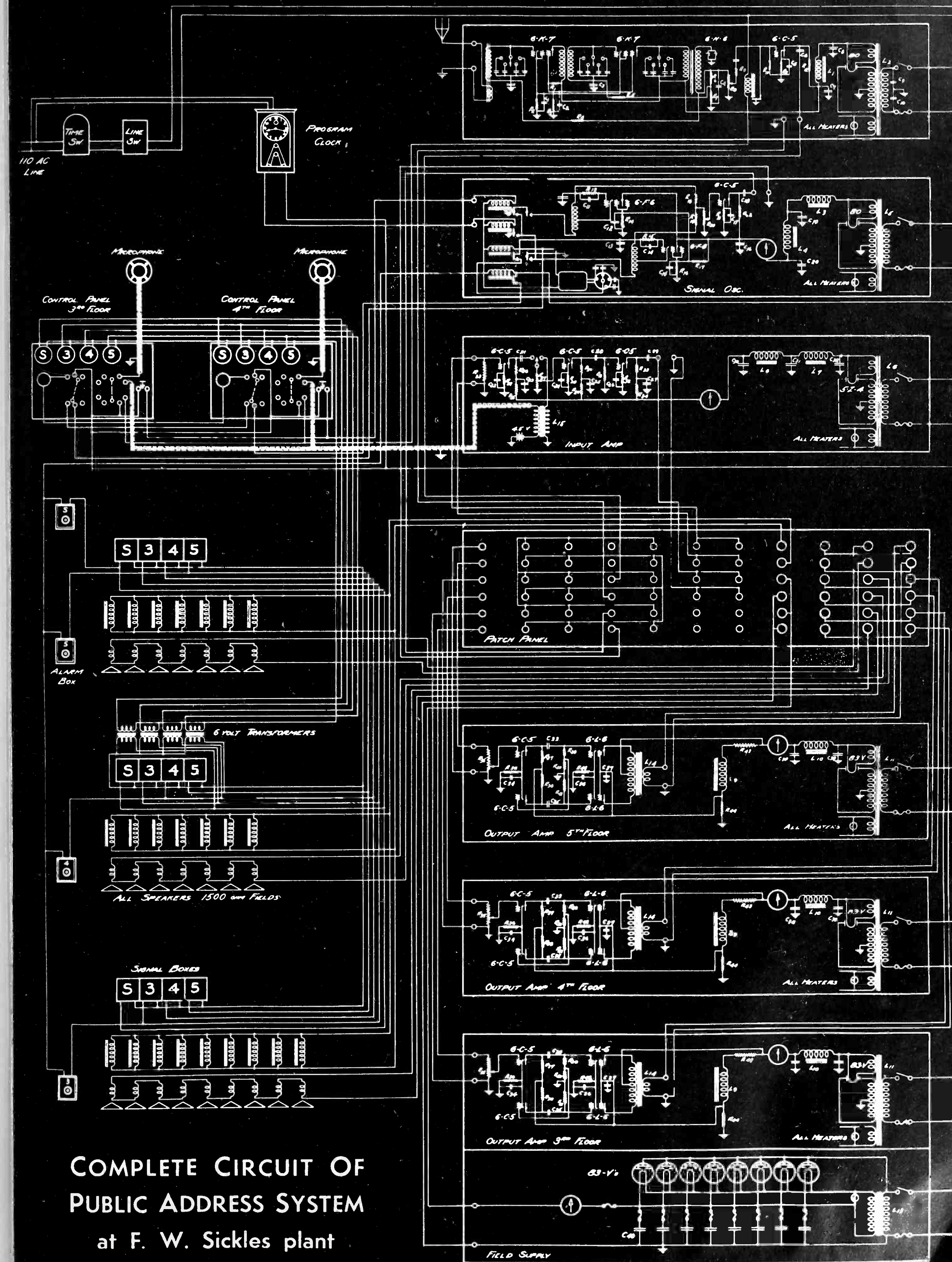
To ring an alarm it is necessary to break the glass on one of the station boxes. This automatically closes a switch that illuminates all the signal lights. The current for these lights passes through a current-operated relay which simultaneously starts the motor driving the rotary switch. This in turn transmits the bugle call signal over the entire system.

Master Control Positions — 3

There are two master control positions, one in the main office, the other in the production office. The four holes with numbers in the center are signal lights in parallel with the signal lights in the factory. These indicate the station from which the alarm was rung. The switch button on the extreme right is used for the auto-call signals. The switch on the left of the auto-call button has a dual purpose. When turned to the left it automatically starts the radio and when turned to the right it connects the microphone to the system. The microphone is used for announcements, instructions, or locating a person not listed on the auto-call. The switch next to the left is used to turn off the fire signals so that instructions may be given through the microphone. When the switch is opened, the red light on the extreme lower left lights to indicate that the alarm system is inoperative. After the glass is replaced on the station box this switch is returned to the normal position which again puts the system in normal automatic operation.

Although never used in the case of a fire this system has worked very efficiently for fire drills. During noon hours the radio gives excellent entertainment, and all announcements that are made during working hours are heard by every person in the entire plant.

The entire system is wired in conduit and every possible part is fireproof. The line feeding the outfit comes directly from the main line. All these precautions were taken so that in case of fire its operation will not be interrupted until every person is out of the building. As a final safety measure powerful flood lights are placed to cover the entire inside of the plant. These are operated by relays that close when the current fails. The power for these lights is furnished by storage batteries.



Complete Circuit Of Public Address System at F. W. Sickles plant

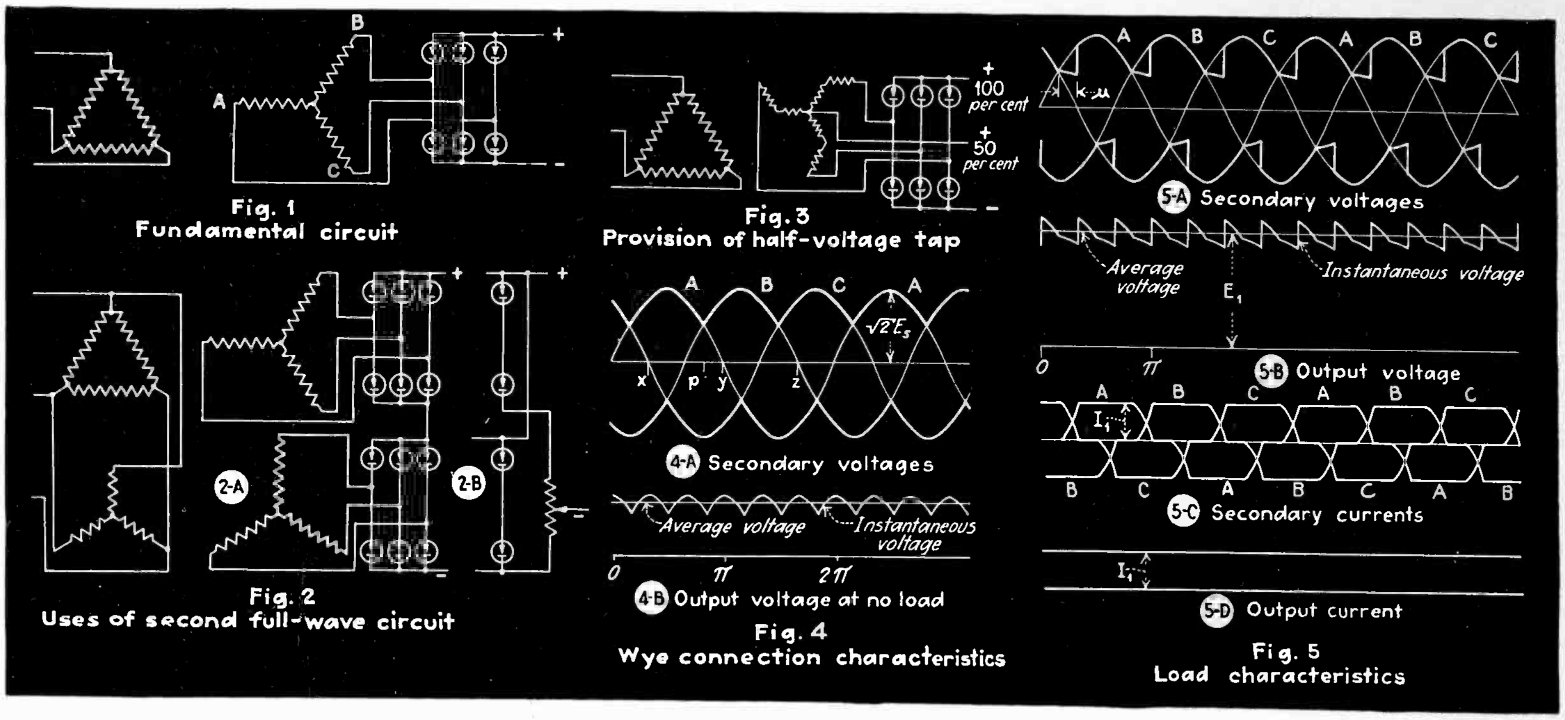


Fig. 1 Fundamental circuit

Fig. 2 Uses of second full-wave circuit

Fig. 3 Provision of half-voltage tap

Fig. 4 Wye connection characteristics

Fig. 5 Load characteristics

Three Phase Rectifier Circuits

For rectifiers having a separate cathode for each anode, such as the Ignitron, a new circuit has been developed which enables stock transformers to be used

By A. J. MASLIN

Transformer Engineer
Westinghouse Elec. & Mfg. Company

THE number and variety of circuits, or transformer connections, which have been devised for use with various rectifiers, are very large indeed. These circuits range from the simple single phase half wave connection, as employed in small battery charging equipments, to complex multiple zig-zag and forked circuits, frequently used to supply d-c power in traction and electrolytic applications. Each circuit has been evolved to give prominence to some characteristic feature, or to suit the individual requirements of a certain type of rectifier. Thus, certain connections are characterized by high apparatus utilization, some by a flat regulation characteristic, or by a minimum alternating component in the output current; while others may be particularly adapted to multiple anode-single cathode arc rectifiers, to high vacuum diode tubes, or to hot cathode gas-filled devices.

The circuit to be discussed herein is restricted to rectifiers having a separate cathode for each anode, as for example the Ignitron, to which it is especially well adapted. It possesses, in fair measure, all of the desirable characteristics previously mentioned. In addition, it is frequently possible to set up the circuit without obtaining special transformers. If the desired output voltage happens to correspond with one of the standard transmission or distribution voltages, stock transformers may be utilized.

This circuit is frequently employed to supply d-c power at moderate or high voltages to radio transmitters. It is an especially convenient connection for testing d-c devices, such as tubes, circuit breakers, and the like. When employed to test transmitting tubes, for example, it is necessary to be able to predict and control the output at short circuit, to avoid completely demolishing the apparatus under test when a failure occurs. As an aid to obtaining the maximum utility from this circuit, the following discussion will describe in detail the various modes of operation, from no load to short circuit, and present equations, and curves, of the current and voltage relationships, for each of the several modes.

The Circuit

A delta-wye transformer (or transformers) and six single anode-single cathode rectifiers, connected as in Fig. 1, comprise the circuit. The output voltage contains an alternating component having for its fundamental, the sixth harmonic of the supply frequency. The circuit thus has the same ripple characteristic as a conventional six anode rectifier, when fed from a star, forked, or double wye connected transformer. By suitably connecting a second three phase full wave circuit, having wye-wye connected transformers, in series (as shown in Fig. 2-A), or in parallel through a balance coil (Fig. 2-B), the fundamental of the alternating component of the output voltage is changed to the twelfth harmonic of the supply frequency. This combination, then, displays the same ripple characteristic as a twelve anode rectifier, fed from a quadruple zig-zag or similarly complicated twelve phase transformer. Another modification of the circuit often has great practical value. If the transformer bank is wound with an interconnected, rather than a wye, secondary, a half voltage tap is available as part of the output circuit, as indicated in Fig. 3. When the half voltage tap is desired, the secondary must be interconnected, to prevent saturation of the transformer core by the residual magnetomotive force, resulting from d-c in neutral voltages of the wye.

First Mode of Operation

The instantaneous terminal to neutral voltages of the wye connected secondary are indicated in Fig. 4-A. The maximum voltage difference between terminals A and B occurs at the instant X, between B and C at Y, and between C and A at Z. By virtue of the valve-like characteristic of the rectifiers, it is the maximum voltage difference between any two of the terminals which appears at the output terminals. The instantaneous value of this maximum voltage difference (or output voltage) for all the terminals, is represented by the ordinate subtended between the upper and lower envelopes (the heavy wavy lines) of the terminal to neutral voltages. When redrawn (as in Fig. 4-B), the output voltage is seen as a direct voltage with an alternating voltage or ripple superposed. The fundamental component of this ripple voltage, as was previously noted, is a sixth harmonic of the supply circuit frequency. Figure 4-B, then, is the no-load output voltage of the circuit.

When a load is connected to the output terminals of the circuit, the current which flows must transfer from one secondary winding to the next, as each in turn achieves the highest potential. This transfer involves the decay of current in one winding and the simultaneous growth of current in another; it is frequently called *overlap*. Since the transformer and the supply system contain reactance, this transfer or overlap requires time. It begins at the instant of voltage equality of two terminals (at P in Fig. 4-A), and continues until the decaying current is zero. The larger the current to be transferred, the greater the interval, or angle, of overlap. During this interval the two phases involved are shorted, or connected together through two of the rectifiers. The potential of the relinquishing phase is increased by the amount of its reactive voltage, while that of the acquiring phase is similarly reduced. When the current in the retiring phase reaches zero, it is prevented from reversing by the valve action of the rectifiers; thus, the upcoming phase assumes he total current, and carries it until it, in turn, transfers to the next succeeding phase. If the load circuit contains sufficient inductance, the output current will be substantially free from ripple. Then, as soon as the upcoming phase has assumed the total current, that current is constant and unvarying, and can produce no reactive voltage. The potential of that phase then jumps to its open circuit value, immediately the transfer is complete. The voltages in the circuit, under a load of the type described, are thus no longer as shown in Fig. 4, but are as illustrated in Figs. 5-A and 5-B, while the currents involved are as indicated in Figs. 5-C and 5-D.

For loads resulting in overlap angles (μ) of less than 60 degrees, there is an interval between current pulses of opposite polarity, during which the windings of a given phase are idle and carry no current. This

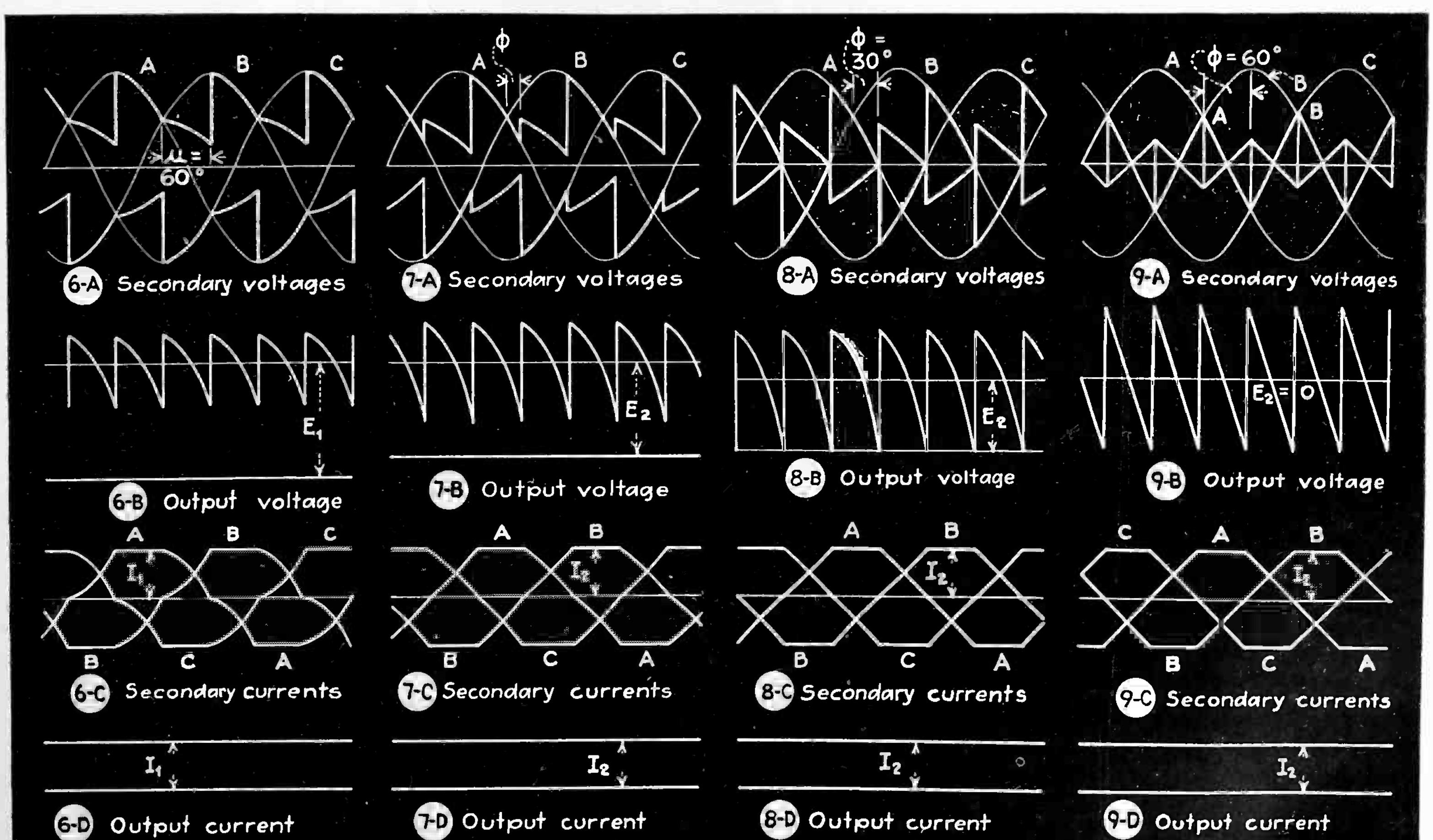


Fig. 6 Maximum load characteristics

Fig. 7 Delay angles of 0-30°

Fig. 8 Delay angle of 30°

Fig. 9 Delay angle of 60°

is clearly shown in Fig. 5-C. As the load increases, the period of idleness decreases until, for the maximum load under the first mode of operation ($\mu = 60°$), it is zero. The voltages and currents for this critical load are indicated in Figs. 6-A to 6-D.

Formulae have been derived, which are applicable when the load, in nature and magnitude, conforms with the foregoing description. It should be noted particularly that the derivation of these equations involves the following assumptions:

1—Zero resistance throughout the circuit. The effect of resistance is to reduce the output voltage. The amount of this reduction is approximately the wattmeter copper loss of the circuit divided by the output current (Watts/I).

2—Reactance lumped in the transformer secondary. Reactance in the primary or supply lines, may be replaced by an equivalent secondary reactance.

3—Zero reactance in the lead to any individual rectifier.

4—A large inductance in the load circuit.

5—Zero rectifier drop. Tube or arc drop reduces the output voltage and, like resistance drop, should be deducted from the calculated value to obtain the true output voltage.

Using the symbols:

- E_s—Transformer secondary voltage to neutral, r.m.s.
- I_s—Transformer secondary current, r.m.s.
- E —Output (d-c) voltage, average value.
- I —Output current.
- X —Reactance per phase, lumped in secondary, ohms.
- μ —Duration of transfer (angle of overlap), electrical degrees.
- 1, 2, 3—Subscripts denoting 1st, 2nd and 3rd mode of operation.

The equations are:

$$E_1 = 1.17\, E_s\,(1 + \cos\mu) \quad \ldots\ldots\ldots (1)$$

$$\cos\mu = 1 - \frac{.816\ I_1 X}{E_s} \quad \ldots\ldots\ldots (2)$$

$$I_{S1} = .816\ I_1 \left[1 - 3\,\frac{(2+\cos\mu)(\sin\mu - (1+2\cos\mu)\mu\pi/180)}{2\pi\,(1-\cos\mu)^2}\right]^{1/2}$$

$$= .816\ I_1\,[1 - 3\psi(\mu)]^{1/2} \quad \ldots\ldots\ldots (3)$$

The expression $[1-3\psi(\mu)]^{\frac{1}{2}}$ is plotted as a function of $\cos\mu$ in text books dealing with rectifiers, or the curve, Fig. 10, may be used.

The Kv-a capacity of the transformer bank required is:

$$\text{Kv-a} = 3\, E_s\, I_{S1} \quad \ldots\ldots\ldots (4)$$

Neglecting the effects of overlap, an approximate rating for the transformer is:

$$\text{Kv-a} = 1.05\, E_1 I_1 \quad \ldots\ldots\ldots (5)$$

which, in comparison with 1.26 *EI* for the double wye circuit, and 1.33 *EI* for the quadruple zig-zag circuit, is very satisfactory indeed.

The above equations, (1) to (5) inclusive, are applicable only for those loads which give rise to an overlap angle of 60 degrees or less ($\mu < 60$). This range, however, usually includes full load and nominal overloads for a given installation, and is the range included in the first mode of operation of the circuit.

Second Mode of Operation

If μ were to increase beyond 60 degrees, each secondary winding of the transformer would be required to carry currents of opposite polarity simultaneously. Since this is clearly

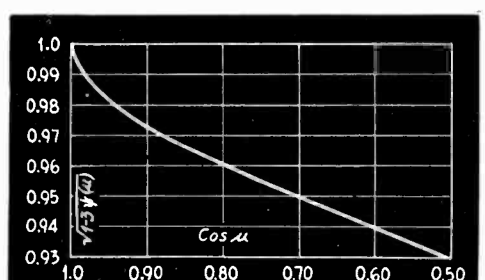


Fig. 10 Expression in rectifier calculation

impossible in this circuit, some other means of permitting an increase in load must come into play. Under this new or second mode of operation, the current must increase in magnitude but not in duration. It is interesting to note that this requirement is not found in circuits having a separate phase for each anode, such as the star, forked, or double wye connections. In them, separate windings carry the currents of opposite polarity; thus, these circuits can, and do have anode or secondary currents of one polarity having a duration greater than 180 degrees.

When phase *A* is carrying the total current, and phase *B* is transferring to phase *C*, it is evident that phase *A* cannot begin its transfer to phase *B* until phase *B* has completed its transfer to phase *C*. When overlap begins at the instant of voltage equality (*P* in Fig. 4-A), the voltage causing the transfer begins at zero value and increases. However, if the overlap of phases *B* and *C* is not complete until after the instant of voltage equality of phases *A* and *B*, the voltage available to cause transfer from phase *A* to phase *B*, when that transfer begins, is greater than zero, and increases as the interchange progresses. The higher the voltage initially available to cause transfer, the larger the current that can be transferred in the allotted interval of 60 degrees. Delayed ignition of the upcoming phase is, then, the phenomena which accompanies an increase in load during the second mode of operation of the circuit. In this manner a larger current is transferred without exceeding the available interval, and the duration of a current pulse of one polarity does not exceed 180 degrees. The heavier the load the greater the delay, for all loads up to short circuit.

When the load is such that the delay angle ϕ is between zero and 30 degrees, the voltages and currents are as indicated in Figs. 7-A to 7-D. The instantaneous output voltage does not drop to zero at any time. As the load increases, the output voltage decreases until, when ϕ equals 30 deg., it is momentarily zero at three points per half cycle. The voltages and currents for this load are illustrated by Figs. 8-A to 8-D. As the load current continues to increase, ϕ likewise increases, and the instantaneous output voltage reverses until, at the load for which ϕ is 60 deg., the *average* value of the output voltage is zero, as shown by Figs. 9-A to 9-D. This may be called short circuit, but only in a restricted sense. It will be noted that the transformer secondary voltages are not zero, due to the large inductance which is still a part of the output circuit. This inductance maintains the output current constant. Hence, during the interval that one phase alone carries the total current, there are no reactive drops to reduce the voltage of that phase below its no load value. During transfer, however, the current in either of the overlapping phases

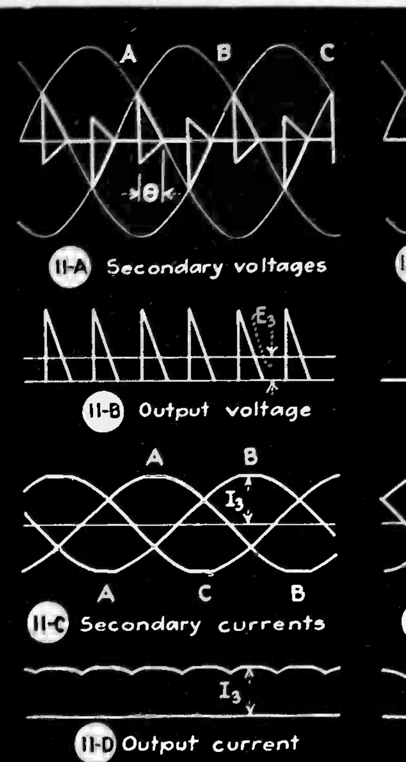


Fig. 11
Data for third mode of operation

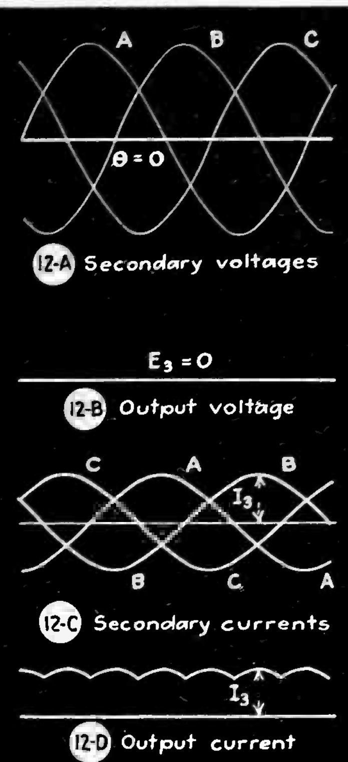


Fig. 12
Conditions at short circuit

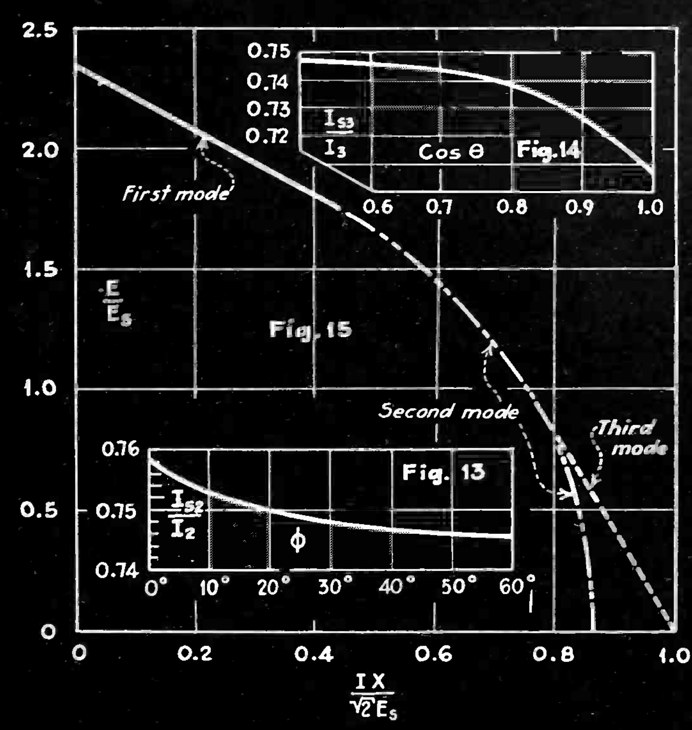


Fig. 13, 14 and 15
Calculating and operating data

is not constant, and their voltages are affected by the resulting reactive drop. From inspection of Figs. 9-A and 9-C, it may be said that the transformer output is at zero power factor; or the circuit may be thought of as functioning alternately as a rectifier and as an inverter.

The voltage and current relationship during the second mode of operation have been analyzed, and the following equations obtained:

$$E_2 = 2.025\ E_S \sin (60° - \phi) \qquad (6)$$

$$\phi = 60° - \cos^{-1} \frac{.816\ I_2X}{E_S} \qquad (7)$$

$$I_{S2} = .816\ I_2 \left[1 - 3 \frac{1.117 \cos^2\phi + .314 \sin\phi \cos\phi + 1.3 \sin\phi - \pi/3}{2\pi\ (\cos^2 60 - \phi)} \right]^{1/2} \qquad (8)$$

For convenience when making calculations, values of I_{S2}/I_2 have been computed, and are plotted as a function of the angle ϕ in Fig. 13.

Eq. (6), (7) and (8) apply only during the second mode of operation (ϕ from 0 to 60 degrees inclusive), and their derivation involves the same assumptions as equations (1) to (5).

Third Mode of Operation

Starting with the load corresponding to $\Theta = 30$ deg. a mode of operation, which results in zero transformer voltage at short circuit, has been synthesized. This third mode requires the gradual elimination of the load circuit inductance. When the load is such that ϕ equals 30 deg., the instantaneous output voltage is momentarily zero, as shown in Fig. 8-B. If a further increase in load current results — not in an increase of ϕ as above — but, in an increase in duration of the periods of zero voltage just noted, the transformer secondary voltages will be zero when the output circuit is shorted. To function in this manner, the wave shape of the secondary current must undergo a marked change. As the periods of zero voltage lengthen, the duration of the flat top of the current wave must decrease until, at short circuit, the current is purely sinusoidal. This is the only wave shape which will, through reactive drop, reduce the transformer voltages to zero in this circuit. The output current now is not constant, but carries a ripple. Figures 11-A to 11-D show the voltages and currents for a load within the range of this mode of operation, while Figs. 12-A to 12-D apply at short circuit.

Using the symbol I_3 to indicate the maximum value of the output current, and Θ to represent the angle through which the secondary voltages are finite (i.e. above zero); the following equations have been derived:—

$$E_3 = 2.025\ E_S\ (1 - \cos\Theta) \qquad (9)$$

$$\cos\Theta = \frac{1.41\ I_3X}{E_S} - 1 \qquad (10)$$

$$I_{S3} = I_3 \left[\frac{2\pi \cos^2\Theta + (6\Theta - 4\pi)\cos\Theta +}{\pi(1 + \cos\Theta)^2} \frac{3 \sin\Theta \cos\Theta - 6 \sin\Theta - 3\Theta + 4\pi}{\pi(1 + \cos\Theta)^2} \right]^{1/2} \qquad (11)$$

Here Θ is in radians. Values of I_{S3}/I_3 have been determined, and are plotted as a function of cos Θ in Fig. 14.

It should be noted that for all values of μ, and all values of ϕ within their respective ranges, and for $\Theta = 60$ deg., the average value of the output current, and its maximum value, are equal. In other words, due to the large inductance in the load circuit, the output current is a pure direct current. However, when the load is such that Θ is less than 60 deg., this is no longer true, due to the ripple current present in the output. The ratio of average to maximum value gradually decreases until, at short circuit ($\Theta = 0$), it has fallen to 0.955.

The complete characteristic of the three phase full wave rectifier circuit, when operating in accordance with the three modes described, has been plotted from the equations given, and is as shown in Fig. 15.

Automatic Selectivity Control

By H. F. MAYER
General Electric Company, Schenectady, N. Y.

Radio receiver selectivity should be adjustable, the control taking place in the intermediate frequency amplifier. Methods of automatic control which widen the band on strong signals. narrow it on weak stations are described

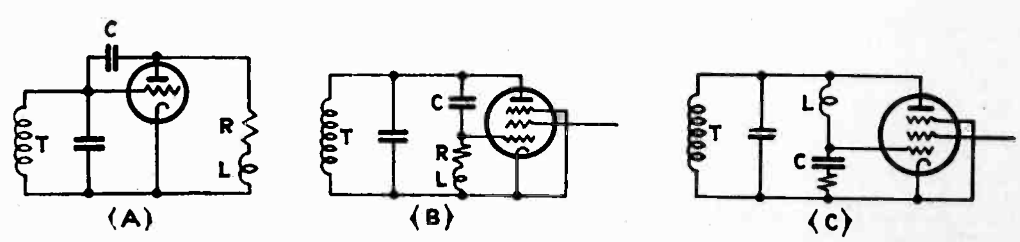
RADIO engineers are becoming more and more aware that means must be provided in modern home receivers for changing the selectivity according to the nature of the received signal. Otherwise there can be no truly high-fidelity reception; such is the layout of the broadcast spectrum and such is the field strength pattern in the region of most listeners. The following notes on methods of automatically changing the selectivity characteristics were presented by Mr. Mayer at the Rochester Fall meeting of the IRE and attracted considerable interest. It is planned that his mathematical analyses of methods of using tubes as variable reactances will be published soon in *Electronics*. — The Editors.

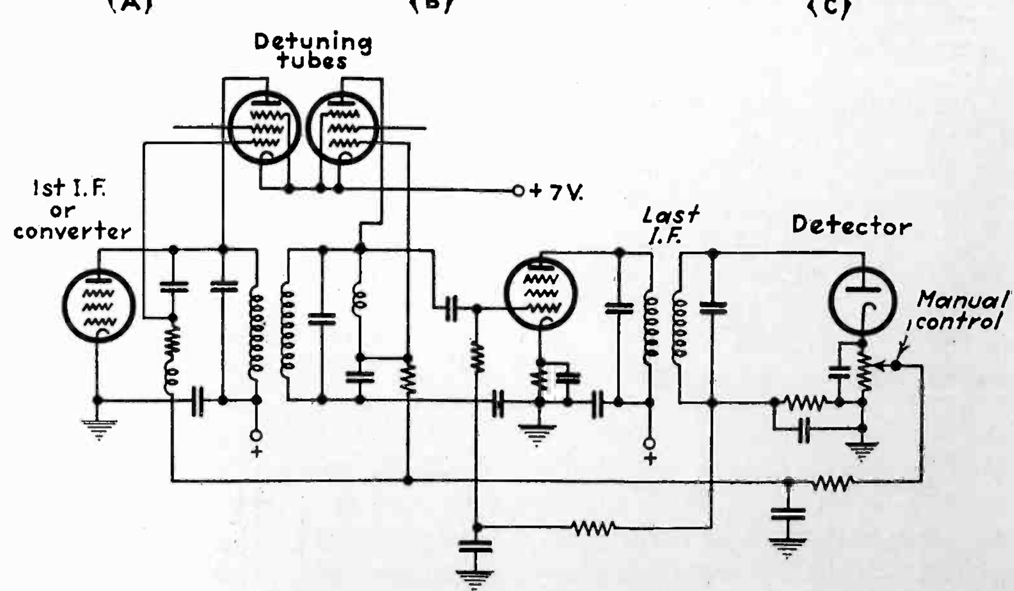
THERE are several ways of using a tube as a variable reactance, particularly where a capacity reactance is obtained by a phase-shift method. These circuits are shown in Fig. 1 where the tube acts as a reactance across a tuned circuit. In both A and B, *R* is small compared to the reactance of *C*. *L* is small, correcting the phase to as near 90 deg. as desired. Often *L* may be omitted. In A the plate resistance does not matter; in B it must be high. Figure 1C draws lagging instead of leading current. Here *R* is small compared to the reactance of *L* and *C* is the compensating reactance. In B increasing the mutual conductance (S_m) of the tube increases the dynamic capacitance, lowering the resonant frequency of the tuned circuit. In C the frequency is raised. The electronic capacitance obtained by A or B is approximately RCS_m.

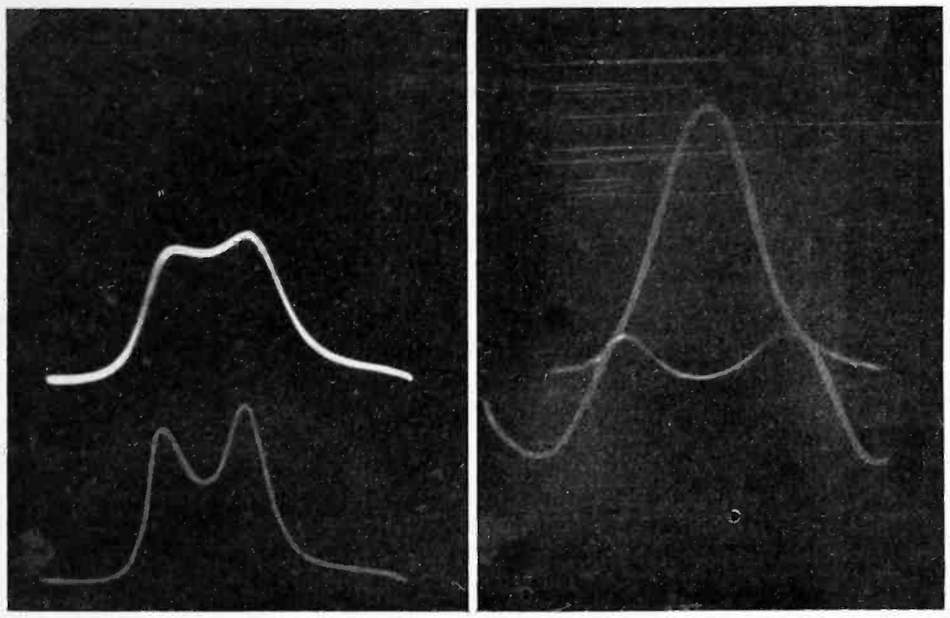
In applying these circuits to a detuning system of automatic selectivity control, the primaries of all transformers are detuned in one direction; the secondaries in the other direction. By using a tube as a capacity on all primaries, and as an inductance on all secondaries symmetrical detuning may be obtained with only one control voltage. Otherwise two oppositely directed voltages are required. Furthermore it is desirable for the detuning tubes to be biased to cut-off at maximum selectivity rather than for one tube at cut-off and one to be at maximum S_m, since the alignment and *Q* of the circuits are most important under this condition.

Since detuning lowers the gain, the ASC will aid the automatic voltage control.

ASC by electronic variation of the coupling of the transformers is a more satisfactory system than con-







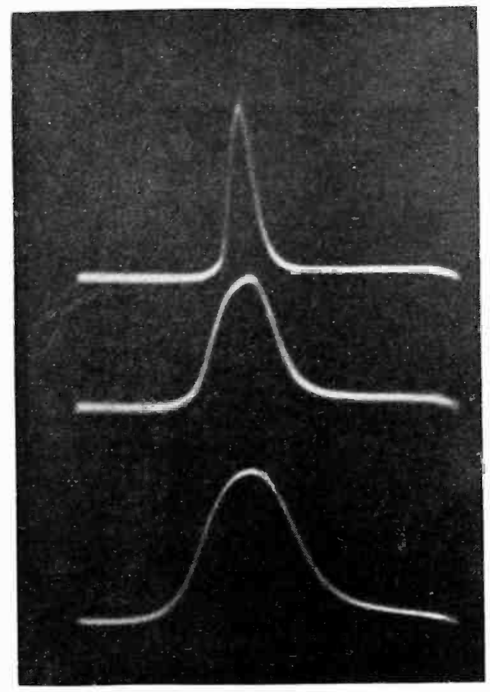


Fig. 4.—(Left) Q control on one stage. Top curve, no feedback. (Center) Coupling control. Top, no feedback. (Right) Coupling and Q control, no feedback on bottom curve

trol by detuning. It requires, at most, one extra tube per transformer. The coupling control tube can be made to increase or decrease the effective coupling (Fig. 3A) with increasing S_m depending upon the polarity of the transformer. The network across the secondary is the same as in Fig. 1B. The coupling is adjusted to the maximum selectivity desired with the coupling tube biased to cut-off. Then as S_m is increased the selectivity curve broadens and becomes double peaked exactly as if the coils were pushed closer together physically. Symmetry is retained. The gain, however, decreases as the band widens. The ASC aids the AVC in holding down strong signals.

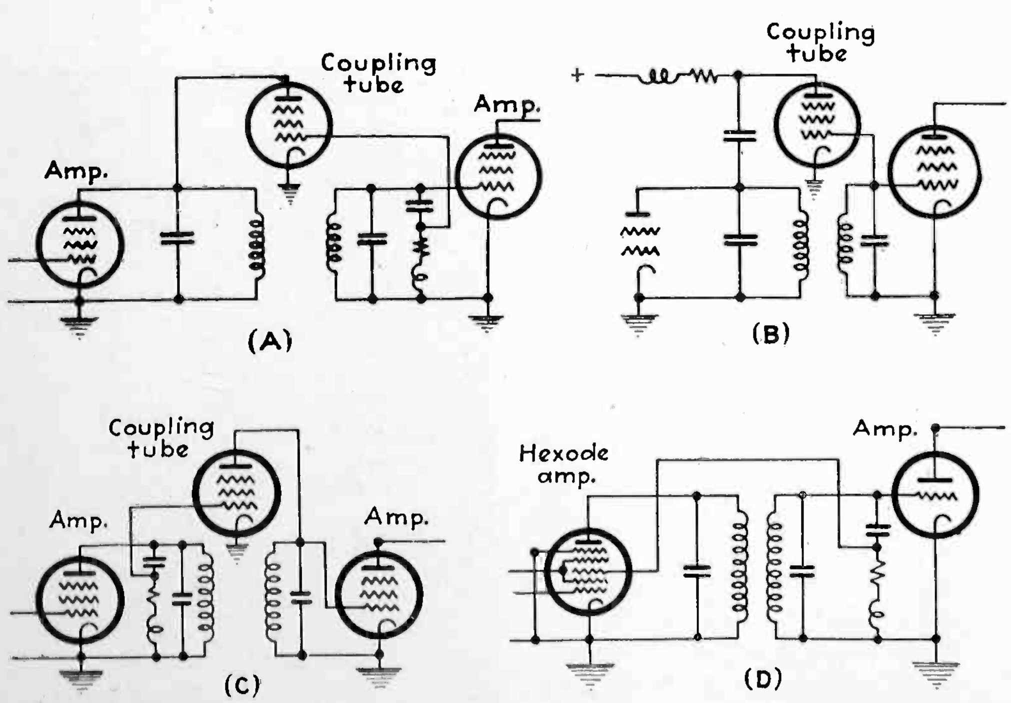
The circuit in Fig. 3C behaves very much like that of Fig. 3A except that the gain increases as the band widens, more rapidly at first and then approaching a limiting value.

If we reverse one winding of the transformer in Fig. 3A or C, we may adjust the coupling to the maximum band width desired with the coupling tube cut off, and use a negative control voltage. Then for strong signals, the S_m of the coupling tube is small and the band width maximum, and for weaker signals S_m increases and narrows the band, at the same time increasing the gain. Unfortunately, if S_m becomes too great, oscillation occurs, which fact limits the usefulness of this circuit a great deal. A way of limiting the gain of the feedback tube to a definite value would make this circuit entirely practical, and perhaps preferable to the other type, for two reasons: It is possible to obtain selectivity better than the transformer itself has, with some extra gain thrown in; and the second, the extra tube can be eliminated by using the circuit of Fig. 3D.

Q Control

Analysis shows that for the case of electronic feedback from secondary to primary the coupling is effectively changed by an amount $k\sqrt{S_m}$ where k is a constant depending on the circuit parameters.

Beers has described an ASC system which might be classified as a Q-control system wherein strong signals cause each tuned circuit to be damped by the plate resistance of a tube. For band widening it would seem preferable to increase coupling, since the slope of the resonance curve is not decreased and the same useful band width could be obtained under worse conditions of interference. However, when seeking increased selectivity, Q control is in some cases preferable to coupling control. The curves of Fig. 6 illustrate this point. Both curves are down 37.5 times at 10 kc. from resonance, but the curve for a high-Q transformer is obviously more desirable than the curve A where the



Figs. 1 and 2 (opposite page)—Electronic reactance control; ASC symmetrical detuning circuit. Fig. 3 (above)—Electronic coupling and Q control circuit selectivity is obtained by a decrease in coupling.

Figure 5 shows two circuits which may be used to increase the apparent Q of the primary of a transformer. Fortunately, it is the primary Q which is most in need of increasing, since it is damped by the tube plate resistance. Circuit B has the advantage of being applicable to a converter stage as well as to any other stage. In both cases, the feedback coil is a few turns coupled as closely as possible to the primary on the

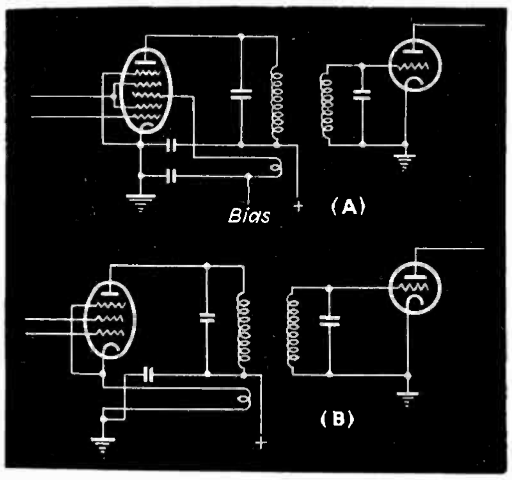


Fig. 5—Circuits for Q control

side away from the secondary. Of course, if too much feedback is used there is danger of oscillation, but it is possible to apply this circuit and obtain an appreciable gain in selectivity with ample safety factor. Furthermore, this provides a degree of automatic selectivity control with no other additions than the feedback coil, as the AVC action decreases the amplification on strong signals, thereby reducing the regeneration and allowing the effective Q to return nearer to normal. However, changing the Q alone is not a very effective way of obtaining large changes in band width, and it is best combined with a coupling-control system. For example, we might use the circuit of Fig. 5B in the converter stage to increase the Q of the primary of the first i-f transformer, and use an auxiliary tube to control the coupling of the first i-f transformer. The effective resistance of the primary circuit is decreased by an amount M_tS_m/C where M_t is the mutual inductance between the primary and the feedback coil, and C is the tuning capacitance.

Both Q and coupling may be controlled if desired, with no extra tubes and no control circuit other than the

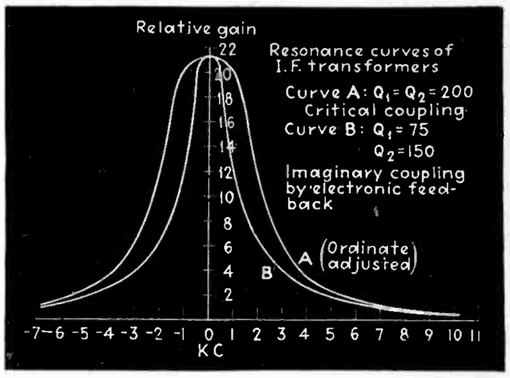


Fig. 6—Virtues of Q control

AVC. Figure 7A shows a method of accomplishing this. A tube with two control grids is required, and feedback is applied to the second control grid from a feedback coil coupled to the primary and a phase shifting network on the secondary. The transformer is connected to give decreasing coupling with increasing S_m, and the simultaneous increase of

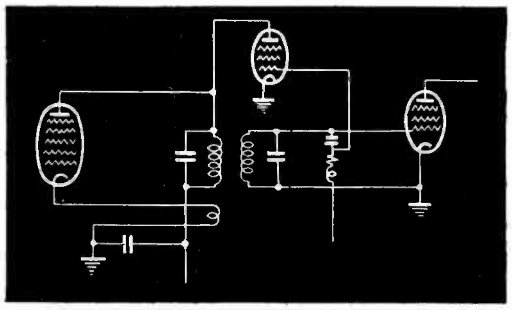


Fig. 7—Coupling control and Q control applied to same stage

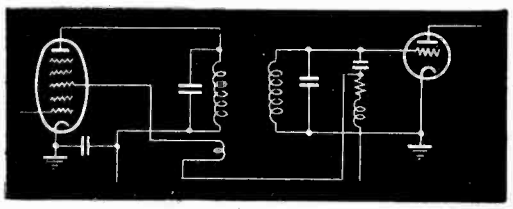


Fig. 7A—Circuit for simultaneous control of Q and coupling

Q prevents the resonance curve from assuming the peaked shape which it would otherwise do. Here again, the practicability of the circuit is limited by the necessary allowances for variation of tube characteristics and line voltage.

There is another type of feedback which is, in a way, a selectivity control. It is simply the random feedback over several stages which exists in a great many sets because of faulty engineering or skimpy design. In some cases, it is tolerated because, offhand, it appears to do more good than harm. It adds gain and selectivity on weak signals, and assumes normal band width on strong signals. Figure 8 shows two sets of curves for a two-stage amplifier with overall feedback. Curve A is the resonance curve with no feedback. Curve B is for feedback of one phase and curve C for the opposite phase. Both phases of feedback are regenerative, but only the type shown by B approaches oscillation at a single frequency. Type C would probably not be tolerated; a transformer winding would be reversed and type B obtained, which does not look quite so bad. However, it actually has less than half the normal band width half-way down, with very little increase in adjacent channel attenuation. If all this random feedback were eliminated from such a set and replaced by the same amount (i.e., the same factor of safety) of planned regeneration, the set would have a fair automatic selectivity control, with no unnecessary sideband cutting and good selectivity.

All three methods of selectivity control described here are easily made purely electronic, which makes them readily adaptable. Of the three systems, coupling control is recommended as producing the best results for the additional parts required. Q control is recommended only in conjunction with coupling control, and then to only a slight degree in order to be safe from oscillation. For the same reason, the electronic coupling should be of the degenerative type, in which case it is perfectly safe.

Editor's Note—Mr. Mayer points out that although he delivered the foregoing paper at Rochester, Mr. J. E. Beggs was closely associated with the research involved.

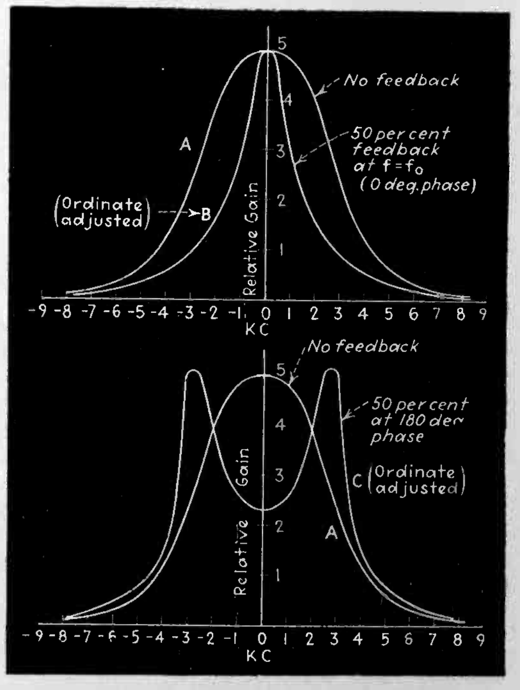
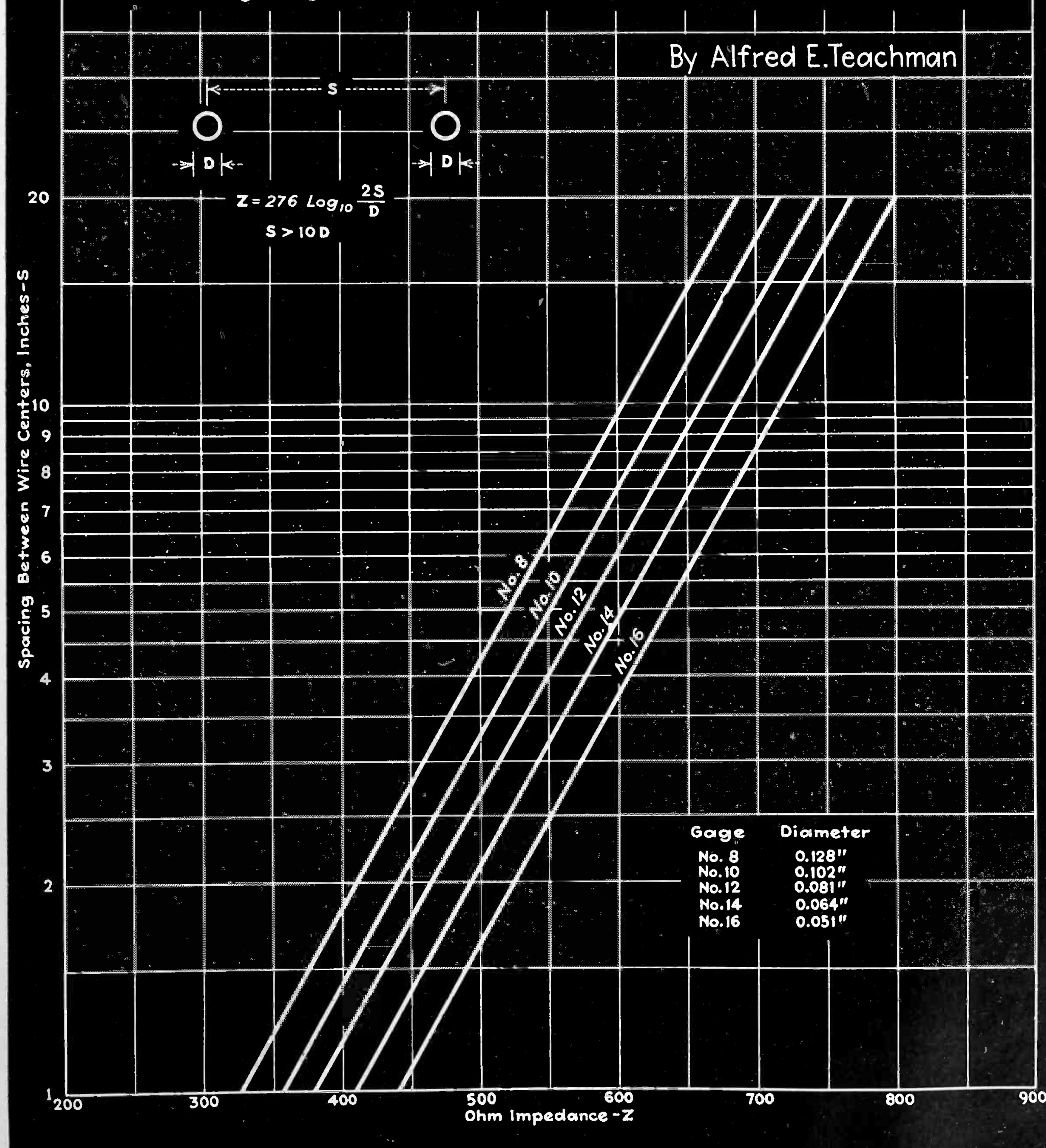


Fig. 8—Effects of random feedback

Impedance Chart for R-f Lines

The surge impedance of parallel-wire lines in terms of wire diameter and spacing, when the spacing is greater than ten times the wire diameter

By Alfred E. Teachman



I.R.E. Fall Meeting

[*Continued from page 13*]

an answer to his question." That there is insufficient talent now available for a wide-spread television service seems certain. Talent must be developed, and it must be given every opportunity to preserve its glamour by the exclusion of audiences from television studios. Dr. Goldsmith pointed out that engineers designing television receivers must be "home-minded" and that they must realize that the home is far

H. H. Beverage, New I.R.E. president

less satisfactory for visible entertainment purposes than a motion picture theatre. He warned against making wide claims for television and its capabilities.

The final papers of the meeting were on subjects of great interest at the present time. R. B. Dome of General Electric read a paper on feedback amplifiers; J. J. Lamb described his work to improve selectivity and freedom from interference in high frequency receivers. Mr. Dome's paper has been printed in full in the first issue of the *RMA Engineer*, published by the Engineering Division of the RMA.

Mr. Dome developed quantitative relations showing the reduction in harmonic distortion, the improvement in regulation of an output tube by the use of negative feedback, and showed the method of developing polar diagrams for a number of representative feedback circuits. Finally he considered multistate amplifiers employing negative regeneration and gave methods for avoiding oscillation.

Mr. Lamb demonstrated the methods of improving selectivity by the use of crystal filters which narrow the band of frequencies passed by the receiver, and by the use of limiter circuits which reduce the amplitude of transient noises. In demonstration, cw signals completely mired up in a locally generated noise (sparks from a vibrator) were made intelligible by a combination of band narrowing and amplitude reduction methods. The efficiency of Mr. Lamb's circuits and apparatus was clearly evident to the listeners.

Antenna Line Terminations

[*Continued from page 19*]

for stray capacity in shielded resistance box by resonating circuit (switch in position No. 2) first with box in circuit and then entirely removed. Difference in reading if capacitor C_2 between two conditions equals capacity of box. This value should be added to each reading of C_2, when circuits are resonated, which is done as above for resistance measurement. The antenna reactance X_2 is equal to capacitance reactance value of C_2 minus capacitance reactance of C_o. When reactance of C_o is greater than that of C_2, then antenna reactance is positive.

When it is found desirable to apply the matching circuits described above and illustrated in Fig. 1 to balanced lines, such as those of the open wire or double concentric types, the value of X_3 derived by the particular formula for cases 1 and 2 is halved and placed on each side of the

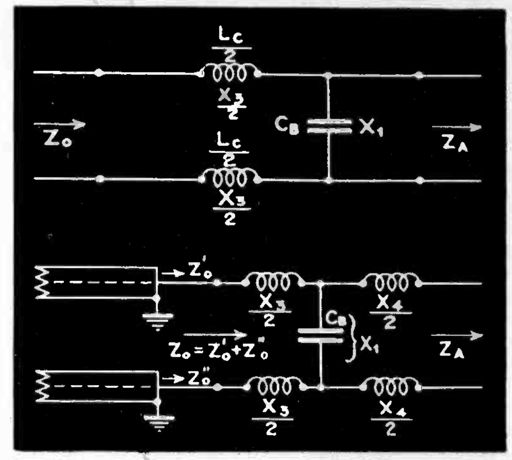


Fig. 8. Balanced circuits

circuit (see Fig. 8), while the value of X_4 is halved and placed on each side of the circuit for Case 3. Under these conditions the formulas given above apply to the respective cases mentioned. The systems become quite useful in matching a given balanced transmission line or r-f circuit into another having entirely different input impedance characteristics.

In the foregoing analysis of antenna matching circuits, they were considered as providing for a given transmission line a termination impedance equivalent to an ohmic resistance at the fundamental frequency. An analysis of the input impedance that such a line "looks into" at various harmonic frequencies discloses that it may assume an infinite number of different impedances containing resistance and positive or negative reactance components, the values of which depend upon the termination circuit constants as well as those of the antenna. The values of antenna resistance and reactance may vary widely with frequency. It is apparent, therefore, that for harmonic frequencies, stationary waves of current and voltage will form on the transmission line as well as in the antenna circuit, unless suitable harmonic filtering is provided either within the vacuum tube transmitter or at the input to the transmission line.

As explained in a previous paper,[3] the effectiveness of a given filter design for various harmonic frequencies depends upon its position in the line with respect to the positions of current and voltage antinodes of the harmonic frequencies along the line.

[3] "Suppression of Transmitter Harmonics", Carl G. Dietsch, Electronics, June 1933, also "Radio Engineering Handbook", Keith Henney, page 655, 2nd ed. McGraw Hill Book Co.

Views and Reviews

Electric Communication and Electronics

By HAROLD PENDER and KNOX McILWAIN, *Editors. Volume 5, Wiley Engineering Handbook Series. (1022 pages, Illustrated; price, $5.00) John Wiley & Sons, publishers, 440 Fourth Avenue, N. Y. City.*

A FEW DOZEN PAGES have been the limit of the radio and wire communication material in the usual electrical engineering handbook. It has been sandwiched in between the section on synchronous motors and safety first precautions. It should, therefore, be a decided satisfaction to the communications engineer to realize that a reference book has been prepared with his special requirements as the prime editorial consideration.

The general style harmonizes with the other volumes of the series and the size is such as to produce a book of convenient proportions. The printing, binding, illustrations, mathematical equations, and tables are handled so as to be of maximum utility. The division into sections rather than into the alphabetical arrangements of former editions of Pender is a vast improvement, and a comprehensive index at the end of the book helps to make the volume of maximum usefulness.

The sections into which the book is divided are entitled: (1) mathematics, units, and symbols, (2) properties of materials, (3) electric circuits, lines, and fields, (4) resistors, inductors, and capacitors, (5) electron tubes, (6) electromechanical-acoustic devices, (7) circuit elements, (8) high frequency transmission, (9) acoustics, (10) electrical measurements, (11) telegraphy, (12) sound-reproducing systems, (13) telephony, (14) facsimile transmission and reception, (15) television, (16) electronic control and navigation equipment, and (17) medical applications of electricity. Each section is prepared by specialists, and considering the enormous amount of work and the number of persons involved, the text is smooth running and well knit together. This is aided by the fact that the volume tends to be more narrative and less terse and mathematical than some other handbooks which have appeared. While any handbook must lag the field of engineering which it covers, the material presented is up to date. The Electrical Engineers Handbook, Vol. V, is an excellent job, by and large, and deserves a convenient spot on the desk of any communications engineer.

Notwithstanding its general excellence, a few sections appear below par and might be improved. The section on thermionic vacuum tubes, consisting as it does of extracts from the 1933 I. R. E. standards report, a list of tube characteristics which seems to belong in catalogues rather than in handbooks, and static characteristic curves of a number of unrelated RCA tubes, might easily be improved by presenting more fundamental material. The bibliographies are not consistent; in some cases they do not appear at all. The section on electrical measurements could be improved by having a few independent viewpoints registered instead of taking that of a single organization. Finally, the section on mathematics could be extended and enlarged to advantage.

As far as the entire book is concerned, however, these are minor points, and we feel that the authors and editors are to be congratulated on doing a fine job. —B. D.

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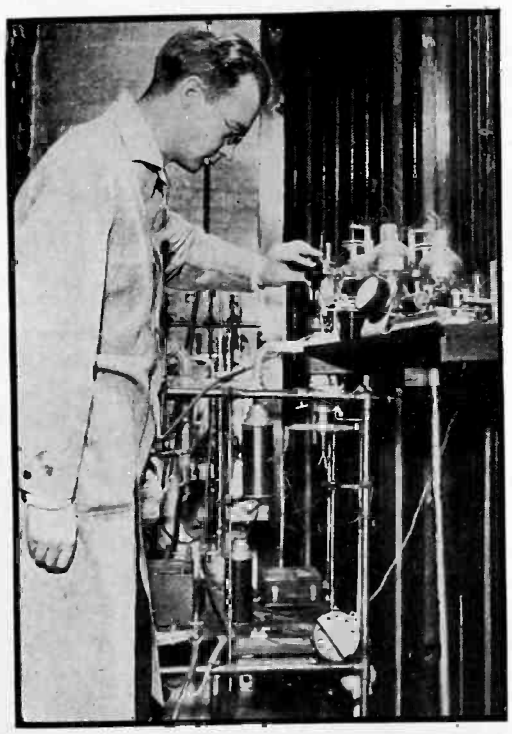
PRODUCES SLOW SPEED ATOMS



In this vacuum tube chemical elements are heated in the lower portion, thus driving a beam of atoms through a fine hole. In the upper portion of the tube, which contains a liquid air trap, the atoms are slowed down so that they may be "photographed" spectrographically. The tube is the invention of Drs. Russel Fisher and Benjamin Carpenter of Northwestern University

Physik und Technik der Ultrakurzen Wellen, Erster Band

(Physics and Engineering of Ultra-short Waves, Vol. 1)

By H. E. HOLLMANN, *Published by Julius Springer, Berlin, Germany, 1936. (326 pages, 381 illustrations, price bound RM36.)*

IN THIS VOLUME the author, who is well known for his work on Barkhausen and Kurz oscillators, has made a very comprehensive review of the various methods of generating damped and undamped ultra-short waves. He defines such waves as composing the range from 1 millimeter to 10 meters wavelength. The first chapter is devoted to spark oscillators of various types with open and closed oscillating circuits, the wavelengths and power outputs that have been obtained, and the methods of supplying the input power and modulation. Chapter II deals with regenerative oscillators, covering the single and multiple tube circuits, the loading problem, a few of the tube types particularly suited for short waves, important points in the practical construction of circuits, frequency stabilization, transit-time effects, and modulation methods. Chapter III covers the retarding-field method of generating oscillations including pure electron oscillations of Barkhausen and Kurz, application of resonant circuits, oscillations of higher order, effects of space charge and residual gases, special tube designs, the theory of electron oscillations with and without resonant circuits, tube construction and circuits for obtaining the maximum power output, and finally the methods of obtaining modulation. Chapter IV deals with magnetron oscillators both of the split-anode negative-resistance type and the electronic type, the underlying theory, construction, the power and efficiency obtainable, and the methods of modulation. The last chapter covers short-wave generation by means of electron and ion streams. The limit of undamped short wave generation is briefly considered.

This book should prove very useful to research workers and engineers interested in the problem of ultra-short wave generation. For these it will serve a complete summary of the development and present state of the art. It is written in fairly simple German, and the many photographs and curves add very much to an understanding of the text.

American readers may be somewhat disconcerted by the different designation of some of the commonly named circuits such as the Hartley, Colpitts, and tuned-grid tuned-plate circuits. The treatment of transit-time effects largely from the standpoint of the inversion theory is perhaps somewhat limited.—E. E. S.

Radio Service Business Methods

BY JOHN F. RIDER and J. V. NEWENHIZEN. *RCA Manufacturing Company, 220 pages, price, $6.00.*

D-c Voltage Distribution in Radio Receivers

BY JOHN F. RIDER, *author and publisher. (92 pages, price 60 cents.)*

Resonance and Alignment

BY JOHN F. RIDER, *author and publisher. 1440 Broadway, New York City. (92 pages, price 60 cents).*

THESE THREE BOOKS for the radio service man are well described by their titles. They are handy in form, useful in content, practical in subject matter. John F. Rider is so well known to the serviceman fraternity that no long winded description of his latest books needs be given of them or their merits.

The first book handled by RCA has 39 pages by Rider and the remainder by Mr. Newenhizen who is a radio auditor and accountant. The second deals with the voltage divider in modern radio equipment, plate circuits, bias arrangements etc. The third book deals with the increasingly important cathode-ray tube as a service tool. It discusses alignment of trimmers, detector circuits, superhets, r-f and oscillator circuits.

Radio Receiving and Television Tubes

BY J. A. MOYER and J. F. WOSTREL. *McGraw Hill Book Company. (635 pages, price $4.00.)*

IN THIS THIRD EDITION of their tube book the authors have revamped the old material and added much new data. As in previous editions the emphasis has been on description rather than technical matters. There are chapters on the construction of tubes, how tubes work, testing vacuum tubes, use as detector, as rectifiers, amplifiers and as oscillators. There is a chapter on television tubes, and one of industrial tubes. A final section gives a good table of tubes and their characteristics as the situation stood when the authors were completing their manuscript. In the meantime, however, the tube manufacturers have brought out quite a few tubes that will not be found in the Moyer and Wostrel table. This is no criticism of the authors—no one could hope to keep up with the steady influx of new tube types.

Einführung in die Angewandte Akustik (Introduction to Applied Acoustics)

BY A. HIRZEL, *Leipzig, 1935 (216 pp. with 154 figures. Price 10.70 German marks minus reductions).*

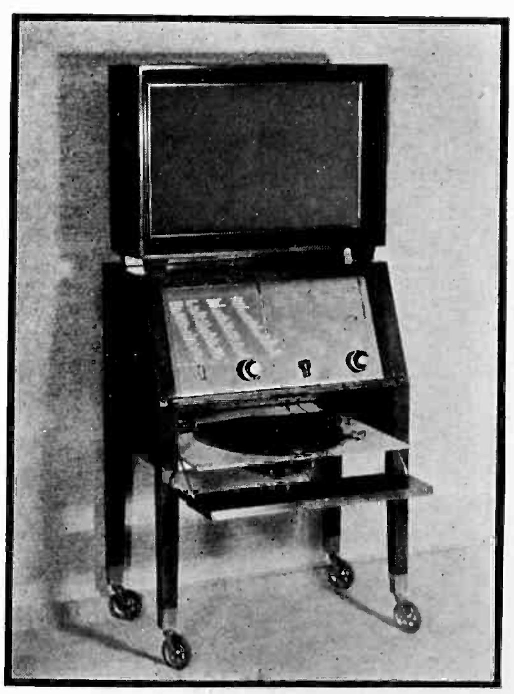
AFTER PRESENTING the fundamental notions of sound waves and vibrating systems, the book proceeds to discuss the devices for receiving, reproducing, recording and measuring sound waves. The last third of the book is devoted to the properties of speech, the acoustics of rooms and the damping of sound in buildings. The authors are members of the German Radio Broadcasting Service so that the radio engineer gets his full share of the subject.

In comparison with the well known book bearing the same title by Olson and Massa the German book treats the subject in half the number of pages. The reduced volume is obtained mainly by the suppression of mathematical developments and demonstrations; on every step the reader is given the proper perspective by the insistence on numerical relations existing between the different factors, in particular in the section devoted to microphones and speech.

Owing to the need for being brief some of the subjects appear easier than they are in reality, for instance, the design of good loudspeakers.

Frequent reference to published articles—English as well as German—allows the authors to introduce a good number of subjects without filling much space, in particular little known subjects, such as the non-linear response of the ears, the limits of sensitivity, the Reisz microphone, the non-linear distortion of microphones. These sources also supply a large number of curves and diagrams not found elsewhere.—RICHARD RUEDY.

DETACHABLE SPEAKER



German radio receiver with speaker which may be separated from chassis

Handbook of Chemistry and Physics

BY CHARLES D. HODGMAN, *Editor. (Twenty-first edition). Chemical Rubber Publishing Company, Cleveland, Ohio. (2023 pages, price $6.00).*

TO READERS having a training in the physical sciences, reviewing the new editions of the *Handbook of Chemistry and Physics* is merely a matter of "carrying coal to Newcastle," for it would be hard to find among them a group not already acquainted with this single volume storehouse of information.

The new edition is divided into sections on mathematical tables, properties and physical constants, general chemical tables, specific gravity and properties of matter, hygrometric and barometric tables, sound, electricity and magnetism, light, quantities and units, and miscellaneous. Considerable material has been revised, 65 pages added. The principal changes made in the 21st edition are the expansion of mathematical tables, the addition of a table of haversines (half versed sines) and material on statistics, a revision and enlargement of laboratory arts and recipes, enlargement of the section on photographic formulas, the addition of a new table on commercial plastics, a revised table of isotopes, and the revision of tables on gas volume reduced to standard conditions.

The pages on vacuum tubes and socket connections appear to be somewhat out of place in this book. It does not represent fundamental information comparable with the majority of the other data given. Space might better have been devoted to fundamental tube equations such as Child's and Langmuir's voltage laws, Richardson's temperature law of emission, temperature-emission characteristics of tungsten, molybdenum, tantalum, and other emitters, the elements of tube design, and definitions of the more important tube factors.

To the engineer the tables of LC constants, ratios of voltage, power, and transmission units, wire tables, physical constants and abbreviations, definitions, and units and conversion factors will be of frequent use. To the research worker and college student, the Handbook is the best single-volume, convenient, and inexpensive substitute for the International Critical Tables with which the reviewer is familiar.—B. D.

TUBES AT WORK

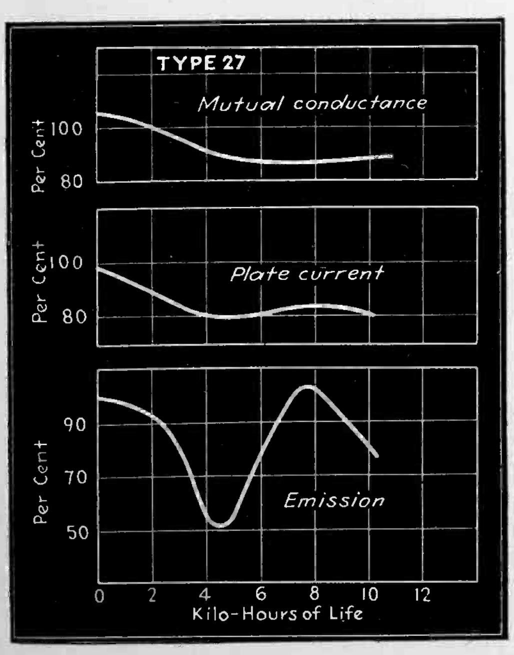
IN the June issue of ELECTRONICS, information on tube life was requested in Crosstalk. Of the several responses that given by Mr. Briggs, below, is of outstanding interest

Factors Influencing the Useful Life of Vacuum Tubes

By THOMAS H. BRIGGS
Raytheon Production Corp.

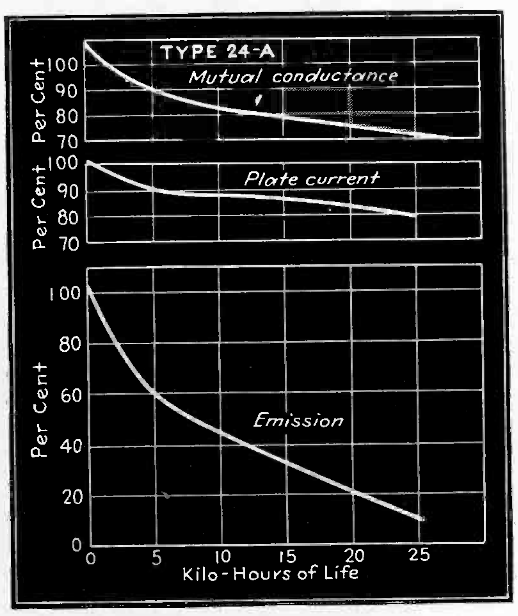
THE USE OF THERMIONIC TUBES in other than radio receiver applications is frequently predicated on the fact that servicing must occur at infrequent intervals, and that the chances of failure of the equipment employing these tubes must be remote. Unless this be the case it too often happens that some time-tried mechanically-acting substitute will be employed. The broadcast listener rarely has occasion to complain of poor tube life in his receiver. Many sets five or more years old still have the original tubes giving satisfactory daily reception. For industrial use, however, continuous tube operation is usually necessary. Thus a year of steady burning in a commercial circuit would be equivalent to three to ten years of home radio service.

The best known examples of long service vacuum tubes are those used in telephone repeater stations. Such tubes are said to be guaranteed for 20,000 hours of life and frequently exceed twice that period. These tubes are manufactured under far different conditions than the usual radio receiving tubes. The exhaust is done on slow speed "trolley" type pumping systems. The "formed" type of cathode coating is used which requires hours to apply. The seasoning processes are long drawn out. All of these things are not now feasible for large scale manufacture of the large variety of broadcast receiving tubes.



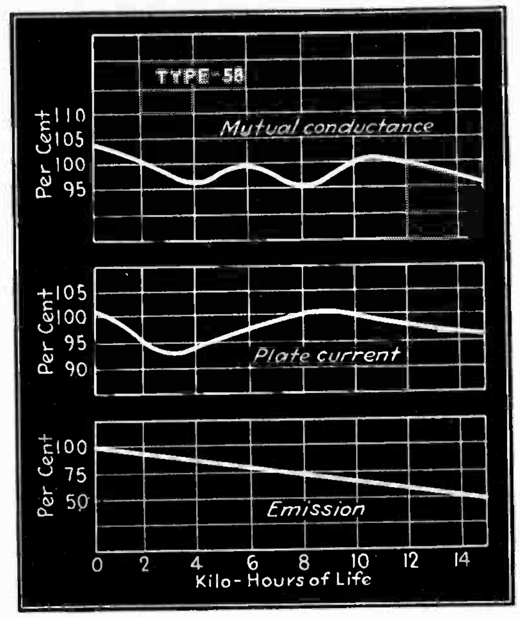
Life characteristics, triode

Inasmuch as these repeater type tubes are not generally available, commercial equipment usually employs the more popular broadcast receiving tubes. These tubes of necessity must have great care exercised during their manufacture in controlling all processes from the beginning of the fabrication of raw materials right through to the final testing operation. They must, however, be produced in quantity, be low in price, and be universally available. Because of these three facts these tubes are in demand for industrial applications. But these three facts also raise the question of the expected tube life.



Life characteristics, tetrode

There need be but little doubt that receiving tubes will stand up satisfactorily for long periods of time if certain simple requirements are met. First, let us see what is possible in the way of life of random samples of popular receiving tubes produced on high speed exhaust machines and burned at rated or over voltage. The three figures show percent variation from published center values of three important tube characteristics as plotted against kilohours of life. Two to three tubes each of three types (24A, 27, 58) were burned from 10 to 25 thousand hours at normal heater voltages and normal or slightly over plate voltages (250-275 v.). The life testing was not terminated through failure of the tubes to perform. At the end of 25,000 hours the three type 24A tubes were placed in a receiver and performed as well as new tubes for local reception, and were only slightly inferior for weaker signals.



Life characteristics, pentode

It will be noticed that although the emission may vary over wide ranges or decrease to a tenth of the original value, that the plate current and mutual conductance curves remained relatively steady. This emphasizes one important point, namely, that proper choice of the type of tube is necessary for commercial equipment. Thus, a tube with low plate current (5-10 ma.) will be able to maintain these values even though the emission is greatly reduced. Whereas, an audio output tube of 30-40 ma. plate current would have this value seriously reduced with a 50% reduction in emission.

An additional fact brought out during this life testing was that certain characteristics varied up and down over wide ranges. This apparently is indicative of changes in the condition of the cathode or grid surfaces due to burning. They are also fluctuations which would probably be encountered during actual service.

One point which is true of broadcast receivers as well as industrial vacuum tube equipment is that the life expectancy of the tubes used is dependent upon the permissible latitude of tube characteristics consistent with satisfactory circuit performance. Thus, a relay circuit demanding tube plate current to be within 10% of the published nominal would have caused rejection of the 24A's shown in the figure after 6,000 hours and of the 27's after 2,000 hours. Whereas, a circuit permitting a 20%

drop would have found all the tubes satisfactory for much longer periods.

The tubes whose life tests have been discussed were burned at near normal voltages. It is frequently customary to increase the heater or plate voltages or both, in an attempt to obtain slightly more gain from each tube. The trend in this direction is well illustrated by the changes in rating and construction of the type 27 tube since its introduction in 1927. Initially it appeared with a bright solid nickel plate. As demands upon it were increased a woven mesh plate of better heat radiating power was made necessary. With the change to the smaller dome bulb and the addition of the 250 v. plate rating instead of 180 v. it became necessary to employ a carbonized nickel plate for still better heat dissipation and to process the grid carefully to avoid grid emission. Accelerated life test results are possible to a certain extent by increasing voltages over the maximum rating. Thus, in the case of the type 78 tube experimental data shows that when the heater is operated at 110% of normal rating that the emission after 500 hours is 96% of the initial value and the mutual conductance is above the initial value. Whereas, similar tubes whose heaters were burned at 130% of rating showed only 44% of the starting emission value, and the mutual conductance was below the starting point. Further, such over voltages accentuate grid emission and allied difficulties. If the heaters had been operated at 87% of normal the emission would have maintained uniformly high values for many thousand hours. This well demonstrates that for longer life lower voltages are necessary. Thus a 2.4 v. or 5.8 v. heater rating and 180 v. on the plate instead of

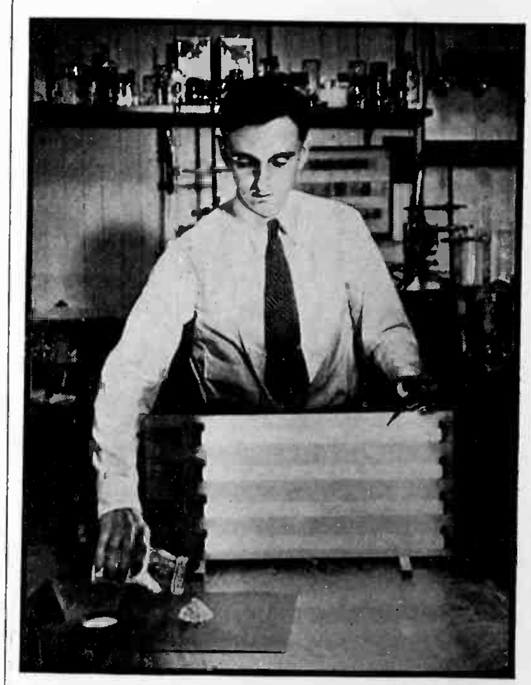
MILLION-VOLT TUBE

This 17-foot monster is a deuteron bombarder, recently constructed at the University of Michigan. It may be used either for producing artificial radioactivity or x-rays of one million volt energy

2.5 or 6.3 and 250 v. would vastly extend the life of the general run of vacuum tubes. However, the heater voltages should not be reduced to such a point that sufficient emission cannot be maintained to satisfy the electron current drain from the cathode to which the tube will be subjected in operation. One of the necessary conditions for maximum life is to have the optimum balance between cathode temperature and electrode voltages and current for given operating conditions. This requirement is most necessary in the case of rectifier tubes. Other factors to be kept in mind in choosing tube types for long life are cool cathode temperatures, cool anode and bulb operating temperatures and adequate spacing between various elements. Cathode temperature may vary considerably between tubes of different types of the same manufacture. This is generally difficult to determine, however, without knowing the actual dimensions of the heater and cathode. It can best be controlled by operating at under rated voltage. Adequate spacing between elements is usually coupled with less gain per tube. While this may seem to be a penalty to the equipment designer it is offset by generally cooler operation, and freedom from mechanical troubles.

Cathode type tubes have practically displaced the filament tubes except for the larger rectifier types. The life of the cathode tubes is usually much superior to that of the filament tubes so that little attention needs to be given

FLUORESCENCE IN GAS-DISCHARGE LAMPS



These tubular lights contain mercury and argon gas which is ionized by current flow. The inner surface of the tube is coated with fluorescent powder which, acted on by the ultraviolet, modifies the color and considerably increases the intensity of the light

Centralab Controls, Centralab Resistors and the new Selector Switches have enjoyed an increased acceptance in 1936.

That acceptance can only be interpreted as a recognition of QUALITY.

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those types, other than the 2-volt battery line. In such cases frequent attention to batteries would mean attention also to tubes, and cost of tube replacement if more frequent would be insignificant compared to power supply.

Where almost instant response of a circuit is required without having the tube heaters constantly burning it is necessary to use filament type tubes. However, the life of cathode type tubes with only heater voltage applied for most of the time is very long.

So far only electrical failures of tubes have been discussed. The mechanical failures may be classed as open heater circuits, short circuits, improperly assembled tubes, and glass leaks. Only in exceptional cases will such troubles be encountered. Where a high degree of insurance against mechanical failure is imperative it is usually feasible to operate the tubes in their circuit for 10 to 100 hours under a closer than normal supervision. In this manner expectancy of long mechanical life can be made much more certain.

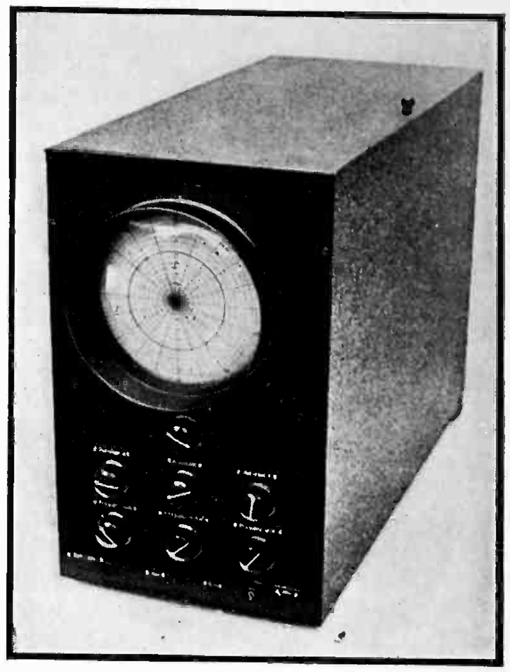
Tubes Measure Protecting Finishes in Automobile Manufacture

For the following information on electron tube applications the Editors are indebted to Mr. L. A. Danse, metallurgist of the Cadillac Motor Car Co., Detroit, Mich.: An interesting application of electronic tubes has been made in the Cadillac Laboratory. It is a control device for indicating the end point on the abrasion testing apparatus for checking anodized coatings on pistons and for checking paint and varnish coatings on car parts. In the old method of reading, the end point was indicated by means of a flashlight cell and bulb with a wire cat-whisker (feeler) which rested against the coating. Inasmuch as the flashlight combination used considerable voltage and current, coatings were sometimes burned through before actual failure had occurred, and premature end points thus indicated. By substituting an electron tube amplifier, the current through the cat-whisker is reduced to a negligibly small amount and the potential involved is low. By utilizing the amplification characteristics of the tube, an indication is given on a good sized lamp even though the potential and current through the cat-whisker which is not sufficient to burn through any part of the coating before the end point is reached.

Electronic devices are also used in this laboratory for measuring the thickness of painted coats on automobile bodies, etc. With such instruments it is possible to plug into any convenient electric light socket and to measure the thickness of the paint on any part of an automobile body, sheet metal or other metal parts.

THE ELECTRON ART

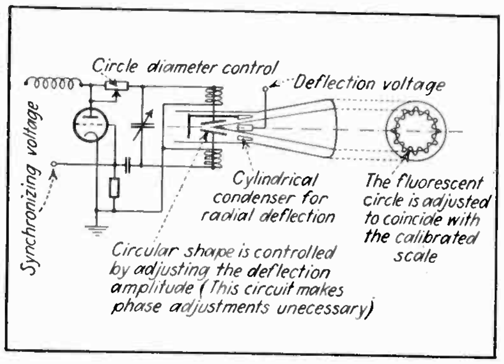
GERMAN polar oscillograph, British tube developments, measurement of a-c millivolts, triode equivalent circuits, government publications in the news review.



Exterior view of polar oscillograph. The calibrated screen is useful in making accurate cathode ray measurements

Polar Coordinate Oscillograph

THE IDEA of writing oscillograms over a circular time base is not a new one. As early as 1929 there appeared in the April issue of the *Bell Laboratories* a description of a mechanically operated polar coordinate oscillograph which enabled transient phenomenon to be photographed. However, the announcement of a polar oscillograph at the German radio show developed by Leybold and von Ardenne, discloses a number of interesting features which are worthy of consideration. In line with present trends in television, the patterns are produced by electrical rather than mechanical methods.



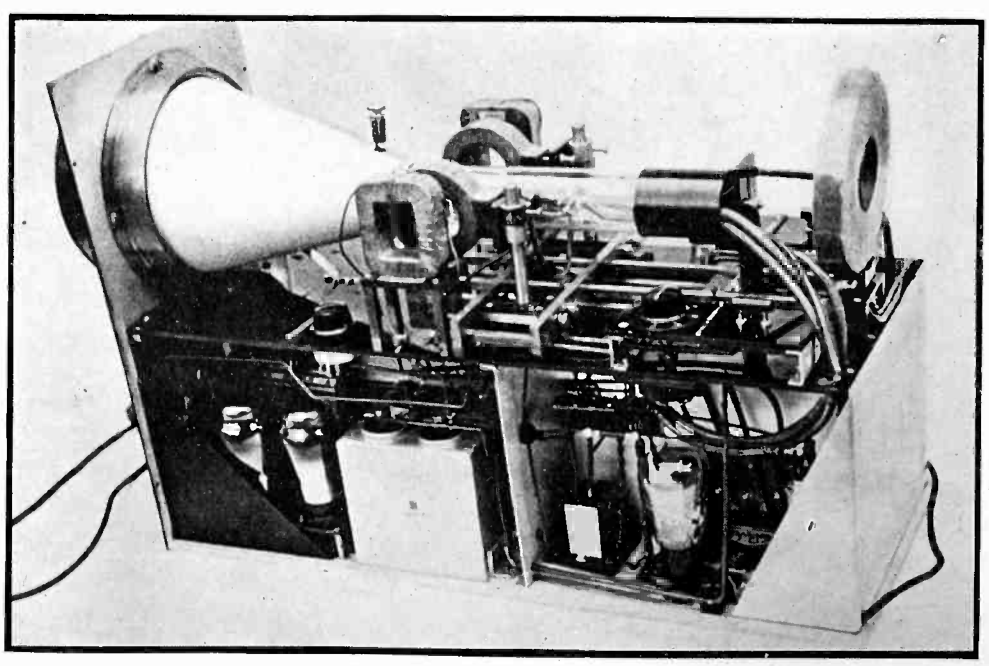
Schematic diagram of the von Ardenne polar oscillograph, showing operating principles

The heart of this oscillograph is a novel time base which provides a circular base upon which voltage variations may be superimposed. It will be seen from the schematic wiring diagram that the circular time base pattern is produced by the combined electric and magnetic forces acting on the electron beam. The deflecting plates are connected to a source of alternating voltage and produce sinusoidal oscillations in one dimension. The magnetic field produced by the current flowing through the deflecting coils, provides a sinusoidal oscillation in another dimension. The circuit construction is such that the quadrature phase displacement between the voltage and current affecting the electron beam produce a circular pattern. The diameter of this circle depends of course upon the deflecting voltage and current and can be varied at will so as to fit the calibrated screen by varying the circle diameter control. The illustration of the interior of the oscillograph shows the deflecting coils quite clearly. To assure the continuous production of the ideal circular figure on the screen it is essential that harmonics in the radial field generator be eliminated.

The circular base has numerous advantages over the commonly used saw tooth sweep systems. The velocity of the electron beam over the screen is constant, the oscillograms can be made to appear continuously and without breaks by proper choice of the frequencies of the time base and deflecting circuits, and the time base for a given screen diameter is more than three times as long as the corresponding diametral base. An extremely accurate time base can be established when the sweep frequency is accurately known, and from this the frequency of the deflecting voltage can be determined with the same degree of precision. When heterodyne methods are used with a highly stabilized constant frequency oscillator it is possible to obtain a precision in frequency determined by that of the oscillator.

The polar oscillograph is particularly suited to the investigation of transients because the length of the time base permits the use of high intensity cathode ray beams without harmful effects to the screen and because the uninterrupted circular sweep enables observations to be made with equal facility on any part of the screen. It is possible to measure very short periods of time and to observe really undistorted oscillograms. The shortest attainable sweep period of the instrument is five microseconds.

NEW VON ARDENNE OSCILLOGRAPH

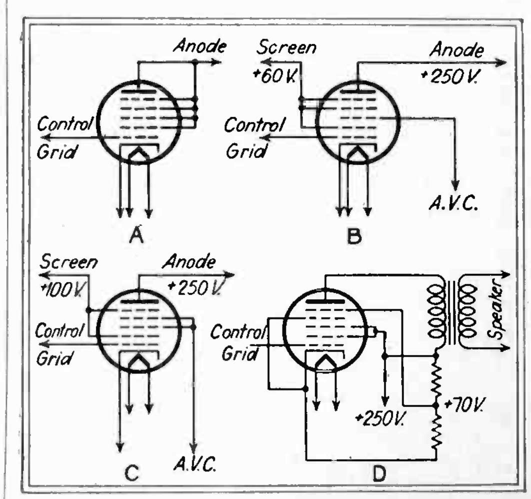


Interior construction of the polar oscillograph. The deflecting coils in the center of the illustration determine the circular time sweep pattern

Recent British Tube Developments

As usual, the news of the Olympia Radio Show, as reported in *Wireless Engineer* is interesting and instructive of what is taking place in radio developments across the Atlantic. The current report in the October issue, from which this abstract has been compiled, devotes most of the space to test and measuring equipment, although a fair portion is given over to recent development of British electron tubes.

The outstanding novelty in the report is the Harries "all stage" multi-element tube, manufactured by Harries Thermionics, Ltd. This tube is an elaboration of the "critical distance tetrode" of Harries, or the "beam power tube" which has been developed independently by Schade of the RCA Mfg. Co. in this country. The all stage "valve" contains an indirectly heated cathode, five grids, and a plate, so that a seven element tube results. The grids are brought out to separate base pins, and by making suitable grid connections on the socket, the tube can be given characteristics suitable for any stage in the receiver.



In all applications the grid nearest to the cathode is used as the control grid, since it is fully screened from the plate by the other grids, and its leads is brought out to a terminal at the top of the tube. When the tube is used as a triode, all other grids are connected to the plate, as shown at A. Four different connections are possible when it is desired to use the tube as a tetrode, and each connection imparts somewhat different characteristics to the "custom built tube". Two possible tetrode connections as a voltage amplifier are shown in B and C. The connection at B gives higher plate resistance and higher transconductance than the connection at C. When automatic volume control is used, the control voltage is not applied to the control grid but to one of the other grids. It is claimed that this results in the advantage of operating the grid on the straight line portion of the $E_g - I_p$ characteristic. The connection at D may be used to provide a "critical distance" output tube.

The idea of changing the characteristics of a tube by changing the grid connections is not new, and has been used in this country for some years with multi-element tubes such as the 59, 46, and 89. However, the idea of building a tube which, with proper connections, can be used with satisfactory (even if not optimum) characteristics in all stages of a receiver is attractive because of the possibility of reducing the total number of variations of tubes in commercial use. Failing this, the idea is still attractive as it may tend to reduce the rate of increase at which new tubes are being made commercially available, many of them without filling any real need.

In addition to this universal tube, two types of tubes of physically small dimensions are also reported. One of these, a Mullard acorn tube appears to be very similar to the 954 tube developed by Thompson and Rose. They are intentionally designed to have short electron paths and transit time, and are provided with lead-in connections similar to the acorn tubes used in the United States.

The other type of "midget" tube is made by Hivac, and appears to be similar in appearance to the Northern Electric peanut or N tubes, although of smaller dimensions. These tubes can be obtained with ceramic bases of low dielectric loss, but do not appear to be as well suited to use in the extremely high frequency range as the acorn tubes.

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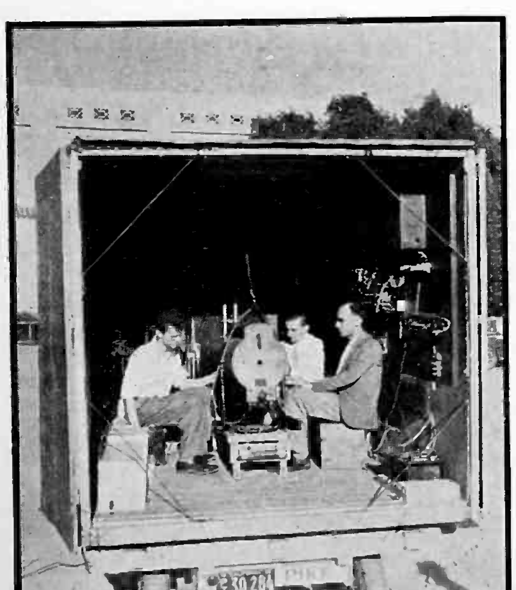
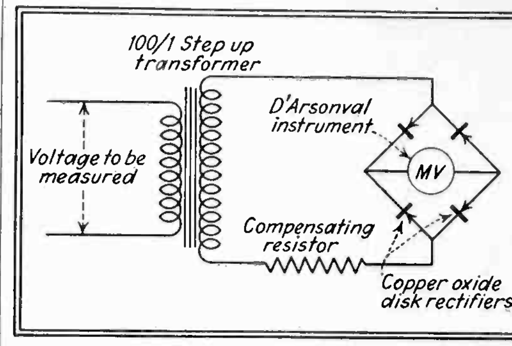
CALTECH'S COSMIC VAN



In this shielded trailer is the cosmic ray apparatus with which Dr. Carl D. Anderson (extreme right) discovered the positron, ready for transportation to Pike's Peak. Dr. Anderson's winning of the Nobel Prize was recently announced

A-C Millivolt Measurements

THE ADVANTAGES of a rectifier type meter with its high sensitivity has recently been extended to enable measurements to be made of low alternating voltages. As reported by Paul MacGahan in the September 1936 issue of *Instruments*, this has been accomplished by using a bridge type of copper oxide rectifier feeding the D'Arsonval instrument as a load. The limitations of wave form error, temperature coefficient, and non-linearity which characterizes copper-oxide rectifiers necessitates the use of a high resistance in series with the rectifier to reduce the effect of these variables upon the accuracy of the instrument. Because of the introduction of this high series resistance it has not been possible, heretofore, to use this type of measuring device for small a-c voltages.



The difficulty has been overcome by inserting a step-up transformer between the voltage to be measured and the series resistor and rectifier arrangement. By means of a transformer having a step-up ratio of 100 to 1, an input voltage of 30 millivolts produces three volts across the rectifier and series resistor, and this can be readily measured. Of course the introduction of the transformer introduces an additional element which can easily restrict the frequency range over which the meter will give satisfactory indications, but the arrangement as shown in the schematic wiring diagram is intended to provide a handy portable unit of fair accuracy rather than a laboratory standard.

Reduction of Machine Noise

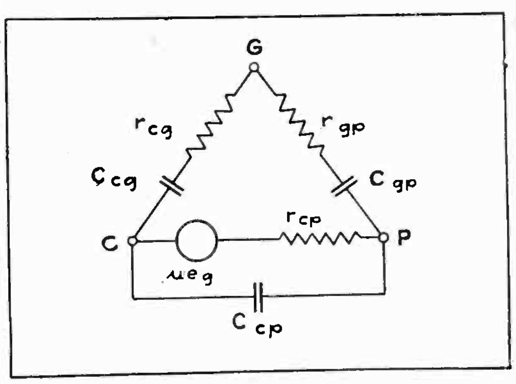
UNDER THE TITLE of "The Role of Acoustical Measurements in Machinery Quieting" in the October 1936 issue of the *Journal of the Acoustical Society of America*, E. J. Abbott gives a summary of a number of difficulties which have been encountered in making acoustical measurements on machines. The advantages and disadvantages of the method of frequency analysis and sound level intensity measurements are set forth.

Equivalent Networks of Triodes

F. B. LLEWELLYN, writing in the October issue of the *Bell System Technical Journal*, reviews the status of triode equivalent circuits and brings the subject up to date so as to apply to very high frequencies. In his article, "Equivalent Networks of Negative-Grid Vacuum Tubes at Ultra-High Frequencies", the various steps in the development of the equivalent network are outlined, and it is shown that the series circuit consisting of a resistanceless generator and a resistance equal to the internal plate resistance, while still useful for elementary discussions and applicable at very low frequencies, is subject to serious limitations where rigor of analysis is required or where tubes are used at ultra-high frequencies.

As the frequencies at which tubes are operated increases, the effect of interelectrode capacitance becomes important. To take these capacitances into account the simple series equivalent circuit may be modified into a delta by placing capacitances between all of the elements. This elaboration is adequate so long as the resistive components of the various arms can be neglected.

The most general delta network for a negative grid triode consists of three series branches, each containing an internal generator in series with an impedance. This type of network has the disadvantage of employing three generators but by a proper definition of the amplification factor can be reduced to a delta with a single generator.



At frequencies where the effects of transit time of the electrons are only moderately important, the diagram given here can be used. This equivalent network has advantages over some other types of networks in that the amplification factors come out to be a real rather than a complex number, the impedance in series with the generator is the usual internal plate resistance obtainable from measurement or static characteristics, and the interelectrode capacitances are the usual ones which have been used at lower frequencies.

MANUFACTURING REVIEW

News

✦ **Erie Resistor Corporation** has recently completed a large addition to its main factory at Erie, Pa., containing over 16,000 square feet and three stories in height. This building houses the plastic molding division and general offices of the company.

✦ **Rowe Radio Research Laboratory** Co. has been recently established to render consulting service on problems of radio receiver design and to give engineering advice in regard to other associated radio and electrical problems. This organization is located at Suite 207–8, 1103 Bryn Mawr Avenue, Chicago, Ill.

✦ **The Bruno Laboratories, Inc.** announces their removal from 20 West 22nd Street to their new quarters at 30 West 15th Street, New York City, where they have leased considerable additional space. Here all activities of the organization will be combined although they retain their laboratories at Teterboro, N. J., and Washington, D. C., devoted to aviation.

✦ **Bausch & Lomb Optical Company** has begun a program of fundamental investigations on the chemistry and physics of glass surfaces to aid in the development of scientific apparatus and ophthalmic instruments. This work is being carried on at Mellon Institute, where this organization has maintained a fellowship since 1931 for research on plant and production problems in optical technology. **Dr. Frank L. Jones** will be in charge of this work at the Mellon Institute. An enlarged staff will continue the work on plant problems at the new research laboratory of the company in Rochester, New York.

✦ **Mirrophonic** sound reproduction equipment has been adopted by Universal Pictures Corporation for their studios. This work includes modernizing the three fixed scoring and dubbing channels, using three new additional Mirrophonic recording machines, and installing new equipment in the review rooms.

✦ **National Union Radio Corporation**, 570 Lexington Avenue, New York City, announces the appointment of **J. H. Robinson** as Director of new product research. Among Mr. Robinson's duties will be that of seeking out and analyzing the marketability of new products, patents in the field of radio, electronics, television and electrical industries.

✦ **Canadian Broadcasting Corporation** has as its new officers **Maj. W. E. Gladstone Murray**, as General Manager and **Dr. Augustin Frigon** as Assistant General Manager. These men, associated with the British Broadcasting Corp. and the Quebec Electricity Commission, respectively, are well versed in the art of broadcasting and in the knowledge of its problems.

✦ **The American Rolling Mill Company** has begun the construction of a new research laboratory to replace the building destroyed by fire about a year ago. The building will incorporate the use of porcelain enameled sheets, other decorative metal products, and glass blocks. The building will be located adjacent to the company's offices, in Middletown, Ohio.

✦ **Belden Manufacturing Company** has completed its new manufacturing plant in Chicago, and is still at work on the new plant being constructed at Richmond, Indiana. The Chicago building adds 20,000 sq.ft. of floor space and will be used to extend the wire mill and tinning plants.

New Products

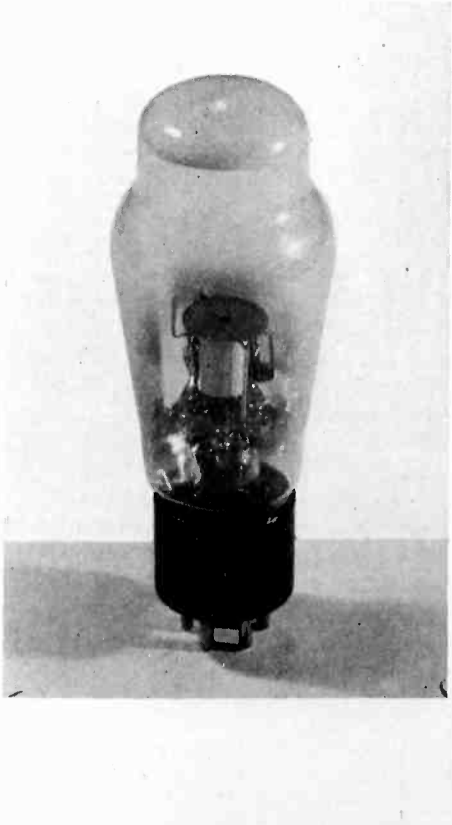
Electron Microscope Tube

ALLEN B. DU MONT LABORATORIES, INC., Upper Montclair, New Jersey, have recently developed an electron microscope tube referred to as the Type 889. This tube is designed to demonstrate the principles of the electron lens and how they can be used to function as a microscope.

The specification of this electron microscope tube are as follows:

Diameter of screen	2 inches
Overall length of bulb	6¾ inches
Base	7 prong
Image	Green
Type of cathode	Indirect heater
Filament volts (AC or DC)	1.5
Filament amperes	1.5
Focus electrode volts	0 to —300
Anode voltage	500 to 1000

In the Type 889 the surface of the oxide coated nickel cathode is enlarged approximately twenty-five times and projected on a fluorescent screen at the end of the tube. The necessary voltage to operate the Type 889 may be obtained from a simple power supply.

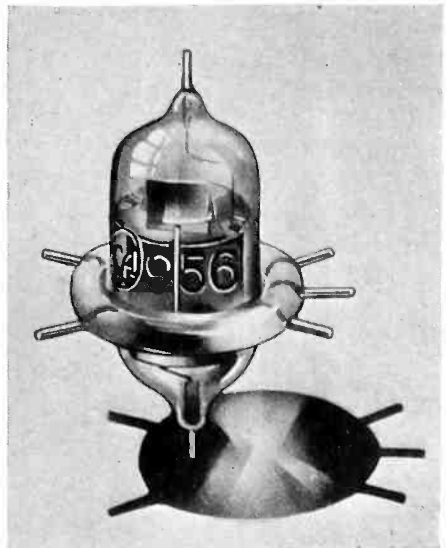


Instantaneous Recording Equipment

THE "MASTERTONE" is one of the several new instantaneous recording outfits manufactured by Recording Equipment Mfg. Co., 6611 Sunset Boulevard, Hollywood, Calif. This is equipped with a full synchronous motor, 78 r.p.m.; a precision overhead lathe type feed; built-in pre-amplifier for microphone; 12-inch turntable; matched cutting head; balanced crystal reproducing arm; high quality two-cell balanced crystal microphone; 7 watt recording amplifier; 8 inch matched loudspeaker. It lists, complete, for $350.

Acorn Pentode

RADIOTRON announces the RCA-956 acorn type super control r-f amplifier



pentode which reduces cross-modulation and modulation distortion. Operating at minimum bias 956 will give a voltage gain of 4 or more at a wave-length of 1 meter.

Coil Form

HAMMARLUND MANUFACTURING Co., INC. has developed a giant coil form for use in transmitters. It employs the low loss insulating material known as XP-53, such as is used in the SWF coil forms. No artificial coloring to cause losses. Forms are grooved ribbed to permit air spaced windings for maximum efficiency. Flexibility of mounting is a point stressed; the form may be permanently mounted by means of a special pair of brackets, or temporarily mounted in the familiar plug-in coil fashion, in the regulation socket. Hammarlund Mfg. Co., Inc., 424 W. 33rd. Str., New York City.

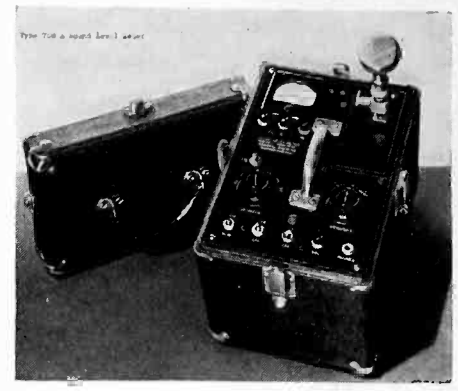
Analyzer

AN A-C BRIDGE and condenser analyzer combination for the radio serviceman has been announced by the Tobe Deutschmann Corporation, Canton, Mass. The particular features of the instrument are the points that in addition to the usual dynamic tests for shorts, opens, and intermittent condenser conditions, power factor can be read directly, and capacities measured with greater precision than on ordinary capacity meters. It also functions as a resistance bridge.

Built-in neon tube for direct condenser check, with 6E5 electric eye null indicator for bridge balance. Also uses one 01A tube. Resistance range: 1 ohm to 1 megohm. Capacity range: 10 $\mu\mu$f to 100 μf.

Measuring Instruments

General Radio Company, in its September-October issue of "The Experimenter" announces the release of three new products. Type 620-A, a terrodyne frequency meter and calibrator is designed for frequency measurements above 10 megacycles by using harmonic methods, however, the entire range of frequencies between 300 kc. and 300 mc. can be covered. The accuracy of measurement is 0.1%, or better. Price, rack mounted model $490.00; cabinet model $555.00.



Type 759-A sound level meter permits measurements to be made in the range from 24 to 130 decibels above the standard reference level of 10^{-16} per sq. cm. at 1000 cycles. Price, including tubes and batteries $195.00.

Type 487-A megohmmeter applies the principle of the ohmmeter to resistance measurements in the megohm range. A vacuum tube voltmeter is the indicator. Between 200,000 ohms and 5,000 megohms, the accuracy is 5%. The top range is 50,000 megohms. Price, including tubes $95.00.

Carrier Shift Indicator

The Supreme Model 565 carrier shift indicator is now available to amateurs and experimenters. It is reasonable in price but sufficiently versatile in function and accurate in results to serve as the principle means of indicating carrier shift, over-modulation, and serve as a monitor. It covers five amateur bands, 1715 to 200 kc., 3500 to 4000 kc., 7000 to 7300 kc., 14,000 to 14,400 kc. and 28,000 to 30,000 kc. It can be operated as an over-modulation indicator, a carrier shift indicator, to ascertain improper bias, excitation, impedance, etc., an absorption type wave meter, a listening monitor, an indicator of proper neutralization, a resonance indicator during tuning process, an indicator when adjusting the transmitting antenna and as a field strength indicator. A-c and d-c volt and d-c milliampere ranges of 0/7/35/-140/350/700/1400. Power supplied from batteries which are self-contained. Portable, flexible and accurate. A-c volts circuit calibrated at 60 cycle frequency unless otherwise ordered, at slight additional cost. List price $26.95. Supreme Instruments Corp., Greenwood, Mississippi,

Self-contained Phototube Relay

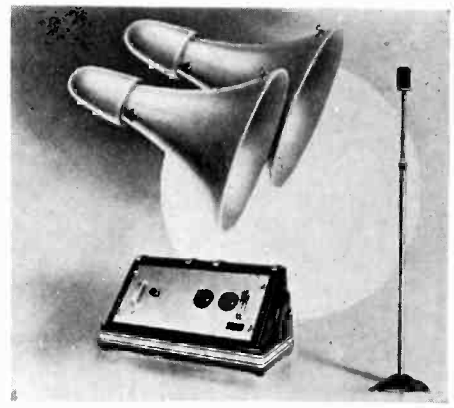
THE TELETOUCH CORPORATION, 37 West 54th St., New York City, announces a self-contained phototube relay, in which both the light source and the phototube are mounted. No separately-mounted light source is required, the light being reflected by a passing object into the phototube, a feature which greatly adds to the convenience of the device. An earlier model, which made use of a separate amplifier, and required the services of an electrician for installation, was used principally for window-lighting purposes. The latest model contains amplifier and sensitive unit in the same casing, and can be installed simply by plugging into the light-socket. The device is called the "Teletouch Ray".

Mirrophonic

AT A RECENT sales convention of Electrical Research Products, Inc., at the Hotel Pierre, New York City, a new system for sound reproduction in the theatre was displayed. It has a film pulling mechanism known as the "Kinetic Scanner" in which a damped mechanical impedance provides uniform film velocity. It also has an improved optical system in which a physical slit is replaced by a cylindrical lens combination. A harmonic suppressor in the amplifier increases the dynamic range appreciably. The speaker system resembles that used in the Western Electric Stereophonic three-dimensional sound demonstration in which Leopold Stokowski took part.

Outdoor Public Address System

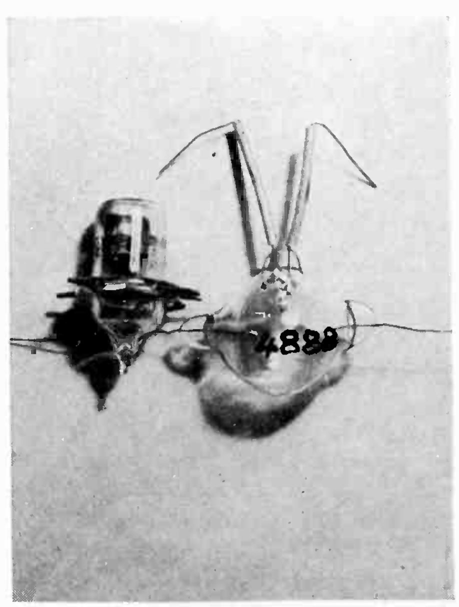
The Techna Corporation, 926 Howard Street, San Francisco, California, is now ready to market a complete outdoor public address system including



microphone, amplifier, and two exponential horn type dynamic speakers. The amplifier is mounted in a metal cabinet identical to Techna 21J. The 15-Watt beam power amplifier provided for use with the 21J series incorporates all the features of advance public address design and includes the use of the new 6L6 beam power tube. Type 21J4, price $230.00.

Thermocouples

Rawson Electrical Instrument Company of Cambridge, Massachusetts, approached several years ago by MIT professors developed thermocouples for



radio frequency measurements. These converters of heat into electricity have no frequency error up to 60–70 Mc. They measure currents from 5 ma. to 1 ampere. The couple is iron-constantan. They are now offered for general sale at $15 each.

Rectifilter

For supplying d-c power for speech amplifier filaments in broadcast stations, motion picture theaters, motion picture studios, public address and centralized radio systems, Raytheon has developed a line of battery eliminators known as Rectifilters. They produce d.c. from 110 volts a.c. Experience in two hundred installations indicates that these units not only take the place of batteries but are sometimes superior in results obtained. Their cost is less because of their long life; the service is less than on batteries.

An essential design feature is the stabilized d-c output. A special circuit is used which holds the d-c output substantially constant regardless of the load. Another feature is the high degree of smoothing employed. The ripple (a-c) component) remaining in the d-c output is only –80 db and this may be reduced to –120 db through the use of an auxiliary filter.

The most popular Rectifilter is the 12 volt model which has been made in sizes from 1 to 18 amperes with prices varying from $90 to $216.66 to the user.

Further details and prices may be obtained by requesting Bulletin DL48-118 from the manufacturer, Raytheon Manufacturing Company, Electrical Equipment Division, 100 Willow Street, Waltham, Massachusetts.

Crystal Frequency Monitor

TYPE GC crystal frequency monitor designed by Westinghouse to fill a need for general utility tool in the ultra-high frequency communication field. It is a single portable unit of convenient size for carrying. May be used for the accurate adjustment of all transmitters

of a system to the desired frequency and for positive alignment of the oscillator, i-f and r.f. stages of receivers to the transmission frequency. It may also be used for the crystal monitoring of transmitter frequency as aural monitoring of transmitter quality. Manufactured by Westinghouse for the Gamewell Co., Newton, Mass.

Marker

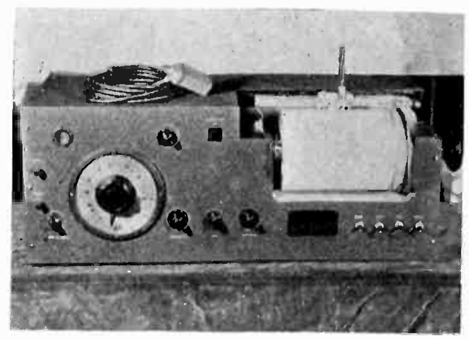
AN INGENIOUS portable electric tool which can be used for marking on practically any material, metal or insulated, is available from the Ideal Commutator Dresser Company, Sycamore, Illinois. It consumes 75 watts from 110 volts, 60 cycles, can be used for writing on dies, tools, glassware, drafting room instruments, etc.

Molded Paper Condenser

THE NEW SOLAR molded paper condenser has just been introduced to the trade. It is a paper condenser, encased in Bakelite molded into "domino" shape, and carries the trade name "Domino." This unit is completely insulated and is mechanically and electrically stronger than the tubular type which they replace. They range in capacity from .001 mfd. at 1000 working volts to .25 mfg. at 200 volts. Solar Manufacturing Corporation, 599 Broadway, New York City.

Automatic Recorder

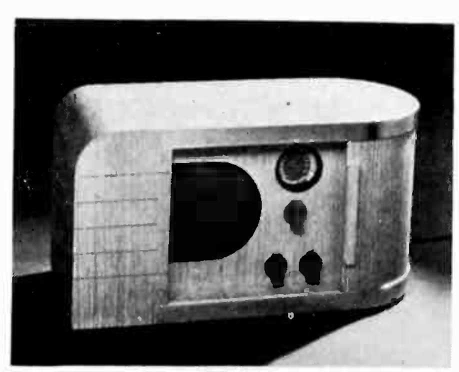
A NEW CONTRIBUTION to acoustical measurements was shown publicly for the first time at the IRE Rochester Convention by Tobe Deutschmann Corp., Canton, Mass. This is a practical means of analyzing loud speakers or microphone performance under normal working conditions producing a rapid graphic record capable of being checked at any point accurately. It consists of an amplifier and a beat frequency oscillator coupled to a cylindrical drum carrying the recording chart. The oscillator is continuously variable from 40 to 12000 cycles. The



frequency calibration is approximately linear and the amplifier produces sufficient output to operate directly the recorder controls and actuate the pen. Output variations over a 40 db. range can be recorded. This range can be covered in approximately 1 second and the time required for recording of the complete frequency range can be controlled from 1 minute to approximately ten minutes.

Silent Radio

THIS LONG AWAITED paradoxical device developed by Dictograph Products Co., Inc., 580 Fifth Ave., N. Y. City, solves the radio problem in the home or hotel where one may want to listen but others may not. By means of a loudspeaker the output may be heard by any number of listeners, or the sound may be



directed to a single individual by means of bone conduction. This radio should have application in offices and has been recommended by police officials for taxicab riders' use. The radios will be made by well known set manufacturers under license from Dictograph.

Index to electronics—Volume IX

January to December issues, inclusive, 1936

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Television:

Tubes:

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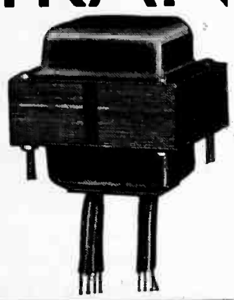

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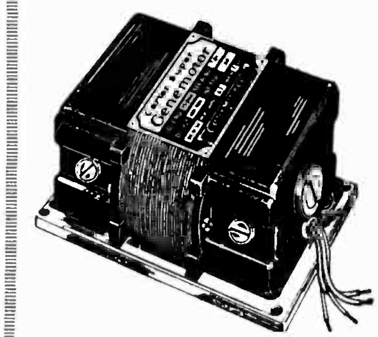

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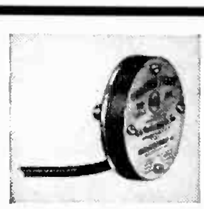

1 RCA Vibration Pick-Up uses a piezo-electric crystal which when vibrated produces an A.C. voltage of similar frequency. Permits determining plane of vibration, frequencies and amplitudes. $20

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INDEX TO ADVERTISERS

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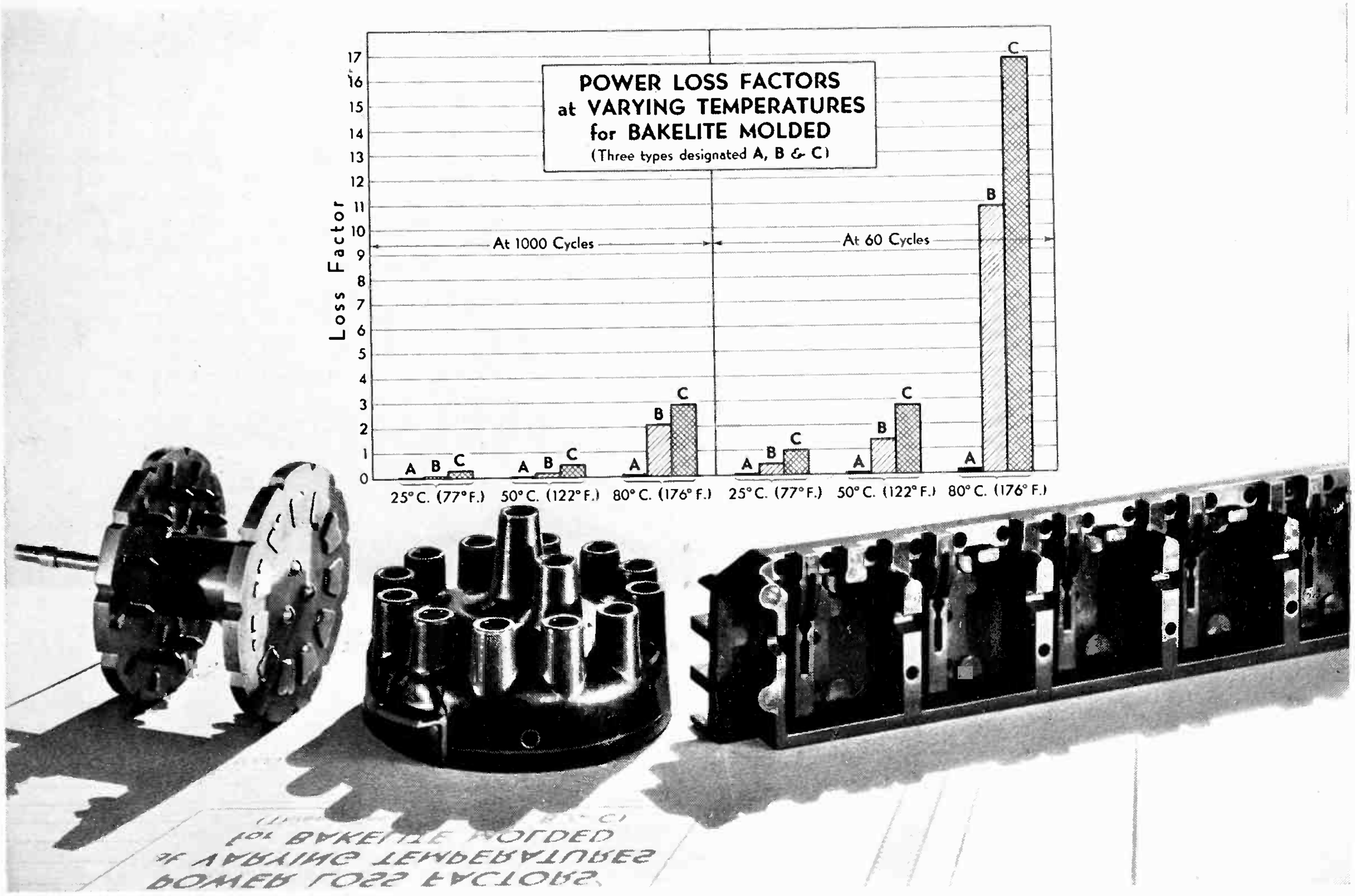

THE various temperatures at which any electrical device may be called upon to operate—and the variations in electrical frequency, as well—must be carefully considered in selecting dielectrics. Unless power loss of the material remains consistently low throughout the entire range of working temperatures and frequencies, practical efficiency of the device may suffer appreciable losses.

In Bakelite Molded, engineers and designers have available several different dielectrics with differing electrical properties. The diagram, reproduced above, shows a few critical values for the power loss factors of three types of Bakelite Molded. It indicates how well Bakelite Molded meets power loss requirements in nearly any practical range of temperatures and frequencies.

The numerous types of Bakelite Molded now available also provide similar useful variations in other important electrical, mechanical and chemical characteristics. Through proper selection, appropriate combinations may be obtained to meet countless needs of the engineering designer. Our engineers would welcome an opportunity to cooperate with you in determining the type of Bakelite Molded best suited to your needs.

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BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

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Ruggedness
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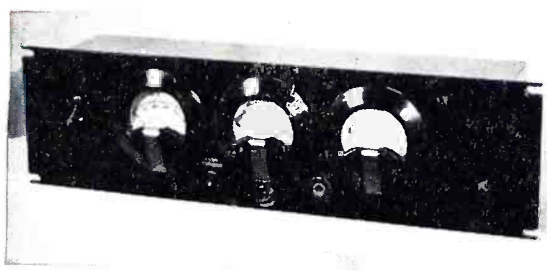
This desire for the finest is fulfilled in RCA's new speech input equipment shown on this page.

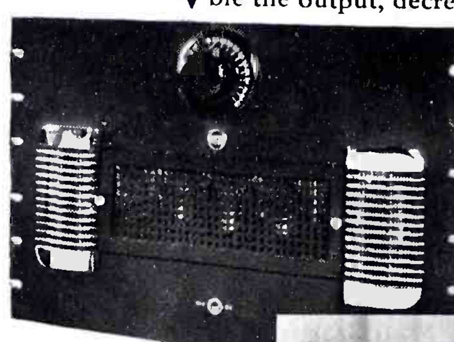
RCA equipment has attained superiority by virtue of its quality and performance characteristics. An overwhelming majority of broadcasting studios using RCA equipment prove this. And as the leader in this field RCA offers you this new equipment confident that its performance will make today's finest broadcasting stations even *better* tomorrow. Complete technical information and literature are yours for the asking. Simply write to the address below. No obligation.

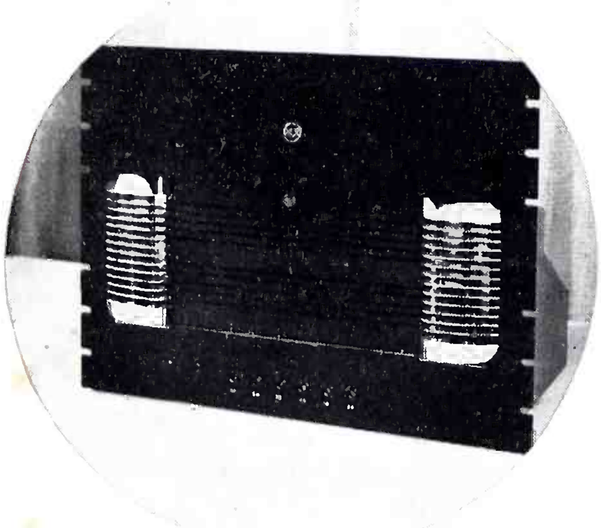
↑ "Tops" in meter and switching panels . . . This four-position mixer panel includes 4 wire-wound balanced ladder attenuators. Key switch with each meter provides extra input circuits—either remote lines, transcription circuits, or additional microphone circuits.



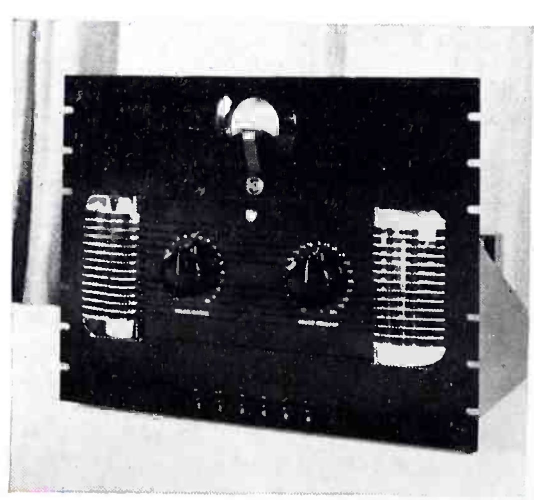
← Extremely Modern Meter Panel 15-C . . . Has new, streamlined meter cases with illuminated dials. D.C. Volt Meter, 0-250 volts. Milliammeter, 0-10 M.A. A.C. Line Volt Meter, 0-150 volts.

High Fidelity Monitoring Amplifier, Type 94-C . . . An improvement over popular RCA Type 4194-B, with double the output, decreased distortion, double the gain (sufficient for direct operation from transcription equipment). Advanced mechanical design and improved appearance. Greater accessibility and better ventilation. New type volume control which may be remotely located in control console for convenience. ↓

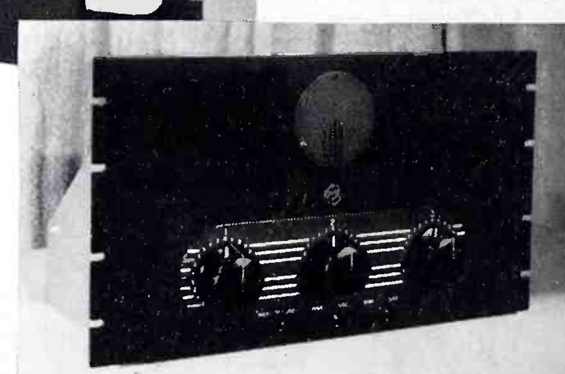




← Advance Designed Pre-Amplifier, Type 41-C . . . Panel door in front opens to provide quick and easy access to all tubes. Has hinged chassis construction and easy accessibility to wiring and component parts.



Program Amplifier Type 40-D . . . With new "peak reading" volume indicator and illuminated volume indicator meter. An improvement over popular RCA Type 40-C, having better accessibility, more ventilation, increased volume indicator range and push keys for instant individual tube metering. →



↑ New Tri-Amplifier Type 58-A . . . Something entirely new in speech input units, providing pre-amplification of 3 microphone outputs, high level, three-position mixing system, switching of three extra 250-ohm inputs. Unexcelled high-fidelity performance characteristics.

RCA Broadcast Equipment

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