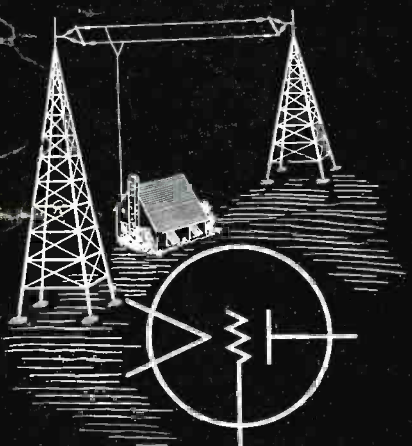
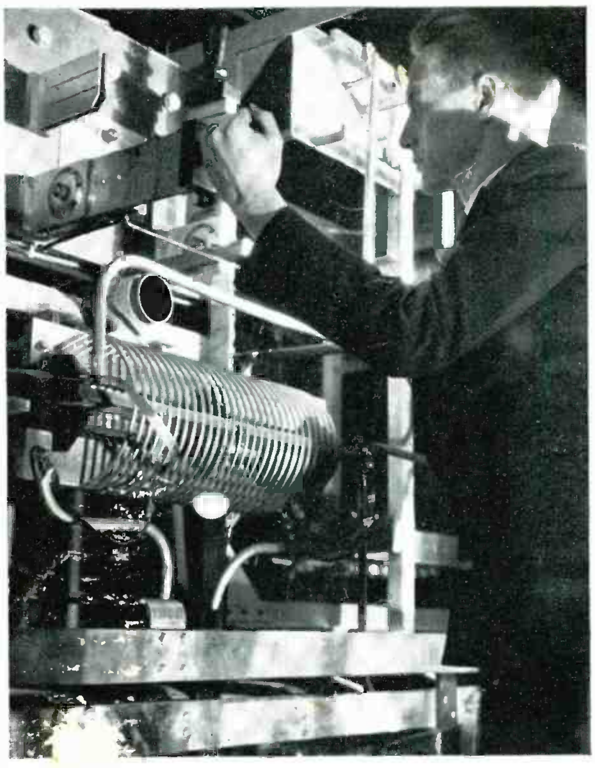
MAY, 1934

Radio Engineering





VOL. XIV NO. 5

The Journal of the Radio and Allied Industries

An Open Letter to Radio Tube Manufacturers

May 15, 1934

Dear Mr. Tube Maker:

Have you been operating your plant for many months at little or no profit - possibly even at a loss? Have you been wondering for some time how you could meet the increased costs imposed on your business by various codes and turn your losses into profit - or increase your profits?

If so, we offer you a positive solution to your problems in the form of a fine, pure metal for internal vacuum tube parts at half the cost! Because of its purity it is more uniform and reliable. It is lighter in weight. It has a higher heat resistance. It has less occluded gas. It welds more easily and may be adapted to any shape, form or condition. It may be had in softer temper for deep drawing, bending and forming. It has a higher heat conductivity and getter cups flash better. Plates are more rigid - yet will withstand more heat. Less gas means less ionization and longer life. Thus you may produce a tube of greater uniformity, strength, efficiency and life.

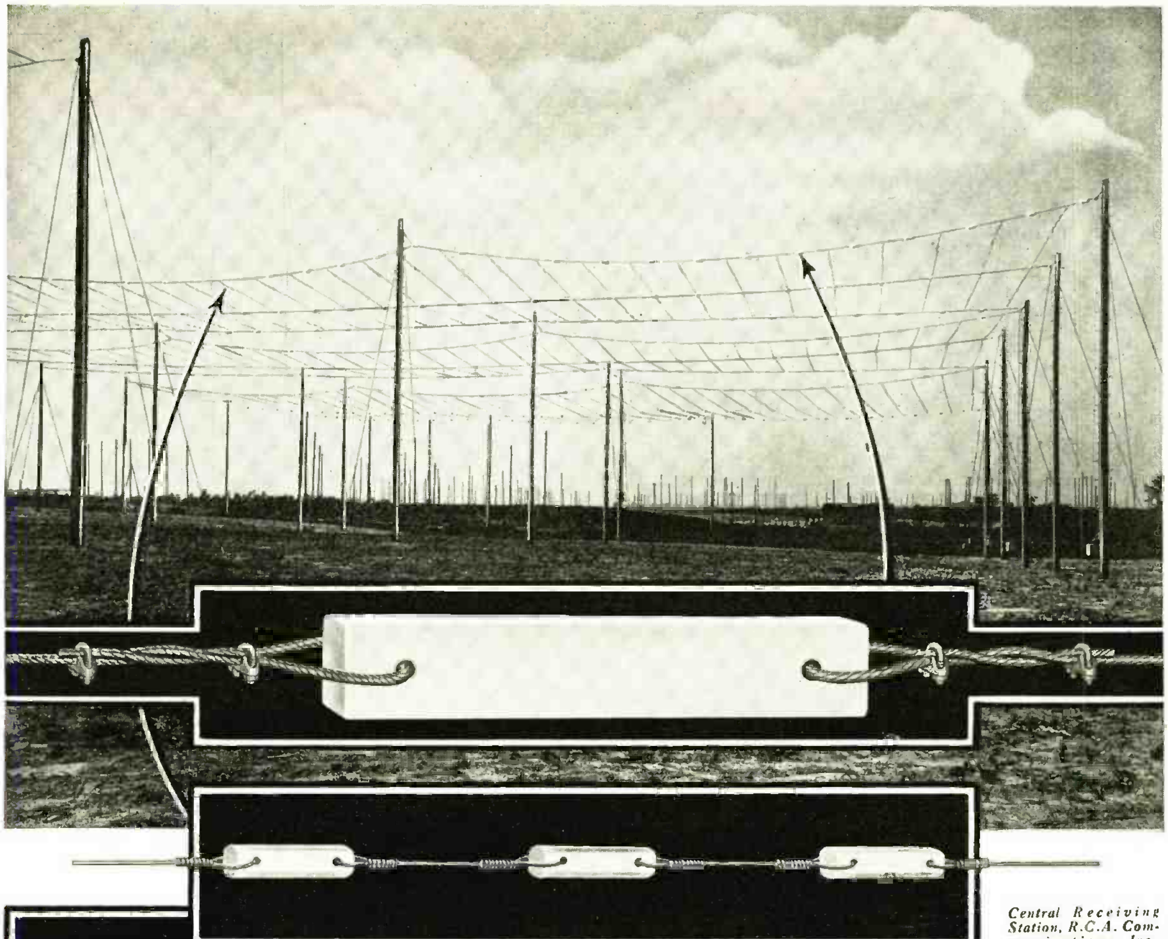
There is an old saying that the best is cheapest in the long run but it is not often that the cheapest is best in the long run. This is true of the new metal. If you are using 25,000 lbs. of strip and wire in a year, your saving in cost will be about $12,000 annually. If you are buying 120,000 lbs. you can save over $60,000 a year. This is quite a lot of money and worthy of your serious consideration!

Frankly, wont a better material that will save you from $1,000 to $5,000 a month (or more) help to turn your losses into profit or increase your profits handsomely?

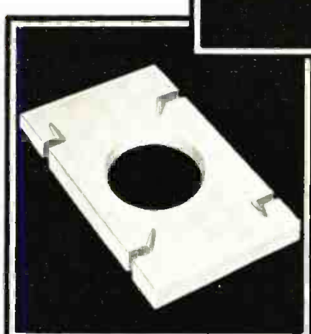
If you agree, please get in touch with us so that you may benefit from the use of this new material - SVEA METAL.

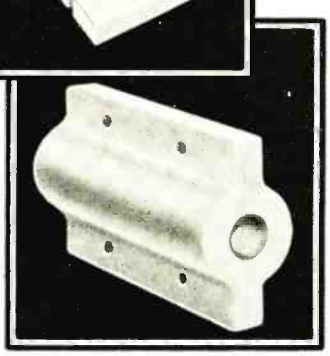
Very truly yours,

SWEDISH IRON & STEEL CORPORATION
17 Battery Place - New York City



Central Receiving Station, R.C.A. Communications, Inc., Riverhead, Long Island, N. Y.





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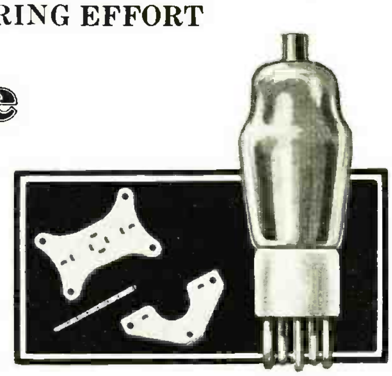
IT insulates the antennas of the world's greatest radio communication system. From antenna to vacuum tube component it guards against high frequency losses throughout the circuit of commercial short wave radio transmitters and receivers.

Just as ISOLANTITE has contributed to the success of commercial radio communication . . . so it will contribute to more efficient and dependable all-wave receivers for the home and hence their wider public acceptance.



Isolantite Inc.
FACTORY *at* BELLEVILLE *New Jersey*

New York Sales Office 233 Broadway

RADIO ENGINEERING

Reg. U. S. Patent Office

Editor
M. L. Muhleman

Member
Audit Bureau of Circulations

Associate Editor
Ray D. Rettenmeyer

Vol. XIV | MAY, 1934 | Number 5

CONTENTS

DEPARTMENTS

RMA CONVENTION

In fitting celebration of the tenth "birthday" of the RMA in Chicago next month, plans have been completed for a large "radio family" formal banquet on June 13 during the joint conventions of the RMA and the Radio Wholesalers Associations.

The entire radio industry, RMA and RWA members, non-members, ladies and other guests are invited to the Tenth Anniversary Banquet of the RMA, to be held Wednesday evening. June 13, in the Grand Ball Room of the Stevens Hotel.

Trade promotion plans of comprehensive and national scope, to stimulate sales of dealers and jobbers as well as manufacturers will be prominent on the program of both RMA and RWA meetings.

A feature of the RMA convention will be a gathering of many radio pioneers who have served under the RMA banner during the past decade.

●

Bryan S. Davis
President

Jas A. Walker
Secretary

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EDITORIAL

ALL-WAVE SETS

TO INFORM THE RADIO buying public as well as the trade, means to establish identification of "all-wave" and other receiving sets have been adopted by the RMA. The object is to definitely classify the new and improved receivers, to avoid misrepresentation and to facilitate merchandising of sets.

Nomenclature and frequency ranges for a standard broadcast receiving set, the "all-wave" receiver and the "standard and short-wave," or "dual-wave" receiver, were adopted by the RMA Board of Directors April 18, at Chicago, following recommendations from the Association's Engineering Division.

The "standard broadcast" receiver is defined to include sets having the regular frequency range from 540 to 1500 kilocycles.

The definition of the "all-wave" receiver applies to sets with frequency ranges from 540 kilocycles to at least 18,000 kilocycles.

The "standard" and "short-wave" or "dual-wave" receiver as defined by the RMA will apply to sets having frequencies between 4,000 and 20,000 kilocycles with a short-wave range covering a ratio of maximum to minimum frequencies of at least two and one-half to one.

The definitions outlined above were adopted by the RMA Board as the simplest possible to correctly advise the buying public and the trade. Detailed standards defining the nomenclature and frequency ranges of three types of receivers will be issued soon by the RMA Engineering Division.

The radio editors of newspapers and class magazines can assist immeasurably by interpreting these classifications for the public—more so, probably, than can the dealers. Efforts have already been made to acquaint the buyer with the underlying difference between "broadcast" and "short-wave" reception, and on the whole there has been a pleasing lack of hokum.

The magazine, *The New Yorker,* always with an eye to the whims and fancies of the city and suburban dweller, lists "short-wave radio" as the latest and most popular indoor sport. In a recent issue an associate writer recounted with considerable accuracy the classes of receivers available, what one might expect from each class, and generally what the buyer should keep in mind when looking over the market with a view to purchasing.

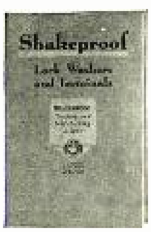
Some of the more active radio editors, with a clear understanding of short-wave reception, have published articles dealing with matters other than frequency coverage, listening times, etc. The public has been hearing a great deal from these men about the judgment of "all-wave" receivers by the number of points on the wave-changing switch, the size of the tuning dial and its scale, the ratio of the vernier control, and whether or not the receiver has one or more active tuned radio-frequency stages on the short-wave bands.

The public is learning to select these receivers. Most purchasers will look for the features listed above, and in time may demand even more than is being offered. Any general scientific item gets out of the laboratory and into the open market when it becomes convenient to operate. The greater the convenience, the more apt is the item to meet large sales. Such features as; a beat-frequency oscillator employed as a station finder; enlarged or magnified dial scales; mechanical band spreading; and tuning control panels made adjustable so that one may tune without fatigue, may have to be added before "all-wave" receivers become generally acceptable.

Manufacturers of "all-wave" and "dual-wave" receivers should place more stress on the advantages of a special antenna for short-wave reception. A noise-reducing aerial is almost a necessity in just those areas where the potential market is largest. Within the last month, two new types of "all-wave antenna systems" have been developed, both of which appear to be worthy of the name. These systems eliminate the necessity of employing two aerials for an "all-wave" set. Though they are not easily installed, the radio service man can erect them with no difficulty. The buyer should be informed of this by the manufacturer or dealer.

SHAKEPROOF

Tight Locking TERMINALS *that prevent* CIRCUIT FAILURES



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

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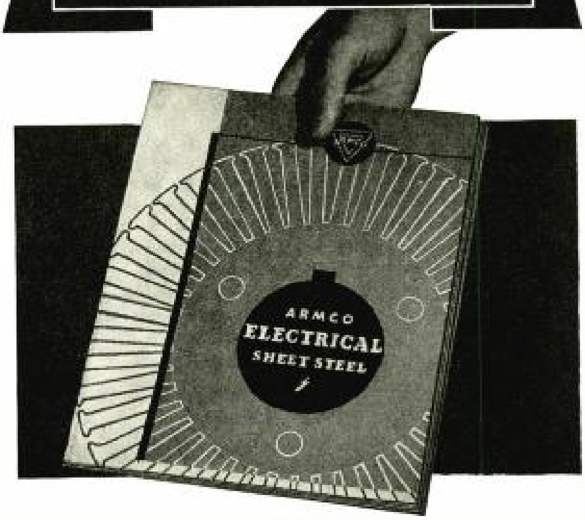

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RE-5-34

A close-up of several

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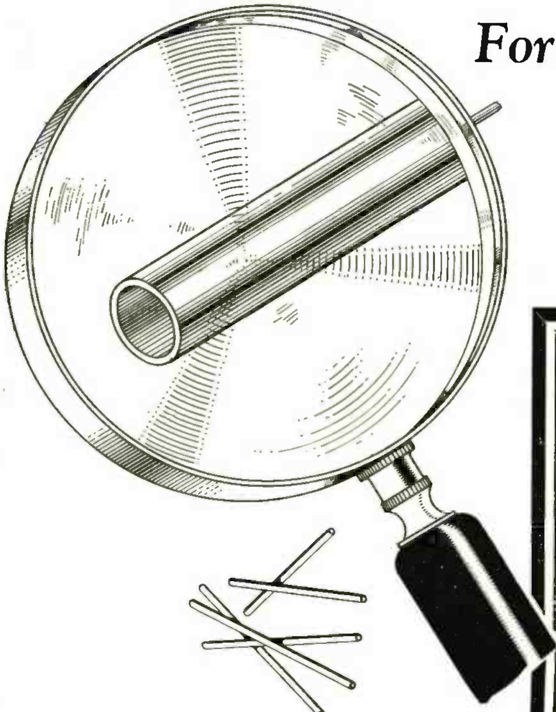
For Radio Tube Construction!



UNIFORMITY

All Summerill Seamless cathode tubes are uniform in density of material and accurate to size both in diameter and wall thickness. This permits the smoother application of the emissive coatings, insuring better operating, longer lived tubes.

RIGIDITY

The seamless construction of Summerill Cathode Tubing assures a greater mechanical strength and eliminates weak spots due to lap overs and crimping.

PURITY

Summerill Cathode Sleeves are made of the purest nickel commercially obtainable. The highest heat dissipation is achieved.

CAPACITY

Our modern plant and up-to-date manufacturing methods permit us to make Seamless Tubing of all types in any quantity you may require, on short notice.

SIZES

Standard sizes in Cathode Sleeves are from .016" outside diameter and larger with walls of .0015" to .002". We are prepared to cut to your length ready for assembly.

DELIVERY

The care used in making Summerill Cathode Sleeves extends to the shipping case, a container constructed to insure the tubes against damage in transit. There is no waste through crushing or bending. Each tube arrives in perfect condition, just as it was when packed.

A Few More Summerill Specialties

- Aircraft Tubing
- Hypodermic Needles
- Golf Shaft Tubing
- Fishing Rods
- Deisel Engine Feedlines
- Industrial Control and Bourdon Tubing
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- Stainless Steels and Other Alloy Tubes
- Condenser Tubing
- Refrigerator Tubing

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Bridgeport, Montgomery County, Pa. PHILADELPHIA DISTRICT

RADIO ENGINEERING

FOR MAY, 1934

Ninth Annual I. R. E. Convention

HOTEL BENJAMIN FRANKLIN • PHILADELPHIA • MAY 28-29-30

APPROXIMATELY TWENTY-EIGHT PAPERS will be delivered during the three days of the Ninth Annual Convention of the Institute of Radio Engineers, at the Hotel Benjamin Franklin, Philadelphia, Pa. They will represent to a great degree a gauge of the progress made during the last year or two in any number of divergent lines of radio and allied research.

A complete listing of the technical subjects to be covered, with their time of delivery, will be found on the following page. Included in this list are many subjects of particular interest in respect to commercial transmitter and receiver design, and other subjects offering indication of the direction being taken by many of our foremost engineering and research men.

The paper on the new WLW 500-kw transmitter includes data on the vertical radiator, with measurements comparing its performance to the performance of the standard "T" antenna formerly used. Also a description of the high-level Class B modulator producing audio-frequency outputs of 350 kw, the "isolation" operation of the control circuit and the concentric transmission lines.

Of special interest is the paper, "High-Fidelity Receivers With Expanding Selectors," by Wheeler and Johnson. It may be summarized as follows:

A high-fidelity receiver for general use requires means for continuously expanding or contracting the resultant band width of all the carrier selectors in order that the best compromise between fidelity and selectivity may be chosen for any given operation conditions. An expanding selector ("XPS") arrangement is provided whose expansion is controlled by moving the tuning knob in the axial direction. Tuning the receiver when the band width is expanded is generally undesirable because accurate tuning is difficult and the operator hears only part of the number of the available signals. Therefore, an interlocking mechanism is provided which permits the operator to tune the receiver only when the band width is contracted. The operator is thereby constrained to follow the correct procedure of first tuning with maximum selectivity and, secondly, expanding to improve the fidelity to the extent permitted by noise or adjacent channel interference. Several methods for expanding are available.

CONVENTION COMMITTEE HEADS

Standing left to right—E. B. Patterson, Entertainment; A. F. Murray, Exhibitor; Knox McThorin, Registration Information. Seated left to right—E. W. Engstrom, Papers Technical Session; H. W. Bylers, Treasurer; W. F. Diehl, Convention Chairman; Jesse Haydock, Publicity; E. L. Forstall, Program. Not in picture: Pierre Boucheron, Publicity; Mrs. W. H. W. Skerrett, Ladies' Committee Chairman; R. L. Snyder, Treasurer; Harry Sadenwater, Entertainment.

A companion subject, "Acoustic Testing of High-Fidelity Receivers," by Wheeler and Whitman, is treated from a fresh angle. Acoustic testing of radio receivers is most useful as an aid to designing the receiver to reproduce uniformly the required range of audio frequencies. The problem is fundamentally the coordination of transmitter pick-up and receiver reproduction, to give the listener the illusion of being present at the original performance. The mounting of the loudspeaker and its position in the listening room materially affect the sound reproduction. The resultant effect is readily analyzed in terms of the average sound in the listening room, as measured at several positions by means of a non-directional crystal microphone. Receivers designed on this basis are found to give excellent reproduction when the transmitter technique and other conditions are adequate for high-fidelity reception.

The principal difficulties in the design of high-frequency receivers reside in the complexity of the multi-range circuits. In the paper, "The Design and Testing of Multi-Range Receivers," by Harnett and Case, several circuits and a unit assembly arrangement are described which improve the frequency calibration and simplify the design. Testing is facilitated by the use of simplified signal generators having "piston" attenuators. The attenuator comprises a pair of coplanar coils, coaxial coils or condenser plates, one fixed and one movable axially in a moderately long cylindrical copper shield. The attenuation in decibels is directly proportional to the displacement of the movable element, and the calibration can be computed.

COMPLETE I. R. E. CONVENTION PROGRAM

SUNDAY, MAY 27.

Registration; 4:00 P. M.-6:00 P. M.

MONDAY, MAY 28.

9:00 A. M.:

Registration and opening of exhibition rooms for inspection.

10:00 A. M.-12 NOON:

Official welcome and technical session. Addresses by C. M. Jansky, Jr., President of the Institute; W. F. Diehl, Chairman of the Convention Committee; Harold Pender, Dean of the Moore School of Electrical Engineering, University of Pennsylvania, and W. R. G. Baker, Vice President and General Manager, RCA Victor Company, Inc.

TECHNICAL SESSION, CRYSTAL BALLROOM.

"A Lapel Microphone of the Velocity Type," by R. F. Olson and R. W. Carlisle, RCA Victor Company, Inc., Camden, N. J.

"Westinghouse KYW in Philadelphia," by R. N. Harmon, Westinghouse Elec. and Mfg. Company, Chicopee Falls, Mass.

"Nonlinear Theory of Maintained Electrical Oscillations." By B. Van der Pol, Philips' Incandescent Lamp Works, Eindhoven, Holland.

10:00 A. M.-12 NOON:

Official greeting at ladies' headquarters.

12 NOON-2:00 P. M.:

Luncheon and inspection of exhibits.

12 NOON-2:30 P. M.:

Ladies' luncheon and shopping tour.

2:30 P. M.-4:30 P. M.:

Trip No. 1—Ladies' inspection trip to WCAU studios.

2:00 P. M.-4:00 P. M.:

TECHNICAL SESSION, CRYSTAL BALLROOM.

"The WLW 500 Kilowatt Broadcast Transmitter," by J. A. Chambers, Crosley Radio Corp., Cincinnati, Ohio; G. W. Fyler, General Electric Co., Schenectady, N. Y.; J. A. Hutcheson, Westinghouse Elec. and Mfg. Co., Chicopee Falls, Mass., and L. F. Jones, RCA Victor Company, Inc., Camden, N. J.

"Comparative Analysis of Water-Cooled Tubes as Class-B Audio Amplifiers," by I. E. Mouromtseff and H. N. Kozanowski, Westinghouse Elec. and Mfg. Co., East Pittsburgh, Pa.

"Some Engineering and Economic Aspects of Radio Broadcast Coverage," by G. D. Gillett and Marcy Eager, Consulting Engineers, Washington, D. C.

3:00 P. M.-4:00 P. M.:

TECHNICAL SESSION, BETSY ROSS ROOM.

"Some Chemical Aspects of Vacuum Tube Production," by R. E. Palmateer, Hygrade Sylvania Corporation, Emporium, Pa.

"Contact Potential," by R. M. Bowie Hygrade Sylvania Corporation, Emporium, Pa.

"Hot-Cathode Mercury Rectifier Tubes for High Power Broadcast Transmitters," by H. C. Steiner, General Electric Co., Schenectady, N. Y.

4:00 P. M.-6:00 P. M.:

Annual meeting Sections Committee, Independence Room.

4:00 P. M.-6:00 P. M.:

National Association of Broadcasters, Engineering Committee Meeting, Lafayette Room.

4:00 P. M.-6:00 P. M.:

Inspection of exhibits.

8:00 P. M:

Trip No. 2—To the Franklin Institute.

TUESDAY, MAY 29.

9:00 A. M.:

Registration and opening of exhibition rooms for inspection.

10:00 A. M.-12 NOON:

TECHNICAL SESSION, CRYSTAL BALLROOM.

"Theory of Electron Gun for Cathode Ray Tubes," by I. G. Maloff and D. W. Epstein, RCA Victor Company, Inc., Camden, N. J.

"Cathode-Ray Oscillograph Tubes and Their Applications," by W. H. Painter, and P. A. Richards, RCA Radiotron Company, Inc., Harrison, N. J.

"The 'Sound Prism,'" by Knox McIlwain and O. H. Schuck, University of Pennsylvania, Philadelphia, Pa.

10:00 A. M.-12 NOON:

TECHNICAL SESSION, BETSY ROSS ROOM.

"A Mechanical Demonstration of the Properties of Wave Filters," by C. E. Lane, Bell Telephone Labs., Inc., New York.

"Control of Radiating Properties of Antennas," by C. A. Nickle, R. B. Dome and W. W. Brown, General Electric Company, Schenectady, N. Y.

"Measurement of Harmonic Power Output of a Radio Transmitter," by P. M. Honnell and E. B. Ferrell, Bell Telephone Labs., New York City.

"Frequency Standards and Frequency Measuring Equipment," by J. K. Clapp, General Radio Co., Cambridge, Mass.

"North Atlantic Ship-Shore Radiotelephone Transmission During 1932-1933," by C. N. Anderson, Bell Telephone Labs., Inc., New York City.

12 NOON-5:00 P. M.:

Trip No. 3—Ladies' luncheon and bridge at the Pennsylvania Athletic Club.

12 NOON-3:00 P. M.:

Trip No. 4—To RCA Victor plant, Camden. Luncheon will be served at the plant through the courtesy of the RCA Victor Company.

3:00 P. M.-5:00 P. M.:

TECHNICAL SESSION, CRYSTAL BALLROOM.

"An Experimental Television System,"
Introduction—E. W. Engstrom.
Transmitter—R. D. Kell, A. V. Bedford, M. A. Trainer.
Relay Circuit—C. J. Young.
Receivers—R. S. Holmes, W. L. Carlson, W. A. Tolson.
RCA Victor Company, Inc., Camden, N. J.

3:00 P. M.-5:00 P. M.:

RMA Service Managers' meeting, Independence Room.

7:00 P. M.:

Informal Banquet.

WEDNESDAY, MAY 30.

9:00 A. M.:

Registration and opening of exhibition rooms for inspection.

10:00 A. M.-12 NOON:

TECHNICAL SESSION, CRYSTAL BALLROOM.

"The Design and Testing of Multi-Range Receivers," by D. E. Harnett and N. P. Case, Hazeltine Corporation, New York.

"High-Fidelity Receivers with Expanding Selectors," by H. A. Wheeler and J. K. Johnson, Hazeltine Corp., New York.

"Acoustic Testing of High-Fidelity Receivers," by H. A. Wheeler and V. E. Whitman, Hazeltine Corp., New York.

"A Common Source of Error in Measurements of Receiver Selectivity," by E. N. Dingley, Jr., Bureau of Engineering, Navy Dept., Washington, D. C.

10:00 A. M.-12 NOON:

TECHNICAL SESSION, BETSY ROSS ROOM.

"Recent Studies of the Ionosphere," by S. S. Kirby and E. B. Judson, Bureau of Standards, Washington, D. C.

"An Analysis of Continuous Records of Field Intensity at Broadcast Frequencies," by S. S. Kirby, K. A. Norton and G. H. Lester, Bureau of Standards, Washington, D. C.

"Modern Methods of Investigating Ionization in the Atmosphere," by G. L. Locher, Bartol Research Foundation, Swarthmore, Pa.

"Seasonal Variation in the Ionosphere," by J. P. Schafer and W. M. Goodall, Bell Telephone Labs., New York.

10:00 A. M.-5:00 P. M.:

Trip No. 5—Ladies' sight-seeing trip, including visit to Valley Forge, where luncheon will be served.

12 NOON-2:00 P. M.:

Luncheon and inspection of exhibits.

2:00 P. M.-4:00 P. M.:

TECHNICAL SESSION, CRYSTAL BALLROOM.

"Development of Transmitters for Frequencies above 300 *Megacycles,"* by N. E. Lindenblad, R.C.A. Communications, Inc., New York City.

"An Electronic Oscillator with Plane Electrodes," by B. J. Thompson and P. D. Zottu, RCA Radiotron Company, Inc., Harrison, N. J.

"Transmission and Reception of Centimeter Waves," by I. Wolff, E. G. Linder and R. A. Braden, RCA Victor Company, Inc., Camden, N. J.

Tube Metal Characteristics

BY
H. C. TODD
Engineer
SWEDISH IRON & STEEL CORP.

IN LESS THAN A season on tube production the objections to the use of Svea Metal have been dissipated. Many of the objections were imaginary, due as much to natural reluctance to change as to a confusion between Svea Metal and Swedish Iron. There were, of course, some real grounds for misgivings at first. Oxidation and carbonization presented two different problems for solution. They were no different from thousands of other problems which have long since been solved by intelligent engineers, but they did, nevertheless, serve for a time to delay progress with the new metal.

These two factors are worthy of special comment, supplementing what has already been written:

OXIDATION

As mentioned in previous articles, iron, however pure, will oxidize readily at ordinary temperatures unless certain elementary precautions are taken. A certain percent of oxide, of course, is bound to be the source of gas if it is permitted to remain on the plate, but any trace of iron oxide present on the surface of the plate will diffuse into the metal during bombardment. It is only necessary to exercise reasonable care that the metal does not come into contact with undue quantities of moist or fume-laden atmospheres between the time when the part is thoroughly cleansed in hydrogen and the time when it is mounted.

If a layer of oxide is permitted to collect on the surface of the plate, and remain, there is likely to be a gassy tube with, possibly, lower emission. An iron plate properly cleaned and placed on the mount with reasonable promptness will give a high emission and cause no trouble whatsoever. All of this refers mainly to primary plates.

For other internal tube parts an oxide coating on the metal does not seem to have an injurious effect and some engineers have expressed the definite opinion that it is beneficial for purposes of radiation. It is well known that tubes with oxidized nickel plates have been made, and are still being made, on a commercial scale. Many thousands of tubes containing Svea Metal plates which have been purposely oxidized are now on the market and tests of these tubes show them to be highly efficient and superior in many respects. The whole subject of oxidation may be summed up by saying that if there is any question as to the effect of iron oxides on the plates these may easily be avoided by simple precautions and proper bombardment. It is the writer's belief that the objections are prompted mainly by consideration of the appearance of the plates rather than by the injurious effects. It must be remembered that while some are objecting to the appearance of any oxides, others are purposely subjecting the metal to a uniform oxide coating which not only gives a uniform appearance to the part, but at the same time produces characteristics in the tube which are sought after and desired.

CARBONIZATION

As previously written, some considerable quantities of Svea Metal have been carbonized. A number of lots have been put through with excellent results comparable to any other carbonized material within the writer's knowledge. Several coils of carbonized strip have been sent to critical tube makers' laboratories for test purposes and approved. This strip has been run through the standard tube-making process, including stamping and forming into plates, and undergone bombardment in the tube, and the reports were entirely satisfactory.

When, however, it came to a reproduction of the strip, difficulties were experienced due to the fact that experimental lots had been made in a small unit without sufficient equipment to adequately control temperature regulations, time and treatment. Thus it has been found necessary to make many modifications to the original unit and add various controls which would enable the operator to repeat a previous operation. This work has involved some time and caused a considerable delay. The furnace, however, is now in operation and it is hoped and expected that carbonized strips will be available within a short period of time. There can be no doubt but that what has already been done so satisfactorily can be repeated with precision and accuracy with the new equipment.

The third of a series of articles relative to the characteristics of Svea Metal as compared to other materials, and its application in the manufacture of vacuum tubes. The important subjects of oxidation and carbonization are covered in detail.

With these two problems thus disposed of there remained only a third matter which had been a stumbling block to the immediate adoption of the material—namely, the difficulty of convincing those interested that *there is a tremendous difference between Svea Metal and Swedish Iron!* It was only after careful analyses and physical and chemical tests were made by the engineers themselves in their own laboratories that the wide difference between Swedish Iron and Svea Metal was demonstrated beyond a question. For the purposes of our readers, the writer wishes to state here that these differences may be summed up in a few words as follows:

STRUCTURE

All Swedish Iron is of *fibrous* structure—Svea Metal is of extremely fine *crystalline* structure. Swedish Iron contains slag, fairly high percentages of carbon, silicon, phosphorus, sulphur and manganese. Svea Metal contains no slag and its total impurities combined are less than four hundredths of one percent. Swedish Iron blisters badly at higher temperatures and, in fact, begins to blister when much heat is applied to it. Svea Metal, on the other hand, does not blister and may be heated up to 1,000 degrees C. without blistering. Swedish Iron, due to its method of manufacture, is very liable to contain air pockets or blow holes or pipings. Svea Metal is free from all such defects. Swedish Iron rusts quite readily. Svea Metal resists oxidation to a high degree and if properly treated will not oxidize under ordinary atmosphere conditions for several months. Swedish Iron contains a high percentage of occluded gas, whereas Svea Metal is practically free from this, having been thoroughly degasified in the process. Swedish Iron is merely a raw material made by the Lancashire process which is used as a *base* and *from which* Svea Metal is made by special processing.

METAL CHARACTERISTICS

Thus it may be understood that those who jumped to the conclusion that Swedish Iron could be applied to internal vacuum tube use were destined to

(*Continued on page* 19)

ACOUSTICS AND

By FRANK MASSA
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● A quantitative discussion of the acoustical requirements necessary for high-fidelity sound reproduction, with special references to frequency and volume range, amplitude distortion, resonance effects, studio and room acoustics.

INTRODUCTION

THE RADIO SET HAS long passed the stage of being considered a scientific toy and the past decade of development has enormously contributed toward giving radio a prominent place among the necessities of present-day civilization. Having achieved this position, it is only natural that more stringent demands are continuously being imposed upon the quality of reproduction.

Unfortunately, until relatively recent times acoustical engineering was not sufficiently developed to quantitatively determine and specify the conditions necessary for real high-fidelity reproduction; consequently, the use of the term served only to qualitatively state that the new equipment sounded better than the one which it was intended to replace. Today, however, we have reached a stage where we are capable of quantitatively specifying most of the conditions necessary for high-fidelity reproduction. It is the purpose of this paper, therefore, to give some quantitative idea regarding the various factors that are involved in connection with the faithful reproduction of speech and music.

A list of such factors that are definitely known to influence the quality of reproduced sounds is given below, and each item will be briefly discussed in this paper.

A. Frequency range.
B. Volume range.
C. Amplitude distortion.
D. Resonances in the system.
E. Acoustical characteristics of the studio and the reproducing room.
F. Volume level of reproduction vs. volume level of the original sound.
G. Binaural effect.

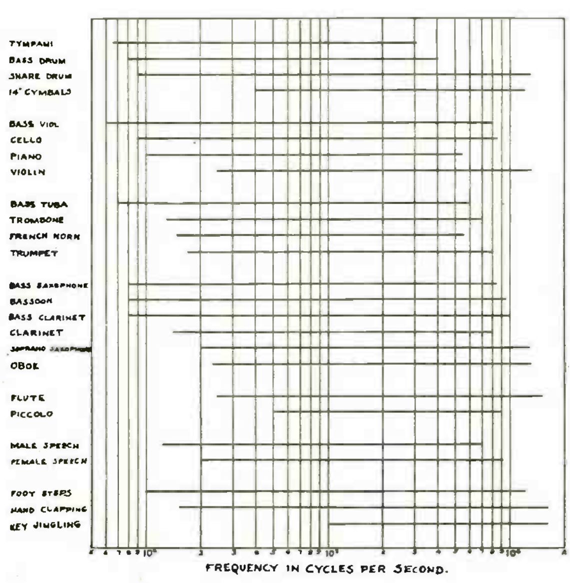

Fig. 1. Showing the frequency range required for the faithful reproduction of various musical instruments, speech, and noises. (after Snow)

(A) FREQUENCY RANGE

Frequency range is undoubtedly the most important single factor in the determination of the merits of a reproducing channel. Today, it is well known that the human ear can recognize as sound, vibrations varying from 20 cycles per second to 20,000 cycles per second. Obviously, this complete range of frequencies is not always necessary for certain types of reproduction. For example, the ordinary telephone manages to get along with a frequency range of approximately 500 to 1500 cycles. Although this range is only a very small part of the audible range, the intelligibility of speech over the telephone is fairly satisfactory; however, the characteristic of the reproduced voice is far from that of the original.

Many investigators have tried to get a quantitative idea of the frequency range necessary to reproduce various types of sounds so that the reproduction could not be recognized from the original source. The most comprehensive study has been published by W. B. Snow,[1] in which the effect on the quality was observed, by a group of persons with normal hearing, when various portions of the frequency range were cut out from the reproduced sounds.

Fig. 1 shows the results of such a test. It is interesting to note from the figure that noises such as footsteps, hand clapping, key jingling, etc., require frequencies above 10,000 cycles for faithful reproduction, while most instruments and speech are faithfully reproduced when the high-frequency limit is less than 10,000 cycles. Most of the sounds shown in the figure do not require less than 80 cycles for their faithful reproduction. The bass viol and organ (which is not included in the instruments tested) require frequencies extending down almost to the lower limit of audibility.

To faithfully reproduce male speech, a frequency range of 120 to 7000 cycles per second is necessary, while for female speech, a range of 200 to 9000 cycles is required.

In addition to the results shown in

[1] W. B. Snow, "Audible Frequency Ranges of Music, Speech and Noise," J. Acous. Soc. of Amer., July, 1931, p. 155.

HIGH FIDELITY

Fig. 1, an 18-piece orchestra was also investigated under similar conditions and the effect on the quality caused by removing high and low frequencies is shown in Fig. 2. The author's own experience has shown that the large majority of listeners could detect a change in quality in reproduced music when the frequency range was made less than 80 to 8000 cycles. Certain types of selections required up to 10,000 cycles for satisfactory reproduction and for noises such as paper tearing, key jingling, etc., a range up to 14,000 cycles was necessary.

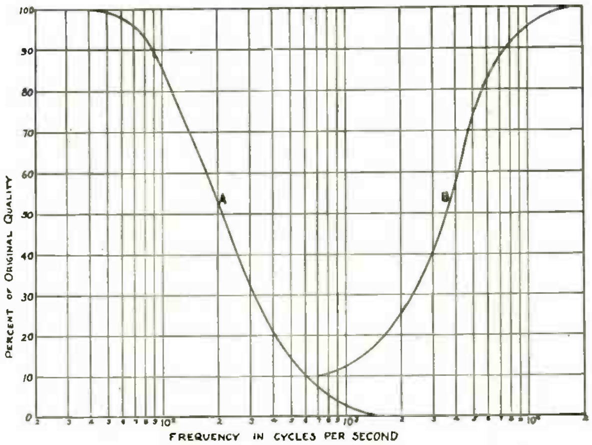

Fig. 2. Showing the effect of removing high and low frequencies on the quality of reproduced orchestral music. (A) All frequencies below abscissa removed. (B) All frequencies above abscissa removed. (after Snow.)

(B) VOLUME RANGE

By volume range in speech and music, we mean the ratio between the highest and lowest values of acoustic intensities produced by the sources of sound under normal conditions. The range of intensities capable of being recognized by the human ear as sound varies with frequency,[2] it being about 80 decibels at 100 cycles and about 110 to 120 decibels in the range of frequencies between 500 and 12,000 cycles. Obviously, it is apparent that a range of 120 decibels is not required for the reproduction of ordinary speech and music, since we are aware that the common types of sounds never reach the threshold of pain under normal conditions.

The peak speech power measured for a large number of spoken syllables shows that the volume range required for speech reproduction,[3] if it were possible to hear just above threshold intensity, to be about 50 decibels. In most rooms, the existing noise (which even in the most quiet living room is more than 20 decibels) does not permit hearing down to the threshold limit of audibility. Therefore, it is not necessary to reproduce down to the extreme low levels which would be masked by the room noise. A practical volume range necessary for high-fidelity reproduction of speech is about 40 decibels.

For musical reproduction the required volume range is higher than above. The absolute power outputs in different frequency bands for various instruments have been measured[4] and Table I shows some of the results that were obtained. From the tabulated data, it follows that to cover the peak intensities of the various instruments a volume range of about 70 decibels is required. The necessity for a noiseless environment for the enjoyment of this wide volume range is a very important requirement that must be met.

TABLE I

Peak Power of Musical Instruments

Instrument	Whole Spectrum Peak Power Watts	Corresponding % of Intervals	Band Containing Maximum Peaks	Band Peak Power Watts	Corresponding % of Intervals
36" × 15" Bass Drum—A	24.6	6	250-500 C.P.S.	9.8	1
36" × 15" Bass Drum—B	1.2	1½	20-62.5 250-500	0.24 0.19	1 4
30" × 12" Bass Drum—C	13.4	1	125-250	1.7	1
34" × 19" Bass Drum—D	4.9	3	20-62.5	1.2	9
Snare Drum	11.9	2½	250-500	3.7	1
15" Cymbals	9.5	7½	8000-11300	0.95	1
Triangle	0.050 0.012	1 37	5600-8000	0.017	6
Bass Viol	0.156	2	62.5-125 125-250	0.078 0.078	3 2
Bass Saxophone	0.288	25	250-500	0.228	4
BB♭ Tuba	0.206	17	250-500	0.082	18
Trombone	6.4	5	500-700 2000-2800	0.064 0.051	1 4
Trumpet	0.314	18	250-500 500-700	0.047 0.047	1½ 4½
French Horn	0.053	6	250-500	0.053 0.013	1 18
Clarinet	0.050	5½	250-500	0.0055	2½
Flute	0.055 0.014 0.0035	1 1½ 38	700-1000 1400-2000	0.0045 0.0045	4 2
Piccolo	0.021 0.084	10 ½	2000-2800	0.021	3
Piano-A, 1st Method	0.166	16	250-500	0.166	7
Piano-A, 2nd Method	0.437	16	250-500	0.437	7
Piano-A, 3rd Method	0.198	16	250-500	0.198	7
Piano-A, Average	0.267	16	250-500	0.267	7
Piano-B—Average	0.248	16	250-500	0.248	14
15-Piece Orchestra Av. of 2 Methods	9.0 2.2	1½ 16	250-500 2000-2800	0.45 0.32	1½ 12
18-Piece Orchestra Av. of 2 Methods	2.5	8	250-500 2000-2800	0.80 Not Taken	3
75-Piece Orchestra—A	8.2	6	125-250 250-500 2000-2800	0.82 1.03 1.03	2 12 1½
75-Piece Orchestra—B	13.4 66.5	9 1	250-500 8,000-α	6.7 5-3	1 1
75-Piece Orchestra—C	13.9	1½	250-500 2000-2800	1.4 1.4	6 1½
75-Piece Orchestra—D	13.8	6	125-250 250-500 2000-2800	1.7 1.7 1.7	2 11 1
Pipe Organ—A	3.5	1½	250-500	1.75 0.44	1 8
Pipe Organ—B	12.6	36	20-62.5	10.0 2.5	1 22

(C) AMPLITUDE DISTORTION

The study of permissible amplitude distortion that can be present without effecting the quality of reproduced

[2] Fletcher and Munson, "Loudness, Its Definition, Measurement and Calculation," J. Acous. Soc. of Amer., Oct., 1933, p. 82.

[3] L. J. Sivian, "Speech Power and Its Measurement," Bell System Technical Journal, Oct., 1929, p. 646.

[4] Sivian, Dunn and White, "Absolute Amplitudes and Spectra of Certain Musical Instruments," J. Acous. Soc. of Amer., Jan., 1931, p. 330.

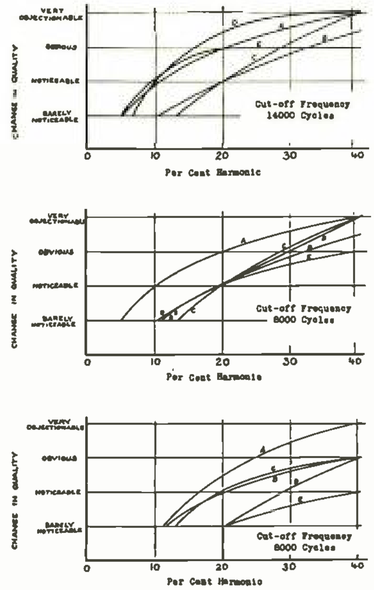

Fig. 3. Showing effect of harmonic distortion on the quality of reproduction of speech. (Single tube overloading, 2nd harmonic predominant). A, C and D are male speakers; B and E are female.

sounds has received very little attention. Some time ago, the author made a quantitative investigation of the allowable distortion in reproduced speech,[5] and definitely found that as the frequency range was increased the permissible distortion became less. Also, less third harmonic distortion could be tolerated than second harmonic distortion.

Figs. 3 and 4 show the change in quality for reproduced speech, with frequency ranges of reproduction up to 14,000, 8000 and 5000 cycles, as a function of second and third harmonic distortion. Each curve in the figures marked with a different letter represents a different speaker, and the system of rating adopted for the judgment of quality follows:

Barely noticeable—The amount of distortion which just began to produce a detectable change in quality (by comparing the distorted output with the undistorted output).

Noticeable—The amount of distortion which produced a detectable change in the quality of reproduction without comparing with the undistorted reproduction.

Obvious—The amount of distortion which could be definitely identified as such in the output (the distortion just becoming objectionable).

Very objectionable—The amount of distortion which is unbearable to the average listener.

From Figs. 3 and 4, the minimum distortion required to produce a noticeable change in the quality of reproduction is tabulated in Table II.

[5]F. Massa, "Permissible Amplitude Distortion of Speech in an Audio Reproducing System," Proc. I.R.E., May, 1933, p. 682.

(D) RESONANCES IN THE SYSTEM

In section A, the frequency ranges required for various sounds were shown without mention of the tolerable variations in the response throughout the range. We have found that if peaks rising more than 4 decibels above the average response level were introduced in a high-quality audio system they could be detected by several listeners, particularly if they were introduced in the mid-frequency range.

A particularly bad form of resonance is the so-called "cabinet resonance" which results when most cabinets containing loudspeakers are placed near a wall. The action of the cabinet is similar to that of a Helmholtz resonator which results in the amplification of a small low band of frequencies giving rise to a "barrel" effect in the reproduction. This type of resonance must be obviously overcome in a high-fidelity system. Several methods are available for solving this problem, such as enclosing the back of the cabinet (provided the volume of the enclosure is large enough not to resonate with the mass of the loudspeaker cone within the desired range of reproduction) and inserting absorbing material in the enclosure to prevent standing waves, or the use of "absorption resonators" which are "tuned" to the natural frequency of the cabinet and placed in the cabinet to absorb the excess sound pressure which would otherwise be set up.

Another form of resonance to be guarded against is that due to the reaction of a small room on the sound source at low frequencies. Sometimes a loudspeaker may be located in the room so that for a particular frequency the standing wave pattern set up may be such that the sound source is at a pressure loop, in which case the energy radiated will greatly increase. In some cases this may be corrected by changing the position of the loudspeaker or by increasing the absorption in the room.

(E) ACOUSTICAL CHARACTERISTICS OF THE STUDIO AND THE REPRODUCING ROOM

The building up of sound energy in a room due to multiple reflections from the walls is known as reverberation. The reverberation time, which is the time required for the sound energy in a room to decrease 60 decibels after the source is cut off, is the most important single factor in the acoustical design of auditoriums and studios. It is generally known that if the reverbation time is below a certain value, the quality of the reproduced sound is characterized as being "flat." If the reverberation time is above another value, the sound becomes "jumbled" and loses articulation or intelligibility. The range between these two limits is known as the optimum reverberation time and its value varies with the size of the room, the frequency, and the type of program being played. For example, the reverberation time required for music is usually higher than that required for speech.

In general, the optimum reverberation time of an auditorium must be higher at the lower frequencies than at the higher frequencies if the loudness of each tone is to decrease at the same rate. If the reverberation at the lower frequencies were not prolonged, the low-frequency sounds would die out faster than the high-frequency components, due to the non-linear relation between intensity and apparent loudness at the lower frequencies. It actually requires a smaller change in intensity at the lower frequencies than is required at the higher frequencies for the same change in loudness; thus to keep the low frequencies from dying away faster than the remaining components it is obvious that the low-frequency reverberation must be increased.

Numerical values for optimum reverberation times for different sizes of rooms and various frequencies may be found in an article by W. A. Macnair[6]

[6]W. A. Macnair, "Optimum Reverberation Times for Auditoriums," J. Acous. Soc. of Amer., Jan., 1930, p. 242.

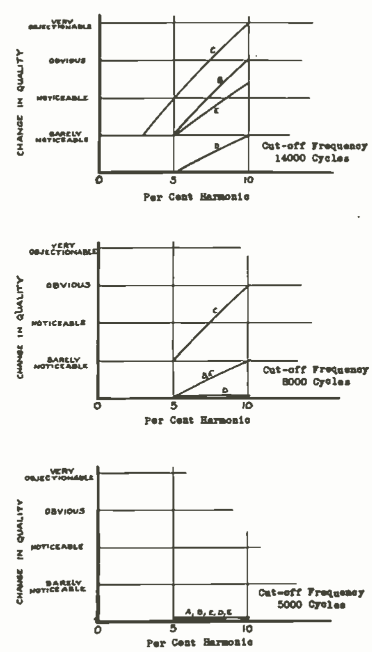

Fig. 4. Showing effect of harmonic distortion on the quality of reproduction of speech. (Push-pull overloading, 3rd harmonic predominant). A, D and C are male speakers; B and E are female.

in which he also gives the findings of other investigators.

If a room or studio is to be acoustically correct as a link in a high-fidelity system, reverberation time measurements should be made to cover the entire frequency range of the system. It often happens that materials show peaks or dips in their absorption characteristics either inherently in the material or else arising from the method of installation. In many instances the material is installed in panels which display natural periods of vibration resulting in reduced reverberation times at the resonant frequencies. Also, at the higher frequencies, there is absorption of sound in the air itself and this factor, too, must be taken into account in designing the acoustical characteristics of a room.

In the past, it was found that if an orchestra were playing in a broadcasting studio in which the reverberation had to be kept low, the musicians found it difficult to keep in tune. The "live end—dead end" studio was designed to remedy this trouble. In this type of studio, one end is left quite "alive," i. e., low absorption, while the remainder of the room is heavily damped with acoustical absorbing material. The orchestra is placed in the "live" end, where they find it very easy to play, and the microphone is located in the "dead" section of the studio so the effective overall reverberation is correct.

(F) VOLUME LEVEL OF REPRODUCTION VS. VOLUME LEVEL OF THE ORIGINAL SOUND

If speech or music is transmitted over a "flat" channel and reproduced at the same loudness level as the original source, the balance (i. e., the ratio of high to low frequencies) will be the same and hence the quality, in so far as frequency characteristic is concerned, will not be changed. If, however, the reproduced intensity of the sound is at a different loudness level than the original, frequency discrimination will occur due to the variation in the frequency response sensitivity of the human ear with changes in loudness. As the intensity level of the reproduced sound is decreased, the apparent decrease in loudness for the low-frequency components will be greater than the decrease in loudness for the high-frequency components and hence the quality becomes "thin" or lacking in low frequencies. The amount of frequency discrimination for a specific condition is obtained from Fig. 5. Assuming the source of sound to produce an average loudness level of 70 decibels, the frequency discrimination in the ear at this level is shown in curve A (Fig. 5). If the average level at which the sound is reproduced is 40 decibels, the frequency characteristic of the ear at this level is shown by curve B. The difference between the two curves (curve C) shows the loss in apparent low-frequency response due to reproducing a 70-db source at a 40-db level.

In order to keep the same relative proportions of high and low frequencies when the sound is being reproduced at the low level mentioned above, it is obvious that the amplifier characteristic must be as shown on the 40-db curve

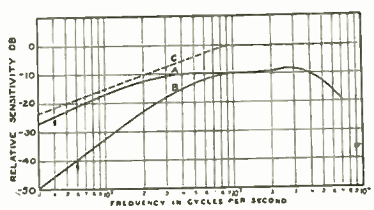

Fig. 5. Curve A shows relative loudness of a constant-intensity sound 70 db above threshold; curve B the same for 40 db above threshold. Curve C shows decrease in loudness occurring at various frequencies when a sound source of 70-db level is reproduced at a 40-db level.

in Fig. 6. In the same figure are shown the compensations required for reproduction at 50- and 60-db levels as well. Thus it is obvious that to maintain the proper frequency balance in sounds which are reproduced at relatively low levels, the low-frequency sensitivity of the amplifier must increase as the volume is decreased in the manner indicated in Fig. 6.

(G) BINAURAL EFFECT

In all the foregoing discussions, the conditions which were specified may be termed the one dimensional requirements for high-fidelity reproduction. Another requirement that must be met is that of binaural reproduction. When

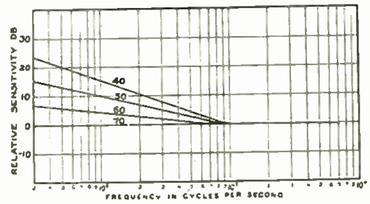

Fig. 6. Increase in low-frequency sensitivity required in an audio system at the various loudness levels of reproduction marked on the curves. (Loudness level of original source = 70 db.)

the original source of sound is being heard by a human being, his two ears permit him to discriminate against undesired sounds as well as to locate the positions of the various components. In general, when the sound is reproduced over a single channel, the ability to discriminate among the various components enormously decreases and the reproduction appears "cramped."

If two microphones placed in the ears of a dummy are used for picking up the source of sound and each microphone output is transmitted over a separate channel, each of which supplies power to an earphone placed on the same ear as the microphone is placed on the dummy, the reproduction will have a binaural effect. An alternative method employs several channels, each connected to a loudspeaker arranged in the same relative position at the point of reproduction as the microphones occupy in the studio. This latter method effectively transfers the sound sources to the listening room, spreading them out more or less in the same manner that they appear in the studio. The main disadvantage to the above systems of binaural reproduction is the requirement of more than one transmitting channel.

By employing directional sound-collecting and sound-dispersing systems, it is possible to discriminate against undesired sounds and to reduce the effective reverberation with a single transmitting channel, thereby approaching the conditions obtained in a binaural system. For the details of the operation and possibilities of this system, the reader is referred to a comprehensive paper[7] on the subject which is soon to be published in the *Journal* of the Society of Motion Picture Engineers.

SUMMARY

From the brief discussions given above, we may conclude that the following acoustical requirements must be met for high-fidelity reproduction:

1. The frequency range must never be less than from 80 to 8000 cycles, and,

(*Continued on page* 19)

TABLE II
Per Cent Harmonic Necessary to Produce a Detectable Change in the Quality of Reproduced Speech

Cut-off Frequency of System	Directly Comparing Distorted Reproduction Against Undistorted Reproduction: Single Tube Overloading (2nd Harmonic Predominant)	Directly Comparing Distorted Reproduction Against Undistorted Reproduction: Push-Pull Overloading (3rd Harmonic Predominant)	Without Comparison Against Undistorted Reproduction: Single Tube Overloading (2nd Harmonic Predominant)	Without Comparison Against Undistorted Reproduction: Push-Pull Overloading (3rd Harmonic Predominant)
14,000	5%	3%	10%	5%
8,000	5%	5%	10%	7%
5,000	12%	>10%	17%	>10%

[7] H. F. Olson and F. Massa, "On the Realistic Reproduction of Sound with Particular Reference to Sound Motion Pictures." Presented at the Spring Convention of the S.M.P.E. at Atlantic City, April 23 to 26, 1934.

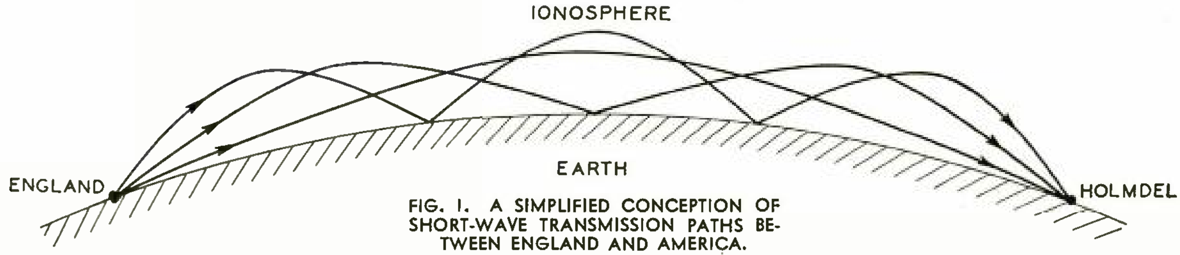

FIG. 1. A SIMPLIFIED CONCEPTION OF SHORT-WAVE TRANSMISSION PATHS BETWEEN ENGLAND AND AMERICA.

Direction of Arrival of Waves

By C. B. FELDMAN • BELL TELEPHONE LABORATORIES

A SIMPLIFIED VERSION of the mode of propagation of short radio waves, on a London to Holmdel circuit for example, might be represented as shown in Fig. 1. Here the waves are shown leaving England at three different vertical angles, suffering one or more reflections in the ionosphere, and as a result being received at Holmdel at three different angles with the horizontal. The lengths of these three paths differ and thus waves traveling by them will be delayed by different amounts and, as a result, shifted in phase relatively to each other at the receiving station. The amount of phase shift in degrees will vary with the frequency, and thus selective fading results.

PATHS OF PROPAGATION

Transatlantic propagation is by no means so simple as Fig. 1 suggests. It involves several layers in the ionosphere and considerable non-uniformity over the circuit due to the varying latitude and longitude. Completely discrete paths are never found, but instead a number of more or less separate clusters of paths are observed, each cluster comprising several paths of nearly the same delay and angle. Sometimes an almost continuous distribution of paths seems to exist. Invariably, however, the waves of greater delay possess the higher angle with the horizontal.

Receiving antennas used at the present time have a directional response broad enough to include all the important angles of arrival. As a result, therefore, the received signals suffer a certain amount of fading because of the superposition of signals of the same frequency but differing in phase. With a view to improving short-wave reception, investigations are being carried on at the present time at Holmdel to determine the angle of reception of short waves sent out from England. Efforts to measure these angles by means of a continuous carrier signal are handicapped by interference of the several waves. The mean angle of the cluster of waves and an estimate of the angular spread can be obtained by employing a continuous carrier, but the angles of the individual waves cannot. The studies have been carried out, therefore, by transmitting a series of very short pulses spaced far apart in time relative to the duration of a single pulse. Under these conditions each single pulse is received as a sequence of echoes; the delay between these echoes being caused by the difference in the lengths of the paths they travel. Each of the echoes, on the basis of Fig. 1, will be received at a different angle.

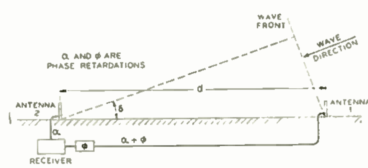

Fig. 3. Two antennas a known distance apart and connected together through a phase changer make it possible to determine the angle of arrival.

TRANSMISSION OF PULSES

The pulses employed are approximately 0.2 millisecond in duration and they are transmitted at the rate of fifty per second. The separation of the pulses is thus 100 times their duration. They are sent out from England by the British Post Office in synchronism with the 50-cycle power system. At Holmdel they are picked up with wide-band receivers, and the envelope of the rectified output is displayed on a cathode-ray oscillograph provided with a linear time axis making sweeps in synchronism with the pulse frequency of fifty per second. This time axis is obtained with a time constant sweep circuit of the conventional type employing a saturated diode as a resistance and a gas-filled tube as a condenser discharger. Synchronization of the sweep with the frequency of the transmitted pulses is accomplished by taking advantage of the frequency stability of the British and American power systems.

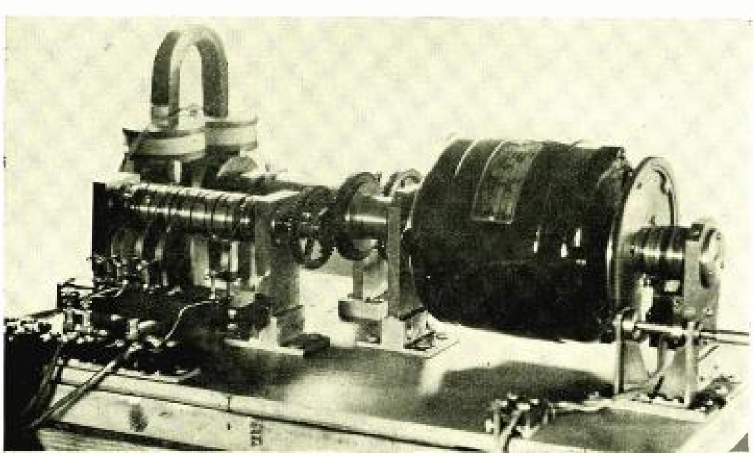

Fig. 2. The synchronous motor that controls the sweep circuit is mounted so that its frame may be rotated for the adjustment of phase.

● A very interesting article dealing with the equipment and means employed for determining the direction of arrival of radio waves between England and America. The angle of reception is determined by the use of two receivers.

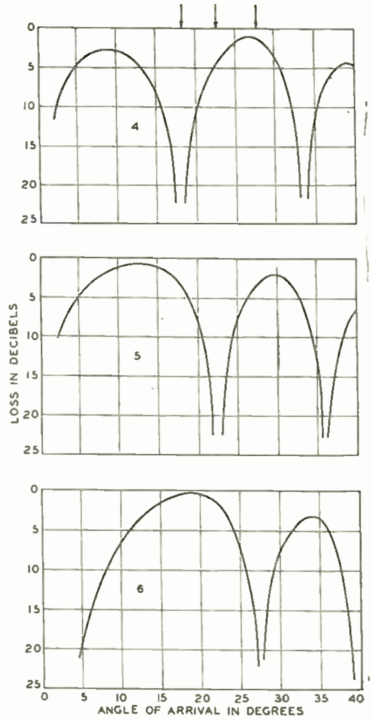

Fig. 6. By moving the phase changer the receiving pattern is shifted so as to bring the null positions to successive angles.

At Holmdel, where 60-cycle power is available instead of the 50-cycle power supplied at Rugby, a 60-cycle synchronous motor is geared down in a 6-to-5 ratio, and a magnetic switch, operated by the low-speed shaft, is used to control the sweep circuit.

FREQUENCY CORRECTION

In both England and the United States the power systems are used to

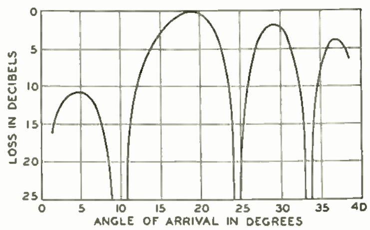

Fig. 4. For any position of the phase changer there will be a series of vertical arrival angles that result in a null reading.

operate electric clocks and their average frequency is therefore maintained very accurately to the nominal value. There may be slight variations from normal over short periods, however, and to allow correction for these variations as well as for differences in phase, the motor frame is mounted in bearings so that it may be rotated with a crank, as shown in Fig. 2. This is turned just enough to maintain the pulse patterns in a constant position on the front of the cathode-ray oscillograph.

Two receivers are employed. One is connected to a simple half-wave vertical antenna, and the other to a combination of two similar antennas spaced several wavelengths apart in the direction of the great circle from the transmitting station. The two antennas are connected through an adjustable radio-frequency phase changer. A schematic of the arrangement is shown in Fig. 3. The outputs of these two associated antennas will be out of phase by an amount which is a function of the distance between them as measured in the direction of the incoming wave. This distance is equal to the horizontal distance, d, times the cosine of the angle that the received wave makes with the horizontal. Thus, the phase displacement of the output of the two antennas is a measure of the angle of reception, and the phase displacement in turn is measured by the amount of phase shift required to bring the two outputs into phase opposition and thus to produce a null reading. Since the two antennas are spaced several wavelengths apart, however, there are several angles of reception that will produce a null reading for the same setting of the phase changer. A typical reception curve for the two antennas for one position of the phase changer is shown in Fig. 4.

RECEPTION ANGLE

In determining the angle of reception the output of the two receivers, one connected to the single antenna and the other to the two associated antennas and phase changer, are alternately connected to the cathode-ray oscillographs in such a way that the two traces are displaced, that of the single antenna lying above the other. Each of the 0.2 millisecond pulses, because of multiple of reflections in the ionosphere, will arrive as a series of echoes. When picked up by the single antenna they will thus cause a series of deflections of the electron stream of the oscillograph. These will be separated in time—from left to right along the tube—by an amount dependent on the difference between the lengths of the paths they travel. The relative heights of the deflections will depend on the signal strengths of the various paths.

The output of the double antenna, displayed below that of the other, will show the same received signals but the relative heights will depend on the position of the phase changer. As this is moved the relative heights vary because of the relationship between phase shift and angle of reception already discussed. When one of the deflections disappears, indicating that the output of the two component receivers are in

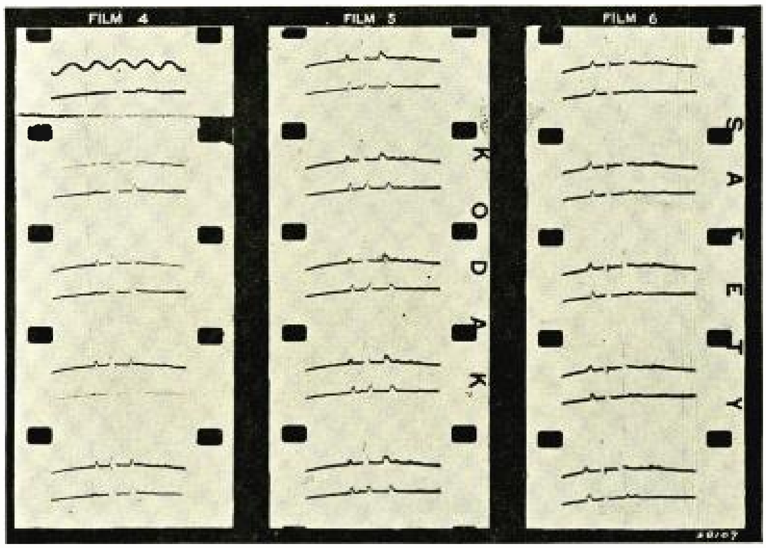

Fig. 5. Three sections of film each frame of which shows the output of the single antenna, above, and the double, below.

phase opposition, the angle of arrival of that particular echo may be determined from the position of the phase changer. Ambiguity due to the several null angles may be avoided by using various antenna spacings.

The motor controlling the sweep circuit also drives a commutator that alternately connects the two receivers to the oscillograph. Since there are fifty pulses per second, each receiver traces its curve on the oscillograph 25 times per second, which, because of the persistence of vision, appears as a stationary trace. Any motion is due to a phase shift between the power systems of England and the United States, and is corrected by rotating the frame of the synchronous motor by the crank provided. The traces on the oscillograph are photographed on a 16 mm. motion picture film.

DETERMINING ANGLE

The method of determining the angle of the various paths is indicated by Fig. 5, which shows three sections of film each for a different position of the phase changer. In the upper frame of film 4 is the trace of a 1000-cycle wave used for timing purposes. In the other frames of this film can be seen the traces of the envelopes of three groups of received pulses; the upper trace in each frame being that from the single antenna and the lower, from the two associated antennas. In this film the earliest or left hand pulse is practically obliterated on the lower traces, thus indicating that the phase changer has brought the outputs of the two antennas into phase opposition and that the angle of arrival for that particular pulse is determined. Films 5 and 6 indicate similar conditions for two other positions of the phase changer. In film 5 the middle pulse is brought to essentially a zero indication, and in film 6, the right hand pulse.

The effect of moving the phase changer is to shift the receiving pattern of Fig. 4 along the axis of angles and thus to change the angle of reception which will give a null indication. This is illustrated in Fig. 6. The three positions of the receiving pattern indicated here correspond to films 4, 5, and 6. The angles of reception of the three groups of echoes are indicated at the top of each diagram, and the patterns have been shifted by the phase changer so as to make phase opposition apply to each successively.

CONCLUSION

This particular method of determining the angle of reception is known as the rejection method, since one of the paths after another is rejected. Other methods are employed to meet different conditions. Angles ranging from a few degrees to about 40 degrees with the horizontal have been observed. The average relation between difference in angle and difference in delay is about 7 degrees per millisecond. All of the waves have been found to arrive substantially within the great circle plane-departure of more than two degrees being uncommon.

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Steel Rectifier Tubes

A HIGH-VOLTAGE GRID-CONTROLLED TUBE CAPABLE OF DELIVERING ONE MILLION WATTS

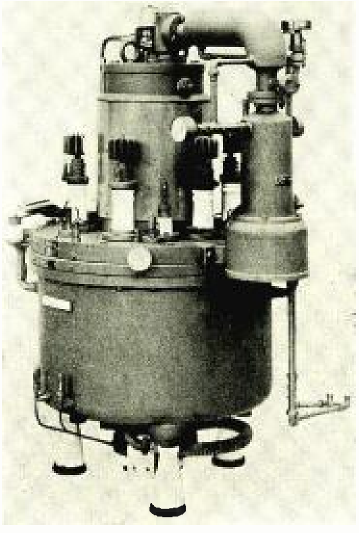
DEMONSTRATIONS OF THE operation of the first high-voltage grid-controlled steel rectifier tube made in the United States were held recently at the Allis-Chalmers Manufacturing Company plant in Milwaukee before several groups of prominent radio engineers from many parts of the country. Compared to the largest glass vacuum tubes used in broadcasting stations at the present time, this steel rectifier tube is of entirely different construction, of a much larger size, and higher rating. It is about six feet in height and three feet in diameter, and weighs more than one ton. See accompanying illustration.

This new steel tube is actually equivalent to six rectifier tubes combined into one. It contains no filament, but makes use of a mercury arc, and therefore cannot burn out. It is continually maintained in proper condition by means of vacuum pumps.

The tube is rated up to an output voltage of 25,000 volts d-c, and has been successfully tested at higher voltages. This voltage is much higher than required by any radio transmitters today, and is several times higher than attained by motor-generator sets used to supply direct current power to radio broadcasting transmitters. The tube will deliver one million watts of direct current power.

It takes less than one second to place this new steel rectifier tube in service, and it can be completely controlled from a remote operating position. The arc drop loss within the tube is so small that it can be operated at more than 99.9 per cent efficiency.

An outstanding feature of this new Allis-Chalmers grid-controlled steel rectifier tube is that it can automatically protect radio equipment by cutting off power in less than 1/60 second to clear a flashover in the transmitter and can automatically replace power on the transmitter in less than 1/10 second thereafter. The speed of operation of the new tube in automatically cutting off power to clear a flashover is very much more rapid than the speed of operation of circuit breakers, and after clearing a flashover power may actually be restored to the transmitter before most high speed circuit breakers could have even opened the power supply circuit to interrupt the flashover short-circuiting current.



The new grid-controlled steel rectifier tube. Vacuum is maintained with a pump.

Another outstanding feature of this new type of rectifier tube is that its direct-current output voltage can be adjusted to any value between maximum and zero by means of a very simple control circuit operating on the tube itself. This eliminates the necessity of using voltage regulators or transformer tap changing switches.

Whereas this high-voltage grid-controlled steel radio rectifier tube is the first one to be built in the United States, about three dozen have already been made by the Brown-Boveri Company in Eureope, an associate of Allis-Chalmers.

High-Fidelity RECEIVERS

By A. GERARD HANLEY

PART 3

● Little-known advantages of linear detection are discussed, and there is given a circuit providing linear detection at small inputs. Channel control, audio transformers, and tone and gain controls, are also covered.

THE USE OF A linear detector for high-fidelity reception is too well known to require justification here. However, there are certain advantages to linear detection not generally realized which will be briefly reviewed.

In a square-law detector the fundamental audio output is proportional to the product of carrier and sideband amplitudes. Therefore, high-frequency noise of a given amplitude, be it hum, tube noise, or thermal noise, will result in an audio noise output proportional to the carrier. If the carrier is increased, the noise will increase proportionally. In the case of a linear detector, however, the fundamental audio output is proportional to the sideband amplitudes alone and is independent of the carrier amplitudes. Therefore, for a constant input of high-frequency noise to a linear detector the resulting noise output for an increasing carrier will be constant and will not rise with the carrier.

This may be shown by assuming a modulated carrier input of the form:

$$E = A \cos \omega t\ (1 + K \cos pt)$$

and assuming the selectivity of the receiver is slowly increased. Then for a square-law detector the set noise (i.e., thermal agitation and tube noise) out of the detector will increase linearly with sensitivity, while the signal output will increase as the square of the sensitivity.

AUTOMATIC VOLUME CONTROL

It is customary to use the change in plate current due to rectified carrier to change the bias on the amplifier tubes for automatic volume control. In a square-law device the change in d-c is proportional to the square of the carrier input. This can be made to function satisfactorily for low percentage modulation. However, for deep modulation the change in plate current is effected by sidebands as well as carrier. In this case then, it would appear that the peaks of sidebands would tend to compress the audio output. At 100-per cent modulation, then, we would expect d-c voltage applied to the control grids to be twice that for no modulation. If the mutual conductance of the amplifier tubes is a linear function of grid bias, as is largely true, then a compression of audio output of 6 db would occur for 100-per cent modulation. Actually it may be worse than this depending on the point of operation (i.e., the strength of the carrier). However, it is certain to be at least 6 db. In the linear detector, the direct-current output is proportional to carrier alone and independent of sideband amplitude. Therefore, no compression of the audio output can occur when the change in plate current in a linear detector is used for automatic volume control.

It was pointed out earlier in this series that the second harmonic of the audio signal will appear in the square-law detector output. It was also shown that the ratio of second harmonic to fundamental was equal to 25 per cent of the percentage modulation, so that at 50-per cent modulation, the second harmonic would be 12.5 per cent of the fundamental and at 100-per cent modulation it would be 25 per cent. In a linear detector no harmonics of the audio signal appear. Another source of distortion in square-law detection for deep modulated signals results from beats between sideband frequencies. Again, such action does not occur in linear detectors. For a modulated wave of the form $[A \cos \omega t\ (1 + K \cos pt)]$, we have for the outputs in the two cases:

Square law—

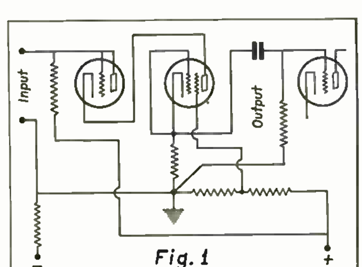
$$L = \frac{A^2}{2} - \frac{A^2K}{2} \cos pt + \frac{A^2K^2}{4} \cos 2\,pt + \ldots$$

high-frequency terms.

Linear—

$$L = \frac{A}{\pi r} + \frac{Ak}{2\pi r} \cos pt + \ldots$$

high-frequency terms.



Circuit for providing linear diode detection for both small and large inputs.

FULL-LINEAR DIODE CIRCUIT

Now it is well known that the diode detector is linear for all but small inputs. In general this makes but little difference, since all signals for which high quality is essential will necessarily be of large amplitude. Moreover, when AVC is used the detector will be operated at high levels for all but signals near the noise level. However, the diode can be made linear even for small inputs by use of the circuit of Fig. 1. This is accomplished by employing an additional tube in which it is possible to obtain a reversed plate current and having a linear plate current-plate voltage curve beyond the reversed current portion of the characteristic. The dynatron action of an ordinary screen-grid tube may be used for this purpose. The diode is arranged to prevent the current reversal in the unstable portion of the screen-grid tube. In this way a very sharp cutoff may be produced, and the rest of the characteristic can be made substantially linear. This circuit is of more interest in measuring equipment than in radio receivers, however. Nevertheless, it indicates some of the possibilities where the number of tubes and the power drain are not important.

The use of a separate diode for AVC is usually justified by employing delayed AVC, which might cause intolerable distortion of weak signals if the same diode were used both for detection and AVC. It is not generally realized that delayed AVC is advantageous even if a squelch circuit is used. Since the delay bias is usually chosen so that the signal must be of sufficient magnitude to completely load up the receiver before overcoming the bias, it follows that the AVC characteristic will also be more uniform.

CHANNEL CONTROL CIRCUITS

It is good practice to employ one or two highly selective circuits before the squelch circuit as illustrated in Fig. 2. (See Wurlitzer circuit in this issue.—Ed.) These circuits should be carefully adjusted to the center of the i-f band, so that they will respond only to the carrier as nearly as possible. This prevents their operation by noise. When properly done, a noise voltage 50 to 100 times as great as the weakest carrier will usually be required to operate the squelch circuit. The highly selective circuits associated with squelch circuits must be extremely stable, as must be the i-f amplifier, in order to insure proper tuning.

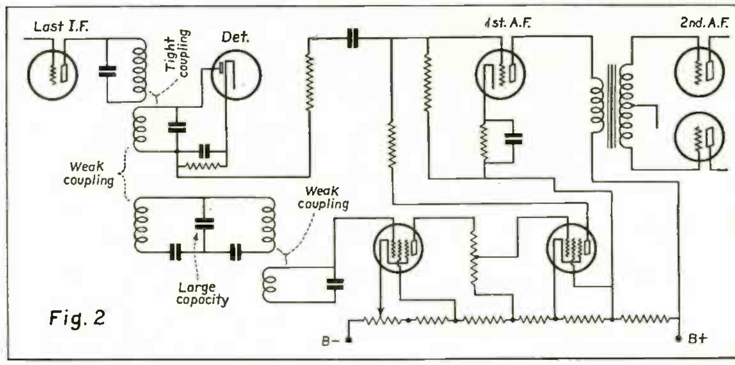


Fig. 2

Schematic of a channel control circuit which will unlock the audio channel only when the receiver is tuned close to the carrier. The selective circuits are tuned to the center of the i-f band and are not effected by noise voltages.

AUDIO-TRANSFORMERS

It goes without saying that high-fidelity audio-transformers are required in a high-fidelity receiver. However, it is not generally realized that high fidelity does not necessarily mean high cost. For example, assuming unity coupling between primary and secondary, it is generally assumed that low-frequency response increases with primary inductance. This is, of course, true, but just as in everything else the point of diminishing returns is soon reached, and unless this is kept in mind the transformer costs may be unduly high.

It was once common practice to tune the primary with the plate by-pass condenser at some low frequency, say 50 cycles, to boost low-frequency response. This is still a very satisfactory method of procedure and from a purely practical standpoint is frequently entirely adequate unless worked too hard. A gain of 4 or 5 db at 50 cycles is entirely practical.

The matter of primary inductance of input and interstage transformers may, by reference to Fig. 3, be investigated as follows:

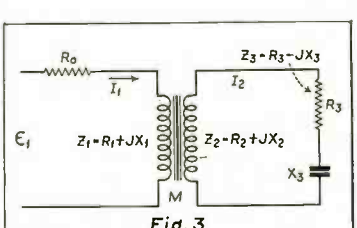


Fig. 3

Breakdown of an audio-frequency transformer circuit.

$$\text{Let } K = \sqrt{\frac{L_2}{L_1}} = \text{turns ratio}$$

At low frequencies, the input impedance of the tube is large and to a first approximation the impedance looking toward the primary is:

$$Z_1 = R_1 + JX_1$$

$$\text{Whence: } I_1 = \frac{\xi_1}{R_0 + JX_1} \text{ nearly}$$

$$\text{Then: } I_2 = \frac{\omega M \xi_1}{(R_0 + JX_1)\, Z_3} = \frac{KK_1\xi_1}{(R_0 + JX_1)\, Z_3}$$

At low frequencies it is justifiable to neglect Z_2 in comparison with Z_3,

$$\text{whence: } \xi_2 = Z_3 I_2 = \frac{KX_1\xi_1}{R_0 + JX_1}$$

$$\text{Let } T = \frac{\xi_2}{\xi_1}$$

$$\text{Then: } T^2 = \frac{K^2X_1^2}{R_0^2 + X_1^2}$$

From practical considerations let:

$$\frac{\omega^2M^2}{X_1} = K^2X_1 = A$$

$$\text{Then: } T^2 = \frac{K^2A^2}{K^4R_0^2 + A^2}$$

$$\text{Setting } \frac{\delta}{\delta K}(T^2) = 0$$

We have: $K^2A^2(4K^3R_0^2) = 2KA^2(K_4R_0^2 + A^2)$

That is, T is a maximum when:

$$A = K^2R_0 \text{ or } R_0 = X_1$$

For any frequency greater than ω, say ω_1

$$X_1 = \omega_1 L_1 = \frac{\omega_1}{\omega} R_0$$

$$\text{And } T^2 = \frac{K^2 Ro^2 \frac{\omega_1^2}{\omega^2}}{Ro^2 + \frac{\omega^2 + \omega_1^2}{\omega^2}}$$

And $T = K$ when $\omega_1 \gg \omega$

Therefore, the frequency at which $X_1 = Ro$ holds should be well below the desired low-frequency cutoff. Thus let it be required that the response of the transformer fall less than 0.5 db from 300 cycles to 60 cycles.

If $\omega_1 = 3\omega$
$T^2 = .9K^2$
$T = .95K$
If $R_0 = 10^4$

$$\text{then } L_1 = \frac{10^4}{\omega} = \frac{10^4}{2\pi.20} = 84 \text{ henrys}$$

Had three times this value been employed a gain in response of about 0.25 db would result at 60 cycles, which hardly appears worth the effort.

If unity ratio interstage transformers are used, the leakage may be short circuited by a condenser C_1 as shown in Fig. 4. Such a condenser might be of the order of 0.1 to 1.0 mfd, depending on the degree of shorting required and the magnitude of the leakage. In this figure C_2 might be used to resonate the transformer at a low frequency to increase low-frequency response as well. The effect of leakage reactance may, also, be largely annuled by terminating the transformer in a resistance. In general, compensation methods of increasing the fidelity of response are not to be recommended. If used with a reasonble degree of care, however, they may be made very effective.

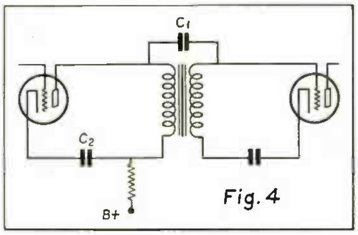
POWER TUBES

If the receiver response at low frequencies is good and an adequate loudspeaker system is used, considerable care should be taken to keep the a-c ripple input low and to avoid any tendency toward motorboating. A high-fidelity receiver should also have a wide volume range and this implies a low hum level. In many modern receivers, a large part of the hum is introduced in the power stage. In general, this is due to poor balance in the output transformer associated with filament type tubes. There appears to be no good reason why push-pull pentode 2A5's or

42's, both of which have unipotential cathodes, should not be used in high-fidelity receivers. In correctly designed circuits operated below the overload point the distortion is negligible from listening tests even with trained observers. While the use of such tubes does not mean that balance of the output transformer is of no importance, it does permit the use of commercial tolerances and provide practical immunity from output stage ripple.

TONE AND GAIN CONTROLS

It seems that some of the arrangements for increasing selectivity or decreasing the receiver response at high frequencies is essential in a high-fidelity design. Of course, this may be accomplished by a variable band-width intermediate-frequency amplifier stage or by



The leakage in a unity-ratio inter-stage transformer may be short circuited by a condenser (C1).

equivalent low-pass filters in the audio circuit. If a diode is used for the second detector there appears to be no preference so far as performance is concerned. It is generally agreed, however, that the latter is the simpler and the cheaper of the two.

Once the intermediate amplifier is adjusted and arranged to operate properly with squelch circuits, etc., it is poor policy to hamper it with adjustments or controls of any sort. Once it is set up, it should be left strictly alone and it should be made sufficiently stable that it will require as little tinkering as possible during the useful life of the receiver.

Control circuits should be used in the first audio stage if possible to prevent transients of annoying amplitude being set up by these circuits. It can be demonstrated or proved mathematically that filters or tone controls behave better in circuits of low volume. The need for such arrangements has already been emphasized and it seems that more and better tone controls will be required in high-fidelity receivers than ever before.

(Conclusion)

TUBE METAL CHARACTERISTICS

(Continued from page 9)

find many troubles such as gas, blisters, rust, lack of uniformity, brittleness and similar troubles which might be expected of an impure raw material. Because of the much lower price of cold-rolled Swedish Irons and their introduction into the market promptly after Svea Metal, one or two concerns purchased and attempted to use them. The disastrous results naturally led to a quick condemnation of Swedish Irons—including Svea Metal. It was a costly venture for these tube makers and indirectly deprived them for some time of the many advantages and profits which would have accrued from the immediate use of Svea Metal. The primary reasons for the success of this new material may be traced to certain characteristics—namely, the following:

1—Uniformity
2—Adaptability
3—Low shrinkage
4—Heat resistance
5—Conductivity
6—Low gas content
7—Low cost.

Much has been written regarding these advantages and it will suffice to comment on them only briefly. It does not take an engineer to realize that as a material approaches its pure state there are fewer variable factors which tend toward lack of uniformity. Whereas, most metals deal in impurities in terms of tenths of percents, Svea Metal impurities are down in the thousands of percent and this obviously means a uniformity throughout the metal. Uniformity likewise may be translated into stability and reliability.

ADAPTABILITY

Adaptability is another important element in the use of any metal. Svea Metal has been made on production for deep drawing and punching parts down to a Rockwell hardness of 78 and it has likewise been made with a Rockwell of 110. Thus the temper shows an adaptability to wide variation. It maintains throughout its range of temper a strength and rigidity essential to proper tube construction.

Because of its uniformity and its adaptability it has a low shrinkage factor. There is little, if any, material to be discarded other than the natural waste from original stampings and formings.

The heat resistance of the metal gives it longer life and high efficiency and, conversely, tubes made from Svea Metal show a peak efficiency throughout their life period.

Conductivity also is important. It has a higher conductivity than nickel and this is of particular value in the flashing of getter cups.

Of course, low gas means low ionization and longer tube life. While most metals under bombardment give up a surface gas they are very likely to retain internal gases throughout bombardment and be placed in the vacuum tube in this condition. Svea Metal, by reason of its thorough degasification contains less than half the gas found in most other metals and practically the only gas carried by it is that contained in the microscopic pores of the surface, most of which is hydrogen from the firing process. This surface gas is given up readily upon evacuation and the metal thereafter does not tend to give off gas in the tube. Thus, during the life of the tube there is no added impedance to electronic emission provided, of course, that the plates are put into the tube in clean condition and the tube properly evacuated.

ACOUSTICS

(Continued from page 13)

in certain cases, it must be extended more in each direction.

2. The volume range of reproduction must be of the order of 70 decibels and the noise level in the reproducing system (including room noises) must be very low in order to prevent masking of extreme low end of volume range.

3. The amount of amplitude distortion, if it consists mostly of second or third harmonic distortion, must be less than 5 per cent.

4. The frequency-response characteristic of the complete system must be free of peaks which rise more than 4 decibels above the average level.

5. There must be no selective absorption of sound in one particular frequency band, and the reverberation times of both the studio and the reproducing room should be higher at the low frequencies than at the high frequencies in order that the loudness of all frequencies will die down equally.

6. If the average volume level at which reproduction is taking place is lower than the volume level of the original source, it is necessary to increase the low-frequency response sensitivity of the amplifier in order to correct for the losses which take place in the human ear. The lower the reproduced volume level, the higher must the low-frequency response be raised.

7. To secure complete realism in high-fidelity reproduction, it is necessary to use a binaural system, which requires two independent channels. A directional sound collecting and reproducing system on a single channel approaches a binaural system due to its ability to discriminate against undesired sounds and to focus the attention on the main source.

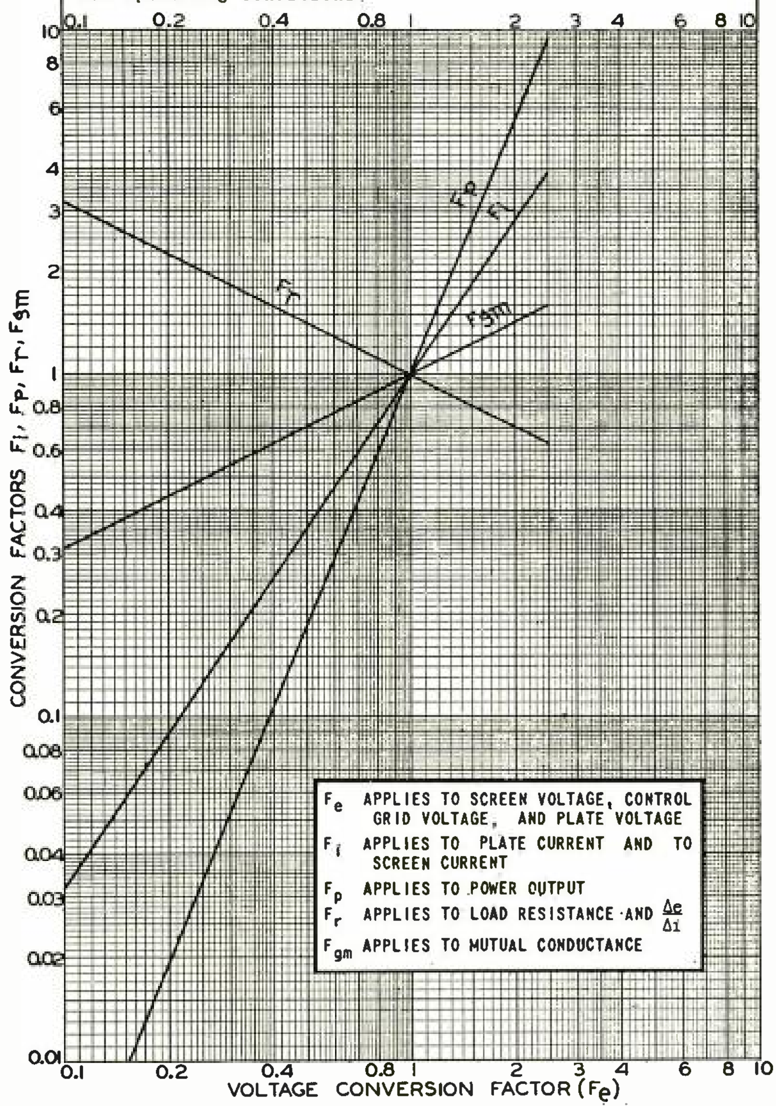
CONVERTING PENTODE CHARACTERISTICS

ALTHOUGH VACUUM TUBES are generally operated with the "typical" electrode voltages recommended by the manufacturer, special circumstances sometimes make it necessary to use tubes at other voltages. In such cases, new operating conditions which will give the best results must be obtained.

TABLE I

	250-*Volt Condition*	*Factor*	200-*Volt Condition*
Plate Volts	250	$F_e = 0.80$	200
Screen Volts	250	$F_e = 0.80$	200
Control Grid Volts	-25	$F_e = 0.80$	-20
Plate Milliamperes	32	$F_i = 0.71$	22.7
Screen Milliamperes	5.5	$F_i = 0.71$	3.9
Mutual Conductance (Micromhos)	1800	$F_{gm} = 0.90$	1620
Load Resistance (Ohms)	6750	$F_r = 1.12$	7550
Power Output (Watts)	3.4	$F_p = 0.58$	1.98

These curves are especially useful for power pentodes in calculating with fair accuracy from published operating conditions, other operating conditions to meet special plate voltage requirements. First, determine the ratio of the new plate voltage to the published plate voltage nearest the desired new conditions. This ratio, the Voltage Conversion Factor (F_e), is then used to determine the new screen and the new control grid voltage. It is also used to determine from the curves, factors for the other new operating conditions.



The new conditions can be readily obtained for pentodes by means of the accompanying chart, worked up by RCA Radiotron Co., Inc.

If, for example, the 89 with pentode connection is to be used with a plate voltage of 200 volts, what will be the correct operating conditions? The "typical" values given by the manufacturers are for plate voltages of 250, 180, 135, and 100 volts, none of which quite fits the case. The ratio of the new plate voltage to a known voltage (250 volts) is 200 ÷ 250 = 0.8. This is called the voltage conversion factor and is identified as F_e. Multiplying all voltages by F_e gives the new voltages shown in Table I.

By means of the accompanying curves and the voltage conversion factor (F_e), the new values of the screen and the control grid voltage, the plate and the screen current, mutual conductance, power output, and load resistance can readily be determined. The factors F_i, F_p, F_r and F_{gm} are the ordinates read from the curves at the abscissa value of 0.8. The accompanying table gives the calculated values for a plate voltage of 200 volts.

In the same manner, operating conditions can be determined for other voltage ratios. This method is particularly adaptable to output pentodes where the plate and the screen current are fairly high and vary according to the 3/2 power law, and where the voltage conversion factor is not over two to three or less than one-half to one-third.

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WURLITZER CHANNEL CONTROL SYSTEM

AN INTERESTING METHOD of insuring correct tuning and eliminating interstation noise is the channel control system used in the Wurlitzer 13-tube superheterodyne receiver, Model SA-133, which under certain conditions silences the audio channel and under other conditions unlocks the audio channel.

The schematic diagram of this system is shown in the accompanying illustration, from which it can be seen that two tubes are used; namely, a channel control tube, C, and a silencing

COMMENT . . Production

or relay tube, S. The operation of this system follows:

Operation

First, consider the arm of the 15,000-ohm channel control adjustment 8 to be at the negative side. There will then be zero bias on the channel control tube, C, and this tube will draw plate current irrespective of signal conditions in its grid circuit. This plate current, in turn, passes through resistor 4-9 and biases tube S to cut-off, giving normal bias on the first a-f tube. Therefore, the channel control will be inoperative, the receiver operating as the usual superheterodyne with automatic gain control.

However, if the arm of the channel control adjustment is advanced to the positive side, the bias on tube C will increase past cut-off. Now, if exactly cut-off bias is applied to tube C, the plate current through 4-9 stops, the bias on tube S returns from cut-off to normal which allows plate current to flow in the plate circuit of tube S through resistors 2-4 and 11-12, the current through 2-4 produces a voltage in series with the normal bias developed across resistor 2-14, and these combined voltages bias the first a-f tube to cut-off, thus silencing the audio channel.

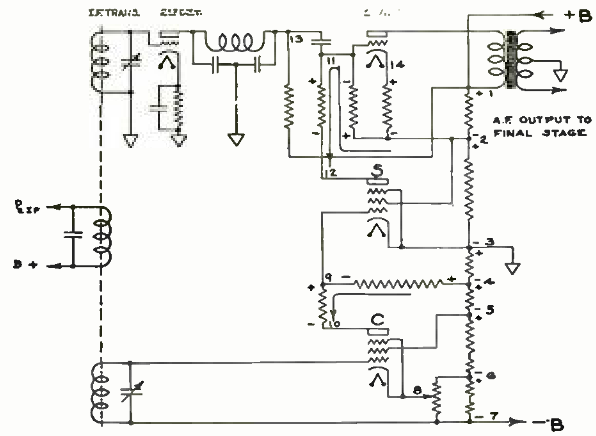
If a signal of sufficient strength is applied to the grid of tube C, this tube will draw plate current, biasing tube S to cut-off and returning the audio channel to normal operating conditions. The signal strength required to perform this operation is determined by the degree past cut-off to which tube C is biased.

The signal to actuate the channel control circuits is induced in a tuned tertiary winding of the third i-f transformer so coupled to the primary that the selectivity at the grid of the tube C is considerably greater than the selectivity at the grid of the second detector. As a result of this, the signal at the grid of tube C will not be sufficient to unlock the audio channel unless, of course, the receiver is tuned almost exactly to the carrier. Since the receiver signal does not pass through this selective control circuit, the high-frequency response is not impaired by the amount of selectivity.

Ratio of Noise to Signal

It becomes more difficult for a signal to unlock the audio channel as the ratio of noise to signal increases. Since this is a rather peculiar situation, an explanation is thought to be of interest.

The signals that operate both the channel control and the automatic gain control circuits are derived from the plate circuit of the second i-f, a 58. Now any signal impressed on the grid of the automatic gain control tube tends to reduce the sensitivity of the receiver. Also, any signal impressed on the grid of the tube C tends to unlock the audio channel. Again, the conductance of the automatic gain control coupling circuit is a direct function of frequency, and the conductance of the channel control coupling circuit is practically zero except for the frequency at which the i-f transformer has been tuned—at this frequency the conductance is high. If a voltage of any frequency not including the i-f, such as noise, appears in the plate circuit of the second i-f, this voltage will be transferred to the grid of the automatic gain control tube and result in a reduction of the sensitivity of the receiver. However, this voltage will not be transferred to the grid of the channel control tube owing to the frequency discrimination of the channel control coupling circuit and will, therefore, have no effect on the channel control circuits.



Skeleton diagram of the channel control system used in the Wurlitzer SA - 133 superheterodyne. C is the channel control tube, and S the silencing tube which controls the bias on the 56 a-f triode.

In other words, the only voltage that will have any effect upon the channel control circuits is one whose frequency is almost equal, or equal, to the frequency to which the i-f transformer is tuned. The automatic gain control circuits function to maintain a constant voltage across the plate load of the 58 second i-f tube with little regard for the frequencies present in that voltage.

Example

The automatic gain control circuits function to maintain a constant voltage across the plate load of the second i-f. If this voltage is made up of only the i-f signal, a certain voltage will be transferred to the grid of tube C. If, however, this voltage is made up of equal parts of signal and noise, and is the same value as in the first case, only half as much voltage will be impressed on the grid of tube C. If this voltage is comprised wholly of noise, the automatic gain control circuits function to maintain this voltage at almost the same value as though it were at i-f, but the channel control coupling circuit transfers none of this voltage to the grid of tube C, and the audio channel remains quiet.

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HIGH FIDELITY

THE RMA HAS recognized the high-fidelity receiver but is inclined toward the belief that a name other than "high-fidelity" might be more appropriate and more descriptive.

A change of name will at least forestall inquiries from fluffy women as to whether or not "high-fidelity" receivers will keep their husbands home nights.

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BUREAU OF STANDARDS BULLETINS

THE THREE FOLLOWING bulletins have been released by the U. S. Department of Commerce, Bureau of Standards:

Research Paper RP621

"A Radio Direction Finder for Use on Aircraft," by Wilbur S. Hinman, Jr.

Research Paper RP629

"Radio Observations of the Bureau of Standards During the Solar Eclipse of August 31, 1932," by S. S. Kirby, L. V. Berkner, T. R. Gilliland, and K. A. Norton.

Research Paper RP632

"Studies of the Ionosphere and Their Application to Radio Transmission," by S. S. Kirhy, L. V. Berkner, and D. M. Stuart.

Copies of these bulletins may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., at a cost of 5 cents each.

A Chronological History
of electrical communication
—telegraph, telephone and radio

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

PART XXIX

(1135) Six incorporated wireless telegraph companies in the United States operate 122 tower stations, and during the year handled 163,617 messages. The total income for the year was $122,154, and the expenses $169,782.

(1136) 625 railroads in the United States report 33,441 telegraph offices employing 68,197 telegraph operators and train dispatchers. The number of Morse telegraph instruments in use (sets) is 99,519, and 4,384 instruments of other systems. Total cells of battery in use is 383,891 cells of primary and 13,411 cells of storage battery. Telephone sets for railroad use number 30,115. The miles of telegraph and telephone pole line number 224,476. Railroad telegraph departments during the year handled 258,589,333 telegrams on railroad service and 5,923,483 commercial telegrams.

(1137) William Thompson (Lord Kelvin) dies. (Born in England 1824.)

(1138) Lee DeForest procures a United States patent for an audion amplifier of pulsating or alternating current.

(1139) David T. Kenney obtains U. S. patent 847947 (March 19) for electric vacuum cleaners.

1908 (1140) Thomas A. Edison receives the John Fritz medal in recognition of his many telegraphic and other electrical inventions.

(1141) Marconi stations in Canada and England are opened for radio telegraph service across the Atlantic.

(1142) Bell telephone companies absorb 350,000 telephone stations previously owned and operated by Independent telephone companies.

(1143) Louis A. Ferguson is elected president of the A. I. E. E.

(1144) The Telepost Company is organized for the purpose of establishing a telegraph system to place in operation the high-speed chemical telegraph invented by P. B. Delany.

(1145) Railroads throughout the United States and Canada install additional telephone facilities along their lines with the object of furthering the handling of train orders by telephone in place of the telegraph.

(1146) On July 1 all through and local passenger trains on the New York, New Haven and Hartford Railroad, operating between Grand Central Terminal and Stamford, Conn., are operated by electric power.

(1147 An Electrical Exposition is held at Marseilles, France, September 14-21.

(1148) R. A. Fessenden has constructed a 70,000-cycle alternator with an output of 2.5 kw. at 225 volts, for radio signaling purposes. Fessenden reports successful radio telephone tests between Brant Rock, Mass., and Washington, D. C., a distance of 600 miles.

(1149) The International Telegraph Convention is held at Lisbon, Portugal.

(1150) During the year the sales of electrical apparatus in this country amounted to $250,000,000; electric railways earned $350,000,000; central electric light and power stations earned $225,000,000.

(1151) Long-distance toll telephone service is placed in operation between New York and Denver, Colo.

(1152) A "loaded" toll telephone underground cable is placed in service between Chicago, Ill., and Milwaukee, Wis.

(1153) The price of aluminum is 23 cents per pound.

(1154) The Pennsylvania Railroad tubes under the Hudson River, New York, are completed. The electrical equipment will be installed in 1909.

(1155) The Pennsylvania Railroad Company installs an experimental line of concrete telegraph poles near New Brighton, Penna. An installation of fifty-three reinforced concrete poles installed near Maples, Ind., a few years ago is giving satisfaction.

(1156) The Excello Arc Lamp Company, marketing a "flaming-arc" electric lamp, meets with considerable success.

(1157) Louis Steinberger, of Brooklyn, N. Y., brings out several new forms of high-tension insulators.

(1158) The gross sales of the Western Electric Company for the year ending November 30, were $30,000,000. The company has built and delivered a complete telephone exchange equipment for Paris, France.

(1159) The Union Switch and Signal Company is awarded contracts for 500 miles of automatic block signal equipment for the Chicago, Rock Island and Pacific Railroad and similar equipment for 750 miles on the lines of the St. Louis and San Francisco Railroad.

(1160) A Convention of Telegraph Engineers is held in Budapest, Hungary. All large countries are represented with the exception of the United States.

(1161) The Mexican Telegraph Company's gross receipts for the year were $811,342. The company pays ten per cent in dividends on its common stock.

(1162) The Central and South American Telegraph Company's gross receipts for the year were $1,664,506.

(1163) During the year telegraph and telephone companies purchased 2,562,239 wood poles. Electric light, power, and railway companies purchased 531,497 poles.

(1164) The Consolidated Telegraph and Electrical Subway Company, New York, this year reports assets amounting to $14,131,658. The company supplies conduits for all of the high-power wires for light and power. Of the 18,750 shares of stock of the company the New York Edison Company owns 15,160 shares.

(1165) The Empire City Subway Company, New York, reports assets of $11,768,317. The company furnishes underground conduits for all low-tension wires, telegraph, telephone, etc., in New York. Of the 43,240 shares of the company, the New York Telephone Company owns 38,025 shares.

(1166) The first 15-cycle, single-phase, 11,000-volt, a-c. electric railway in the United States, using electric locomotives, is placed in operation by the Visalia Electric Railroad Co., Visalia to Lemon Cove, Calif., a distance of twenty-two miles.

1909 (1167) The *S. S. REPUBLIC* and *S. S. FLORIDA* collide off the American coast (January 23). The *REPUBLIC* sinks after all of her passengers and crew are rescued by other vessels called to her assistance by wireless telegraphy.

(1168) The tungsten filament electric lamp, recently introduced, has a wide application in lighting service.

(*To be continued*)

NEWS OF THE INDUSTRY

DARDELET THREAD HANDBOOK

The Dardelet Threadlock Corporation, Dept. HC, 120 Broadway, New York, N. Y., have available for distribution to responsible parties copies of the recently released "Dardelet Thread Handbook."

The Handbook is pocket size, has a flexible leatherette cover and contains 220 printed pages dealing with the theory and design of the threadlock principle, tests, dimensions and specifications, thread forming, heat treatment, plating, gaging and measuring, applications, etc.

It is suggested to those who are unacquainted with the Dardelet self-locking screw thread that a request also be made for a copy of Bulletin No. 5 as well as a copy of U. S. Department of Commerce Research Paper No. 227, dealing with the electrical resistance of contacts between nuts and bolts.

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NEW BRUSH OFFICES

The Brush Development Company announces the removal of their offices and factory from 3715 Euclid Avenue, Cleveland, Ohio. to Perkins Avenue at East 40th Street of the same city.

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GENERAL CABLE BULLETIN

The General Cable Corporation have a new bulletin on URC Weatherproof Wires and Cables, which contains a great deal of interesting and valuable information on weatherproof defects and their causes, temperature susceptibility, asphalt saturants, and Weather-ometer test, the latter including a bend, melt, and drip test

A copy of this bulletin may be had free upon request to their offices at 420 Lexington Avenue., N. Y. C.

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HAZELTINE-A. K. LITIGATIONS TERMINATED

A complete settlement of all outstanding patent litigation between Hazeltine Corporation and Atwater Kent Manufacturing Company including its distributors and dealers has been reached and the agreements signed.

Under the terms of settlement all actions and counteractions, instituted at various times since the original suit was filed eight years ago, are withdrawn, and the Atwater Kent Manufacturing Company is granted a license under the patents of Hazeltine Corporation and its subsidiary, Latour Corporation.

Hazeltine Corporation acquires the exclusive power to grant licenses, particularly to Hazeltine Corporation licensees, under all of the patents owned by the Atwater Kent Manufacturing Company in the field of radio.

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NEW CORNELL-DUBILIER CATALOGS

Two new catalogs have just been issued by the Cornell-Dubilier Corporation of 4377 Bronx Boulevard, New York, and are available to the trade free of charge. Both contain important news of the latest condenser developments and will prove of timely interest and practical use.

Catalog No. 126 is for the amateur and broadcast station engineer, and contains useful information on all types of mica, oil and pyranol transmitting condensers with ratings from 600 volts d-c to 60,000 volts d-c. Many special and interesting units are described and illustrated.

Catalog No. 127 is the revised General Catalog for use by consulting and designing engineers, manufacturers, distributors and others interested in the large variety of condensers made by the Cornell-Dubilier Corporation.

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NEW KENYON CATALOG

Kenyon Transformer Co., Inc., have just released their new Spring catalog.

It is somewhat changed in form from earlier issues, as it appears in two parts. The Laboratory Standard, the Portable, the Transmitting, and the All-Purpose lines appear in one catalog of twenty pages, and these are presented with full detailed information in tabular form. The Replacement line is covered in a separate eight-page folder and contains many new items, both in the power transformers and audio line.

Copies may be procured free on request.

•

NEW PIONEER PLANT

For the third time in less than three years the Pioneer Gen-E-Motor Corp., of Chicago, manufacturers of rotating type auto-radio "B" eliminators and electric motors, have found it necessary to move to a new and larger plant.

At each change their production facilities and plant size have been more than doubled. This new plant, located at 466 W. Superior Street, has been necessitated by the very heavy production scheduled this summer on auto-radio "B" units for the leading radio set manufacturers.

For several weeks previous to moving, new machinery was installed at the new plant, and when completed, production was resumed at more than double the former rate, without a single day's shutdown.

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FLECHTHEIM ANNOUNCES NEW APPOINTMENT

A. M. Flechtheim, President of A. M. Flechtheim & Co., Inc., manufacturers of paper and licensed electrolytic condensers, recently announced the appointment of Sanford L. Cahn as General Sales Manager.

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GOAT TUBE SHIELDING CIRCULAR

Goat Radio Tube Parts, Inc., 314 Dean Street, Brooklyn, N. Y., announce the edition of an up-to-date circular on tube shielding. In addition to general discussion of shielding, details are given regarding the Goat form fitting tube shield manufactured by this Company. Copies of the circular are available to recognized tube and set manufacturers.

•

"BERT" DOWDEN PASSES ON

Reporting the death of A. G. "Bert" Dowden, one of the most widely known men in radio, and Atwater Kent sales representative in the Eastern territory, James Hitchcock, assistant sales manager of the Atwater Kent Manufacturing Company, writes:

"From New York to Southern Tennessee, Atwater Kent distributors and dealers will mourn the death of their friend, "Bert" Dowden at 4:30 P. M. on Monday, April 30th in the William Penn Hotel, Pittsburgh, Pa. "Bert's" kindly heart laid down on the job and his friendly smile and sympathetic understanding look were lost to his numberless friends forever.

"A. G. Dowden, much better known as "Bert," joined the Atwater Kent organization in 1929. His supreme knowledge of the art of selling was second only to his personal appeal as a trustworthy and reliable representative of a great manufacturing company. His pals in the Atwater Kent organization, and I think everyone who has had the privilege of his friendship, grieve his passing, as will hundreds of Atwater Kent dealers in New York, Pennsylvania, West Virginia, Kentucky, and Tennessee."

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NEW PLASTICS BULLETIN

General Plastics, Inc., North Tonawanda, New York, have issued a new bulletin on Durez Molding Compound, written especially for designers and engineers.

The bulletin, which may be obtained free on request, includes data on the characteristics of the molding compound as applied to its mechanical applications.

•

THORDARSON TRANSMITTER GUIDE

The Thordarson Electric Mfg. Co., 500 West Huron St., Chicago, Ill., have issued a 32-page booklet known as "Transmitter and Power Amplifier Guide No. 344." The price is 15 cents.

The Guide contains the diagrams and constructional data on numerous amateur transmitters, speech amplifiers, power supply systems and power amplifiers. There is also a section given over to plate and filament transformers, chokes, audio coupling units, line coupling units, etc.

Of particular interest is the data on page 18 given over to new type air-cooled plate transformers.

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COLUMBIA STOCK SALE

John F. Ditzell, President of the Columbia Phonograph Company announced the sale of all of the Columbia Company's stock interest in the Public Broadcasters' operations of Radio Station WJJD, Chicago. The Public Service Broadcasting Company, Ralph Atlas, president, is the purchaser.

The Public Broadcasters was the wholly owned subsidiary of the Columbia Phonograph Company and was operated by the same executive personnel as the parent company.

The consideration or terms were not announced.

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NEW GRAMMES AIRPLANE DIALS

L. F. Grammes & Sons, Inc., manufacturers of metal products of numerous types, are now in production on their new type of airplane dial with indirect lighting, as well as new escutcheons.

The airplane dials are made in a number of types, in some of which the dial numbers are stamped out of the metal and lighted from the rear.

Complete information may be obtained by communicating directly with the manufacturer.

New Products

FLEXIBLE RESISTORS

The Clarostat Manufacturing Co., Inc., 285 North 6th Street, Brooklyn, N. Y., have announced a new line of flexible resistors. These units have a resistance tolerance of ∓10 per cent, and not more than one per cent change of original value when wound upon a three-eighths inch diameter arbor. These resistors are wound upon a flexible center piece, which is in turn covered with insulation and the end connections soldered on, the color being the standard R. M. A. and the terminals being No. 24 B & S tin-coated copper wire. These units have, in addition, a tensile strength of 50 pounds, and a continuous watt rating.

•

RCA VICTOR FIELD INTENSITY METER

The RCA Victor Type TMV-75-B Field Intensity Meter is said to possess greater stability, higher accuracy, and wider range of field intensity and carrier frequency. The complete equipment is shown in the accompanying illustration and consists of the Field Intensity Meter and a separate case to house the loops, plug-in coils, and batteries.

In general, this instrument will measure from 6 volts down to 20 microvolts per meter for frequencies varying from 500 to 20,000 kc, and is made up of a loop type superheterodyne receiver having an i-f of 300 kc. The gain of the set is controlled by a 300-kc resistor-attenuator in the i-f amplifier, an additional attenuator being required to measure extremely high frequencies. Four sets of plug-in coils and four loops are required to cover this frequency range, while the calibration is maintained by a calibrating oscillator and mutual inductor attenuator.

A choice in batteries is permitted, the equipment requiring 1.6 amperes at 6 volts for the "A" and 25 ma at 135 volts for the "B" supply. It is further stated that because of the calibration method used, loop constants do not have to be measured, which eliminates a number of operations necessary in former equipment of this sort.

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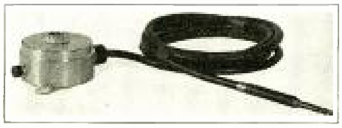
NEW AIRPLANE MICROPHONE



A new airplane-type transmitter has recently been perfected by Automatic Electric Company, of Chicago, Illinois, designed to effectively exclude all extraneous sounds and operate with high efficiency under the difficult conditions of vibration and noise encountered in airplane operation. This transmitter is designed to be used both for inter-communication between pilots and observer, and also for radio transmission to ground stations.

Its current-carrying capacity is rated up to 400 milliamperes for inter-communicating use, but it is recommended that not more than 100 milliamperes be used when operated in conjunction with the radio apparatus, since best transmission results at approximately that figure. A button is provided for quickly switching the microphone in and out of the circuit as desired. A rubber-covered cord is supplied with the transmitter, together with a plug which is standard with most commercial companies.

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CATHODE-RAY TUBES

The Allen B. Du Mont Laboratories of Upper Montclair, N. J., announce three new types of cathode-ray tubes: Types 34-8, 54-8, and 94-8. These tubes are similar to the types previously supplied with the exception that separate leads are taken from each deflection plate, which in certain cases is of considerable advantage as it eliminates the asymmetric effects caused by having one deflection plate of each pair connected to the anode. Since in normal tubes the voltage required to give full-scale deflection is about 5 to 15 per cent of the normal accelerating voltage, when one deflection plate of each plate are tied together the effective accelerating voltage is made to fluctuate by plus or minus 5 per cent or plus or minus 15 per cent when full-scale deflections are produced, the positive peaks applied to the isolated deflector plate being added to and the negative being subtracted from the effective accelerating voltage. With separate leads from each deflection plate this effect may be eliminated by a symmetrical push-pull arrangement in which both pair of plates of a pair are connected to the anode through input circuits of equal impedance and oscillate in potential symmetrically about the ground potential of the anode.

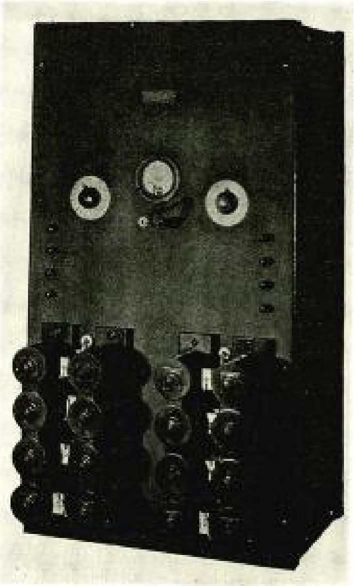
The Type 34-8 tube has a three-inch screen, the Type 54-8 a five-inch screen, and the Type 94-8 a nine-inch screen.

•

LOW-VOLTAGE RECTIFIER

The Model A9S Low Voltage Rectifier, manufactured by the Gates Radio and Supply Company, Quincy, Ill., is said to be adaptable to Western Electric talking picture systems requiring 12 volts at 4 amperes for each projector, though it is not limited to talking picture service, as the voltage and current supply is standard for practically all broadcast speech amplifiers.

The Model A9S copper-oxide rectifier illustrated here delivers a total of 12 volts at 8 amperes in two sections of 4 amperes each; i.e., it is two complete 12-volt, 4-ampere rectifiers. In addition, the total power consumption is 220 watts, and the ripple content is 0.1 per cent.



The unit is constructed on a panel 19 inches wide and 30 inches high which is mounted on a heavy angle-iron frame built from 1¼-inch angle iron. Dust covers enclose the various component parts, and the rectifying elements are mounted on the front of the panel to insure good ventilation. Further, a rheostat is provided for each section to make adjustment for variances in line voltages, while a voltmeter allows checking of both rectifiers.

Further information may be had by writing to the above company for Bulletin 19.

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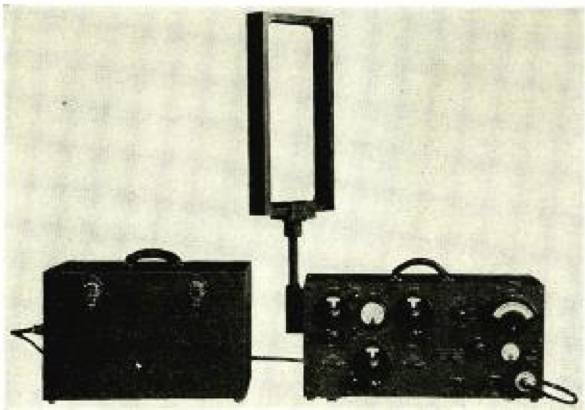
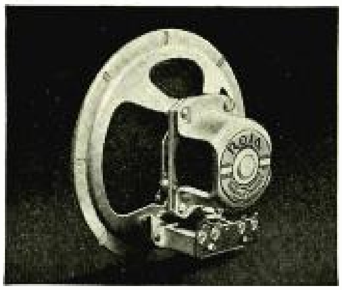
ROLA AUTO-RADIO SPEAKERS

The Rola Company, 2530-70 Superior Avenue, Cleveland, Ohio, have recently announced a new series of dustproof units designed for automobile radio receivers.



Illustation of the RCA Victor Field Intensity Meter, together with the loop aerial and battery case.



This new construction embodies a domed center cap, new spider construction and acoustic filter assembly, which protects the voice coil and air-gap against the entrance of metallic particles of dust and other foreign substances. This, however, in no way restricts the free movement of the voice coil, it is said.

The same construction is now being applied to household sets to eliminate the problem of metallic particles picked up in the assembly of receiving sets and which eventually find their way to the loudspeaker.

OCTAVE TONE CONTROL

The Octave Tone Control, a patented tapped condenser which eliminates the usual resistance strip, was especially developed for tone control by the Filtermatic Manufacturing Co., Philadelphia, Pa. This unit is sturdily built, compact, and is constructed with bronze plates, mica dielectric, and bakelite case. All exposed parts are plated to prevent corrosion, and it is impregnated with condenser wax, making it practically moisture proof.

This tone control can be supplied either with or without a power switch. The shafts are ¾ inches long to permit their use as original equipment, although shafts of any desired length are available. Threaded ⅜-inch diameter mounting bushing permits single hole mounting in ⅜-inch or 7/16-inch hole. The bushing is ⅜-inch long permitting mounting on panels up to ¼-inch thick. The unit measures 11/16 of an inch by 1⅝ inches, and only two soldered connections are required.

The Octave Tone Control has a variable capacity of from 50 mmfd. to .006 mfd., and was developed especially for the grid circuit. The unit is composed of seven steps of capacity. However, they state that there is no noticeable interruption between capacities; rather it produces a smooth, gradual tone taper.

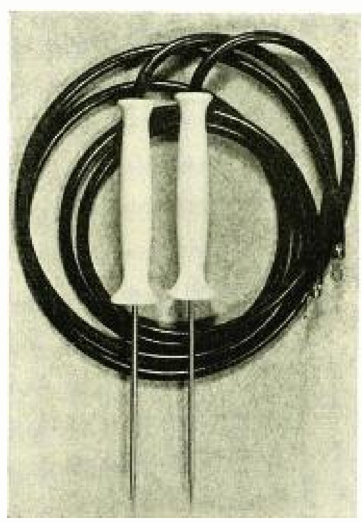
"HIPERM" ALLOY TRANSFORMERS

The United Transformer Corporation announces an addition to their line of transformers. This new group, designed for portable use, are compact and light in weight. The fidelity of these units measures up to high-quality broadcast standards, they state, being uniform in response from 40 to 12,000 cycles. It is further stated that these high-fidelity transformers are the smallest quality transformers of their class, and have only been made possible through the development of "Hiperm" Alloy, a nickel-iron alloy having a high initial permeability. The alloy is not only used for the core material, but also for the shielding case. Another feature contributing to their size is the elimination of all extended mounting flanges, these being replaced by simple threaded metal inserts in the case allowing mounting with terminals either up or down.

A 50, 125, 200, 250, 333, and 500 ohm variable impedance line arrangement is incorporated in transformers used to couple to one or two grids, one or two plates, velocity microphone, crystal microphone, photocell, and to another universal line for mixing purposes. Three sizes of cases are used, two of which are given here. The case used for mixing, input, interstage, and low-level output transformers is 1⅞ x 2⅛ x 2¾ inches. Audio reactors, filter reactors, and audio equalizing networks are housed in a larger case, being 1⅞ x 3 3/16 x 2¾ inches.

ISOLANTITE TEST ELECTRODES

Isolantite, Inc., of Belleville, N. J., manufacturers of high grade ceramic insulators, with New York Sales Offices at 233 Broadway, have introduced a new set of high potential (hipot) test electrodes having Isolantite insulating grips, nichrome electrodes and detachable high



voltage cables 5 feet long with suitable terminal lugs. These electrodes are furnished in pairs, one with red and one with black cable. Cables of special lengths will be furnished to customer's specifications.

These electrodes should prove invaluable in laboratories, testing departments and in service and repair organizations.

REMLER LADDER TYPE ATTENUATORS

Remler Company, Ltd., San Francisco, announces newly designed Ladder Type Attenuators, which mount attractively either a 2⅜" hole or by means of 3 screws through the panel. Attenuation is increased in 53 steps of ¾ db. each to 45 decibels.

A rising attenuation characteristic serves to completely fade the program from 45 decibels to infinity. Flat frequency characteristic from 20 to 20,000 c.p.s. Extremely low noise level. Heavy laminated wiping contact arm. Improved unifilar winding with finest quality silk covered resistance wire.

The unit is enclosed in an aluminum shield 2 5/16 inches deep.

Standard impedances of 50, 200 or 500 ohms. Special values available on order.

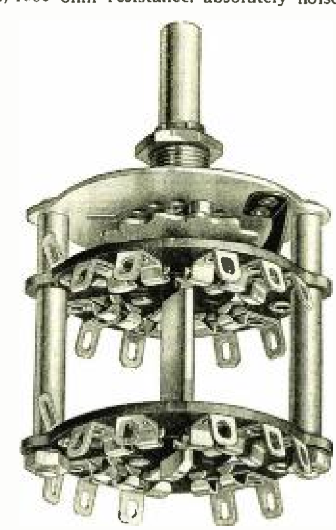
These Remler Ladder Type Attenuators are said to meet the most exacting voice circuit requirements for broadcast transmission, recording and projection.

DUREZ TUBE BASE MATERIAL

A fast molding Durez tube base material is now being produced by General Plastics Incorporated, North Tonawanda, New York. This material cures on thin wall pieces, is readily branded, has excellent performing qualities, and lends itself to production molding with a small number of rejects, they state. It has, in addition, a transverse strength of from 10,000 to 12,000 pounds and an impact strength of 0.145 to 0.150 ft. lbs.

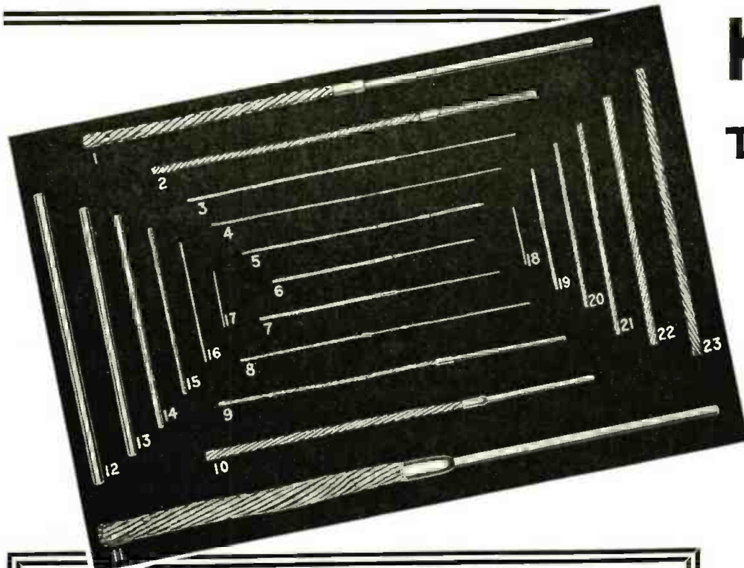
ALL-WAVE SWITCH

C.R.C. has announced a compact and efficient All-Wave Switch. The diameter of switch is 1-9/16" single ⅜" hole mounting; the indexing mechanism prevents stopping between positions; biting contact with 1/1000 ohm resistance. absolutely noiseless



action, and low capacity are among the advantages claimed. In addition, the C.R.C. All-Wave Switch can be built up to as many sections as desired, each section being an independent unit allowing any switching combination from eleven position single pole to two position six pole, including innumerable combinations.

Approved and Used by Leading Tube Manufacturers!



KULGRID "C"

(Pronounced "COOL-GRID")

TUNGSTEN-WELDS

KULGRID "C" STRAND

- Does not oxidize or flake under high temperatures during beading, stem making, sealing-in and exhaust operations.
- Does not get brittle. Strands once welded *stay welded* and remain flexible at all times.
- Welds easily and permanently with Tungsten. *All strands bond firmly* to Tungsten producing welds of lower resistance.

Kulgrid Wire Applications

KULGRID "C" WIRE

Designed for use as lateral grid supports. Maintains rigidity and better alignment than copper. Highly conductive core and non-corrosive sleeve lowers operating temperatures and reduces grid emission. Welds readily to Nickel.

* Measured on .005" diameter wire.

KULGRID "I" WIRE

Designed for use as grid wire proper for round grids. Elongation 10 to 18%. Breaking strength .9 to 1.15 kg.*

KULGRID "S" WIRE

Designed for use as grid wire proper for flat grids. Elongation 10 to 20%. Breaking strength 1.0 to 1.4 kg.*

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PRODUCTS DIV.

UNION CITY NEW JERSEY

Dependable Sensational Performance!

BUD

Laboratory-Built

P. A. Equipment

5 DAYS FREE *Trial*

Try BUD Sound Equipment For Five Days Absolutely Free!

ELECTRO-DYNAMIC UNITS
DOUBLE BUTTON CARBON MICROPHONES · 4 & 6 FT.
ALL ALUMINUM TRUMPETS
FIELD EXCITERS · AIR COLUMN HORNS · LOW AND HIGH FREQUENCY UNITS FOR WIDE RANGE THEATRE USE

WE invite careful, critical inspection of our entire line of BUD laboratory-built sound equipment. We suggest that you conduct your own comparative test. We CHALLENGE you to duplicate BUD performance and BUD DEPENDABILITY AT ANY PRICE! Write today for descriptive literature and prices and details of our FREE FIVE DAY TRIAL offer.

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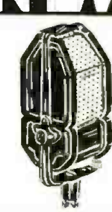
1129 JACKSON ST.
TOLEDO, OHIO-U.S.A.

NEW VELOCITY MIKE



Amperite Model SR80. For studio and public address. Reproduction of the highest fidelity. Free from background noises. **Directional quality** reduces acoustical feedback. Frequency response, 25 to 14,000 C.P.S. (Maximum difference 1 db.). Output 90 decibels. Pickup range on front side, 120°; on the back side, 20°. (Can be changed to order). Output impedance 50 to 200 ohm. Other values if requested. **Highest grade (35% Cobalt)** steel magnets, insuring extremely long life. Ribbon of specially treated and beaten aluminum alloy that can't be stretched or distorted. Not affected by temperature, pressure or humidity. Elastic coupling between microphone and stand absorbs all shocks and mechanical vibrations. **Write for Bulletin SR80.**

NEW PICKUP

LIFELIKE—MORE ECONOMICAL

The new Amperite phonograph pickup *requires only one stage of audio amplification,* yet gives lifelike reproduction. Connected directly on ordinary radio set, resulting in flat response 30 to 5000 cycles. No wiring changes, no filters necessary. Simple, rugged. *A quality pickup; yet reasonably priced. Write for literature.*

NEW AMPERITE for 2V. Tube

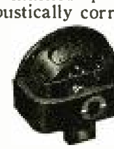
Dry cell operation demands radio tube filaments with low current drain. Such filaments are easily overloaded. A 10% overload decreases life of filament 25%; a 15% overload, 40%, etc. Amperite, the automatic voltage regulator, keeps the filaments at the proper voltage and prolongs the life of the tubes and battery.

Write for Bulletin 2V.

AMPERITE Corporation 561 BROADWAY NEW YORK

P. M. LOUDSPEAKER

The P. M. 8 Loudspeaker units manufactured by Sound Systems, Inc., 1311 Terminal Tower, Cleveland. Ohio, are adaptable to sound and centralized radio systems for schools, hospitals, and hotels; are housed in finished spun aluminum cabinets; are acoustically correct and durable;



and the sensitivity, tone fidelity and power handling ability of these speakers are comparable to that secured in the finest of electro-magnet energized types, it is stated. In addition, no field current is required, the magnetic air-gap and voice coil are secured against the entrance of metallic particles and dust that are attracted to these parts, a new and efficient type of magnet core construction and other features of assembly give increased flux density. These units are equipped with transformers to correspond to any of the standard output tubes.

PORTABLE P-A UNIT

Sound Systems, Inc., 1311 Terminal Tower, Cleveland, Ohio, have a portable p-a system that consists of an amplifier, dynamic speaker, and crystal mike. One cabinet finished in black leatherette with back cover for transportation houses the amplifier and dynamic speaker, the latter having a special voice coil to prevent damage from dust, metallic particles, and the like. This Model PAC-3 has a three-stage, high-gain audio circuit and operates with a crystal microphone into the grid of the first stage and either a crystal or high-impedance pickup into the second stage, the crystal microphone having a frequency response from 30 to 10,000 cycles. Special

polarized plugs are provided with a program switch. One 56, one 57, one 2A5, and one 80 tube are required, and the amplifier operates on 110-115 volts, 60 cycle current. A tuned frequency filter is incorporated in the circuit which permits the use of the microphone at high gain in close proximity to the speaker without microphonic feedback, it is stated.

NEW MODULATION METER

The Type 66-A Modulation Meter produced by the General Communications Laboratories, Inc., Ridgefield Park, N. J., is an instrument which, they state, is not only direct reading but actually measures modulation degree, maintaining an accuracy of 5 per cent on transients as fast as one-tenth second. In addition, the following advantages are claimed: complete absence of replacement or upkeep cost, low initial cost, complete absence of calibration and manipulation in use, and carrier shift indication.

The operating frequency for this unit is 100 kc to 30 mc, the power supply being a-c, 110 volt, 60 cycle. In addition the audio-frequency response is from 0 to 24,000 cycles per second.

The instrument is mounted on a standard relay rack panel, finished in baked black crystalline lacquer and suitably engraved. A nickel-plated brass shield protects the instrument from injury and eliminates the effects of stray electric fields. The shield is easily removable by means of four thumb screws.

FARATRON INVISIBLE CONTROL

The Lumenite Electric Company of Chicago presents the Faratron "Invisible Control" Relay, a new electro-magnetic device available in a sufficient number of types to meet all requirements. The units are furnished with power relays capable of carrying 30 amperes a-c, double outlets for normally "on" or normally "off" power loads. The units operate from 110 volts a-c or d-c. They are housed in black steel cases approximately 7" x 6" x 6".

Three general methods of control are available to operate the power relay in its complete cycle. First, operation by approach whereby the unit responds to the approach of a body from a distance. Second, operation by touch or contact where the body increases the "antenna" length for the resulting action. Third, the grounding of the "antenna" in connection with some mechanical control.

The unit may be used for automatic control in industrial, lighting, and advertising systems, to mention only a few.

VACUUM TUBE BASE PINS

Patents have recently been issued to the Waterbury Brass Goods Corporation, Waterbury, Conn., covering their seamless vacuum tube base pins. These pins may be obtained in numerous shapes and sizes so that almost any requirement may be met satisfactorily.

In addition to numerous other articles, such as eyelets, small wire terminals, shells for screening, and the like, this company specializes in the manufacture of screen grid caps.

"UNIVERSAL" RECORDERS

Two types of semi-professional recorders were placed on the market in April by the Universal Microphone Co., Inglewood, Cal., to be used by stations, agencies and sponsors for air checks, making permanent records of radio programs, personal recordings and other purposes.

The models will come equipped with a volume indicator, volume control, off and on switch and a Universal combination pickup and recording head. There will be two speeds, 33 1/3 and 78 RPM. One type will record on blank aluminum discs up to 12 inches and another up to 16 inches.

They are to be mounted on natural finished wood ready for use on 50-60 cycles, 110 v.a-c. Two impedances are provided, 400 and 5000 ohms. There will be a single model, and a dual turntable for continuous recording.

ADJUSTOHM RESISTORS

Ward Leonard Electric Co., Mount Vernon, New York, have brought out a complete line of "Adjustohm Resistors" which may be readily adjusted to the correct resistance for the need.

The vitreous enamel covering most of the resistor provides protection against mechanical injury and prevents the wires from shifting.

Loosening a screw on a metal contact band permits adjustment of the resistance to the desired value. Potentiometer connections may be obtained by using end terminals and band connections.

The units are procurable with wattage ratings of 20, 40, 80 and 160, and in values from 1 to 100,000 ohms.

NEW FLUORESCENT SCREEN

Improvements in technique have enabled the Allen B. Du Mont Laboratories of Upper Montclair, N. J., to overcome the blackening of the fluorescent screen, when the electron beam is allowed to remain stationary, on all cathode-ray tubes having the high-intensity screen developed previously by that laboratory, it is said. This means that the life of the screen is materially increased as the darkening caused deterioration of the fluorescent screen and hence loss of light. Furthermore, because of this defect in cathode-ray tubes it has not previously been practical to use them for certain purposes, such as, sound recording or indicating meters where the spot or line light remained stationary for a considerable period of time.

AMPLEX CONDENSER INDICATOR

A condenser indicator that indicates open condensers, leaky condensers, and the replacement capacity necessary, has been announced by the Amplex Instrument Laboratories, 240 West 23rd Street, New York,

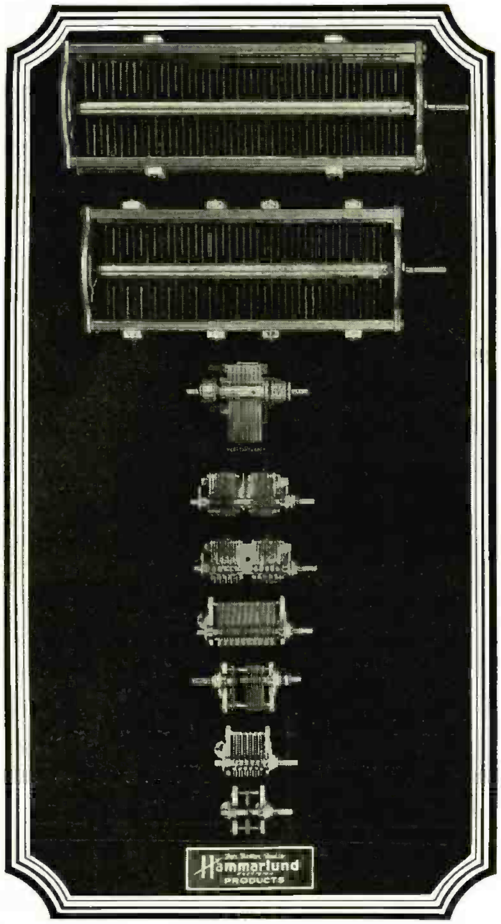
N. Y. The unit is 7" x 4½" x 1¾" and is direct reading—no curves or calculating being necessary. The switches are positive action self-cleaning with analyzer knobs. The unit is made to test all condensers up to those having a 600-volt peak, and it is made to cover two ranges; namely, by-pass from .0001 to 1.0 mfd, and filter from 2.0 to 12.0 mfd.

U. S. E. TYPE 26-B AMPLIFIER

The Type 26-B amplifier made by the United Sound Engineering Co., 2233 University Avenue, St. Paul, Minn., is designed to handle large sound installations. The chassis construction makes this amplifier suitable for standard rack mounting or for portable use, and all connections are made through socket receptacles at the rear and sides of the chassis. Master gain control, power switch, and tone control are mounted on the panel.

The 26-B has 4 stages, a rated maximum undistorted output of 26 watts, and a gain of 97.6 db at 60 cycles, the hum level below maximum rated output being 60 db. The input impedance is approximately 500,000 ohms, and the field current supply is 40 watts available for up to six 2500-ohm fields with no compensation required when using none or any part of field supply. The microphone current supply is 10 mills, sufficient for one double-button carbon microphone. This unit uses one 57, one 56, three 59's, and one 83, its power supply being 110-volt a-c, 60 cycle.

INDEX TO ADVERTISERS



24 YEARS *of* LEADERSHIP

THE basic refinements which, in 1910, made Hammarlund Condensers the choice of radio pioneers now make them still the unchallenged preference of today's leaders.

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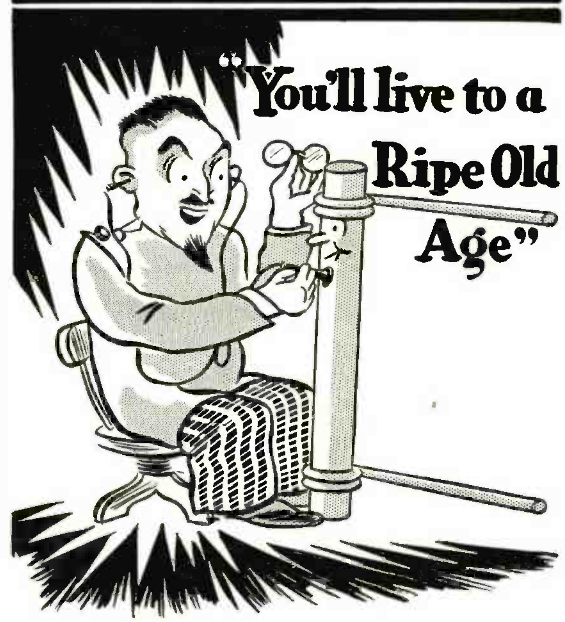

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Adjusting condensers in same plane. New type of trimmer. Round can 1 7/16" diameter. Insulated trimming screws.

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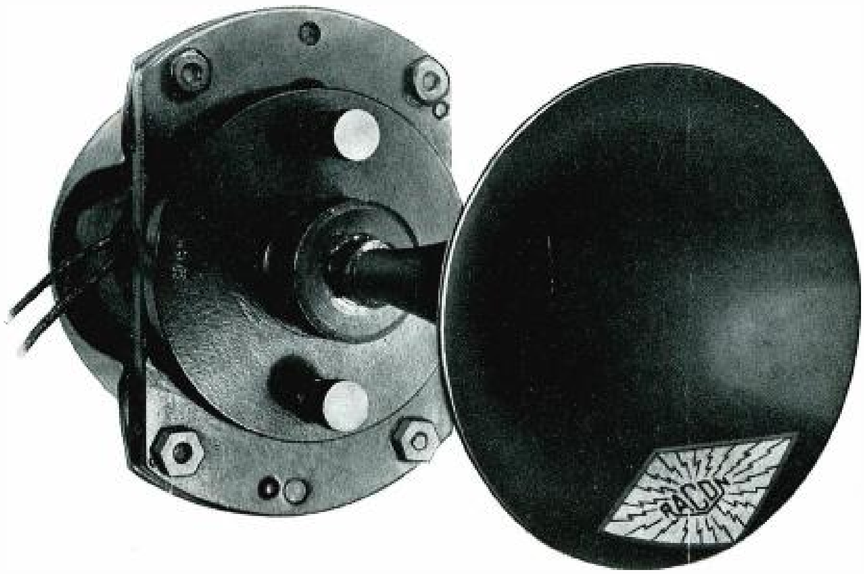
High Fidelity Speakers



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To meet 1934 HIGH FIDELITY specifications RACON offers a new Electrodynamic type High-Frequency Loudspeaker. This new unit will reproduce faithfully all components present in the source from 3000 to 10,000 cycles, uniformly, without peakiness, shrillness or over-accentuation. This unit is not a modification of a low-frequency unit, nor is it intended to introduce "psychological highs" that are not present in the source. It is not a makeshift. It is a true High-Frequency Loudspeaker.

The manufacturer's model is supplied with horn, in one assembly, as illustrated. Voice coil and field coil leads supplied in length specified. Various field resistances available. A sample will be sent gladly to established manufacturers requesting it by letter or by wire.

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