Radio Digest

SELECTED RADIO TECHNICAL ARTICLES

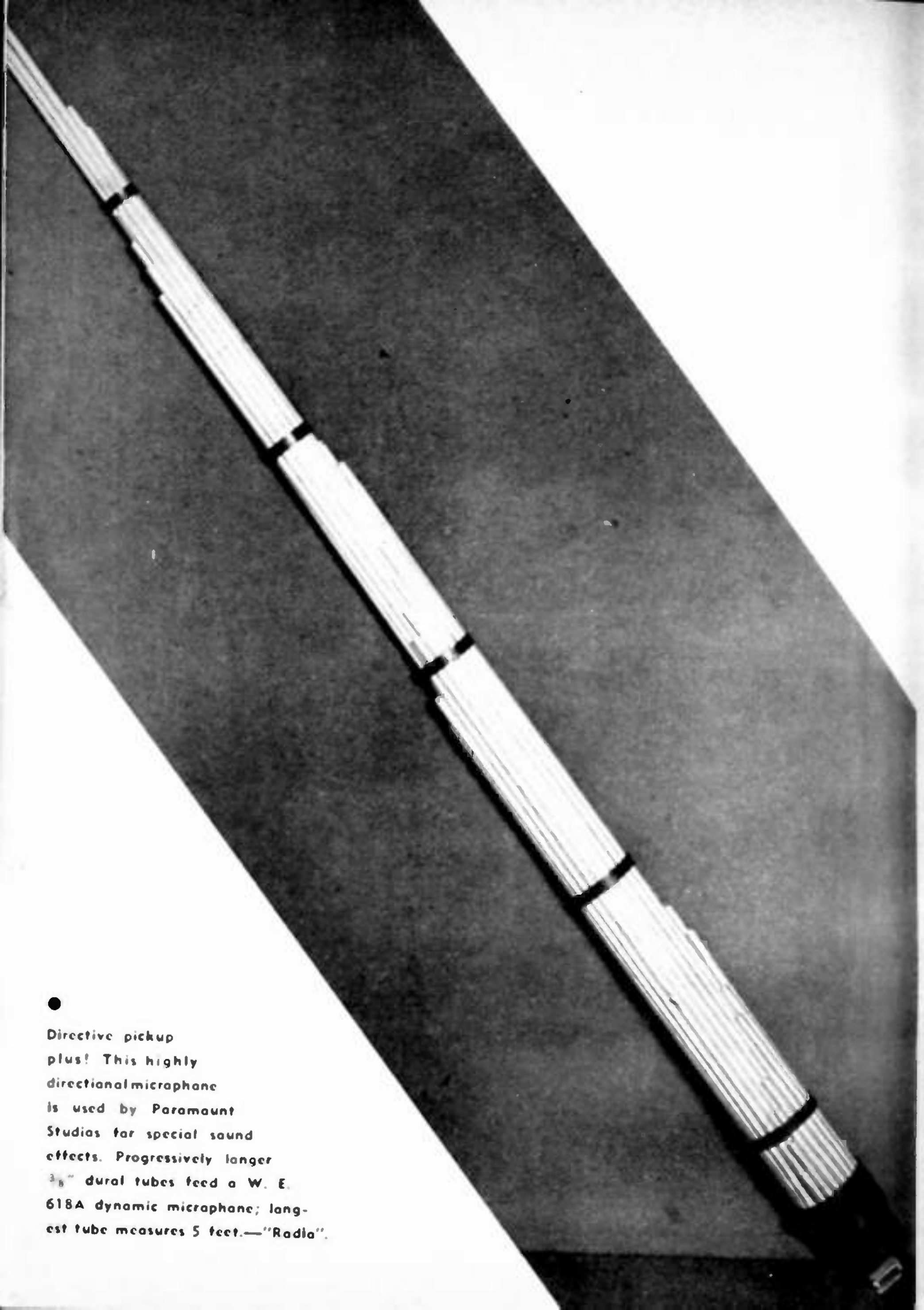
UR • EXPERIMENTAL
EERING • SERVICE
WAVE • TELEVISION
ONICS • COMMERCIAL
OMMUNICATION
DCAST OPERATING

(Another RADIO Publication)

HIGHLIGHTS FROM THIS ISSUE

25¢ U.S.A. & CANADA

MAY AND JUNE, 1938



Directive pickup plus! This highly directional microphone is used by Paramount Studios for special sound effects. Progressively longer $\frac{3}{8}$" dural tubes feed a W. E. 618A dynamic microphone; longest tube measures 5 feet.—"Radio".

RADIO DIGEST

● NUMBER 6 MAY and JUNE, 1938 ●

We present:

RADIO DIGEST • No. 6 • M. M. Lloyd, Managing Editor

Editors: W. W. Smith, Ray L. Dawley, B. A. Ontiveros

25c per copy. By subscription: 12 issues, $2.50 in U.S.A., Canada, Newfoundland, Spain, and all Pan-American countries; elsewhere, $3.00 or 12s. 6d. (British postal orders accepted.)

Published every two months by Radio, Ltd., 7460 Beverly Blvd., Los Angeles., Calif.

¶ From RADIO,
April, 1938

A Card-Indexing System

• For Radio Men

With the wealth of information made available in recent years by the various magazines in the field of radio communication, a system of filing this material for easy and quick reference is quite important. In this article, Mr. Curran discusses his adaptation of the Dewey System of Decimal Classification, a systematic method of filing, to the needs of radiomen.

BY GEORGE W. CURRAN

YOUR back copies of RADIO, *I.R.E. Proceedings*, or whatever your favorite technical radio magazine may be, constitute a very valuable source of information. In these back files will often be found material unpublished in text books or elsewhere. To prove their value to yourself take twelve issues from a year or two ago and glance through their pages. You will invariably find a number of articles containing material pertinent to some problem recently at hand and which would have been very useful had you been able to find them at the time.

As your file of back copies increases in size, it also increases in potential value, but unfortunately a new condition also develops which tends to minimize its value. The quantity of reference material becomes so large that a search for any particular information becomes a considerable task.

As a solution to this problem, the writer has been using for several years a system of card indexing which is simple and easy to maintain and which makes the finding of any given reference an easy matter. All of the articles as they are published are cataloged on cards according to subject matter. This places all of the references pertaining to any one subject in a group by themselves with the date and page of publication quickly available.

The system used is the same as that used by the Bureau of Standards in compiling the "Radio Ab-

325.1	Beam antennas (cont'd)	
Simple rotary, 28mc	Jun 37	QST-50
Flat-top beam	Jun 37	Radio-10
Push-button directivity	Jun 37	Radio-56
Multiple unit, steerable for s-w reception	Jul 37	IRE-841
Notes on flat-top beam	Jul 37	Radio-14
Feeding the push-button ant with concentric line	Jul 37	Radio-15
Mechanical suggestion for amateur rotatable	Jul 37	Radio-49
Erecting Bruce folded array	Jul 37	Radio-51
"Flop-over", reversible horizontal directivity	Nov 37	Radio-16

How a typical index card on beam antennas will look. Note the general method of recording the references.

stracts and References". It is known as the Dewey Decimal System and details of the classification may be obtained from the Bureau of Standards Circular no. 385 or by consulting the August, 1930, issue of the *Proceedings*, page 1433. These published forms also include an alphabetical index which is convenient to have but not necessary.

The Dewey classification extends over the whole general field of knowledge. The subject that we are interested in, radio, is placed thus:

Class	600.	Useful Arts
	20.	Engineering
	1.	Mechanical
	.300	Electrical
	.080	Communication
	.004	Radio

Hence all of the references pertaining to radio would be cataloged in a large library under the general number heading of (621.384). In an indexing of radio subjects only, however, it would be superfluous to write this number each time and it is the practice to abbreviate the number (621.384) by the letter R.

An idea of the form taken by the classification table for radio may be had by considering its main divisions:

R000. Radio
R100. Radio Principles
R200. Radio Measurements and Standardization
R300. Radio Apparatus and Equipment
R400. Radio Communication Systems

355.2 VT Transmitters-Crystal controlled. Bi-push, 3 band, 6A6, 6A6, PP 6L6's April 37 Radio-8

FIGURE 1

R500. Application of Radio
R600. Radio Stations
R700. Radio Manufacturing
R800. Nonradio Subjects
R900. Miscellaneous Radio

The classification (R000) is for material of a general nature which cannot very well be placed under a specific heading. (R100) is for articles dealing mainly with theory and not with particular apparatus or methods. (R200) is for the filing of all articles having to do with the measurement of any of the fundamental quantities of radio. (R300) is one of the large departments in indexing the contents of your references as thereunder will appear all of the articles on equipment construction.

(R500) and (R600) are of small use to the amateur. Under (R700) might be filed shop hints. (R800) has been reserved for subjects which cannot strictly be classed as radio subjects. Examples are articles on batteries or motor-generator sets. (R900) has never been used by the writer although it would undoubtedly have use in more elaborate filings.

Each one of the above general headings is subdivided again and again, narrowing down so as to cover specific items. Consider for instance R200-Radio Measurements The main subdivisions are:

R210. Frequency
R220. Capacity
R230. Inductance
R240. Resistance; Current; Voltage
R250. Generating (transmitting) apparatus
R260. Receiving apparatus
R270. Intensity (field intensity, signal intensity, noise, etc.)
R280. Properties of materials
R290. Other radio measurements

In turn the sub-headings under R210-Frequency Measurement, are:

R211. Circuit resonance methods
211.1 Frequency meters
212. Parallel wire methods
213. Harmonic methods
213.1 Harmonic amplifiers
213.2 Multivibrators
214. Piezo-electric standards

```
355.5 VT Transmitters-General and
      Miscellaneous.
        Reducing harmonic radiation
                    April 37 Radio-18
```

FIGURE 2

Space does not permit the presentation of the entire classification but its completeness can be appreciated by observing that altogether there are about 480 items in the tables covering everything in radio from A to Z. Further, the system is flexible so that any one of the 480 can be further extended to suit the individual needs of the user. In case you do not have the August, 1930, issue of the *I.R.E. Proceedings* or do not wish to send for the Bureau of Standards circular, the former could be consulted at a public library and the table copied down for future use. There are also a number of explanatory notes regarding the use of the table which will be found helpful.

Now as regards the use of the system.

The cards in the index used by the writer are the standard 3" x 5" lined filing cards which are kept together in a heavy cardboard filing case which is approximately 5" wide by 4" high by 11" deep. The unit is very similar to ones found in the card index files of public libraries.

The box with index tabs and a supply of cards can be purchased at a book or stationery store at a nominal price. The only identification to be found on the one in use here are the words "Weis Re-order No. 35"; however, it is a standard item and should be obtainable without difficulty. This particular size card has been found convenient; however, one of larger dimensions, say 5" long by 4" or 5" high, might be more suitable since more entries could be then placed on one card.

The index tabs are labelled R000, R100, R200, and so on through R800. These are placed in the box with R000 in front and the rest following in order. The cards of the index are filed behind the proper index tab. This segregates the cards into groups according to the main divisions of the system.

As an illustration of the use of the system, let us take the April, 1937, issue of RADIO. The first article appears on page 8 titled "The Bi-Push Tri-Band Exciter or Transmitter". Vacuum tube transmitters appear in the classification table under the number R355, with further subdivisions according to frequency, viz.,

355.1 Low Frequency (10-100 kc.)

355.2 Medium frequency (100-1500 kc.)
355.21 Broadcast frequency (550-1500 kc.)

and so on. However, the writer has been using a different subdivision which has been found more suitable:

355.1 C.w. Crystal controlled
355.2 Telephone
355.3 Portable (and transceivers)
355.4 Keying methods and devices (break-in)
355.5 General and miscellaneous

with the remainder of R355 the same as in the published table. Most of the present day transmitters are crystal-controlled so that most of the transmitter articles will be indexed under 355.1, excepting telephone, of course. The few that are self-excited may be filed under 355.5, or if portable under 355.3.

According to the above then, the first article on page 8 should be indexed under the number 355.1. A card would then be made out, to be put in its proper place behind the index tab R300, as shown in figure 1.

This would be the first entry on that card; subsequent articles having the same classification number would be entered below until the card was full, when another would be started. It is desirous to have the entry contain the maximum amount of information, at the same time making it as brief as possible in order not to occupy too much space on the card. Whenever possible, the title of the article should be used, but where it does not contain the necessary amount of information the writer has been making substitutions as illustrated above. The tube complement is usually included, since that is usually one of the most important details and at the same time it gives a clue as to the kind of transmitter being written about. The number 37 is used as an abbreviation for 1937 to save space; the 8 is of course the page number. If the reference being indexed was from the Institute *Proceedings*, the letters "IRE" would appear instead of "Radio". Abbreviations in the text of the entry are also useful in saving space, but they should not be carried to the extreme. Future deciphering might be difficult.

Since we are considering references having to do with transmitters, we will skip the article about "Q" antennas (it would be filed under R320) to the one on page 18 titled "Reducing Harmonic Radiation". The information in this article applies to all transmitters in general and therefore belongs under 355.5. The card would look like figure 2.

The next transmitter article is on page 22, "Ten-Meter Mobile Crystal Control". This would be indexed under 355.3 as figure 3 shows.

If any of these transmitter articles had contained special items

```
355.3 VT Transmitters-Portable
      (Transceivers).
    10 meter, xtal, 6A6 PP osc to
    6A6 PP, phone
                    April 37 Radio-22
```

FIGURE 3

of interest, as for instance a new way of keying or a power supply of special design, the references should be entered again on other cards under the index number for keying (355.4) and for a.c. power supplies which is (356.2). Cross indexing of this kind greatly increases the utility of your card index.

The above outlined procedure is followed for the remainder of the articles in the issue. The ten or fifteen entries necessary for one issue will take only a short time, especially after you become more familiar with the system. The complete classification table may look rather lengthy or complicated but its arrangement is logical and soon seems comparatively simple. The articles appearing in the Institute *Proceedings* are handed out on a silver platter, so to speak, inasmuch as the publishers furnish the Dewey classification number at the bottom of the first page of each article.

Reproduced on page 5 is a sample of a completed card, this being 325.1 Beam Antennas. An inspection of this sample card will indicate the general method of recording the references. The (*cont'd*) alongside the heading indicates that this is not the first card under 325.1, Beam Antennas. There are other cards before this one, and, as the card is filled, there are probably other cards listing the same subject following this one in the file.

You will be surprised to note how rapidly the number of entries in your file will increase, especially if, having the time available, you extend your indexing to include issues from the preceding year or so. When done an issue or two at a time, this will not take long to accomplish; the time expended will probably be small compared to the time saved in the future when you come to search for some badly wanted reference.

The writer attaches a great deal of value to his index which now has approximately 3000 entries under about 270 different headings, some of the references from as far back as 1921. With a reasonable amount of work anyone could soon build up a similar index of great usefulness.

From Electronics
April, 1938

CATHODE RAY OSCILLOGRAPH

• *Its Applications*

BY H. F. MAYER
General Engineering Laboratory, General Electric Co.

TO AN increasingly greater extent the communication engineer is studying the characteristic curves and performance records of his apparatus on the screen of a cathode ray oscillograph rather than a sheet of graph paper. Instead of recording columns of data and plotting a new series of points each time a parameter is varied, he snaps a switch and the curve appears. He may even vary the parameters while viewing the curve, and thereby locate an optimum point quickly and accurately—as in the now familiar system of aligning radio receiver intermediate frequency stages by means of a frequency-modulated signal and an oscillograph.

This paper deals with a single one of the many possible applications of the oscillograph; namely, the tracing of vacuum tube characteristics. The circuits described here are all completely electronic and require no rotating switches or other moving parts. While this limits the performance in certain respects, it extends the opportunity of using the system to those who may be without the facilities for building a mechanical commutator.

The most elementary circuit, designed to trace the plate current vs. plate voltage curve of a diode rectifier, is shown in figure 1. As the curve desired has plate voltage for its abscissa and plate current for its ordinate, one of the horizontal deflection plates of the oscillograph is connected to the cathode of the rectifier and the other to the anode; the vertical deflection plates are connected across a resistor, R_1, in series with the rectifier, to receive a voltage proportional to the plate current. Then an alternating voltage of any wave form and frequency may be applied to the rectifier and R_1 in series and the oscillograph spot will move always along the curve of plate current vs. plate voltage.

Figure 2 shows a more useful refinement of this circuit. In order to make the curve extend to the values of current attained on peaks in actual operation, it is necessary to use a voltage which is positive for only a small part of a cycle so as to avoid excessive average current and consequent overheating of the tube. This is accomplished by inserting a load resistor R_2 shunted by a condenser, C, and applying a higher a.c. voltage. The blocking rectifier is inserted to keep the inverse voltage from reaching the oscillograph plate, and the high resistance, R_3, to permit the charge to leave the plate after reaching it through the blocking rectifier. This circuit became an almost indispensable part of a test set during the development of a small, high-vacuum rectifier.

In testing the tubes, the load, R_2, and the voltage are adjusted to operate the tube at full output and rated inverse peak voltage. Then with the tube cold, the high voltage and the filament voltage are applied simultaneously, and the building up of emission as the fila-

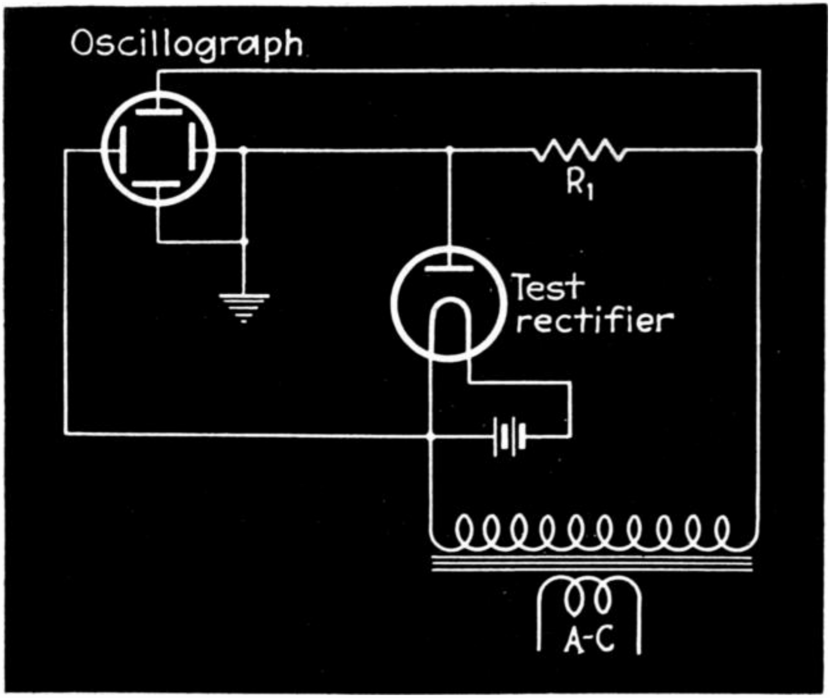


Figure 1. Elementary cathode ray tube circuit for tracing the voltage-current characteristics of a diode.

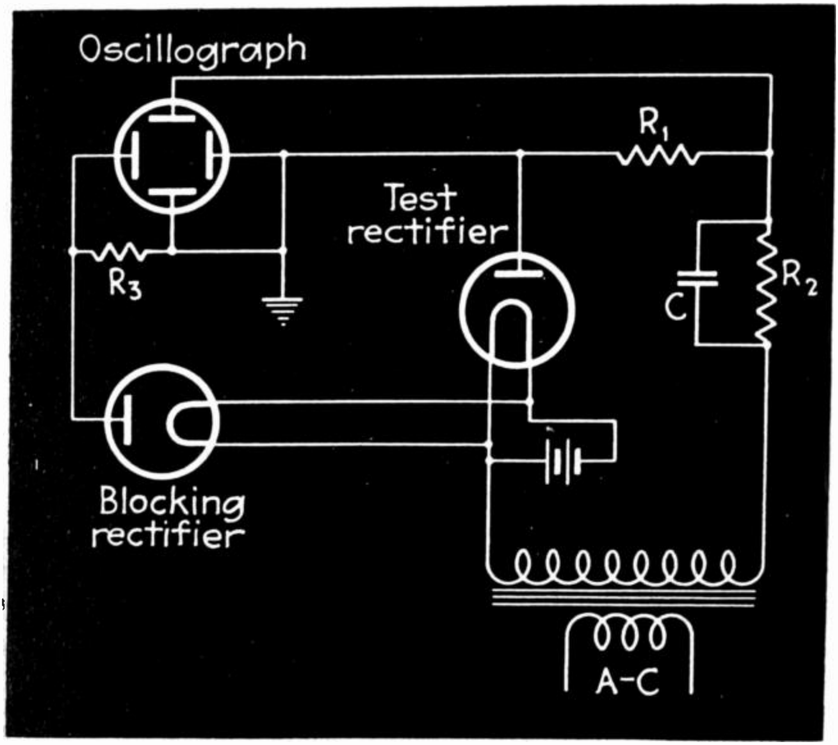


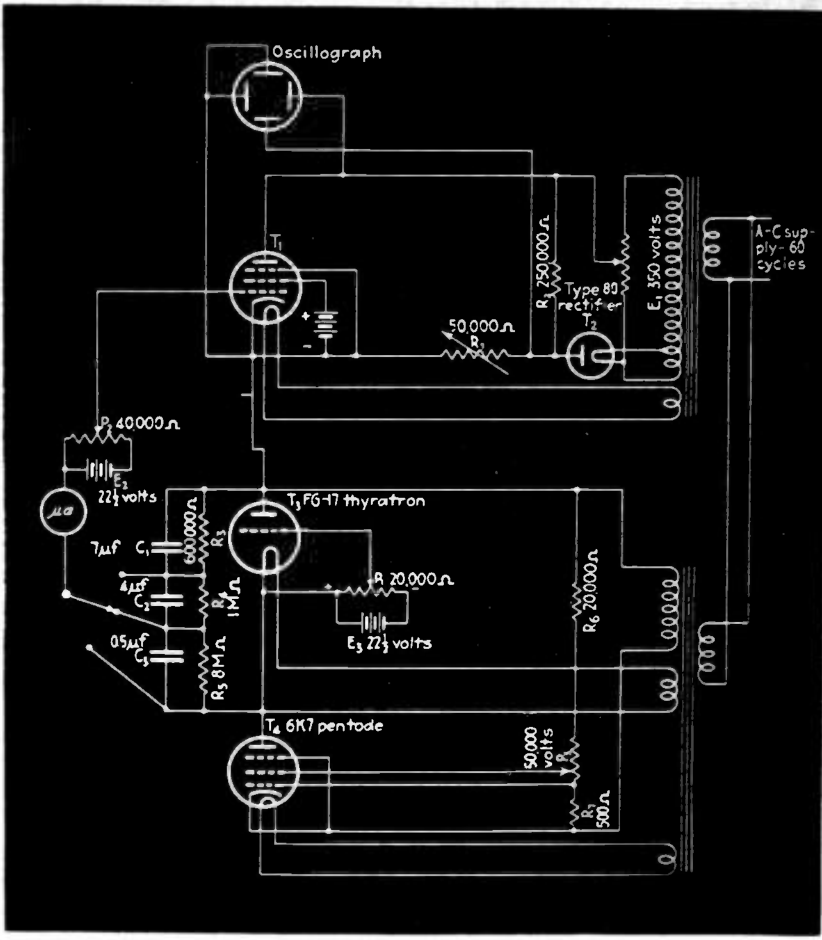
Figure 2. Refinement of the diagram of figure 1 which enables peak values of current and voltage to be recorded.

ment heats is observed on the oscillograph. The time required for the curve to reach the lower limit set for satisfactory operation is a measure of the emitting quality of the cathode. The presence of gas is immediately apparent from the shape of the curve, as is low emission. Cathode sputtering is evidenced by a flash of current at lower-than-normal plate voltage, and an arc-back shows as a surge of current in the negative direction.

To trace the characteristic curves of an amplifier tube requires a more complicated circuit. The one shown in figure 3 has given good results. This circuit provides a family of curves of plate current vs. plate voltage for various equally spaced grid voltages. The principle of obtaining the proper coordinates is the same as in the case of the diode, the extra apparatus here being for the purpose of providing the various grid voltages. An alternating voltage, E_1, is applied to the tube under test and the series resistor, R_1, through the rectifier, T_2, which, with the high resistance, R_2, serves to block the negative half-cycle of voltage.

Thus on each positive half-cycle the oscillograph spot traces the plate-current plate-voltage characteristic of T_1, for the grid bias at that time, and during each negative half-cycle remains stationary at the

Figure 3. Schematic wiring diagram of cathode ray oscillograph suitable for tracing the characteristics of multi-element amplifier tubes.



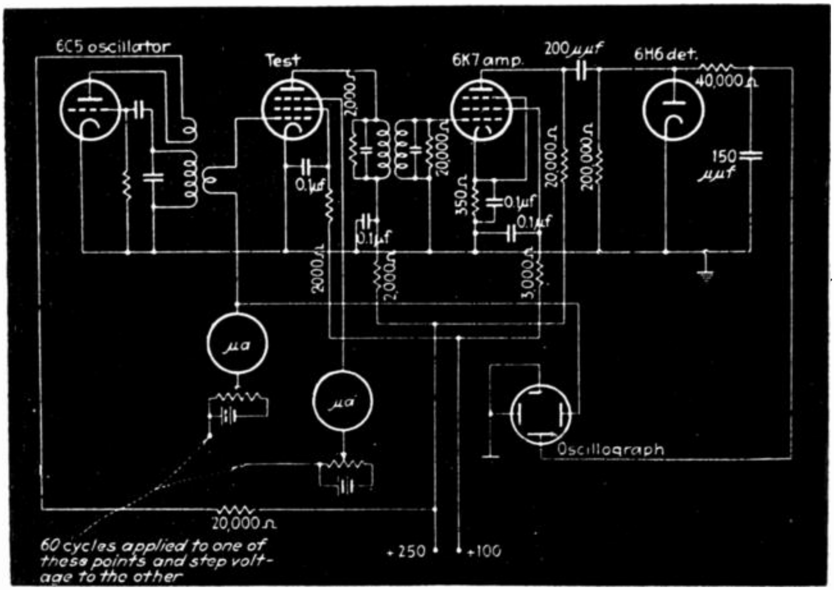


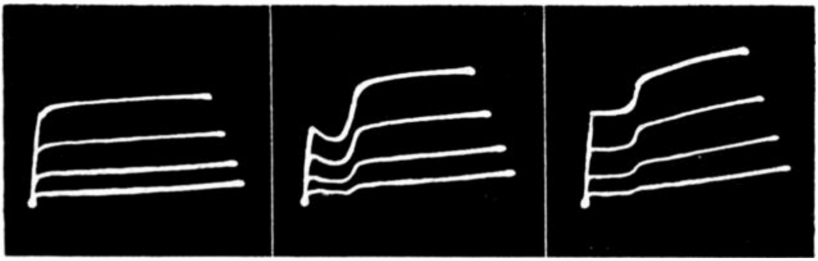
Figure 4. Cathode ray oscillograph circuit for tracing the transconductance as a function of the control grid voltage.

origin.

To trace a complete family of curves for various grid voltages, the grid voltage must be held constant during positive half-cycles, while the spot is moving, and changed by a fixed increment during negative half-cycles. This is accomplished by charging the condenser chain, C_1 C_2 C_3, through the pentode, T_4, in steps, and finally discharging it through the thyratron, T_3. C_1 C_2 C_3 is charged in steps due to the fact that the pentode, T_4, has an alternating voltage on its screen and control grids, and hence conducts only during alternate half-cycles.

The voltage, E_5, is phased with respect to E_1 so as to make T_4 conduct during negative half-cycles of E_1. Since the current passed by T_4 is substantially independent of its plate voltage, so long as it exceeds the screen voltage, the increments of the charge applied to C_1 C_2 C_3 are equal. The amount of the increment depends upon the setting of the screen potentiometer, P_3. When the voltage on C_1 C_2 C_3 reaches a value determined by the setting of P_1, the thyratron fires and discharges C_1 C_2 C_3.

The other details of the circuit are of minor importance, but contribute to the stability and flexibility. The reason for using three condensers C_1 C_2 C_3 instead of a single



Figures 5A, 5B, and 5C, from left to right, showing the characteristics of a 6J7 tube. The conditions under which measurements were made are given in the text.

one is to provide three ranges of maximum bias voltage. The resistors, R_1, R_2 and R_3, permit a reasonable grid leakage current to flow in the tube under test.

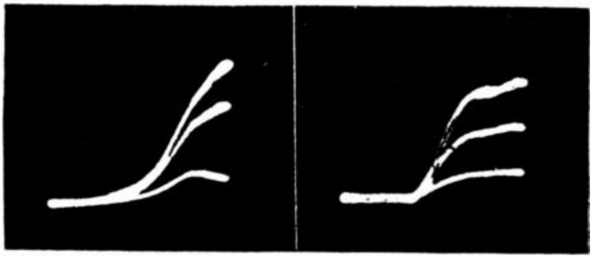
The potentiometer, P_2, across the battery, E_2, permits adjustment of the minimum bias to zero, which it would otherwise not be, since the thyratron may discharge in the condensers to almost any voltage, depending upon the circuit constants. The microammeter in the grid circuit of the tube under test facilitates the adjustment of P_2.

The oscillograms of figure 5 show the results of a few minutes' work with the camera. The curve of figure 5A represents the characteristics of a 6J7 with current as ordinates and plate voltage as abscissa. The control grid voltage is the parameter. The screen grid voltage is 90 volts and the suppressor grid voltage is 0.

Figure 5B represents the same conditions except that the suppressor is connected to the screen. In figure 5C, the suppressor is connected to the plate, but other conditions are the same as in the other two diagrams.

Another tube characteristic which may be traced in a fairly straightforward manner is the mutual conductance vs. grid voltage. The circuit of figure 4 accomplishes this by using the tube as a high-frequency amplifier with a low impedance load in the plate circuit and a small grid signal, and plotting the rectified output against the variable grid

Figures 6A and 6B, left to right. These curves show the transconductance of 6K7 with control grid voltage and with no. 3 grid voltage as abscissae, respectively.



voltage. The signal is supplied by a 175 kc. oscillator to the grid whose mutual conductance is under consideration.

If we wish to plot no. 1 grid mutual conductance against no. 1 grid voltage for various no. 3 grid voltages, then the signal and a 60-cycle voltage are applied in series to grid no. 1, and the step-voltage, generated by the circuit of figure 4, is applied to the no. 3 grid. The output of the detector feeds the vertical deflection plates of the oscillograph, and the horizontal deflection plates are supplied by the same 60-cycle voltage as the grid of the tube under test.

It is desirable to include a microammeter in the lead of each grid having one of the variable potentials in order to adjust the minimum bias to zero. The order of magnitude of the deflecting voltages obtained from this circuit is such as to require an oscillograph having an amplifier in each of the deflecting plate circuits.

Some curves taken with this circuit are shown in figure 6. Figure 6A shows the transconductance of a 6K7 as ordinate with control grid voltage as abscissa and no. 3 grid voltage as the parameter. Figure 6B shows the transconductance of the 6L7 as ordinate, no. 3 grid voltage as abscissa and control grid voltage as parameter.

Candor

AFTER much scurrying around, a technical employment agency finally found a Ph.D. for a company who wanted a physicist who could write. His job was one of translation so the man in the street could understand what his company was doing. In conference with his prospective employer, everything went well. His technical qualifications were 100 per cent. Finally he was asked, "Do you write?"

"Yes," he said, "but the editors send it all back."

Pleased with the young man's candor, they promptly gave him a better job in another department, and at latest reports the company was still trying to find a physicist who can write.

—Electronics.

REBUILDING TRANSMITTING TUBES

ONE of the most interesting phases of radio is the rebuilding of power tubes. When a tube is received, it is tested for vacuum with a high-frequency coil to determine if there is a slow leak or crack somewhere in the tube—also as to whether or not there is any vacuum in it.

Next is to determine whether the gas is air or if it is gas that has been liberated from the electrodes. If the gas is air, new stems are needed. If the job is a water-cooled tube, the metal-to-glass seal may be cracked or leaky which can generally be repaired if it is hard glass. If it is soft glass, it will probably require a new bulb and a glass-to-copper seal.

We are now ready to break the vacuum at the tip off and open the tube with a hot wire. The grid and plate are examined for defects. Then the filament is measured with a micrometer to determine the diameter. A new filament is formed of the same diameter and spot-welded to the leads. The grid and plate are accurately put back in place and the necessary getter cups mounted.

The bulb is washed out to remove the old magnesium getter and metallic deposits from the original exhaust procedure with acids and water, then dried out with acetone. After the bulb is dry, the tube is ready to be sealed together and the exhaust tube attached.

It is now ready to exhaust and is sealed to the vacuum manifold. A preliminary vacuum test is made for leaks. If o.k. up to this point, it is baked in an electric oven, at from 400° for lead glass to 500°C for hard glass, for at least one hour or until the gas and water vapor is completely exhausted.

An ionization gauge gives a constant check on the gas liberated. The next step is to carbonize the filament to its proper conductance, about 80 per cent of its original conductance, if it is a thoriated filament. If it is a pure tungsten filament, no carbonizing is needed. A high-frequency water-cooled vacuum-tube furnace or coil is put around the tube and the parts outgassed slowly at first, then the temperature is raised to 1300°C or higher while there is an air blast on the tube which keeps the glass from collapsing.

The parts are bombarded alternately internally and externally at the highest temperature they will stand and still hold their correct shape from 6 to 18 hours or until there is no more gas liberated. It is baked again to clear the glass from gas deposited during the bombardment of the metal parts.

The getter is flashed and the elements sparked out with a coil. The tube is generally bombarded again before sealing off. The bases are mounted and baked on, after which it is put in an aging rack for some time to stabilize its operation.

—John W. Jaffray in "Communications."

¶ From Communications,
April, 1938

A 200-300 Mc. Broadcast Pack Transmitter, Receiver

BY L. C. SIGMON
Chief Engineer KCMO

IN DESIGNING a pack transmitter to be used for relay broadcasting, the following facts are considered of primary importance.

The transmitter must be as light in weight as practical for good voice quality and frequency stability. The pack must be of such size that it will not interfere with the normal movements of the person wearing it . . . especially in buildings and other congested places.

The antenna system is also of importance in that it must be used both inside and outside of buildings during broadcasts . . . the antenna must be short enough to pass through standard doors.

Still another important consideration is electrical interference when broadcasting from varied locations.

The ultra-high frequencies of 500, 300, 200, and 100 megacycles were chosen for the experimental licenses of KCMO's pack transmitters. The frequency of 100 megacycles was abandoned because of the length of the rods required in the plate and grid circuit of the oscillator for the required degree of frequency stability, as well as the antenna length.

The frequencies now in actual use for the relay pack transmitters are 200 and 300 megacycles. The 200-megacycle frequency is used more than the 300 because of the variation in signal strength on 300 megacycles when working under low steel ceilings and near metal objects.

The 300-megacycle transmitter is used mainly for the talk-back circuit between the remote engineer and the operator of the 200-megacycle transmitter and receiver. Another advantage of working at 200 and 300 megacycles is the lack of any noticeable interference.

Figure 1 (pictorial section) shows the pack transmitter with the 300-megacycle transmitter attached to the projecting pipe. Each end of the pipe contains a plug so that transmitters of different frequency may be plugged in. The antenna

Editor's Choice

From "Communications" for April comes this article on a pack transmitter for relay broadcasting. It is Editor Ray D. Rettenmeyer's choice from the material in the recent issue which he believes readers of "Radio Digest" would find most interesting.

projecting out of the transmitter is a quarter-wave. All transmitting controls are locked in place after the transmitter is set on frequency. The antenna to the right is the receiving antenna and is also a quarter-wave.

The modulating unit is enclosed in the upper left-hand corner of the pack transmitter proper; the upper right-hand part contains the receiver. The meter on the front reads the total plate current of both transmitter and receiver, the current being approximately 20 mils. The left-hand dial is the regeneration control and the right-hand dial the receiver tuner. The central bar knob is for audio gain control. The switch breaks both the "A" leads and "B" minus voltage.

The lower part of the pack transmitter contains three "B" batteries (45-volt) and two 3-volt "A" batteries. The total weight of the batteries is only four pounds, eight ounces. In testing the pack transmitters, a small power supply was constructed to replace the batteries.

The jacks for the microphone and headphones are located in the left and right-hand corners on top of the pack unit. The back plate of the transmitter pack is attached with self-tapping screws. Four rubber

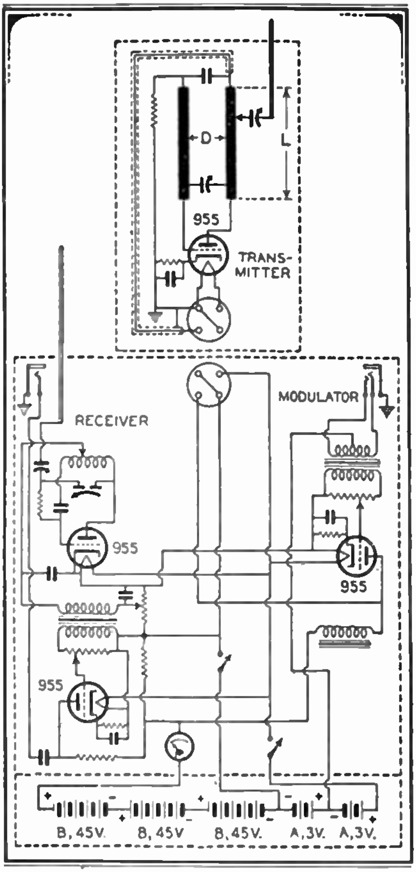


Figure 3. Schematic diagram of the 300 and 200 Mc. broadcast pack transmitter and receiver.

sponges are provided, one on each corner of the back plate so that the pack will fit comfortably.

The microphone used is a double-button carbon type. Dynamic microphones have been used with excellent results, but are somewhat heavier.

The transmitter is elevated above the pack so that the antenna projecting from the top of the transmitter is in the clear of the person wearing the pack and others in the vicinity. Figure 2 (pictorial section) shows the 300- and 200-megacycle unit out of the case. The construction is almost self-explanatory. The tuned lines in the grid and plate circuits were used to provide the required degree of frequency stability, as well as improve the circuit efficiency. The rods used are ⅜-inch, solid brass, and less than ⅛-wavelength long. The spacing between centers of the brass rods is ¾ of an inch. The distance between the rods can be varied but longer rods will be required.

The problem of insulation is not serious at these ultra-high frequencies with the construction shown. The voltage is slightly less than maximum at the tube socket and at a voltage node at the end of the rods. A standard socket is used for the 955 acorn tube. The condenser shunted across the end of the grid and plate rod is a special high-frequency unit. It was found necessary to shield the plate voltage lead. The transmitter should be grounded at only one place on chassis, this being near the grounded filament lead.

The tuning of the transmitter is accomplished by means of a penny soldered off-center to an 8/32 threaded brass rod. The reason for the penny being soldered off-center is to give a vernier tuning effect. Another small plate is soldered to the grid rod to complete the tuning condenser. Construction details are shown in figures 2, 3.

The plate rod is also tapped every quarter of an inch from the end with a 6/32 tap for approximately 1¾ inches. This is to locate the proper coupling point for the antenna condenser. The transmitter proper is constructed on 16 gauge aluminum, but copper is preferable when weight is not an important factor. The case of the pack transmitter is made of 22 gauge cold rolled steel.

The modulator unit is of the Heising type, using another 955 tube. See figure 3.

The quality of voice transmission from the pack transmitter is very good, provided the transmitter is not modulated too heavily. The greatest source of distortion was due to the non-linear characteristics of the regenerative detector used in the receiver. If a low percentage of modulation is used, the distortion is not at all objectionable. All programs broadcast from the relay pack transmitter go through an equalizing circuit which also helps to improve the quality of transmission.

The farthest distance so far tried for reception was three-quarters of a mile over open country. No doubt greater distances can be covered with higher power. The approximate power of the transmitters is 0.1 watt.

The 300- and 200-megacycle pack transmitter for KCMO was not designed to cover a great distance, but to be used inside large auditoriums and for the man-on-the-street broadcasts, etc., where it is usually necessary to use several hundred feet of microphone cable. The signal received is piped back to the station through a remote amplifier and telephone lines.

The reason for incorporating the receiver in the pack transmitter is to permit the person wearing the pack to receive instructions from the remote engineer, or so that when two pack transmitters are used in conjunction, each announcer carrying the pack will know what the other is saying and doing.

Figure 3 shows the circuit diagram of the receiver used in the pack transmitter. The receiver is shown separately in figure 5 (pictorial section). It was found necessary to make some slight changes in the receiver so that it would tune to better than 300 megacycles. The removal of two stationary plates from each of the tuning condensers and the spreading of the turns of each coil will usually accomplish this. Transformers were also added to the receiver so as to match a 500- or 50-ohm line, these transformers being bridged across the grid circuit of the 6C5 audio transformers. Receiver antennas are of the tuned type and are made from a 72-ohm concentric transmission cable. The outside copper tubing is an odd number of quarter wavelengths, the projecting wire being a half wavelength long. In our first test quarter-wave antennas were used on both transmitter and receiver. It was found that by using half-wave antennas on the receiver and the transmitter about 4 or 5 db gain could be expected. The antennas now being used are one-quarter wavelength long for transmitters and half wave antennas on the receivers that feed the remote equipment.

Some tests of interest that have been made are the enclosure of the pack transmitter in a completely copper plated cabinet. The receiver was at a distance of approximately two hundred feet. There was very little drop in signal when the transmitter was completely enclosed, either on 200 or 300 megacycles. One of the most remarkable things about the 300-megacycle signal is that no interference of any kind has been received, and very little on 200 megacycles.

One of the most serious problems so far experienced on 300 megacycles is the variation of signal strength due to some interference effect in and around metal structures. This condition is not noticed in the open until a half mile or more away from the receiver. Rapid movements of the person carrying the pack transmitter had no effect on the reception within reasonable distances.

From Occupations
April 1938

Looking Ahead to Television Occupations

ALFRED N. GOLDSMITH

Modern science and invention constantly are creating new occupational opportunities in a rapidly changing world. The accompanying article by a prominent New York City consulting industrial engineer gives a forward-looking review of what may be expected occupationally with the coming development of television.

A STUDY of occupational possibilities in the field of television before that interesting art has made its commercial debut is possibly premature and certainly hazardous. It savors slightly of planning the Panama Canal shortly before the discovery of America. At best, any vocational analysis of the television of the future must be read with several provisos in mind.

In the first place, a normal engineering development of television is assumed. That is, it is taken for granted that technical knowledge of television will increase apace, enabling the practical solution of the remaining engineering problems of television within a reasonable time. If any apparently insuperable obstacles should prevent the engineers from designing equipment meeting the reasonable needs and desires of the future television equipment purchasers, this might upset all calculations. We are all familiar with arts where normal progress has been retarded by dangers or hazards which the engineers have not as yet been able to overcome. There is a slight but nevertheless existent chance that such obstacles might put off the commercial advent and general acceptance of television for some time.

In the second place, a normal economic development of television must be regarded as probable in any analysis of its occupational possibilities. Television transmitting and receiving equipment is elaborate and relatively costly. Television program construction will be more complex and expensive than rad program construction of today. The television art is a comparatively luxurious one.

Manifestly, such an art can hardly be introduced rapidly on a large scale in times of marked economic depressions, nor can it be expected to win public favor under such circumstances. The television programs will be paid for, under our present system of broadcasting operation, by advertising sponsors in the main. The sponsors will in this way purchase a portion of the purchasing power and general good will of the looking and listening public.

But the size of the audience, its purchasing power, and its mood will all influence the extent to which the advertiser can justifiably support television broadcasting. Accordingly, there is an action and reaction between economic conditions and television success. If times are bad, the programs must be restricted which, in turn, affects the public response that justifies the broadcasting of the programs. Only in reasonably good times can this circle of effects be broken advantageously. Accordingly, those contemplating television as a career will watch closely for times of general economic recovery since it is in such times that arts like television can be expected to flourish and to afford opportunities for a multitude of new workers.

Assuming that television comes into its own in the next five or ten years, probably the best way to outline the various occupational opportunities which it will offer, and the requirements of each position, will be to describe the activities of the field in some detail (with the various prospective openings italicized).

- Manufacturing Opportunities

Let us start at the factory where the necessary equipment for television transmission and reception originates. Here are needed *apparatus engineers* who are capable of doing research, development, and design work in that complicated field. These men must be technically trained and well-qualified along conventional radio lines in order to meet the more difficult problems of television. These radio engineers are, in fact, electrical engineers with specialized training in the particular field of communications.

In the factory there are also needed *tube engineers* who will handle the similar problems of vacuum-tube and cathode-ray-tube production which are an integral part of the television transmitters and receivers. Some of these men may be university-trained physicists who are prepared to enter the equally complex but more commercial fields of tube research and design.

The usual factory personnel will be required for television equipment construction, including *test men, supervisors, production and manufacturing engineers,* and the like. The qualifications here are similar to those for positions of the same type in other fields except that the manufacturing and test problems are probably more difficult and more rapidly changing than in most other fields, thus demanding a flexible, responsive, and original mind as well as great native energy and determination.

- Tronsmitting Stotion Jobs

Once the television transmitter has been built and shipped, it must be installed in the television transmitting station and thereafter maintained. At this point an entirely new series of openings will exist.

Television *station engineers* will include *field-survey engineers* who will determine the best location for the station and its antenna system and who will study the strength and acceptability of the signals throughout the service range of the station. These men will also furnish the data which will satisfy the governmental authorities that the station is covering its territory with an adequate service in the physical sense.

The equipment must be maintained in good condition at all times, and emergencies must be met, and this is the job of the *maintenance staff* of the station. Men of great reliability and prompt resourcefulness are required for this type of work.

The television-station studios will require a staff of their own of considerable size and of wide diversity of tasks. Considering the technical men only for the moment, there will be *lighting experts* who will arrange and control the powerful illumination which floods the sets (scenery) in the studio and the actors. These men must be skilled electricians capable of handling, shifting, and controlling illumination in any desired fashion.

There will be the *microphone* or *sound men* in the studio who will place and control the microphone supports or booms which hold the microphone close enough to the actors to pick up speech or music, while still keeping the microphone outside of the field of view of the camera. Here men with steady hands, quick responses, and a cool way of working effectively will be required (particularly in the stress of high-speed operations during the studio performance).

In the control rooms of the studio, there will be *sound-control men* and *picture-control men* who will handle respectively the quality of the sound and the picture which is being transmitted. These men will be technically trained, probably as junior engineers, and they must have quick responses, good judgment, and manual skill in getting the picture and sound results which will best please the audience.

Sometimes, the television transmissions will be from sound-motion-picture film which has been previously made. For example, a film newsreel may be transmitted. This requires that there shall be *projectionists* who will handle and project the film on the television pickup whereby it is sent to the audience. Here too there will be necessary *film-sound control men* and *film-picture control men* who will carefully monitor the transmissions.

• Camera Men

The *television-camera men* will constitute a new profession as well. These men handle the television pick-up or "camera" which is trained on the action and carefully and continuously focussed. The reactions of these camera men must be instantaneous, they must work with perfect coordination in groups where several angle-shots of the same scene are to be transmitted, and they must be resourceful and artistic in their pictorial sense.

It should be remembered that the television broadcast cannot be altered after it is transmitted. The *first* transmission to the audience is the *last* transmission, in general, and there is no opportunity to rectify errors or limitations by a succession of "takes" (as is commonly done in present-day motion-picture production). Accordingly, the job of television-camera men will be exacting and important.

The television-camera men in the studio will be a part of a larger group, for it is clear that the outdoor television pick-ups will require the services of men of similar qualifications and perhaps as great resourcefulness to meet the multitude of complicated, partly unforeseeable, and sometimes uncontrollable conditions to be encountered in outdoor jobs. The outdoor camera man will necessarily be of somewhat the same type as the present successful newsreel camera man who can meet an emergency promptly and effectively.

Since a fair portion of television programs may be, as stated above, from film, it will be necessary to film program material, recording both picture and sound in the same way as now done by the motion-picture studios and newsreel companies. This will lead to a demand for *film camera men, sound recordists, editors, cutters,* and other men of the types found in the motion-picture studios of today. The demand in these fields may develop fairly rapidly as the program "hunger" of television broadcasting rapidly increases after its commercial inception.

• Television Service Men

Still considering work of primarily technical nature in the television field, it is clear that the television receivers of the future must be installed correctly and kept in good operating condition. This requires the existence of a good-sized group of television *service men.* Such men must be familiar with the circuits of television receivers, their operation, the testing of the receivers for faults and their correction, and the best method of installing and maintaining the receiver in the home.

The public response to television will depend in some measure on the skill, honesty, and diplomacy of these service men, particularly during what may be the more or less difficult early days of commercial exploitation of television.

Governmental regulation of radio broadcasting, as at present, will lead to the need for a number of *radio supervisors* in the various districts of the country charged with the inspection and supervision of the operation of the stations to determine that the Federal regulations are observed and to report on matters of service to the Federal Communications Commission.

Further, the staff of the Commission will necessarily include *engineering* and *legal* experts in the new field of television. Those interested in entering the Government service may find openings of this sort congenial in the future.

There will necessarily be a considerable number of related or adjunct activities to those mentioned above in related fields. For example, once television broadcasting is carried out on a nation-wide scale, it will be necessary that the programs, in part at least, be syndicated or carried by wire or radio.

If wire methods are used, the "coaxial cable" will likely find considerable application. The construction of such cables, their installation, their operation and maintenance will then form one of the fairly extensive activities of the Telephone Company with the creation of a corresponding *television-cable staff*.

To the extent that radio-relay methods of syndicating network programs are used in the television field, there will have to be established a *radio-relay staff*, consisting of engineers, maintenance men and the like to keep the connecting links in perfect operating condition.

- Opportunities For Writers

Leaving the field of technical television occupations, it is evident that there may exist a bewildering multiplicity of opportunities for persons of the necessary originality, energy, and application. Programs cannot be started until there are *authors*.

Since the television lookers may be practically insatiable in their demands for program material, it will tax the inventiveness and strength of the authors to the utmost to supply the steady flow of interesting and usable material for the television programs of the future.

The material prepared by the authors will, in some instances, require revision or adaptation by *re-write men* or *script men* who will have to be high-speed literary lights of special ability to meet the instant and considerable demands of the program staff.

- Directors, Actors, Musicians

The casting and production of the programs will require a number of persons, including, of course, *directors* who will know how to build up, rehearse, and present television programs. These men can be drawn partly from the legitimate or "little" stage and the motion-picture studios. In part, however, they will have to be trained at dramatic schools which may be established for the purpose.

At this point there is reached what may be the most serious television demand of all, namely, the demand for qualified *actors*. By "actors" are meant all those appearing before the television camera and microphone including *musicians*, *announcers, dramatic* and *comedy characters, commentators, vaudeville actors, lecturers, interviewers,* and the like.

It must be remembered that we do not as yet know just what are the desirable qualifications for a television actor. The nature and psychology of the home audience, the limitations and opportunities of home presentations, the technical capabilities and restrictions of the television screen, and the general economic problems of television will all affect the suitability of a given person as a prospective television actor. Since only a minor fraction of the aspirants will please the radio public, it follows that a great number of applicants will be necessary to meet the situation.

However, the career of a television actor will be appealing to many and, in spite of the long odds against the individual, it is likely that there will be intense competition from a horde of applicants for these openings. Probably those who have been adequately trained and have had successful experience in somewhat similar fields will stand the best chance of successfully entering this new field.

A considerable number of studio openings will necessarily exist in the television field, for example, jobs for *carpenters, scenic painters, set artists* or *designers, costume experts, wardrobe mistresses, make-up men, historical-research specialists* (who will see to it that no historical inconsistencies or inaccuracies are present in the performance) and the like.

Such openings will increase only rather slowly in number as time goes on, since it is likely that the full development of the television field as a branch of the art of the stage will take a generation or more because of the many and novel problems which are involved.

- Caution!

One final word may be in order in the form of advice to the person who is thinking of entering the field of television. Don't push and run—walk; and watch where you are going.

Speed in rushing into the field will not be nearly so helpful as first knowing where your abilities lie, cultivating those abilities by training in fields similar to television, and then everlastingly sticking to the job of perfecting your talents and their application once you have entered the television field.

Remember that television success will come rather as the result of a prolonged marathon of effort than from a brief gold-rush of enthusiasm.

At a distance of eighteen feet, the roar of the King of Beasts measures about 87 db above the threshold of hearing.—Master Servicing.

From RCA Review
[illegible]

The Monoscope

[illegible]

MONOSCOPE is the name which has been given to a device of special type of tube designed to produce a video signal of a test picture or pattern enclosed in the tube. Since the picture must be enclosed in the tube, the Monoscope is not suitable for developing a video signal which represents action. However, a signal of excellent fidelity can be obtained for a still picture which contains halftones or consists only of lines.

Two general types of tubes which can be used for this purpose are: first, the type which utilizes the primary current of the scanning beam to produce the video signal, and second, the type which makes use of the secondary emission current obtained when a suitable material is scanned with an electron beam.

Briefly, the first type of tube has a signal plate of some desired configuration cut from a conducting surface. When the plate is scanned, a signal current is obtained each time the beam strikes the plate. As a result, the video signal will pro- [illegible]

[illegible]

technique of preparing signal plates was developed which permits the accurate reproduction of all types of subject matter. The structure of a tube employing this principle will now be described.

• Monoscope Structure

The photograph of figure 1 shows the Monoscope. (See pictorial section.) The tube consists of an electron gun, a signal plate, and a collector enclosed in a highly-evacuated envelope. The electron beam is scanned over the signal plate by an electro-magnetic deflection system.

The electron gun which supplies the scanning beam must be of high quality if the best video signal is to be obtained. The electron beam should be very small when it strikes the signal plate if good resolution is desired. The beam current should be reasonably high because the video current varies directly with beam current. However, the size of the beam should not be sacrificed to obtain high beam currents. The electron gun developed for Iconoscopes, provides a small beam with adequate current, and therefore, was readily adapted to the Monoscope. The final anode of this gun operates at 1000 volts, and a very small beam can be obtained for currents of several microamperes. The use of this gun proves to be an advantage in test work when it is desired to use a Monoscope in an Iconoscope camera.

The signal plate is made from aluminum foil and carbon. The surface of the aluminum has a natural coating of aluminum oxide which has a reasonably high secondary-emission ratio while the carbon has a relatively low ratio. It

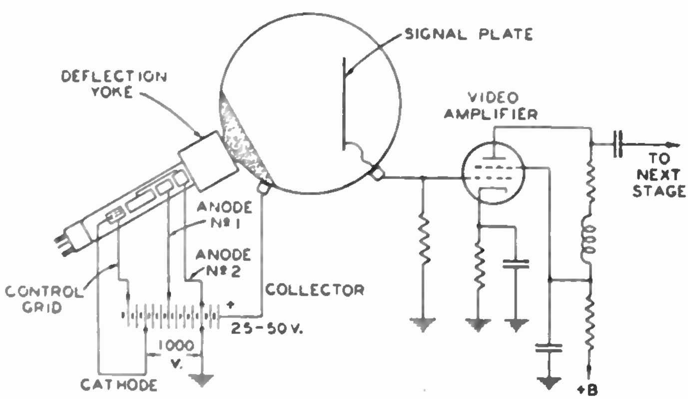


Figure 2. Schematic diagram showing Monoscope connections.

was found that aluminum foil developed for advertising and packing purposes as well as special inks developed for printing on metal foils were satisfactory materials for signal plates. As a result, the advantages and flexibility of commercial printing processes can be utilized.

The desired picture or pattern is printed on aluminum foil with a black-foil ink. The only other processing necessary before sealing the signal plate in the tube is to fire it in hydrogen. This process removes the volatile matter from the ink and thus leaves it practically pure carbon.

Subject matter for reproduction on a signal plate can be divided into two classes: black and white, and half-tones. Cartoons are a good example of the first, while snapshots, which contain tones between black and white, illustrate the half-tone group.

Photo-engravings are made of the subject matter for printing the signal plates. The black-and-white material is treated as a line-cut, but the half-tone material must be broken into a number of dots of various sizes depending on the half-tone value. This is done when the photo-engraving is made by photographing the material through a suitable screen. A screen is used which will break the picture into more elements than are used in the television scanning system for which the tube is designed. As a result, this technique of obtaining half-tones does not limit the resolution of the television system and the half-tone effect is reproduced just as in a newspaper photograph.

In order to give the picture the correct polarity on the Kinescope, i.e., so that white corresponds to white in the original, it is necessary to make the signal plate in a definite manner, depending on the number of stages in the video amplifier. If the video amplifier has an odd number of stages (as is normal between Iconoscope and Kinescope) the picture on the signal plate of the Monoscope should have blacks and whites reversed, but should not have printed matter reversed. The reversal of blacks and whites is necessary because the aluminum oxide, although white in appearance, has a higher secondary-emission ratio than the carbon, and, therefore, produces a signal which corresponds to black.

The secondary-emission current from the signal plate is collected by a conductive coating on the bulb wall. This coating is operated at a potential positive with respect to the signal plate, which is operated at the same potential as the final anode of the electron gun.

• Monoscope Operation

The electrical operation of the Monoscope is very similar to that of the Iconoscope except that a collecting voltage is required for the secondary-emission from the signal plate. However, no optical system is required because the test picture or pattern is enclosed in the tube. A typical connection is shown in figure 2. For convenience, the second anode is operated at ground potential. The first stage of the video amplifier may be operated with self-bias or fixed bias. In the latter case the bias adds to the collecting voltage, but the value of the combined voltage is not critical for potentials above 20 or 30 volts.

The video amplifier must be of high quality to amplify faithfully the video signal. If the signal is to be used for test work, the frequency band of the amplifier should be broader than the circuits under test so that limiting conditions will not be confused.

• Monoscope Uses

The Monoscope may be used for a variety of purposes. In commercial applications, frequently repeated announcements and advertisements could be taken from a Monoscope. Fixed backgrounds for studio work could be obtained—the final signal being a suitable combination of video signal from an Iconoscope for action and from a Monoscope for background.

However, the biggest field for the Monoscope is in television testing. The same video signal can be obtained from day to day, and the quality is not affected by such variables as poor optical focus, dark spot, and amplifier noise. The Monoscope, therefore, is an important devise for checking performance of Kinescopes, receivers, and studio systems.

1. Kinescope Tests

The television-tube manufacturer is concerned with how well his product will perform when reproducing video signals. Short-cut tests have been tried, but give poor correlation with the results obtained when an actual picture is reproduced. However, the quality of the latter is difficult to reduce to a quantitative basis unless the test picture or pattern has a specific

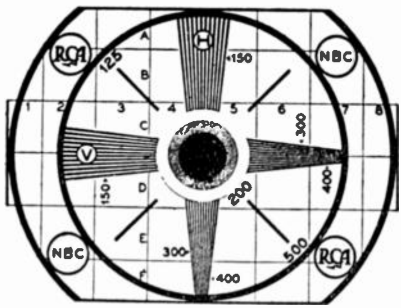


Figure 3. Test pattern for checking resolution.

character from which can be accurately converted into a reliable video signal. The Monoscope is admirably suited for this purpose.

Simple tests insure the quality of the video signal used for rating the Kinescope. If the scanning on the Monoscope is reduced and that on the Kinescope is maintained at normal, an enlargement of the scanned portion of the signal plate will be seen on the Kinescope. This enlargement removes the possible limitation of Kinescope resolution.

Also, the reduced scanning lowers the frequency band of the video signal so that the video amplifier does not limit the resolution. Under these scanning conditions, the focus of the electron gun in the Monoscope can be accurately set to give

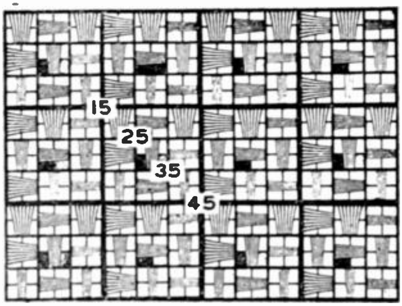


Figure 4. Test pattern for checking all parts of scanning pattern.

maximum resolution. The electron gun used in the Monoscope will give a resolution of 500 to 600 lines without difficulty; therefore, it more than fulfils the requirements of the present system of 441 lines. Figure 3 shows a test pattern which is often used for checking resolution. The lines used to form the half-tone circles in the center can be easily seen when the scanning is condensed.

After the focus of the Monoscope is set for maximum resolution, the resolution of the video amplifier can be checked. This is done by making the Monoscope scanning normal size and increasing the scanning on the Kinescope. The latter is necessary to remove the possible limitation of Kinescope resolution. If a test pattern similar to figure 3 is used, the resolution of the amplifier is easily checked by noting the resolution of the "V" in the upright position. The resolutions of the Monoscope and video amplifier should be appreciably more than the resolution to which the Kinescope is to be rated. Under these conditions, the limits of the Kinescope resolution can be determined and reliable test data obtained.

Experience has shown that the resolution in all parts of the scanning pattern on a Kinescope may not be uniform. Figure 4 shows a test pattern which is suitable for checking all parts of the scanning pattern under similar conditions. Each section carries "V's" which correspond to resolutions of 150 to 450 lines. Also, tones between black and white are included to give a check on the modulation characteristic.

With such a pattern as this, the Kinescope can be rated under different bias conditions with various amounts of video signal input. An illuminometer can be used to check the light output for a definite signal. Experience has shown that such elaboration is necessary to obtain reliable test information. Perhaps, as the art progresses, suitable short-cut tests can be devised.

2. Receiver Tests

A standard source of high-quality signal has numerous advantages in the development and production testing of receivers. Various resolution patterns serve as good "yardsticks" for measuring receiver characteristics if they can be converted into video signals of good fidelity. As has been pointed out, the Monoscope is particularly useful for this purpose. By adding standard synchronizing impulses to the Monoscope signal and modulating a small transmitter, a very useful test signal can be obtained for readily checking the receiver.

3. Television System Tests

When a television system is installed, numerous tests must be made to adjust the various circuits. The Monoscope materially aids such testing. For instance, any extraneous signals entering the grid circuit of the Iconoscope can be easily detected. Since the video signal from the Monoscope is directly proportional to the beam current, any variation in beam current is revealed as a modulation of the video signal. Therefore, any extraneous signal or hum in the circuits is revealed.

When the shading signals which are sometimes added to the Iconoscope video signal are removed, the video-amplifier can be checked for pick-up and frequency response by using a Monoscope video signal. Such tests help to separate confusing factors which often combine to give poor over-all operation.

Because there are not any halftones in the video signals from a Monoscope except those that are created by the limitation of resolving power of the beam, the signal is rich in the higher-order harmonics which make up the corners of a square wave. This type of signal is exceptionally good for showing the transient response of video amplifiers.

The Monoscope is a type of tube which has proved very useful for testing of television devices and circuits. It is believed that the Monoscope will aid materially in advancing and perfecting the art of television.

(See pictorial section for photograph of this device.)

New Stations Planned

THE FCC has created a new class of station, the educational broadcast station, which will be non-commercial in character and subject to the rules and regulations governing other high frequency broadcast stations. This answers the ancient cry of educational agencies that they be given a place in the radio sun.

These stations will be licensed to organized non-profit educational agencies for the advancement of their educational work and for the transmission of educational and entertainment programs to the general public. No sponsored or commercial programs may be transmitted, and all commercial announcements must be cut from programs rebroadcast by these stations from regular broadcast stations.

Educational stations will operate on twenty-five single channels (frequencies) spaced 40 kc. apart from 41,020 to 41,980 kilocycles.—"RADIO".

MEN IN RADIO...

WILHELM WEBER—1804-1891

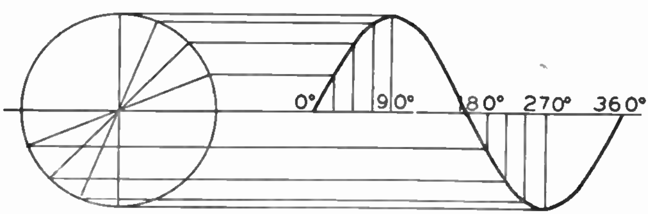
WILHELM EDWARD WEBER, the German physicist, was born at Wittenberg on Oct. 24, 1804. He was the younger brother of Ernest Heinrich Weber, the author of Weber's "Law".

With his colleague, K. F. Gauss (from whom the unit of magnetic field density, the gauss, gets it name) Weber showed that it is both theoretically and practically possible to define them, not merely in terms of other arbitrary quantities of the same kind, but in terms of which the units of length, time and mass are the basis. Thus started the never-to-be-ended argument as to whether the metric system of designation for electrical units, or some arbitrary system, was the more practical.

But the strength and soundness of Weber's argument for the universal adoption of the c.g.s. system really gathers force rather than losing it, with the passing of the years. It is no little tribute to his genius that the system is practically universally used by scientists. Weber's theory of electricity was founded on the views of Techner, who considered that positive and negative charges move in a conductor with equal and opposite velocities. From this Weber worked out the law of forces between charges.

His work on electricity did much to stimulate other mathematical physicists to emulate his example.. He also carried on extensive researches in the realm of magnetism, and developed Faraday's ideas regarding the explanation of diamagnetic phenomena. In his observations in terrestial magnetism Weber not only employed an early form of mirror galvanometer but, about 1833, he devised a system of electro-magnetic telegraphy which worked successfully over a distance of 9000 feet.

In conjunction with his elder brother he published, in 1825, a well-known treatise on wave forms.. In 1833 he collaborated with his younger brother, the physiologist Edward Friederich Weber, in an investigation into the mechanism of walking. Weber died at Gottingen, Germany, on June 23, 1891, at the age of 87. —The Ohmite News.



SINE CURVE—A TYPICAL WAVE FORM.

From Radio Review of Australia
April, 1938

"Q" versus "Z"

WHICH IS THE REAL "FIGURE OF MERIT"?

The modern r.f. amplifier or mixer valve with its high plate resistance has confronted the receiver design engineer with a problem he did not even have to think about a few years ago—that of designing interstage coupler primaries so that a high dynamic resistance is presented to the preceding valve.

In practice, the fact that a tuned circuit has a dynamic resistance is often disregarded and design is carried out along "cut and try" lines until a tolerable state of efficiency is achieved. Whether this "tolerable" efficiency is always the optimum can be questioned; it would seem that a more logical design procedure for r.f. and i.f. interstage couplers could be evolved by taking the primary impedance into consideration. Some notes on this subject, together with an outline of the procedure for computing coupler primary impedance, are presented in this article.

Of late years there has been rather a tendency to regard the factor "Q" as the only item of importance in tuned circuit design. Admittedly, the value of "Q" may be regarded as a reliable index to the efficiency of a tuned circuit alone, but the fact that a tuned circuit rarely operates alone must not be lost sight of. This means that when optimum efficiency is desired the relationship of the tuned circuit to the valves with which it works must be considered.

The conditions existing in an r.f. or i.f. amplifier are, in many respects, similar to those under which an a.f. amplifier operates. In the latter, matching of the load to the valve is usually regarded as being of prime importance yet, in an r.f. and i.f. amplifier, *direct* consideration is rarely given to this factor.

It will be noted that the word "direct" was used in the preceding paragraph. This is because the value of the r.f. and i.f. plate load is rarely even thought about in terms of impedance—most technicians apparently regarding the factor "Q" as something in the nature of a synonym to "impedance," although it is really only one of the factors which regulate the impedance of a tuned circuit.

If we accept this assumption—that "Q" and "Z" are largely regarded as synonymous—, it is quite easy to understand how the present trend towards higher and higher "Q" values, without regard to any other factors, has come about. We know that the majority of r.f. and i.f. amplifier valves in use have plate resistances far higher than can be conveniently "matched" by any tuned load, therefore (still accepting the above assumption), the higher the "Q" the nearer we will be to obtaining a correct "match."

• Definition of "Q"

Just how mistaken such a procedure is can readily be demonstrated by considering the real nature of the factor "Q." First of all, this factor is derived by dividing the reactance of a tuned circuit element by its resistance at the frequency under consideration. This means that the factor "Q" may be regarded as an index to the efficiency of a coil (or condenser), and also as an index to the selectivity of the circuit in which the coil or condenser is employed.

In both cases, the efficiency and selectivity vary with "Q" and in the same direction. This means that any move towards higher "Q" values for tuned circuit elements must result in greater tuned circuit efficiency and higher selectivity, *but it does not necessarily mean that the overall efficiency of the stage in which the tuned circuit is employed will be increased.*

Before elaborating on the last part of the last sentence, it must be pointed out (although it should be obvious) that in most cases, a limit to the value of "Q" which can be employed is set by the side-band requirement of broadcast reception. It has been shown previously that selectivity increases with "Q"; consequently, the limit of usable "Q" is reached when the side-band attenuation becomes objectionable.

This reveals another fallacy in the "higher Q" method of design because even if the impedance of a tuned circuit always increased with "Q," no one would dream of suggesting that the overall efficiency of an r.f. or i.f. amplifier stage is determined by the degree of side-band cutting which is tolerable—yet, in effect, this is what technicians are doing by thinking in terms of "Q" to the exclusion of all others.

• Derivation of "Z"

Revert now to our contention that overall stage efficiency does not necessarily increase with the "Q" of the tuned circuit elements—which is the same as saying that tuned circuit impedance does not necessarily follow the variations in "Q" of its elements.

The impedance of a parallel-resonant circuit, which is the type of tuned circuit used for the vast majority of r.f. and i.f. couplers, is equal to the product of its reactance and its "Q." This means that the reactance of the elements in a circuit is equally as important as their "Q" in determining the effective impedance. A little thought along these lines will show that *an increase in "Q" without consideration of the reactance can actually result in a reduction of tuned circuit impedance.*

• Some Examples

An example will serve to demonstrate this. We will assume that we have an i.f. transformer using a 0.9 millihenry coil tuned to resonance at 465 kc. by means of a 150 μμfd. condenser. The reactance of the tuned circuit elements in an assembly such as this will be approximately 2,200 ohms. By using multistrand litz and a good iron core, it will be possible to obtain an effective "Q" value of 140 for the coil so that, as the effect of the condenser (if it is a good one) on the "Q" factor will be negligible, the impedance of the circuit at resonance will be

$$X.Q = 2{,}200 \times 140 = 308{,}000 \text{ ohms.}$$

To the adherents of the "higher Q" technique, this assembly wouldn't look so good, however, and some way of increasing the coil "Q" would be sought. The simplest way of doing this is to reduce the size of the coil, thereby reducing the r.f. resistance of its winding and its self-capacity. By working along these lines, we can build a coil with an inductance of about 0.5 millihenry and an effective "Q" factor of 200—apparently a vast improvement. This coil, when tuned by a condenser of 250 μμfd., will resonate at 465 kc. and it would seem that we now have a much more efficient circuit for use in our i.f. transformer.

A check-up on the reactance, however, reveals that this has dropped to 1,400 ohms and, calculating the impedance as before, we find that

$$X.Q = 1{,}400 \times 200 = 280{,}000 \text{ ohms,}$$

a drop of about 28,000 ohms in the resonant impedance of the circuit. Under some circumstances, the extra selectivity provided by the higher "Q" circuit might be desirable; but, if this is not the case, we are confronted by the fact that the chase after "Q" has resulted in lower overall efficiency from the stage in which the tuned circuit is to be employed.

An alternative to this is provided by designing the existing 0.8 millihenry coil for higher "Q," instead of merely reducing the inductance and getting an increased "Q" as a result of the smaller amount of wire necessary. If we can improve the design of the 0.8 millihenry coil without altering its inductance, the higher value of "Q" will result in an increase of the tuned circuit impedance.

For example, if by some means we are able to increase the "Q" of the 0.8 millihenry coil to, say, 150, the reactance remains constant and the resonant impedance becomes:

$$X.Q = 2{,}200 \times 150 = 330{,}000 \text{ ohms.}$$

This means that a gain in both stage efficiency and selectivity will be obtained. Summing up, then, it should be clear from the above that the factor "Q," by itself, is by no means as important in tuned circuit design as is generally believed.

Two factors determine tuned circuit impedance—the real index to overall stage efficiency—and both of these should be considered as of equal importance when optimum performance is sought.

- Considering the Valve

At this point, another factor presents itself for consideration—that of varying the design of interstage couplers to suit different valve types.

We have already admitted that the majority of r.f. and i.f. amplifier valves in general use have plate resistances which are too high to be conveniently "matched" by the tuned circuits they work into. Even so, this does not absolve the receiver designer of the responsibility of bearing in mind the variations between different valve types and arranging his interstage couplers to best advantage for the type in use.

Unfortunately, however, there is a distinct trend towards the use of a common type of tuned circuit for all valves—the reasoning (if any) apparently being that the "mismatch" is so bad in any case that a variation either way does not matter.

Nothing could be further from the truth. For a start, reference to fundamental valve theory tells us that the gain obtained from a pentode varies almost directly with the load resistance, when that load is less than the plate resistance of the valve. This means that a given percentage variation in the primary impedance of an r.f. or i.f. interstage coupler will result in an almost equivalent variation of the stage gain in the same direction.

The second factor is that the plate resistance of the valve may be regarded as a resistive shunt across the primary tuned circuit of the interstage coupler. It is well known that the effective "Q" of a tuned circuit may be altered by shunting a resistor across it, so, looking at the problem from this angle, we can see that a circuit having a certain effective value of "Q" when operated with a valve having a plate resistance of, say, 0.5 megohm, will have a higher effective "Q" when operated with a valve having a plate resistance of double the value. This means, in practice, that the selectivity of a given circuit will be improved if it is operated with a valve of higher plate resistance than the one for which it was originally designed. The converse is also true.

The significance of this in the present discussion is that if the selectivity obtained from the circuit when the lower resistance valve is in use is satisfactory, the same degree of selectivity can be obtained with the higher plate resistance valve if a circuit incorporating lower "Q" elements is used. We have already pointed out that an increase in "Q," under certain conditions, can result in a reduction of tuned circuit impedance; the reverse also applies and an increase in tuned circuit impedance can be obtained by reducing the "Q" of the tuned circuit. This factor may be used to advantage in receiver design, and improved performance may be obtained from high plate resistance valves without sacrificing selectivity.

An example will serve to clarify this. We will assume that adequate selectivity is provided by a given tuned circuit when it is operated with a valve having a plate resistance of 0.5 megohm. When used with a valve having a plate resistance of 1.0 megohm, the selectivity increases to such an extent that a reduction in tuned circuit "Q" is indicated as being necessary. We can calculate the reduction of "Q" which will be necessary to restore the selectivity to its original state, but for our present purposes we will assume that a 20% reduction will be sufficient.

There are two ways of obtaining the desired reduction in "Q." The first is to cheapen the design of the tuned circuit, such as by using a lighter gauge of wire for the coil. This will give us the required reduction in selectivity, but nothing else.

The second method is to retain the present basic design and increase the inductance of the coil. This will reduce the "Q" and increase the reactance, thus giving us a gain in tuned circuit impedance. The latter is desirable as it will improve the efficiency of the stage appreciably.

The latter, incidentally, brings to mind a point that should not be lost sight of; namely, that if the original tuned circuit is used with the high plate-resistance valve and the extra selectivity tolerated, the relative efficiency of the stage will be considerably less than when the low plate-resistance valve was used. This is due to the fact that the resonant impedance of the tuned circuit remains fairly constant, no matter the valve with which it is used, and, consequently, the "mismatch" with the high plate-resistance valve will be even more pronounced. This factor alone should be sufficient to influence designers to consider the resonant impedances of their tuned circuits with relation to the valves in use.

The above details provide plenty of reasons for an interstage coupler redesign when valve types are changed and, reverting back to our example, as a "Q" reduction of 20% can be tolerated, this reduction may advantageously be obtained by the second method, i.e., increasing the inductance.

To avoid confusion, we will use the constants employed in our earlier example as a basis for demonstration.

There we had an i.f. transformer with a primary inductance of 0.8 millihenry, tuned by a 150 μμfd. condenser, giving a reactance of 2,200 ohms, a "Q" of 140, and a resonant impedance of 308,000 ohms. We will assume that this is the original tuned circuit which gives adequate selectivity with a valve having a plate resistance of 0.5 megohm. To offset the increase in selectivity due to the use of a valve having a plate resistance of 1.0 megohm, it is necessary to reduce the "Q" of the coil by 20%. This means that the present "Q" of 140 must be reduced to 112, or thereabouts.

The next problem is to determine just how much the inductance will have to be increased in order to bring about this reduction in "Q." Unfortunately, there is no way in which a direct calculation can be made, so that the old "cut and try" technique must be resorted to. For a lead here, we cannot do better than take advantage of the fact that the coil must be tuned by a condenser and it will therefore be advisable to adjust the coil to suit a convenient capacity value.

As the coil is to be increased in size, the condenser must be reduced, so, going down from 150 μμfd. we find that the next convenient value is 100 μμfd. To resonate with this capacity at 465 kc., a 1.2 millihenry coil will be required. This is just 50% more than the existing inductance and, unless heavier wire is used for winding, the "Q" of the finished coil will be somewhat less than the required value of 112 (assuming, of course, that the same form and core are used). However, no very great difficulty will be encountered in building a 1.2 millihenry coil with an effective "Q" factor of 112 and we can go ahead with our computations on this basis.

A check-up on the reactance of the new LC combination (1.2 millihenry and 100 μμfd.) shows that a figure of 3,400 has been achieved. This means that the tuned circuit impedance is now

$$X.Q. = 3{,}400 \times 112 = 380{,}000 \text{ ohms},$$

a gain of about 23% on the original value.

In terms of performance, this means that the original selectivity has been retained and also that the gain of the high plate-resistance stage is over 20% higher than it would have been if the old i.f. assembly were used.

A still greater improvement would be obtained if a coil could be built to resonate with a 50 μμfd. condenser at 465 kc. and still give a "Q" factor of 112. If this can be done, the reactance will go up to nearly 7,000 ohms and the resonant impedance will be about 0.75 megohm. The relative efficiency of the stage in this case would be greater than that of the original assembly with the 0.5 megohm plate-resistance valve.

The need for serious consideration, along the lines indicated above, to be paid to interstage coupler design is made very apparent when the plate-resistances of a few of the valves in general use are inspected.

Looking at the popular 6.3 volt r.f. and i.f. amplifier valves first, we find:—

Types 6D6, 6U7G,
6K7G ....0.8 megohm
Type EF5.....................1.2 megohm

Obviously, an assembly which is ideal for the first three types will not provide anywhere near the same relative efficiency when used with the fourth type.

Now consider 6.3 volt frequency converters:—

Types 6A7, 6A8G....0.36 megohm
Type EK2..................2.0 megohms

The difference between the plate loading requirements of these types is so obvious that no emphasis should be necessary, yet it is a matter of cold, hard fact that receivers are being made which use identical first-stage i.f. transformers for these widely-divergent valve types.

Two valves have been announced overseas which are going to make the problem of first i.f. design even more important. These are the 6K8, triode-hexode, with a plate resistance of 0.6 megohm, and the 6J8G, with a plate resistance of 4.0 megohms. One can readily imagine the bad reputation these valves (especially the 6J8G) will acquire if designers persist in regarding an i.f. transformer as a "universal" coupling device.

Looking at the battery-type valves we find that even greater attention to interstage-coupler resonant impedance is necessary. This is because so many different sets of operating conditions are employed in battery-operated receivers.

Consider the popular 1C6—1C7G type first. No fewer than three sets of ratings are in use for this valve and, as a result, its plate resistance may be anywhere between 0.5 and 0.75 megohm. Obviously, a different plate load is desirable for each class of service.

A similar state of affairs is encountered with the European type KK2 frequency converter. Here the plate resistance may be anything between 1.0 and 2.5 megohms. A plate load which could be classed as "efficient" when this valve is operating under conditions which give it a plate-resistance of 1.0 megohm would be a long way from "efficient" under the 2.5 megohms conditions of operation.

The battery-type r.f. and i.f. amplifiers also vary considerably. Australian type 1C4 has several rated conditions of operation and equally as many plate-resistances. The octal-based replacement for the 1C4 (type 1M5G) has a different set of plate-resistances altogether, and these should be borne in mind when a changeover to the newer valve type is contemplated.

A different set of conditions again is encountered when the European type KF3 is considered so that such a thing as an interstage-coupler which will provide the same relative efficiency when used with any of these types can exist only in imagination.

- Conclusion

The conclusions that may be drawn from the above notes are, therefore:—

(1) the factor "Q," while it may

be accepted as an index to the efficiency and selectivity of a tuned circuit as such, cannot be accepted as a reliable indication of the efficiency of that tuned circuit when it is operating in conjunction with a valve;

(2) the quantity "Z" (resonant impedance) is the only factor which can be accepted as a reliable indication of the efficiency of a tuned circuit when it is operating in conjunction with a valve;

(3) the quantity "Z" for a tuned circuit at resonance is derived by multiplying the reactance at resonance by the effective value of "Q" and, consequently, both these factors must be taken into consideration when designing a tuned circuit which is to act as the load impedance for a valve; and

(4) the widely-divergent plate resistances of valves in common use today warrant greater attention being paid to the design of interstage couplers.

●

From "Ohmite News" . . .

HARDENED copper, the mythical secret of the ancient Egyptians, has been announced as a rediscovery at various times in recent years. But Cupaloy, a new alloy of copper, chromium and silver comes closest to being truly "hardened copper". Cupaloy has 80% to 90% of the conductivity of copper and with suitable heat treatment is stronger than hot-rolled structural steel.

DRYING paint from the inside out has become a standard method with large automobile manufacturers during the last few years. Entire car bodies as well as parts are dried with heat produced in the metal itself by induced currents created by 360 cycle current in coils through which the parts pass. The oven itself remains cool as it is made of non-conducting materials. Car bodies are also dried after washing operations by this method. Three minutes of heating costing about 5c a car are required for this purpose.

ELECTRICAL bug-killing in the soil of greenhouses is the latest novel application of electricity. Passage of current, from a 220 volt source, between metal plates 12 to 18 inches apart, heats the soil to from 150 to 200 degrees Fahrenheit. Only a few minutes heating is sufficient to sterilize the soil, killing a particular pest, the "Nematode," as well as other harmful life.

RCA Review,
January, 1938

Direct-Viewing CATHODE-RAY TUBE

BY I. G. MALOFF
RCA Research Division

EVER since high-definition television pictures were first demonstrated, newspaper writers and laymen have commented on the small size of the picture.

Seemingly it has been of little interest that the size of the picture has had little to do with the amount of information communicated. In early work on high-definition systems a 9-inch diameter cathode-ray tube was used to produce a picture approximately 6 by 8 inches. Most of the present direct-viewing cathode-ray tubes are 12 inches in diameter and produce pictures approximately 7½ by 10 inches. Even so, larger pictures are wanted. Consequently, a great amount of effort and money has been spent here and abroad in the quest for methods of producing large television images having adequate brightness, contrast, and definition.

This paper describes a method of obtaining large television pictures, namely, the method of large direct-viewing cathode ray tube development. This tube was built with the primary purpose of studying television pictures of large size (18 by 24 inches) under conditions where brightness, contrast, and definition were adequate and where the method of reproduction did not limit the performance of the system.

The most important consideration in favor of the large direct-viewing cathode-ray tube is that the total amount of light obtainable from a luminescent screen is directly proportional to the area of the screen. This point will be clarified further.

At present the most widely used luminescent materials for screens in cathode-ray tubes are: the zinc orthosilicate (willemite) and the zinc sulphide. Both materials exhibit the property known as "current saturation." A current-saturation curve of a yellow willemite screen, bombarded by 10,000-volt

This new device for obtaining large bright television images of high contrast and high definition is a direct-viewing cathade-ray tube 4½ feet long and 31 inches in diameter. It is of the continuously evacuated type and gives a picture 18 by 24 inches in size. The paper describes the design and construction of the new tube, the reasons for the development, the difficulties which were overcome, and the results obtained.

electrons in a developmental projection tube, is shown in figure 1.

Measurements show that under the conditions of normal television scanning, this saturation is a function of the area of the scanning spot and not of the total scanned area. But the area of the scanning spot is necessarily a function of the total area, if the detail of the picture is to be preserved; i.e. it cannot be larger than a certain fraction of the total area scanned. In actual practice, since the luminous spot is round, a certain overlap of the scanning lines is permissible. As a limit, after which a serious loss of detail takes place, 50 per cent overlap may be taken. The present tentative standard calls for 441 lines per frame, about 10 per cent of which are blanked out during vertical synchronizing time. The observed picture, therefore, consists of 400 horizontal lines. Allowing 50 per cent overlap, this calls for the line width of one-half of one per cent of the height of the reproduced picture as the limiting maximum line width.

It may be deduced from the curves of figure 1 that at 10,000 volts the maximum useful brightness of this particular type of luminescent screen is 0.7 candlepower per square inch or 100 candles per square foot. The maximum useful beam current (while it is on) is 58 μa per square inch, but when the average power over a period of one complete white frame is considered, it is only 0.80 of the product of volts and amperes (max.).

The factor of 0.80 is introduced because in actual operation the electron beam scans a given picture area for only 80 per cent of the time, since 20 per cent of the time it is extinguished for the line and frame returns or fly-backs.

As to the minimum required brightness of the screen, opinions vary greatly. As a yardstick, the brightness of a motion-picture screen is often used. A committee of the Society of Motion-Picture Engineers concludes that the highlights of the picture should have at least 11-foot lamberts or 3.5 candles per square foot if eye fatigue is to be completely avoided.* The recommendation, however, is that 0.86 to 1.65 candles per square foot be adopted as a temporary standard

*Jour. SMPE, Vol 26 (May 1936) and Vol 27 (Aug 1936)

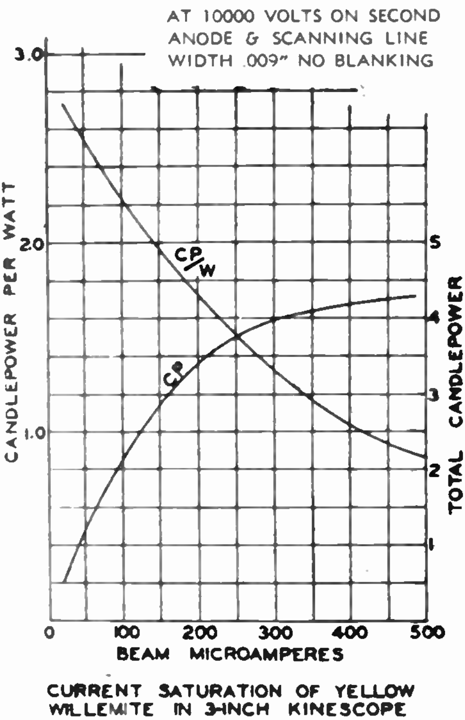


Figure 1—Current-saturation of a willemite screen.

There is very good reason to believe that a television picture should have more light than that. The author's experience indicates that at no time has he seen a television image that was too bright in a normally lighted room. With the tube shown in figure 2, (see page 52) with 1.1 ma. in the beam at 10,000 volts on the second anode, highlights of 40 candles per square foot were obtained. The picture was bright and permitted demonstrations in a brightly illuminated room, but no observer pronounced the picture as being too bright. In a dark room such a picture is definitely too bright.

The reason for low screen brightness being satisfactory for motion-picture theaters is that there is practically no stray light and the size of the image is very large. The theater hall is devoted to the showing of pictures and everybody there is looking at the picture. The television receiver is placed in a room which is used for other purposes. It may be the living room of a residence, a hotel lobby, or a restaurant.

To be of maximum usefulness, a television receiver should not interfere with any other functions of the room. The willemite screen by itself, at 10,000 volts, is capable of giving a surface brightness as high as 100 candles per square foot or 314-foot lamberts or apparent foot-candles. For a screen 18 by 24 inches it would require 25 ma. at 10,000 volts. For the previously mentioned figure at 40 c.p. per square foot, only 6 ma. at 10,000 volts are required. The lower the current density of the luminous spot, the higher is the screen efficiency. At 2 ma. and 10,000 volts a directly bombarded luminescent willemite screen of the type described will have a brilliancy of 14.6 c.p. per square foot or 46-foot lamberts which is nine times the upper brightness limit of the tentative SMPE standard.

During the first quarter of the present year the construction of a direct-viewing TCR tube with screen

18 inches by 24 inches was completed at the Camden Laboratory of the RCA Manufacturing Company, Inc. The tube is of the demountable, continuously-evacuated type and has a metal envelope with a Pyrex sight glass. Figure 3 (see page 52) shows a side view of this tube. The envelope is made of good grade steel ¼-inch thick with arc-welded seams and flanges.

It has the shape of a cone, and is 4.5 feet in length. The outside diameter of the larger flange is 31 inches. A three-stage oil-diffusion pump is directly connected to the tube through a special outlet. For fore-vacuum, a mechanical vacuum pump is connected to the diffusion pump by means of a length of rubber hose. The glass cover is convex outward, 31 inches in diameter and 2 inches thick. This thickness is required because the total atmosphere pressure on the glass is approximately 5½ tons. A special machine was constructed in the laboratory for grinding and polishing both surfaces of the glass. The technique used was that of grinding telescope lenses. A layout of the grinding machine is shown in figure 4 (see page 53).

For vacuum-tight joints between the glass and metal as well as between metal flanges, pure gum rubber gaskets proved very satisfactory. The performance of the tube is quite satisfactory when vacuum of the order of 10^{-6} mm Hg is reached. Normally such a vacuum is reached after 48 hours of operation. The vacuum measurements are made by means of thermocouple and ionization gauges attached to the sleeve connecting the vessel and the diffusion pump.

The tube was designed for 10,000 volts on the second anode. For safety reasons, instead of operating the metal envelope at 10,000 volts positive, it is grounded and the cathode is raised to the same voltage, but negative. This arrangement greatly facilitates the construction of the electron gun. The electron gun used in this tube is shown in figure 5 (see page 53). It gave beam currents as high as 8 ma. at 10,000 volts with corresponding brilliancy of the highlights. However, the best overall performance was obtained with a gun giving 2 ma. in a narrow beam with negligible defocusing and with – 150 volts cut-off grid voltage.

The design of the power supply and video amplifier for the demountable tube offered many difficulties. The cathodes in the last stages of the video amplifier had to be operated at minus 10,000 volts and, of course, had to be capacity-coupled somewhere along the chain to the low-voltage stages. The two coupling condensers during the operation are charged to 10,000 volts and at the same time are required to pass low video frequency currents. All the meters and controls on the last stages of the amplifier had to be insulated for 10,000 volts. A view of the portable outfit containing the video amplifier, synchronizing and deflecting circuits, and high and low-voltage supply, is shown on the right-hand side of figure 3.

In received pictures, the signals of which are taken from an Iconoscope pickup of a regular moving picture frame, it is to be noted that the sides of the image are straight and there is no apparent bulging of the image. The reason for this effect is that the 2-inch thick glass disc is used only as vacuum cover or a sight glass while the luminescent material is deposited on a flat glass sheet ¾-mm thick, which is fastened to the walls of the tube.

The flat appearance of this type of luminescent screen is not its only advantage. The fact that it is flat greatly improves the overall contrast of the reproduced picture. On a concave screen, illuminated parts throw light directly on the backs of the image, thereby reducing the contrast. The fact that the screen glass is thin improves the contrast in details by reducing the well-known "halation" or "the spurious ring" effect.

In conclusion it may be stated that with the tube described, large, bright television images of high detail and of high contrast are obtainable. This tube possesses real entertainment and communication value and may be shown in normally lighted rooms in daytime and at night.

Tape Tags

THE electrical boys at the Douglas Aircraft factory have a neat system for identifying wires. Everyone that has at one time or another puzzled over which wire was which as he looked at a transformer with multileads will be interested.

White adhesive tape as carried by the dime stores will serve the purpose. Cut off a short length from the roll and roll that piece on a typewriter platen. Typing the figures on the adhesive tape makes a neat job or they may be written on in ink. Many different ways of doing this will suggest themselves as the wire size or area to be covered may vary. After typing, place the printed tape on a smooth board, press down firmly, then cut with a sharp knife or razor. In this way a whole string of numbers may be typed at one time and then cut off with the least bit of trouble.

For a lasting tag that will not easily soil, brush on a little white shellac after the tape has been applied to its place.

This scheme is not limited to wires. Dating vacuum tubes, placing your name on a tool, indicating meter polarity, dial markers, marking plug-in coils, and many other uses can be thought of.

No harm to the typewriter if the pressure rollers are released. This avoids pressing tape too hard against platen.

—RADIO.

Communications,
March, 1938

THE DELTA-STAR MIXER

BY J. N. A. HAWKINS

SPEECH-INPUT mixers are used to mix the outputs of two or more sound sources into the input of an amplifier channel. The output of the amplifier channel may modulate a radio transmitter or it may be directly reproduced by loudspeakers as in a public-address system. Also the sound may be stored to be reproduced at some later time, as in disc and film recording.

Mixers may be either electronic or resistive. Electronic mixing has both advantages and disadvantages, but as resistance mixing is almost standard in high-quality mixing circuits, this discussion will describe a new resistance-mixer circuit.

Resistance mixers use either series mixing, parallel mixing, or a combination of the two methods. These older mixing methods will not be discussed in detail as the common circuits can be seen in any broadcast or recording handbook. It is enough to say that some four-position mixers average a 700% impedance mismatch and 17 decibels minimum insertion loss.

In the four-position mixer circuit shown in figure 1 the impedances are matched looking forward or backward, and standard variable pads can be used for any number of inputs from two to sixteen. The inherent mixer loss (minimum insertion loss) is 6 db up to four positions and only 12 db for the sixteen-position mixer.

The same impedance pads which serve as master gain also serve for each input channel, which reduces the number of spare pads necessary. The input and output circuits are identical and can be used interchangeably as either inputs or outputs.

The mixer can do a number of things that the average mixer circuit cannot do. Two inputs can feed up to four separate outputs, each with its own gain control. Four inputs can feed two outputs, or three inputs feed three outputs, with always a separate gain control on each input and output channel.

However, one precaution must be kept in mind. The inputs and outputs must be chosen with care due to the hybrid balance which exists between inputs A and B, C and D, and between E and F. Thus if terminal A is used as an input, terminal B cannot be used as an output as there is nearly infinite loss between A and B regardless of the pad settings. Likewise there is nearly infinite loss between terminal C and terminal D, and terminal E and terminal F. However, the minimum loss between terminal A and terminals C, D, E or F is only 6 db. Thus, while there are six pads shown, this particular arrangement can only be used as a four-position mixer, with the other two pads acting as separate master gain controls in two separate output channels. These two output channels are useful in many services; such as, feeding the main and monitoring amplifiers, feeding a network and a local transmitter, etc. Note that the nearly infinite loss between the two output circuits prevents line noise,

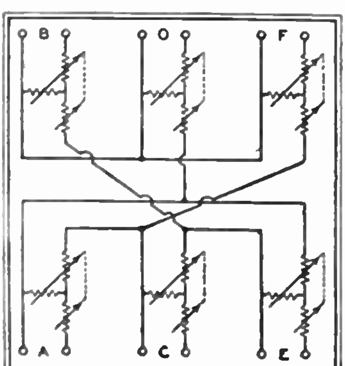


Figure 1. Schematic of the 4-position mixer circuit.

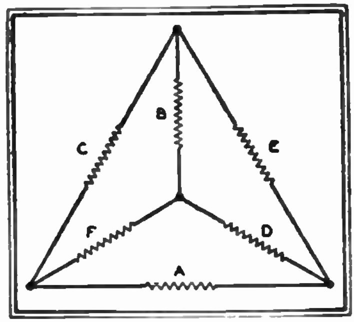


Figure 2. Equivalent circuit of delta-star mixer of figure 1.

switching clicks or other unwanted sounds appearing in one output channel from reaching the other output channel.

The high loss between the terminals in the same vertical plane in the diagram of figure 1 (AB, CD, EF) can be visualized more easily by examining the equivalent circuit of figure 2. It is from this equivalent of the four-position mixer that the arrangement gets its name. Figure 2 will be seen to be a delta network combined with the common star network, both borrowed from common three-phase practice.

Each of the resistances in figure 2 represents the output resistance of the variable pads shown in figure 1, and they are all equal. In figure 2 it will be seen that any voltage applied across A will not appear across resistance B because both ends of B are at the same potential as long as C equals F and E equals D. However, any voltage impressed across A will produce a voltage across the other four resistances C, F, E and D.

By the same token it is seen that any voltage impressed across C will not appear across D. Likewise nearly infinite loss exists between E and F. The circuit resolves itself into a balanced bridge, but it is shown in this form to show that in certain balanced bridges three conditions of balance exist and not just one.

This matter of infinite loss between three pairs of terminals has an unusual and interesting aspect. It means that three studios, for example, can be interconnected by means of microphones and monitoring speakers, so that each studio can talk or listen to the other two studios without singing or audio feed-back as long as the acoustic loss in each studio, from speaker to mike, is greater than one-half of the net gain between any mike and loudspeaker. This condition is easy to realize in practice without special mike or speaker placement.

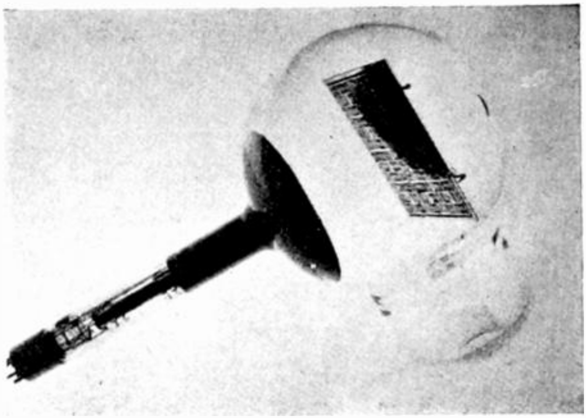
While it is rarely necessary to inter-connect three studios for full triplex conversation, the use of two studios with full duplex facilities is not uncommon. At the present time it requires the use of headphones at one end of the conversation, at least, but with this mixer arrangement loudspeakers can be used at both ends without trouble.

One of the main advantages of the Delta-Star mixer is that standard and similar pads are used throughout. In the four-position arrangement of figure 1, six 200-ohm pads may be used working out of four 200-ohm sound sources and feeding two 200-ohm lines or amplifier inputs. Mixing transformers are not shown in figure 1, but they might consist of 200-ohm isolation transformers to allow the one side of each incoming and outgoing circuit to be grounded. The mixer may be extended up to 16 inputs and 2 outputs, still using 200-ohm pads throughout, and with all impedances matched regardless of the number of inputs. This means that a station can standardize on one impedance for its inputs, outputs, lines, pads and mixing transformers, and yet be flexible enough to meet future mixing requirements.

Studio on Wheels

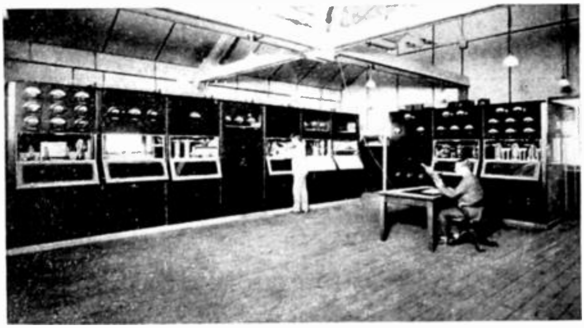
BALTIMORE, MD.—Station WFBR now has a new mobile studio which is built on a trailer 25 feet long, 6 feet wide and 10 feet high. This mobile studio with its control room has all the equipment of the regular studios. It is to be moved by means of a truck which will carry a 500 watt transmitter and turntables. It is planned to visit every town in Maryland with this equipment, to transmit and record programs by local talent and to retransmit the recorded features later from the main station so the participants can hear.—Radio News.

Pictorial Section



THE MONOSCOPE

C. E. Burnett describes, on page 28, this tube which has been designed to produce a video signal of a test picture or pattern enclosed in the tube.



RADIO'S PROVING GROUNDS

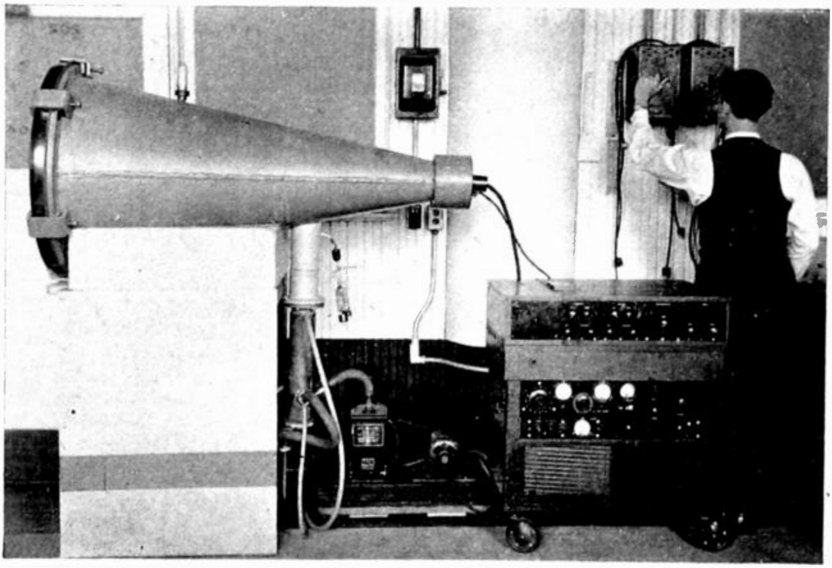
(Above) The first 50-kilowatt transmitter installed in 1927 at Whippany, N. J., site of the Bell Telephone Laboratories' field station for radio testing.

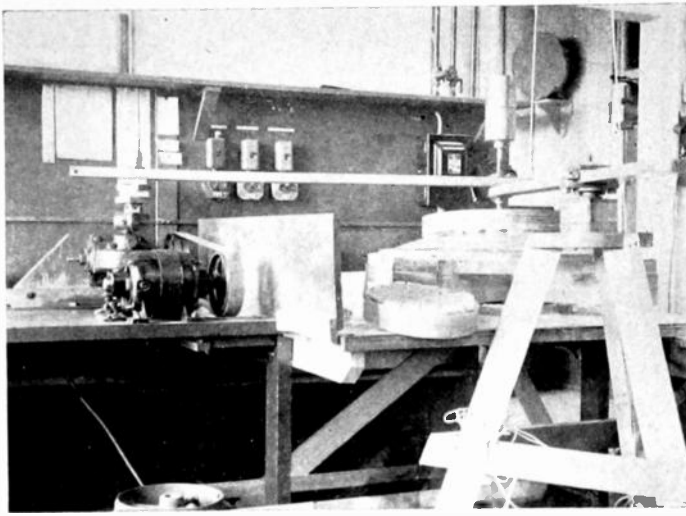
(Left) The "contraption" that was developed to lay-in the ground system at Whippany. The reel is attached to the tractor that draws the plow.

Direct-viewing Type C. R. Tube

Figure 2. (Left) 12-inch direct-viewing television cathode-ray tube for large light output at high contrast.

Figure 3. (Below) Side view of the 31-inch demountable TCR tube.





for large Television Images

Figure 4. (Above) Machine for grinding and polishing glass covers for 31-inch TCR tube described by I. G. Maloff in his article on page 43, "Direct-Viewing Type Cathode-Ray Tube."

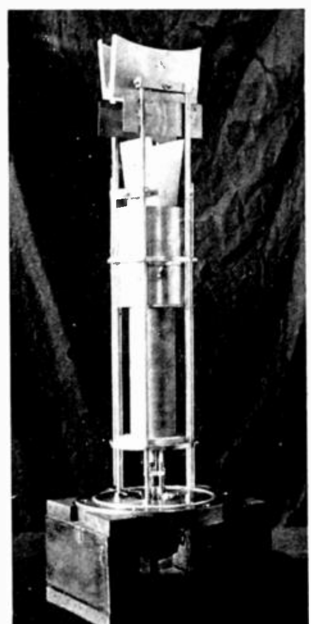
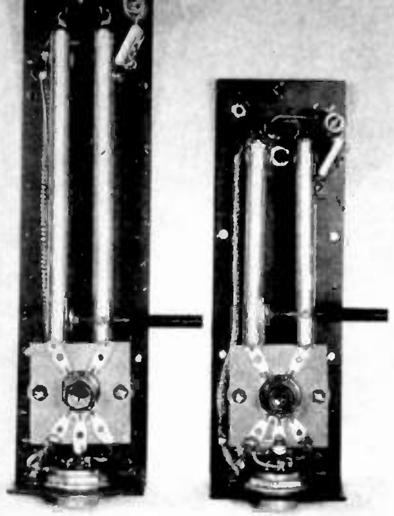


Figure 5. (Right) Electron gun for 31-inch demountable TCR tube.

(All cuts courtesy "RCA Review")

Pack Transmitters and Receivers

(Cuts courtesy "Communications")



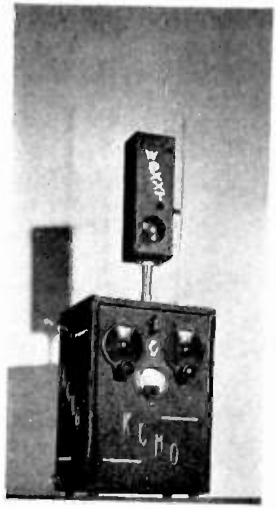
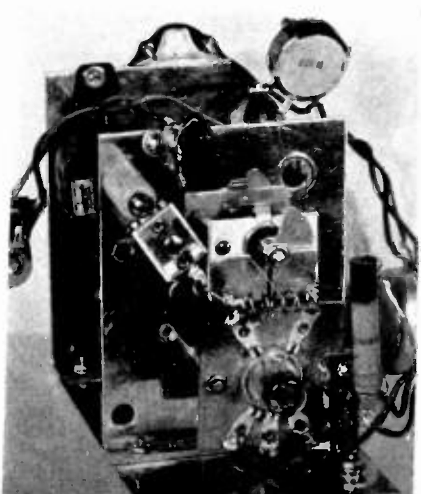


Figure 1. The 300-Mc. transmitter and receiver.

Figure 2. (Top left) The transmitters uncased. Note tuning condenser next to socket.

Figure 4. (Lower left) Side view of the 200-Mc. transmitter. Note 3/8" rod tapped for antenna coupling condenser.

Figure 5. (Right) The 300-Mc. receiver removed from the pack.



Bell Laboratories
Record, March, 1938

Stability of Reception
at Two Meters

BY A. DECINO
Radio Research, Bell Laboratories

ULTRA-SHORT waves which are transmitted to points well beyond the optical horizon undergo variations in the received field intensity that usually are not observed over the shorter distances. This fading is attributed to variations in the amount the waves are bent back to the earth by the refracting property of the lower atmosphere.

An experimental study of the extent of these variations, undertaken by the research department of the Laboratories, has been carried out over a sixty-kilometer path between Lawrenceville and Deal with two-meter waves.

Typical patterns of the fading it revealed are given in figure 2. Record 1 shows fairly steady reception with slow changes of a fraction of a decibel. Such steadiness was of frequent occurrence and has been observed on several successive days. Record 2 shows more rapid variations but still small in amount. The third type of fading produces a gradual variation in received field upon which are superimposed changes more pronounced and of somewhat longer periods than those of the other two records. Most of the fading which was observed was of this general type.

A striking and interesting pattern is that of record 4, where a relatively slow fading accompanies a very slow change amounting to as much as twenty db.

In the fifth case the pattern, when the speed of the chart was increased sixty times, was found to involve a succession of very rapid variations in amplitude. Fading of this character, which occurred more often during the colder days of the year, may have been produced by an air mass moving across the path and redirecting some of the energy to the receiver. A large object might have the same effect; and in fact a similar flutter has been noticed

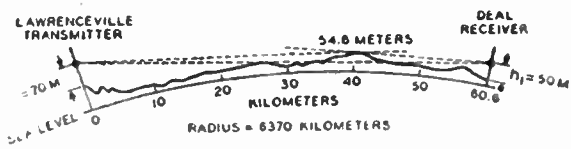


Figure 1—Fading tests were made between Lawrenceville and Deal, New Jersey, over a sixty-kilometer path which was obstructed by a hill 54.8 meters high.

coincident with the passing of an airplane. There were occasions during the tests when the field dropped out completely for a few seconds.

A clearer picture of variations in the received field over a period of several days can be gained from figure 3 where the data on fading has been summarized. The locus of the average field for each hour is shown, with vertical lines indicating the range of fading for that hour.

On some days when reception was stable, only small variations occurred while on others the fading range was of the order of fifteen db. For one watt radiated from a half-wave antenna the field strength during these days was from fifteen to forty-five db above one microvolt per meter, and throughout the year

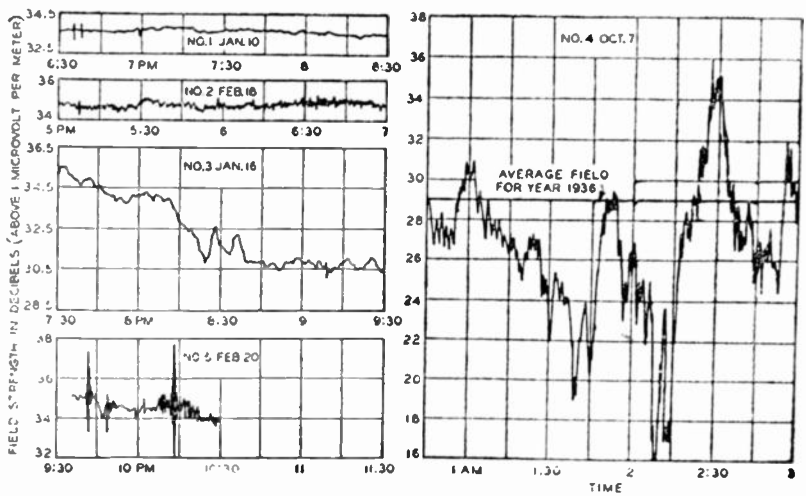


Figure 2—Various types of fading observed on two-meter waves at a distance of sixty kilometers from the sending station. Received field strength values are for radiation transmitted at the rate of one watt from a half-wave antenna.

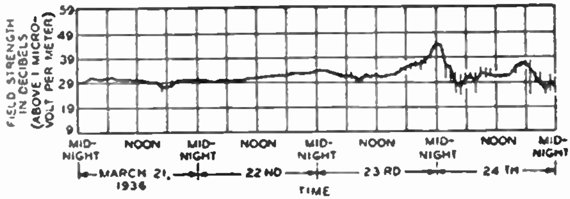


Figure 3—Fading of two-meter waves observed over a four-day period. Vertical lines indicate the range of fading.

it nearly always remained within these limits. The average value of the corresponding field strength for the whole year was twenty-eight db above one microvolt per meter. Thus the field that was measured varied within a range of about fifteen db above and fifteen db below the averaged value.

The instability of these ultrashort waves can be attributed to variations in the refracting power of the lower atmosphere which depends on changes of dielectric constant with altitude. The dielectric constant is dependent on the pressure, temperature and humidity of the air. In general, it decreases gradually with height above the earth. The result is a gradual bending of the waves toward the surface. In practice, the average field strength will vary as atmospheric conditions change this refracting property.

At times, the gradient of the dielectric constant—that is, its rate of change with altitude—may change abruptly or become large enough to bend the wave sharply

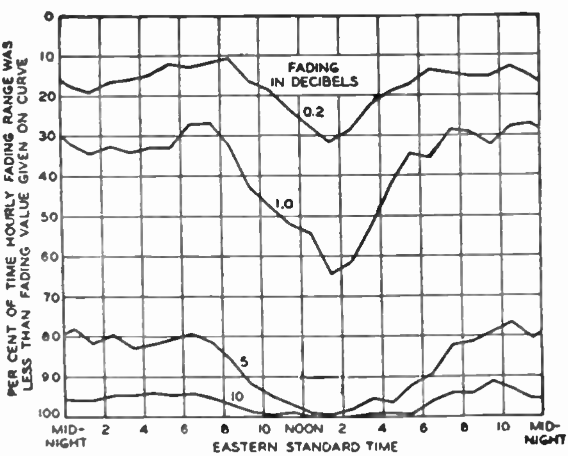


Figure 4—The field strength remained within a range of 5 db 80 per cent of the time for any hour of the day during 1936 and exceeded 10 db about 5 per cent of the time.

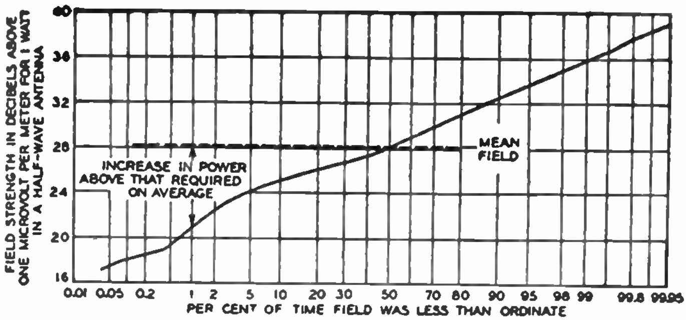


Figure 5—An increase of 7 db in power would raise the received field to 34 db above one microvolt per meter 50 per cent of the time and above 28 db 99 per cent of the time. The average value observed for the year 1936 was 28 db.

back toward the receiver. This gives a multi-path transmission which results in fading by interference, analogous to that experienced by the longer waves where the received field consists of a ground wave and a wave that is reflected from the ionosphere.

The large amount of data available made it feasible to analyze the distribution of fading with time. Figure 4 shows the time distribution for four fading ranges for each hour of the day. For 1936 the field for any hour of the day stayed within a range of five db for eighty per cent of the time. It had a range greater than ten db above five per cent of the time. These curves also show that the fading was least around the mid-day period from ten to four o'clock. Most fading of large amplitude occurred in the evening and early morning hours. In the first part of 1937, reception was more stable than in 1936.

Fading is a factor which must be considered in ultra-short wave transmission when determining what power is needed to insure a given minimum field intensity at the receiving terminal. Theoretical formulas, which have been verified experimentally, are available for calculating the average field strength.

The phenomenon of fading, however, requires an increase in power to maintain the minimum field intensity at that average value. Since the depth of the fading is variable, the required increase in power depends on the percentage of time the field must be above that value. This increment can be obtained from data on the distribution of the field intensity for a representative period.

Figure 5 shows actual intensity was below average value about fifty per cent of the time; and an increase in transmitted power of eight decibels would have maintained the intensity above that average approximately ninety-nine per cent of the time.

Condensed from Pickups,
December, 1937

Radio's Proving Grounds

BY R. V. FINGERHUT

Quiet New Jersey Countryside Becomes Bell Telephone Loborotories' Field Stotion for Rodio Testing
See Pictoriol Section for Photogrophs

FROM dairy farm to experimental radio laboratory is the transformation that has overtaken a section of the countryside near the little town of Whippany, in northern New Jersey. Though the huge barn still stands, no longer does the bovine herd wander out each morning to graze on the hillside. And on that hillside now stand two tall structures that nature never grew. Inside the long building the whickers and grunts of placid animals have been replaced by the clicking of relays and the muffled whine of powerful generators. The posts that mark the place where stalls once stood now support a wicket fence that bears the warning sign, "Do not enter unless all power has been turned off." Instead of milk, the "farm" now turns out sound, and no farmer was ever as much concerned with the purity and quality of his milk as Whippany's engineers are with the purity and quality of their "product."

Early in 1926 a new transmitter, powered at 50 kilowatts, was nearing completion at the Philadelphia plant of the Western Electric Company. Following the design of Bell Telephone Laboratories' engineers, Western Electric craftsmen had set up racks and frames, installed coils and meters and performed the innumerable tasks necessary for the construction of the most powerful broadcasting transmitter ever manufactured on a commercial basis.

Back in New York, engineers at the Laboratories' headquarters were faced with an unusual problem. They wanted to operate the new transmitter for testing purposes, measure its signal strength, design antennas, conduct any number of exhaustive tests and experiments. But to install it at the West Street laboratories was out of the question. Fifty thousand watts of radio frequency power would raise havoc with thousands of receiving sets in New York City, besides interfering seriously with other work going on in the engineers' own building—delicate tests and measurements that demanded the utmost precision.

It was finally decided that the solution lay in using a field laboratory, away from the crowded metropolis and suitable for high powered transmission, where experiments could be carried on without interfering with radio reception. Three men were detailed to find such a place and spent two months in exploring New York's neighboring countryside before they found it at Whippany.

An initial force of four engineers was sent out to prepare the place for use and set up the transmitter which had been shipped to Whippany.

For a time they ceased being engineers and became carpenters in charge of removing the stalls in the main building. After this job had been finished, they became foremen of a gang of ditch diggers during the laying of the extensive ground system, a criss-cross bed of wires buried in the ground over 7,000 square yards in extent. The engineers figured out a method of laying the wires underground that has since been widely adopted. They rigged up a plow with a hollow blade through which wire was threaded and fed from a reel so that when drawn by a tractor the plow would slice deeply into the soil, laying the wire along the bottom of the cut. Across the parallel rows of wire laid by this method ditches were dug and the transverse wires placed, soldered at every point where they crossed. Needless to say it was a tough and muddy job and the sale of hip boots in northern New Jersey reached a new high.

The engineers next became steeplejacks, superintending the erection of the two 250-foot antenna towers which still dominate the scene. These towers were placed well to the front so that the building would be away from the denser portion of the antenna field.

All this time the installation of the transmitter had been going on. Panel by panel, rack by rack, the transmitter grew, until the completed apparatus stood ready to send out over the air the words, "This is radio station 3XN, Whippany, New Jersey."

As soon as the installation had been completed, it was decided to use it for a demonstration of television by radio, coincident with a wired television program scheduled for April 7, 1927. A five-kilowatt transmitter that had been installed in New York was moved out to Whippany and adjusted for use as the image transmitter. The 50-kilowatt transmitter was used for the speech channel. This was the first time that a television program had ever been successfully broadcast by radio and Whippany received its initial taste of newspaper headlines.

Following this spectacular work, the engineers settled down to testing and experimenting with the 50-kilowatt transmitter. Starting in May, 1927, a number of test broad casts were made after midnight, according to commission regulations. Rabid radio fans in all parts of the country, listening in late at night, would suddenly run across a musical program at an unusual spot on their dials. So clear and loud was the signal that many thought they had picked up a local station. Sooner or later they would hear an announcer's voice saying, "This is a test broadcast from 3XN, an experimental station at Whippany, New Jersey."

Engineers took turns announcing at the microphone until one night one of them grew too enthusiastic and broke into the forbidden realm of advertising by adding ". . . . , a 50-kilowatt station developed by Bell Telephone Laboratories and manufactured by the Western Electric Company." From that time on, Artie Dolan had the job of announcer and the faux pas was never repeated.

DXing was at its height at this time and mail from radio fans flooded the local post office. Thousands of letters were received asking for verifications and many were the variations applied to the spelling of "Whippany" by distant listeners unable to find this small town on their maps. At one period, despite the fact that listeners were asked not to write in, 13,000 letters were received from all over the United States and from many distant foreign countries as a result of only ten test broadcasts.

Another problem which occupied Whippany's engineers was that of developing and learning a technique for antenna tuning with their powerful transmitter. In this research one set of engineers would erect an antenna and another group had to figure out a formula for its tuning. It became the great delight of the antenna-erecting group to make the task of the others as hard as possible. This friendly contest resulted in an unexpected discovery. While using all sizes and shapes of antennas a single wire, supported vertically by a balloon, was tried. This form, the original "vertical radiator," had astonishing results. The field strength measuring equipment, sent out in trucks during all tests, showed that with the vertical antenna an increase of more than 40 per cent over the then conventional types could be obtained. The outcome of this was the first vertical radiator, installed at WABC in 1928 and followed by other installations in all parts of the country.

ANOTHER contribution to radio was the result of these experiments in that they developed and improved a technique for field strength measurement and the correlation of the data obtained for use in selecting transmitter sites. This technique has been used in selecting sites for transmitting stations all over the world.

By this time the necessity for and value of a field laboratory had been well demonstrated. The removal of higher-powered radio broadcasting equipment from headquarters had eased the problem caused by the increased amount of radio energy dissipated throughout the building. The concentration of broadcasting activities had made it possible to carry on experiments and tests that could never have been conducted in New York. The success of the work at Whippany had definitely shown it to be an ideal site for the field laboratory.

In 1928 Whippany's engineers took to the air. Elaborate tests of the new aviation radio telephone transmitters were made, culminating in a number of demonstrations that attracted nation-wide newspaper headlines. In one, a representative of every metropolitan New York newspaper was taken up in a Bell Laboratories' plane. Each reporter talked to his city editor from the air. In another demonstration the Graf Zeppelin was guided to its landing by a plane equipped with the new aviation equipment. In a third demonstration, a three-way conversation was held between Whippany, the laboratories' plane and a meeting of scientists at the Massachusetts Institute of Technology. These were the first public demonstrations of plane-to-ground commercial radio telephone equipment.

The next important task of Whippany's engineers was that of testing a circuit designed to improve the operation of all types of radio equipment. This circuit has since become known as stabilized feedback. The first broadcasting apparatus in which it was installed was a one-kilowatt experimental transmitter. After thorough testing in this and other transmitters, it was installed for commercial use for the first time in the 50-kilowatt transmitter at WOR.

In 1933 William H. Doherty, stationed at Whippany, began experimenting with a circuit designed to increase the efficiency of broadcast transmitters. When perfected, it became known as the Doherty Circuit, and in 1937 was awarded the Liebman Memorial prize by the Institute of Radio Engineers.

The present force of engineers, led by A. W. Kishpaugh and R. E. Coram, has just completed the installation of one of the new 50-kilowatt transmitters, replacing the old model which was sold to a commercial broadcasting station and is still doing an efficient job.

It is just a little over ten years since the first 50-kilowatt transmitter was installed at Whippany. But to compare the new transmitter with the model of 1927 is like comparing one of this year's automobiles with one of a decade ago. The transmitter of today may transmit the same amount of power as that of 1927 but, like today's car, for that same amount of output power an enormously decreased amount of input energy is required. The 1937 transmitter has advanced in outward appearance as much as this year's streamlined car has advanced over its predecessors. And in its interior, as in the modern car, is incorporated every improvement that research engineers have developed.

EXPLAINING THE UNIT OF SOUND
As a P.A. Factor

BY ROBERT LORENZEN

MANY articles have been written about the use and application of the decibel. The emphasis has invariably been placed upon the mathematical and technical aspects of this concept and only brief mention made of its physiological and psychological aspects. Yet, for the serviceman to use intelligently the decibel in his work, it is necessary that he also have a clear physical picture of this very important concept.

The decibel[1] (abbreviated db) is a *ratio* of two powers, whether electrical or acoustical power. It is not a measure of a definite amount of power, although, once a standard reference level is given, it may be so used.

In order to get a rough picture of the number of db which corresponds to various differences in acoustical power, let us, for the moment, assume that zero level corresponds to the acoustical power of ordinary conversation, about 10 microwatts. Very faint speech is about 20 db lower in intensity, whereas very loud conversation is 20 db higher. A whisper is about 40 db lower intensity than ordinary conversation.

Both electrical and acoustical power are measured in watts. They both represent power but in different physical forms. Electrical power is convertible into acoustic power and vice versa. It should be kept in mind that the conversion of power from one form to another involves a loss in usable power due to the inefficiency of the apparatus employed to effect this conversion. For example, an amplifier which has a power output rating of 15 electrical watts will not be able to deliver 15 acoustical watts. To

[1]The decibel is mathematically defined as

$$db = 10 \log_{10} \frac{P_1}{P_2}$$

providing that the impedances of the two circuits at which P_1 and P_2 are measured are equal transform electrical watts into acoustical watts a loudspeaker is needed. Assuming that the loudspeaker has an efficiency of 10% then, although the amplifier delivers 15 electrical watts to the speaker, only 1.5 acoustical watts are emitted by the loud speaker as sound waves.

In the laboratory a change of 1 db is perceptible, but under ordinary circumstances a change in power corresponding to 3 db is just discernible. Since power doubles for each 3 db increase, it is clear that the least change that the ear can ordinarily detect requires that the power be either doubled or halved. In practice, for example, this means that if a 10-watt amplifier is replaced by one of 15 watts that the change would go unnoticed, providing that all other factors remain unchanged.

A rough idea of the difference in intensity which corresponds to 50 db can be obtained by listening to a loud sound and then closing the entrance to the canals of both ears. The fainter sound then heard will be about 50 db down from the original sound.

The accompanying chart gives the acoustical level in db for various common sounds. Reference to this chart, together with a little practice, will enable the serviceman to become acquainted with various acoustic levels. Some comments regarding this chart follow.

The *threshold of hearing* or *threshold of audibility* is the minimum intensity of sound which is just audible (10^{-16}) watt. The

DB	SOURCE OF SOUND
130	Threshold of pain
125	
120	
115	
	Hammering on steel plate (2 feet)
110	
105	
100	Maximum power of a full symphony orchestra
	Riveter (35 feet)
95	
90	Pneumatic Drill (10 feet)
	Roaring lion (18 feet)
85	
	Policewhistle (15 feet)
80	
	Very loud radio music in home
75	
70	
	Fifth Avenue and 42nd Street
65	Ordinary conversation (3 feet)
	Thunder (1 to 3 miles); Dog barking (20 feet)
60	
	Church bells (1200 feet)
55	
50	
	Average business office
45	
40	Very quiet radio in home
35	
30	Average room in home
25	
	Quiet garden
20	
	Average whisper (4 feet)
15	
10	
5	
0	Threshold of hearing

zero reference level used in the chart is that of the threshold of hearing namely, 1/10,000,000,000,000,000 of a watt. The ear is an extraordinarily sensitive organ, for if the threshold of hearing were but slightly (approximately 11 db) lower the unaided ear would be able to hear the movements of atoms and molecules.

The *threshold of feeling* or *threshold of pain* occurs when the intensity of the sound becomes so great that sound is no longer perceived as such but rather as a painful sensation. This threshold of pain occurs 130 db above the threshold of audibility.

The decibel ratings are average values for the distances given; the minimum and maximum values may differ by about 10 db.

In table 1 are tabulated the power ratios corresponding to the decibel range from 0 to 130. From this table it will be seen that if one sound is 10 db greater than a second sound, then the first sound has

Table I.

DB	POWER RATIO
0	1
10	10
20	100
30	1,000
40	10,000
50	100,000
60	1,000,000
70	10,000,000
80	100,000,000
90	1,000,000,000
100	10,000,000,000
110	100,000,000,000
120	1,000,000,000,000
130	10,000,000,000,000

ten times the power of the second, if the first sound is 20 db greater than a second, its power is 100 times as great, if the first is 30 db greater than the second, its power is 1000 times that of the second; and if the first sound is 60 db higher than the second, its power is one million times greater.

The intensity range from the threshold of hearing to the threshold of pain is 130 db All tones falling within this range are heard by the ear as sound. By examining table 1 it can be seen that the hearing range (from 0 to 130 db) cor-

Table II.

DB	POWER RATIO
0	1.00
1	1.26
2	1.58
3	2.00
4	2.51
5	3.16
6	3.98
7	5.01
8	6.31
9	7.94
10	10.00

responds to a power increase of 10,000,000,000,000 times. No device as yet made can even approach such an enormous power handling range. A radio or the ordinary phonograph record, for example, can only handle an intensity range of 35 db, or in other words, a power range of 3160 to 1.

Further examination of table 1 reveals the important rule: Power is multiplied by ten for each ten decibel increase

Table 2 tabulates the power ratios corresponding to the decibel range from zero to ten. From this table another important rule can be derived, namely: Power doubles every three decibels. (More accurately, power doubles for every 3.01 db increase, but 3 db is a sufficiently close approximation for all practical purposes.)

Tables 1 and 2 when used together give the decibel equivalent in steps of one decibel for any power ratio within the range of 0 to 130 db. The rule for using these tables is Add the decibels and multiply the power ratios.

From QST*
March, 1938

The Infinite Rejection Principle Applied to Image Attenuation

BY KARL W. MILES and J. L. A. McLAUGHLIN

AN inherent peculiarity of the superheterodyne is its ability to respond simultaneously to signals of two different frequencies which are separated by *twice* the frequency of the i.f. amplifier.

Where the oscillator, mixer and r.f. amplifier tuning condensers are ganged together, as is now accepted modern practice, and the oscillator is tuned i.f. frequency higher than the frequency of the desired signal, the undesired signal of the other response frequency, commonly referred to as the image, will be more or less attenuated because of the selective action of the tuned circuits between the antenna and mixer. The amount of this attenuation, in terms of voltage, is called the *image ratio*, and will depend on the shape of the selectivity curve of the input circuits. The i.f. amplifier selectivity will in no way affect this ratio.

Now at a frequency of, say 1000 kc., the image ratio of a superheterodyne with an r.f. stage ahead of the mixer will be of the order of 10,000 or better, that is, the image signal will have to be 10,000 or more times as strong as the desired signal to give the same output. At 2000 kc. the ratio will be down to something like 1000 and 7 Mc. to about 200. At 14 Mc. a ratio of about 50 is usual and at 30 Mc. a ratio of two or three is considered pretty fair.[1]

Now why does the image ratio become so poor at the higher frequencies? Simply because as the frequency goes up the percentage difference between the signal and image frequencies grows less; in other words, the image frequency is

[1]The image ratio figures are based on an i.f. of the order of 465 kc. and the use of ordinary tubes and circuits at signal frequency. At the higher frequencies, some improvement in performance can be secured by using acorn tubes because of their lesser loading effect on the tuned circuits.—EDITOR.

*Journal of the American Radio Relay League, Inc., West Hartford, Conn.

climbing nearer the nose of the resonance curve and approaching par with respect to the signal frequency.

If we persist in our attempt to eradicate the image by means of purely selective devices at frequencies in the neighborhood of 30 Mc. and higher, we will find that progress is comparatively slow. We can go on adding preselection to the point where the number of stages becomes impracticable to handle and still not duplicate the performance given by a few stages at the lower frequencies.

Some other means of improving image ratios at the higher frequencies obviously is needed. One method which shows promise is a variation of the i.f. infinite rejection system described in November, 1937, *QST*. Similar coupling devices can be made infinitely selective in rejecting the image frequencies.

Figure 1 shows the fundamental circuit. As in the i.f. system, we have a primary L_1 which couples to L_3 through the mutual M and capacity C_3. L_2 and L_3 together form the signal-frequency tuning coil; L_1 and L_4 the image-rejection circuit inductance. The reason for using L_4 will be explained later on.

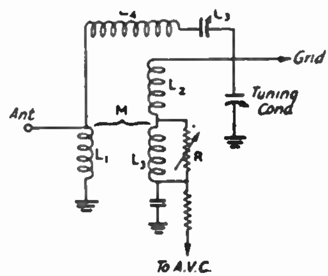


Figure 1—The Image Rejector Circuit.

Values of the components labelled will depend upon the tuning system and other features of the receiver with which the rejector is used. Experimental values determined in one type of receiver are as follows:

C_3—7 and 14 Mc.: 15-μμfd. variable; 28 Mc.: 10-μμfd. variable.

L_1—7 and 14 Mc.: 4½ turns no. 34 d.s.c., diameter ¾ inch. 28 Mc.: 2½ turns no. 34 d.s.c., diameter ¾ inch.

L_2—7 and 14 Mc.: 10½ turns no. 22 d.s.c., diameter ¾ inch. 28 Mc.: 2 turns no. 20 d.s.c., diameter ¾ inch

L_3—7 and 14 Mc.: 3 turns no. 22 d.s.c., diameter ¾ inch. 28 Mc.: 2 turns no. 20 d.s.c., diameter ¾ inch.

L_4—7 and 14 Mc.: 15 turns no. 34 d.s.c., diameter ¾ inch. 28 Mc.: 8 turns no. 34 d.s.c., diameter ¾ inch

R—1000-ohm rheostat

These will serve as a basis for experimental work with a particular set-up. The main tuning condenser is assumed to cover 7 and 14 Mc. at opposite ends of its scale.

The coupling between the antenna (or interstage) input and the grid circuit is the product of M and C_3. For the signal frequency the circuit behaves very much the same as a straight inductively-coupled stage with small capacity coupling at the high-potential side. But for image frequency, the voltage through C_3 equals the voltage induced in the mutual M and, being of opposite sign, cancels out. To make the null infinite, the power-factor corrector R is necessary. With proper power-factor correction, no coupling exists at image frequency.

In practice, because of stray coupling or through direct pickup in some part of the circuit beyond the rejector stage, some image signal may leak through, but with careful design the signal-to-image ratio can be made better than 100,000 at frequencies as high as 36 Mc. This is the highest frequency so far attempted.

Experimental work has been done on single-stage application and on two standard receivers. In one instance, in which the rejector system was inserted in the mixer circuit of a receiver having no r.f. stage, image ratios of over 2000 were achieved at frequencies as high as 16 Mc. Stray couplings by-passing the rejector circuit prevented greater rejection. This gives some idea of the effectiveness of the rejector circuit, however, because an image ratio of 2000 at 16 Mc. is higher than can be obtained in a good receiver with two or three stages of preselection ahead of the mixer.

Figures 2, 3 and 4 are curves showing the front-end performance of a receiver having one r.f. stage ahead of the mixer, the rejection being applied to the r.f. grid circuit. The i.f. selectivity of the receiver is not included in these curves. In each case the rejector is adjusted to signal frequency plus twice the i.f., the signal circuit being tuned to resonate at 7 Mc. in figure 2, 14 Mc. in figure 3 and 30 Mc. in figure 4. The power-factor correction resistor, R, is in all cases adjusted for maximum attenuation of the image. The plots extend to only a ratio of 10,000, or 80 db; the actual signal-to-image ratio is over 100,000 in all cases.

Because of the worth-while improvement in the complete wiping out of image frequencies that this radically different coupling circuit offers, some practical information should be included in this article.

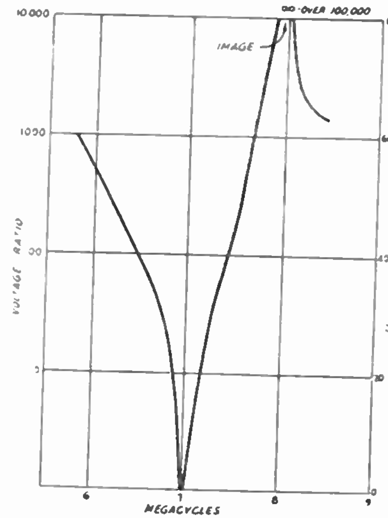


Figure 2. Selectivity curve of r.f. end with receiver tuned to 7 Mc. and image rejector adjusted to 7.93 Mc.

So that interested experimenters may be able to adapt such a device to their present equipment, we have built up a simple r.f. stage which may be connected to any receiver. The parts are few and the construction is simple. The frequency range is from 9 to about 16 Mc. and the unit is intended for use on the 14-Mc. band. This is the range in which the average image starts to become bothersome. The circuit diagram and constants are given in figure 5.

To get the rejector circuit working tenuated. Finally, adjust resistor R_2 for maximum attenuation. When you are sure the system is working properly on this frequency, the receiver and the preselector can be

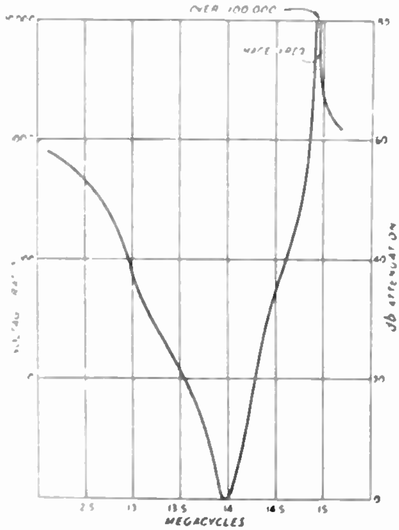


Figure 3. Receiver tuned to 14 Mc. and image rejector adjusted to 14.93 Mc.

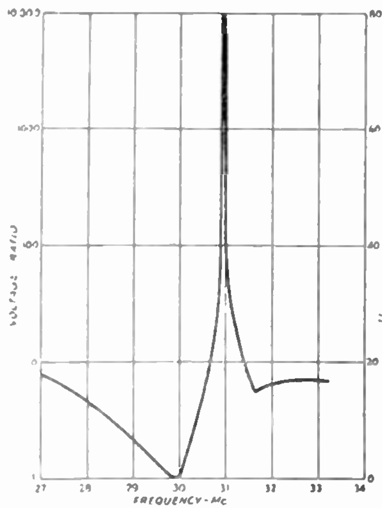


Figure 4. Receiver tuned to 30 Mc. and image rejector adjusted to 30.93 Mc.

The i.f. selectivity of the receiver is not included in these curves or in the curves of figure 2.

properly pick out some band where you know there are images, for example, the region around 13 Mc. Tune over this band until you pick up the image of some 14-Mc. amateur 'phone, and peak up the circuits by means of C_2 and C_4. Then slowly turn the rejector condenser, C_3, until a spot is found where the 'phone drops out or is greatly attuned to the 14-Mc. band and the rejector adjusted to wipe out bad images in this range.

If no rejection point can be found, it may be because L_1 is reversed, C_3 may be too large, R_2 may be too large or too small, or there may be no images at the frequency to which the preselector and receiver are tuned.

If a rejection point is found and the image is still audible, see if the image can be picked up with the antenna disconnected. If so, the image signal is getting in at some point past the rejector circuit and shielding should be tried to reduce this pickup.

No coil information for use on the 30-Mc. band is given because it is difficult to give constants which would have much practical value at these frequencies. The coils have so few turns that the wires leading to them are apt to have as much inductance as the coils themselves, and since C_3 may become less than 1 μμfd., duplication therefore would become quite difficult.

Another reason for not doing so is that at this frequency the rejector preferably should be built into the receiver itself, so that maximum efficiency may be achieved and proper shielding employed to prevent the image signal from being picked up on the output side of the rejector circuit.

The incorrigible experimenter will wind coils for other ranges—perhaps with happy results. To him we offer this advice. Couple the plate of the r.f. stage to the input of the receiver with the shortest possible lead, and on the 30-Mc. range tune the plate circuit of this tube and couple to the receiver through a low-impedance line. It is important to build up the greatest gain possible at these frequencies. The image frequency is so close (in percentage) to that of the signal that with complete rejection of the image there may be appreciable loss of signal strength. At 30-Mc. the gain may drop to about one-tenth of what it was without rejection, so if the r.f. stage gain is kept high—and a gain of ten can be had at these frequencies—the desired signal (with the rejector set to the image frequency) will be at about the same level at the receiver as it was before the selector-rejector stage was added. A great deal of this loss can be overcome by careful circuit construction in attaining maximum Q in the tuned circuit, together with the optimum degree of antenna coupling.

For example, in a production model of the receiver in which this system is used, there is only a 20 per cent loss in gain with the rejector circuit set for maximum attenuation; with an image ratio of 2000 there is no perceptible loss of desired signal.

At 14 to 30 Mc. the rejector condenser capacity (C_3) ranges from a fraction of a μμfd. to but a few μμfd. and resistor R is from 250 to 1500 ohms. The higher the frequency the lower the resistance needed. Some interaction between the rejector control and the selector control may be experienced; in a single stage this is of little consequence, but when built into a receiver with all the tuning controls ganged together may be quite serious. To overcome this defect L_4 (figure 1) is employed. The use of this coil increases the voltage in the rejector circuit and reduces the effect of C_3 on the signal-tuning circuit. When

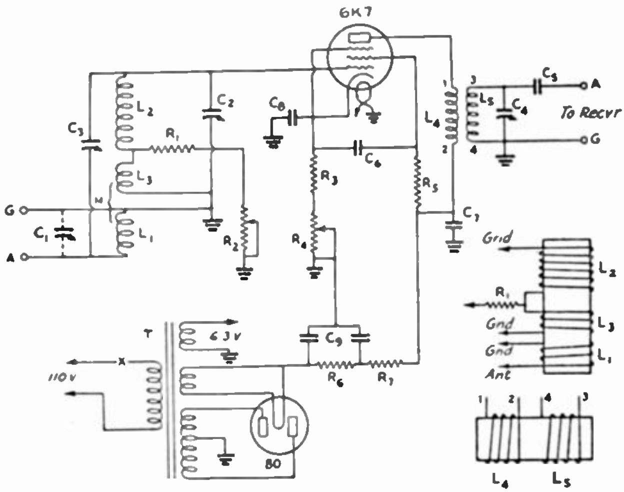


Figure 5—Circuit Diagram of Image-Rejecting Preselector for 9- to 16-Mc. Range.

L_1—10 turns no. 34 s.e.
L_2—5 turns no. 20
L_3—3 turns no. 20
L_1, L_2 and L_3 on same form, diameter 1⅛ inch; L_2 and L_3 spaced ⅞ inch, L_1 and L_3 closely coupled. Note winding direction in drawing.
L_4—15 turns no. 36 s.e.
L_5—5 turns no. 20
L_4 and L_5 on same form, diameter ¾ inch, ⅛ inch between coils
C_1—100-μμfd. variable (optional)
C_2—100-μμfd. variable, input tuning
C_3—20-μμfd. variable, image rejection
C_4—150-μμfd. padder, output tuning
C_5—200-μμfd. fixed
C_6, C_7, C_8—0.05-μfd. paper
C_9—Dual 8-μfd. electrolytic
R_1—600 ohms, ½ watt
R_2—100-ohm variable (power factor correction)
R_3—500 ohms, ½ watt
R_4—10,000-ohm variable (gain control)
R_5—100,000 ohms, ½ watt
R_6, R_7—20,000 ohms, 1 watt
T—Power transformer to deliver 250 volts d.c., with 6.3-volt filament winding

L_4 is used, C_3 becomes considerably smaller.

Although the value of resistance used for power factor correction must be carefully adjusted for maximum rejection, in practice it has been found that a fixed resistor of optimum value for the band over which the circuit is to work will permit dispensing with one control without undue sacrifice of image attenuation. Provided the proper value of fixed resistance is used, highly effective image suppression can be obtained—not the full capabilities of the system, but still capable of relegating practically all image signals to the background. The fixed resistor could be incorporated in the plug-in coils (or switched with the coils in a bandswitching receiver) after the optimum value for each range has first been obtained experimentally by the use of a variable resistor.

To give practical information on coil design and the incorporation of this circuit into existing manufactured receivers is out of the question.

The majority of curves and coil information contained in this article are taken from the work done on the application of the infinite image rejector to a standard "Challenger" type receiver. A rejector was inserted in the r.f. stage and was made to operate over the range from 7 to 30 Mc. The gain of the new receiver with and without the rejector in operation is the same for all frequencies up to 20 Mc. Beyond 20 a slight loss of signal is observed when the rejector is adjusted to the image frequency.

The design of an r.f. amplifier is generally a compromise between gain and image rejection. In the conventional cascaded selective coupling circuits gain and image ratio are inversely related because of the broadening of the resonance curves of the individual circuits when the coupling is adjusted for maximum gain. Since in this system the two functions are distinct and separate, the gain of the r.f. stage can be made considerably higher than normally permissible, thus compensating for slight attenuation of the signal when the rejector is in use in the 30-Mc. band.

With higher than normal gain in the first tube, a better signal-to-noise ratio can be obtained over the frequency range below 30 Mc., with complete freedom from images.

Army Radio Communications Lagging

WASHINGTON, D. C.—War Department experts declared that present army communication methods have become obsolete because of the speed of mobile fighting forces. This was the outcome of observations during the field maneuvers held last summer. According to observers, radio, telephone, and messenger communication has not yet acquired the efficiency needed to supply the commanding officer with the necessary information and to transmit his orders.—Radio News.

From Radio News
April, 1938

The "Pigeon Cooker"

BY J. E. BROWN

Reports that homing pigeons were being slowed up by radio towers, sent the Navy into a flurry of activity. Independently Engineer Brown undertook a similar survey, with the consequent results described in this article.

HOMING pigeons were used as a means of communication long before radio was in existence. Now under the present Signal Corps plan of the U. S. Government, they are still continued as a necessary adjunct to the communications of the military forces.

Occasional reports have filtered through from time to time of the homing instinct of pigeons being disturbed when released in the vicinity of radio transmitting stations. One of these reports covers tests conducted by the navy department of Lakehurst, New Jersey, and shows quite conclusively that the pigeons were affected. Those exposed to radio waves at the antenna of the A T & T transmitter at Ocean Gate, New Jersey, took much longer to return home than did those birds released at the same location, but not exposed.

In order to find out, if possible, what the effect of radio waves on pigeons were, a 100-watt oscillator was constructed in the laboratories of the Zenith Radio Corporation and a series of experiments conducted at many different wave lengths on homing pigeons. This 100-watt oscillator was nicknamed the *Pigeon Cooker.* All tests were conducted at the site of the former WJAZ radio station near Mt. Prospect, Illinois. The oscillator was arranged to have large tank coils so that the pigeons could be placed in a strong field. The oscillator covered the range of 5 to 50 meters.

The first tests were conducted last fall, using 50 pigeons borrowed from various pigeon lofts in Chicago. The pigeons were released one at a time at suitable intervals. The tests were carefully arranged so that only those pigeons intended to be exposed to radio frequency were exposed. The remainder were kept ½ mile away from the oscillator, inside a steel bodied truck.

The following results were obtained:

EXPOSED TO RADIO FREQUENCY

Wavelength	Number of Pigeons	Flying Time
11 Meters	5	17 4/5 Min.
13 Meters	5	17 3/5 Min.
15 Meters	4	20 3/4 Min.
20 Meters	6	23 2/3 Min.
30 Meters	2	17 Min.

NOT EXPOSED TO RADIO FREQUENCY

Number of Pigeons	Flying Time
21	25 1/2 Min.

According to these tests, those pigeons *not* exposed to the oscillator took longer to return home than did those exposed to the oscillator. This was at variance with reports, but there were irregularities in the tests. The pigeons flew the same distance in both cases to the same destination. The only difference in treatment was that those exposed to the oscillator were held in the operator's hand for three minutes in the field of the oscillator; those not exposed were held in hand for a fraction of a minute only, that is, the time actually involved in removing it from its cage and tossing it in the air.

In order to eliminate this irregularity in all future tests, all pigeons, both exposed and unexposed, were held in the hand and in position in the coil of the oscillator for the same period of time. The period of three minutes of holding was decided upon since exposure times as great as ten minutes did not show any different reaction on the pigeon.

The tests previously outlined led to some doubt in the timing of the pigeon's arrival at the home loft. To remove this possibility of error, it was decided to limit the number of birds used to those from one or two lofts so that observers could be stationed at these lofts to secure accurate timing.

Another series of tests were run a few weeks later using 8 birds from one loft. Four were exposed to radio frequency, four were not exposed. Unfortunately the observer at the loft failed to make any accurate record of the pigeon's arrival and hence the test was valueless.

Another test was then made with these same birds and from the same loft in which test birds were released in groups, 4 exposed and released simultaneously; 4 unexposed and released simultaneously. In this test a wavelength of 20 meters was used and the exposed birds took 38 minutes to get home, the unexposed 50 minutes to get home.

These tests were still at great variance with the reports that pigeons were actually slowed up by exposure to radio waves. *The careful check on the pigeons revealed that they did not go straight home, but stopped to eat, loiter, go out of their way, visit with other pigeons and do whatever pigeons do when "not on the job."* Of the birds that were exposed to radio waves, those that were doing this visiting and eating found themselves so disturbed by exposure that they actually flew straight home, giving them better time than heretofore. Pigeons were then chosen which were true homing pigeons, that is, they were perfect specimens, which actually flew straight to their "home" loft.

There was still some question as to the accuracy of the timing of arrival of the pigeons and in order to eliminate fully all doubt on this score, the pigeon loft and services of Mathew Manka, 2815 N. Fairfield Avenue, Chicago, Ill., were hired. As a further precaution a member of the engineering department was stationed at the loft to check the pigeon's return time. In all tests thereafter, careful watch calibration was maintained and the element of possible time inaccuracy removed.

Tests were resumed under these conditions at Mt. Prospect, Illinois, with the following result:

EXPOSED TO RADIO FREQUENCY

Wavelength	Number of Pigeons	Flying Time
5 Meters	1	33 Min.
11.5 Meters	3	29 Min.
15 Meters	4	27 Min.
20 Meters	5	27 Min.
30 Meters	3	31 Min.
40 Meters	4	32 Min.
50 Meters	3	28 Min.

Average Time—29½ Min.

NOT EXPOSED TO RADIO FREQUENCY

Number of Pigeons	Flying Time
2	24½ Min.
2	24½ Min.
3	30 Min.
2	23 Min.
3	37 Min.
2	24 Min.
3	21 Min.

Average Time—26½ Min.
Flight Course—25.6 miles.

About 125 pigeons flown during entire tests.

Above compilation covers 40 pigeons.

It appears from these figures that homing pigeons exposed to radio frequency are affected by the exposure and in some way their ability to return home definitely slowed up. *Here then was confirmation of the reports.* The difference in time used to return home between the exposed and the unexposed birds is not very great; however, it must be borne in mind that the power of the oscillator is not great and its radiated field is very much restricted by comparison with what would exist around a high power radio transmitter. In this respect the results obtained are significant.

During the course of these experiments many other tests were conducted. In some cases fixed permanent magnets were hung around the necks of pigeons. This was done to determine whether the pigeon's homing instinct might be affected by the earth's magnetic lines of force or as has been suggested (since there exist no two places on the earth's surface having the same magnetic field strength) these birds might seek that field strength which exists at the home lofts. It was found that the magnet on the pigeon's neck did not seem to affect his homing ability at all.

It is of interest to note that exposure to radio frequencies in the ranges tested frequently seemed to make the pigeon restless and that at 20 meters the respiration and heartbeat seemed to increase a noticeable degree, and to an extent much more noticeable than at any other wavelength in the range used.

From Electronics
March, 1938

TELEVISION *without Sync Signals*

•

By transmitting the wave-forms of the transmitter scanning voltages, it is possible to send pictures interlaced four-to-one, with flickerless reception at 15 frames per second. A new system developed in the Du Mont Laboratories.

•

RECENT newspaper reports to the effect that the Allen Du Mont Laboratories had developed a system of television transmission in which high-definition pictures are sent in one-half the band-width required in the conventional system, have excited the curiosity of all those who are at present wrestling with the wide-band problem.

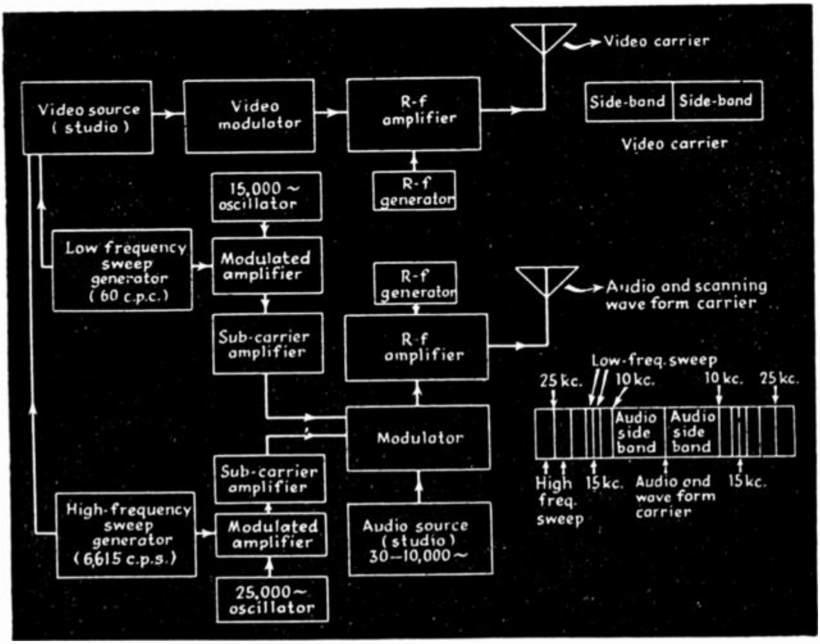
The band-width required for a television channel depends directly on the number of complete pictures transmitted per second. In the new system, the number of complete pictures sent per second (the "frame frequency") has been reduced from 30 to 15, and as a consequence the band-width required is just one-half as great.

It is appreciated that this reduction in picture frequency introduces a high degree of flicker unless special means are taken to prevent it. The means taken in this case is a high interlace ratio, four-to-one as compared with two-to-one in the present R.M.A. standard. The "field frequency" (the number of times the picture area is fractionally scanned) thus remains the same, 60 per second, in the new system as in the conventional system, the only difference being that each interlaced "fractional" frame contains one half as many lines as formerly. The number of lines, 441, and the number of picture elements per line, $4/3 \times 441$ for 4-to-3 aspect ratio, remain the same.

Consequently a flickerless 441-line image is produced, even though there are only 15 complete frames per second. It is true that one-half the information is transmitted in a given time, but except for very rapid motion in the picture, the effect is the same as though 30 complete frames were transmitted.

The achievement of a 4-to-1 interlace ratio has long been desired in television, but it seems impossible to accomplish when the conventional method of transmitting sync pulses is used. In the conventional system, separate sweep-voltage generators are employed at transmitter and receiver, and sync pulses are sent to achieve synchronism between them. To produce a properly interlaced picture by this method, the sync pulses must maintain a time accuracy of less than a microsecond, even when the interlace ratio is only two-to-one. When an interlace ratio of four-to-one is attempted, the degree of accuracy required is so great that the sync signal method falls down.

In the new system, however, all this is taken care of by eliminating the sync signals altogether. Only one sweep voltage generator (producing horizontal and vertical scanning) is employed, that at the transmitter. The *wave-forms* of the vertical and horizontal scanning voltages, produced by this generator, are used as modulating signals



Block diagram of the transmitter. Two carriers are employed, one for video alone, the other for audio and the scanning voltage waveforms.

on an auxiliary carrier. After demodulation and amplification at the receiver, the wave form is then used directly as a sweep voltage for the receiving cathode-ray tube. The receiver is thereby considerably simplified, in principle at least.

No amplitude-operated sync-signal separation circuit is necessary, and no sweep-voltage generators are required. In their place is simply a detector and high-voltage amplifier, at whose output the sweep voltage appears automatically, having been taken directly from the transmitted signal.

• Details of the Transmitter

The transmitter, shown in the block diagram, employs a conventional channel for the video signal, that is, a source of video modulation, a modulating amplifier and an r.f. power amplifier.

The output carrier of this transmitter contains video signals only; no synchronizing pulses are present. The audio-frequency carrier is modulated with three signals: the audio itself, the vertical (low frequency) sweep-voltage waveform, and the horizontal (high frequency) sweep-voltage wave-form.

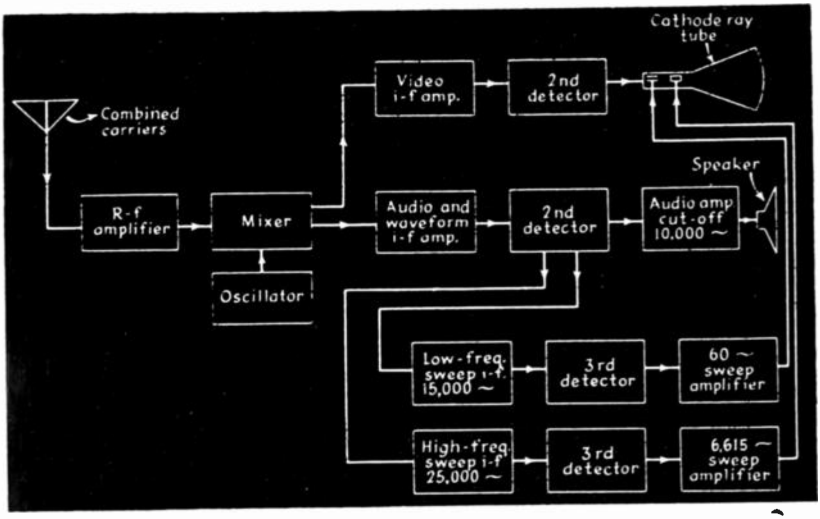
The audio signal occupies the frequencies from 30 to 10,000 cycles. The low frequency sweep voltage wave-form contains a fundamental of 60 cycles per second (equal to the field frequency) and if a simple saw-tooth wave is used, all harmonics up to the tenth, that is, up to 600 cycles. These frequencies are employed to modulate a sub-carrier of 15 kc., which in turn modulates the final carrier—thereby occupying a region above the upper limit of the audio signal.

The high-frequency sweep voltage wave-form has a fundamental of 6615 cycles, for four-to-one interlace. If a simple saw-tooth wave is used, it contains all harmonics up to 66,150 cycles. These components are applied to a sub-carrier still higher in the audio range, say 200,000 cycles. In this system, the entire audio channel, including sweep-wave-forms, is 266 kc. wide.

A very considerable reduction in this band-width is accomplished by the use of a double saw-tooth, scanning in both directions. The picture is then scanned with lines moving alternately left-to-right and right-to-left, and with frames built up alternately from the bottom up and from the top down. The harmonic content of such a double saw-tooth wave contains no important components above the fundamental, and it is feasible to use a sub-carrier of 25,000 cycles.

In this case, the audio carrier contains frequencies only up to 31,615 cycles. This represents a carrier 20,000 cycles wider than would be required for speech alone, but the saving in band-width in the video carrier is about 2 megacycles, vastly greater than the increase in the audio channel.

The complete television channel, in the new system, contains a video carrier with side bands corresponding to a 441-line, 15-frame picture, with blanking signals if conventional saw-tooth scanning is used, no blanking signals being required



Block diagram of the receiver. In the waveform channel, third detectors are used to separate the scanning waveforms from the sub-carriers.

if double saw-tooth scanning is used.

In addition to the video carrier, the channel contains a wide-band audio channel with 30,000 cycle sidebands. These sidebands contain the audio signal, and the waveforms of the low- and high-frequency scanning voltages, which are of the double saw-tooth variety. The sweep-voltage wave-forms doubly modulate, first the sub-carriers of 15,000 and 25,000 cycles, and then the high-frequency audio-channel carrier.

• Reception in the New System

The receiver, shown in the block diagram, accepts both video and audio carriers at once, as in the conventional system. The first mixer tube thereby provides two i.f. frequencies, one containing the video modulation, which is amplified and demodulated in the conventional manner.

The other i.f. frequency contains the audio and wave-form components. The audio is detected and passed to an audio system whose upper cut-off is 10,000 cycles. None of the wave-form components reach the loudspeaker, therefore. The 15,000 cycle output of the second detector is amplified in a 15 kc. i.f. amplifier, passed through a 3rd detector, amplified and applied to the vertical plates of the cathode-ray tube. The 25,000 cycle output of the second detector is passed through a 25 kc. i.f. stage, a 3rd detector and amplifier, then applied to the horizontal plates of the cathode-ray tube.

While the receiver contains tubes and circuits comparable in number to those required for sweep voltage generation and sync signal separation in conventional circuits, the tubes in the new system are operating in non-critical circuits, of conventional design.

Furthermore, the receiver, once built, is equipped to follow the transmitter signal, if the number of line and frames, or even the manner of scanning, is changed. This feature of versatility of the receiver units promises to make it possible to place in the field television receivers which will not become obsolete when greater definition is desired in television pictures.

Synchronism, being maintained by wave-form rather than by pulses, is exact and unvarying. The inability of the receiver to fall out of step with the transmitter makes possible the four-to-one interlace ratio. Even higher interlace ratios have been successfully transmitted, without weaving or pairing of the lines. Furthermore, highly irregular scanning wave-forms have been tried with success, and the sine-wave has been shown to be practical as a scanning wave-form. By employing the easily-transmitted sine-wave as the basis of the scanning, and by converting the sine-wave to a linear wave by passing it through a rectified tube both at transmitter and receiver, linearity of scanning (and consequent evenness of light distribution) are preserved.

Chromium Polish

SO MUCH chromium is now being used in rodio sets and panels that it is well to know thot this finish may be polished. The only moteriols required ore absorbent cotton or soft cloth, alcohol, and ordinary lamp block.

A wod of cotton or the cloth is moistened in the olcohol ond pressed into the lomp block. The chromium is then polished by rubbing the lamp block adhering to the cotton briskly over its surface. The mixture dries almost instontly and moy be wiped off with another wod of cotton.

The alcohol serves merely to moisten the lamp black to a paste and make it stick to the cotton. The mixture cleons and polishes very quickly and cannot scratch the chromium service. It polishes nickel-work just as effectively as it does chromium.—"RADIO".

From I.R.E. Proceedings
March, 1938

RADIO PROGRESS

during 1937

Rather than condense this valuable report of the I.R.E. technical committees into a few pages, the editors have deemed it best to reprint the article in its entirety—footnotes and all—in two sections: Part I, Electroacoustics, and Part II, Electronics, in this issue; radio receivers, television and facsimile, and transmitters and antennas will appear in the next issue.

PART I—ELECTROACOUSTICS

THE advance in applied acoustics in radio consists of the refinement and improvement of existing equipment, combined with developments designed to meet the requirements of new projects. This report divides the field into the following subjects: loud speakers, head telephone receivers, microphones, studios, electromechanical instruments, and measuring instruments and techniques.

• Loud Speakers

Direct radiator loud speakers have been improved by advancements in the design of the mechanism and of the acoustic means for coupling between the driving system and the air at low frequencies.

The acoustic labyrinth[1] has been improved by employing a new material for the lining. This material, besides having very desirable acoustic properties, is self-supporting, so that it obviates the use of metal lath which was a feature of the old construction.

A loud speaker for use in monitoring booths and review rooms to simulate the quality of sound motion-picture reproduction has been developed. The cabinet is designed on the principle of a Helmholtz resonator to improve the low-frequency response. The low-frequency driving mechanism consists of a conventional permanent-magnet dynamic loud speaker. The high-frequency unit consists of a short four-cell horn coupled to a dynamic mechanism. A suitable 800-cycle cross-over network and tone control, together with an adjustment for mechanical phasing of the high- and low-frequency units, permit matching of this loud speaker to the acoustic characteristics of the individual room where it is used.

The introduction of the acoustic phase inverter[1,2] into the mid-price range console class has been made possible by the development of a simple, rigid, nonvibrating, curved panel for enclosing the back of the loud-speaker to provide the capacitive element of the acoustic system. This method of improving low-frequency response has also been applied to a table model during the past year. In addition to improving the quality of reproduction, it has reduced acoustic feedback.

A means for improving the response of a loud speaker in a cabinet consists of a short straight-axis horn associated with the rear radiating portion of a diaphragm. This device has the economic merit of reducing the air-borne acoustic forces upon the walls of the cabinet, permitting a much lighter and, consequently, cheaper cabinet construction. Also, a suitable design allows the cabinetmaker much greater latitude since cavity resonances are largely eliminated, the speaker and horn combination being the dominant element in the circuit.

A study of the mechanical constants revealed the fact that there was a definite oscillatory system existing in most edge structures. An annular flexing edge for a cone diaphragm in which secondary resonances occurring from this area are eliminated without unduly restricting the amplitude range of the compliance has been developed. By confining the constants of the system between the cone proper and the mounting gasket to compliance only, it has been found possible to eliminate nearly all of the irregularities in the response characteristic occurring in the range from 800 cycles to 2000 cycles. This type of a cone edge usually produces low-frequency amplitude distortion since its action may either cause rectification or restriction. In general, this does not seem to be a commercial hindrance, since usually the distortion is purely harmonic and does not contain objectionable transient components.

Considerable research has been done in the field of fibers used in cone diaphragms. It has been found possible, through various combinations of materials, to influence greatly the high-frequency response of cone diaphragms. The introduction of fibers such as wool into the composition of the cone results in greatly increased mechanical resistance. This possibility has been utilized for two different purposes: first, to reduce the high-frequency response for such applications as the automotive-header loud speakers, and second, as a flexing edge of this soft material to be used in conjunction with a somewhat harder body where it is desired to reduce the amplitude at resonance and to minimize secondary edge resonances.

Extensive use has been made of corrugated disks as an outside suspension for centering the voice coil.

This type of suspension provides a means of shielding the air gap against foreign particles, a relatively small stiffness which improves the low-frequency response by reducing distortion, and high rigidity in a lateral direction for keeping the voice coil aligned in the air gap.

Compliances have been used in the cone near the coil to effect a sharp high-frequency cutoff. In addition, this compliance reduces the mass reactance before cutoff and thereby increases the response in this region.

In the allied field of sound reenforcing and public address, two permanent-magnet loud speakers of 60 and 100 watts power rating have been developed. Indestructible materials such as bakelite and metals have been used to insure a long and useful life. High efficiency over a wide range is obtained by means of a multiple-flare horn. The use of a permanent-magnet field eliminates the expense of wiring and providing a means for field supply.

Intercommunicating systems have become popular. The acoustic components are, of course, the microphone and the loud speaker. Most of the systems employ magnetic or dynamic loud speakers similar to those used in small radio receivers. In general the same unit, with suitable compensation, is also used as the microphone. Small loud-speaker units suitably compensated are also used in those systems where a separate unit is employed for the microphone and the loud speaker.

• Head Telephone Receivers

A crystal-type high-fidelity headphone has been developed for use in exact monitoring work of radio broadcasting and motion-picture recording. The new headphone has a uniform response to 12,000 cycles. The impedance of a pair of these headphones is very high, 80,000 ohms minimum at any frequency; consequently the power-source characteristics are not affected.

The sensitivity is approximately one volt per dyne per square centimeter at 1000 cycles. These headphones are exceptionally rugged and will withstand a considerable amount of mechanical abuse with little danger of breaking the crystal element or changing the frequency response.

An extremely lightweight crystal headphone with high output has been developed. The cases and caps are of aluminum. The cases are hermetically sealed so that even the most adverse atmospheric conditions cannot damage them. The cases are small, measuring 2⅛ inches in diameter by 5/16 of an inch thick. The impedance of the headphone is of course high, being of the order of 16,000 ohms at 1000 cycles. Driving impedance of any value from 100,000 ohms down may be used without destroying the quality. However, if an impedance higher than this is used there will be a loss of high-frequency response. The response covers the range from 60 to 10,000 cycles.

• Microphones

The manifold problems of sound collection are so varied and wide in scope that it has not been possible to develop a universal microphone which adequately satisfies all the requirements under all conditions. Directional and nondirectional microphones have definite applications: nonuniform response over a limited range may be fitted for pickup and transmission under certain conditions, weight and size may sometimes be a consideration, while for other uses high output may be more desirable than small weight, etc.

Consequently, each year new microphones are developed to satisfy some new problems in sound pickup or to effect an improvement over existing microphones used in some collection problem.

A high-impedance bidirectional crystal microphone has been developed consisting of a diaphragm-type stiffness-controlled crystal unit operated on the pressure-difference principle. A simple passive network is employed to render the output voltage uniform at all frequencies and substantially in phase with the sound pressure. This unit has been combined with a nondirectional crystal element to give a unidirectional microphone with a cardioid polar directional characteristic.

A convenient and useful feature of this microphone is the provision of a switch for convenient connection of either one or both elements of the microphone to the output terminals, thus making available any one of the three basic response characteristics; that is, nondirectional, bidirectional, or unidirectional to suit operating conditions. The front-to-back discrimination in the unidirectional position is about 20 decibels between 100 and 5000 cycles. No special amplifier characteristics are required for use with this microphone.

Heretofore, in the cases where a microphone having greater directivity than the unidirectional combination of a pressure gradient and pressure microphone was required, the microphone associated with a parabolic reflector has been the only type available. This reflector is directional because its sound-concentrating property is a function of the angle of sound incidence. However, this property is also a function of the frequency, and the normal incidence response of the microphone is therefore distorted. A new highly unidirectional microphone has been obtained by coupling a moving-coil microphone to an acoustic impedance element composed of a bundle of 50 ⅜-inch diameter thin-walled aluminum tubes whose length vary by equal increments from 1¼ inches to five feet.

The function of this variation in length is twofold. First, the multiple resonances of the individual tubes occur at intervals so close together that the net effect of the bundle is that of an acoustic resistance over a fairly wide frequency range. The high quality of the attached microphone is therefore not impaired.

Second, high directivity is secured, because for sound incidence other than normal each tube introduces a different path length with phase cancellation resulting at a composition chamber between the microphone and ends of the tubes. Since this microphone does not distort the quality of direct sound, high-quality pickup may be secured without equalization. The directionality is equivalent to that of a parabola three feet deep and three feet in diameter, but the light weight of five pounds and small diameter of three inches render it more convenient for ordinary use.

- Studios

The design of studies for sound collection has advanced to the point where it is possible to state with reasonable assurance the requirements for good acoustics under a variety of conditions. That is to say, the design of studios is now a fairly definite and precise engineering job.

Sound-absorbing materials for practically every conceivable use have been developed. A tremendous amount of data have been gathered on the properties of sound absorbers. Therefore, this phase of the subject seems to be quite complete.

The problem of the distribution of sound in rooms is extremely complicated. It is quite well known that the performance of radio receivers varies considerably in different rooms. It appears that the difference cannot be attributed to reverberation alone. The free vibrations,[3] (characteristic frequencies or eigentones) of a room have been studied. These investigations indicate a better knowledge of the resonance in rooms is required before it is possible to understand and control the phenomena of intensity distribution and reverberation which are so closely related to room resonance.

- Electromechanical Instruments

A new sound-on-disk recorder has been developed[4] in which the principle of feeding part of the output of the system back to the input of the associated driving amplifier in properly controlled relationship is used. This principle, which is widely used in feed-back amplifiers, replaces the usual practice of providing dissipative elements for the control of an electrically driven vibrating system.

Heretofore, no practical application of feedback to electromechanical systems has been made, possibly because the requirements for stable operation of such systems are difficult of achievement. Through recent developments these requirements have been satisfactorily met. The new recorder is capable of recording on wax or direct-recording material without appreciable effect on its characteristics, which include a uniform response from 30 to 12,000 cycles and exceptional freedom from distortion products. The recorder is extremely simple and affords easy means for field calibration from the feed-back element whose output is in direct proportion to the stylus velocity. These means also make available a monitoring voltage which, properly amplified, gives a precise aural picture of the stylus behavior during recording.

Vertical and lateral high-fidelity crystal phonograph pickups have been improved with low stiffness and low moment of inertia. The stiffness is the order of 1.5×10^6 dynes per square centimeter. Both types operate satisfactorily with as little as 0.4-ounce needle pressure, although one ounce is recommended for general use. This pressure is easily adjusted by means of a sliding weight.

The 12-inch aluminum arm is curved in order to reduce tracking error to a minimum. The frequency response is flat from 30 to 10,000 cycles for either type when fed into the following loads: 30,000 ohms resistance in series with 0.03 microfarad for the vertical pickup, and 15,000 ohms in series with 0.03 microfarad for the lateral model.

A method of recording sound magnetically on steel tape[5] similar in principle to that of the Poulsen Telegraphone has been developed. By making use of perpendicular instead of longitudinal magnetism, the speed of the tape may be reduced to 8 inches per second for recording speech. The low tape speed eliminates many of the difficulties encountered with those systems which made use of longitudinal magnetism. The ratio of the signal-to-ground noise has been substantially reduced. The recording medium is a steel tape having a thickness of two mils and a width of 50 mils.

• Measuring Instruments and Techniques

A distortion meter has been developed for measuring the total harmonic content generated in audio-frequency systems. The meter is used in conjunction with a beat-frequency oscillator having very low harmonic content in the output. A part of the output of the oscillator is fed to the system to be tested and another part to the analyzer. The output of the device to be tested is fed into the harmonic analyzer. The amplitude and phase relations of the fundamentals, from the oscillator and device to be tested, are adjusted by means of suitable networks so that none of the fundamental remains. The remainder is the total harmonic generated in the system under test. This is measured by means of a root-mean-square meter.

A system known as the velocity bridge has been developed for obtaining the velocity of the voice coil of a dynamic loud speaker. The loud speaker to be tested is balanced against a similar loud speaker blocked. When a voltage is applied to the bridge, the output is proportional to the back electromotive force generated in the loud speaker or to the velocity of the voice coil in a dynamic loud speaker.

This system permits recording a graph of the voice-coil velocity versus frequency with automatic or semiautomatic recording equipment, and thereby removes this class of measurement from the point-by-point method which has been used in the past.

An instrument for obtaining a visual indication of the response-frequency characteristics of such audio-frequency apparatus as microphones, loud speakers, transformers, amplifiers, etc., has been developed. The indicating device is a 5-inch cathode-ray tube with a long-persistence screen. By this means as many as 4 or 5 response curves can be compared simultaneously.

The maximum frequency range is 30 to 15,000 cycles per second, but it is possible to observe any desired portion of this range. The sensitivity of the instrument is continuously variable from a full-scale of 6 decibels to a full-scale of 48 decibels. The equipment is portable and alternating-current-operated. Although designed for laboratory use, this apparatus should find other applications such as factory test, field studies in theatres, etc.

In the conventional arrangement for measuring the indoor response of a radio receiver, the pencils of sound reflected from the floor are stronger than any other primary reflections; this is particularly true in the case of the rotating microphone. Due to the dimensions and geometry, the floor reflection causes a marked change in the response characteristic in the mid-frequency range. This effect is so pronounced that often times other effects which seriously impair the response characteristic are masked and may go undetected.

First-order floor reflections may be eliminated by the use of an inclined deflector, which becomes the floor in front of the receiver to be tested, arranged so that sound reflected from this new floor will not strike the microphone. The response characteristic obtained under these conditions is free of first-order floor reflection effects.

An instrument for calibrating vibration pickups has been developed. It consists of a "vibration cell" of rigid construction containing an inertia-actuated Rochelle salt crystal resonated an octave above the highest frequency to be measured. Vibrations from a Rochelle salt crystal driver, or other convenient source, are transmitted through the "vibration cell" to the pickup being calibrated, and the relative output voltages compared. This method has been very useful in checking the response-frequency characteristics of high-output vibration pickups used for field work.

A standard of low-frequency sound pressure was developed following the general theory of previous investigators. This "dynamic piston-phone" consists of a chamber about 50 cubic centimeters in volume and a piston 0.3 centimeter in diameter driven by a moving-coil mechanism, capable of executing strokes of approximately 1.0 centimeter at frequencies between 20 and 100 cycles. The stroke is measured by means of a telescope and scale. The variation in pressure may be computed from the variation in volume. A small crystal microphone is used as a pressure indicator within the pistonphone chamber and thus becomes a calibrated microphone for the measurement of sound-field pressures.

●

PART II—ELECTRONICS

ELECTRONICS appears to have been devoid of radical departures from the trends of the recent past. In the older applications the chief advances are additions to and refinements of the already extensive quantitative knowledge of the behavior of electronic devices. In the newer and more active fields of television and ultra-high-frequency tubes, greatest progress is reported in the extension, improvement, and refinement of methods and devices which have in the recent past been generally accepted as the most promising. It is not within the scope of this report to discuss the significance of these trends, nor to speculate on the future.

• Television Tubes

Electron Optics

In the field of electron optics theoretical and experimental work has continued, so that exact expressions are now known for many of the properties of electron lenses.[1,2,3,4] The knowledge of electron optics has been used to improve electron microscopes,[5,6] the intensification of optical images,[7] and the construction of cathode-ray tubes with multiple beams.[8]

Apparatus has been developed for the automatic plotting of the paths of electrons moving through electrostatic fields.[9,10]

Television Camera Tubes

Sensitivity of the Iconoscope type of tube has been increased and the operating characteristics have been investigated further.[11,12,13] Several new kinds of pickup tubes were developed; some utilize photo-conductive or photovoltaic effects, or secondary-emission amplification of an electron picture to give additional sensitivity or a less spurious signal.[14,15,16]

Television Picture Tubes

The development of cathode-ray tubes has progressed to such a point that large television pictures have been shown by projection on a viewing screen.[17,18,19,20]

Advancements in theory and improvements in the practice of producing fluorescent screens have increased their efficiency and stability.[21,22,23,24] A method of measuring the color of these screens has been described.[25]

A large, continuously evacuated, direct-viewing cathode-ray tube permitting an 18-+24-inch picture has been described.[26]

Oscillograph Tubes

A new type of oscillograph tube has appeared.[27] A study has been made of the ultra-high frequency performance of electrostatic-deflection tubes.[28]

• U. H. F. Vacuum Tubes

Progress in the field of ultra-high-frequency vacuum tubes during 1937 has followed the trend of 1936 in that advancements have been made principally in tubes where the electron-transit time is a small fraction of the oscillatory period. In this group the greatest improvements have been evident in conventional negative-grid triodes including both an extension of the upper frequency limit and a substantial increase in power output in the frequency range of 50 to 1500 megacycles.

Small negative-grid triodes of unusual design have been described[29] which extend the upper frequency limit of triode oscillators to the neighborhood of 1800 megacycles and increase the upper limit of triode amplifiers. From these tubes used as oscillators, a power output of approximately 16 watts at 500 megacycles has been obtained, which is more than double the output reported last year.[30] The special feature of these tubes is that the plate and grid electrodes are supported by leads which in effect go straight through the envelope providing two independent leads to each of these elements. This double lead construction is used to decrease circuit losses, to increase the limiting frequency, and to provide an effective means of neutralization.

The application of special lead and mounting arrangements has been extended to radiation-cooled tubes of larger sizes resulting in outputs of 400 to 600 watts at 50 megacycles.[31,32] The frequency limit of small water-cooled tubes has been extended to 300 megacycles.[33] A high-power water-cooled pentode capable of delivering 6000 watts at 50 megacycles has been described.[34]

The literature indicates a continued investigation of less conventional tubes, particularly those in which the electron-transit time is critically related to the oscillatory period.[35,36,37,38] In this group two interesting types of magnetrons have appeared. One of these[35] has the unique feature that the oscillatory circuit is connected between split end plates which are negative with respect to the cathode and receive a negligible electron current.

The other new magnetron[36] has the unusual feature that the electron emission is introduced at the end of the plate cylinders, rather than uniformly along the axis of the anode as in the ordinary magnetron. This arrangement is reported to eliminate cathode bombardment.

• Receiving Tubes

In the field of receiving tubes, although no radically new developments have been reported, progress has been made in the extension of fundamental theory, in the reduction of noise, in the simplification and improvement of tube structures, and in the use of new materials.

Theoretical studies have been made of the effects of space charge in general,[39,40] more specifically in the grid-anode region.[41] Further investigations into the theory of tube noise have been reported.[42]

The operation and design of multielectrode converter tubes have been the subject of further investigations.[43,44,45,46,47]

There has been evidence of continued activity in the field of beam tubes.[48,49]

Improvements have been made in getters[50] and in structures for minimizing tube noises.[51] Study of contact potential has contributed a better understanding of this subject.[52]

- Transmitting Tubes

Advances in large high-vacuum tubes have extended the high-frequency limit of operation. These developments are treated in the report on high-frequency-tubes.

- Gas Tubes

Most of the advances in gas tubes have found application in the industrial field. Since some of them have possible use in radio, a brief summary is included here.

Considerable progress has been made in the improvement of the ignitron-type of rectifier. Individual sealed-off ignitrons have been developed for use in large multiphase rectifiers providing high-current power supplies.[53] A new type of ignitor rod for reducing the ignitor current required for reliable initiation of the cathode spot[54] has been described.

Thyratrons filled with a mixture of argon and mercury vapor have been developed.[55] These tubes are reported to have the low voltage drop which is characteristic of mercury vapor, but with critical grid characteristics that are independent of temperature over a range much wider than that of tubes containing mercury vapor alone.

Cold-cathode tubes are becoming increasingly important as control or relay devices and are capable of performing many of the functions for which small thyratrons have generally been used.[56,57,58]

- Photoelectric Devices

Progress in photoelectric devices has been limited largely to detail improvements in commercial tubes and to further scientific study of the photoelectric properties of thin films[59,60,61,62,63] and the characteristics and theory of barrier-layer photoelectric cells.[64,65,66,67]

A new type of phototube has been described in which the anode consists of a network of tungsten wires which may be made incandescent as a means of cleaning them, placed parallel to the cathode, saturation being obtained with only three to four volts.[68] The effect of hydrogen on reducing the time lag of argon-filled phototubes was investigated.[69]

FOOTNOTES — PART I

[1]"Radio Progress During 1936," Proc. I. R.E., vol. 25, p. 166; February, (1937).

[2]B. R. Carson, K. A. Chittick, D. D. Cole, and S. V. Perry, "New Features in Broadcast Receiver Design," RCA Rev., vol. 2, pp. 45-59; July, (1937).

[3]V. O. Knudson, "Recent Progress in Acoustics," Jour. Soc. Mot. Pic. Eng., vol. 29, pp. 233-247; September, (1937).

[4]L. Veith and C. F. Wiebusch, "Recent Developments in Hall-and-Dale Recorders," Jour. Soc. Mot. Pic. Eng., vol. 30, pp. 66-104; January, (1938).

[5]C. N. Hickman, "Magnetic Recording and Reproducing," Jour. Acous. Soc. Amer., vol. 9, pp. 77-78; July (1937). (Abstract.)

FOOTNOTES — PART II

[1]E. Brucke, "Geometrical Electron Optics," Funkteck. Monatshefte (Fernsehen und Tonfilm supplement, pp. 1-12; January, (1937).

[2]K. Diels and G. Wendt, "The Eight Image Errors, of Third Order, of Magnetic Electron Lenses," Zeit. fur tech. Phys., vol. 18, no. 3, pp. 65-69, (1937).

[3]E. Gundert, "Demonstration of Imagery Defects of Electron Lenses," Phys. Zeit., vol. 38, pp. 462-467; June 15, (1937).

[4]A. Bouwers, "Convergence of Electrons By Means of Magnetic Coils," Physica, vol. 4, pp. 200-206; March, (1937). (In English.)

[5]L. C. Martin, R. V. Whelpton, and D. H. Parnum, "A New Electron Microscope," Jour. Sci. Instr., vol. 14, pp. 14-24; January, (1937).

[6]H. Gross and G. Seitz, "Production of Electron-Optical Pictures with Photoelectrons," Zeit. fur Phys., vol. 105, pp. 734-737; May 29, (1937).

[7]F. Coeterier and M. C. Teves, "An Apparatus For the Transformation of light of Long Wave Length Into Light of Short Wave Length. III. Amplification By Secondary Emission," Physica, vol. 4, pp. 33-40; January, (1937). (In English.)

[8]M. Knoll, "Electron-Optical Arrangement For Multiple Cathode-Ray Tubes With Incandescent Cathodes," Arch. fur Elektrotech., vol. 31, pp. 41-42; January 23, (1937).

[9]D. Gabor, "Mechanical Tracer For Electron Trajectories," Nature, vol. 139, p. 373; February 27, (1937).

[10]D. B. Langmuir, "Automatic Plotting of Electron Trajectories," Nature, vol. 139, pp. 1066-1067; June 19, (1937).

[11]B. V. Krusser and N. M. Romanova, "A Cathode-Ray Transmitting Tube," Izvestiya Elektroprom. Slab. Toka, no. 4, pp. 20-23, (1937).

[12]V. K. Zworykin, G. A. Morton, and L. E. Flory, "Theory and Performance of the Iconoscope," Proc. I.R.E., vol. 25, pp. 1071-1092; August, (1937).

[13]H. Iams, R. B. Janes, and W. H. Hickok, "The Brightness of Outdoor Scenes and Its Relation to Television Transmission," Proc. I.R.E., vol. 25, pp. 1034-1047; August, (1937).

[14]M. Knoll and F. Schroter, "Electronic Transmission of Pictures and Signs With Insulating or Semiconducting Films," Phys. Zeit., vol. 38, pp. 330-333; May..1, (1937).

[15]H. Iams. and A. Rose, "Television Pick-Up Tubes Wth Cathode-Ray Beam Scanning," Proc. I.R.E., vol. 25, pp. 1048-1070; August, (1937).

[16]"Super-Emitron Camera," Wireless World, vol. 41, pp. 497-498; November 18, (1937).

[17]D. B. Langmuir, "Theoretical Limitations of Cathode-Ray Tubes," Proc. I.R.E., vol. 25, pp. 977-991; August, (1937).

[18]R. R. Law, "High Current Electron Gun For Projection Kinescopes," Pro. I.R.E., vol. 25, pp. 954-976; August, (1937).

[19]V. K. Zworykin and W. H. Painter, "Development of the Projection Kinescope," Proc. I.R.E., vol. 25, pp. 937-953; August, (1937).

[20]A. Castellani, "Projection With Cathode-Ray Tubes," Television, vol. 10, pp. 413-414; July (1937).

[21]H. W. Leverenz, "Production of Cathode-Ray Tube Screens," Jour. Opt. Soc. Amer., vol. 27, pp. 25-35; January, (1937).

[22]T. B. Brown, "Brightness of Cathode-Ray Luminescence at Low Current Densities and Low Voltages," Jour. Opt. Soc. Amer., vol. 27, pp. 186-192; May, (1937).

[23]W. B. Nottingham, "Potential and Luminescence of Insulated Willemite Cathode-

Ray Screens," Phys., Rev., series 2, vol. 51, p. 591; April 1, (1937).

[24] I. G. Maloff and D. W. Epstein, "Screens For Television Tubes," Electronics, vol. 10, pp. 31-34 and 85-86; November, (1937).

[25] G. A. Fink and R. M. Bowie, "Specification of Screen Color of Cathode-Ray Tubes." Presented before Rochester Fall Meeting, November 8, 1937. Electronics, vol. 10, pp. 13-14; December, (1937).(Abstract.)

[26] I. G. Maloff, "Direct-Viewing Type Cathode-Ray Tube For Large Television Images." Presented before Rochester Fall Meeting, November 9, 1937. Electronics, vol. 10, pp. 13-14; December, (1937). (Abstract.)

[27] M. von Ardenne, "A New Polar Coordinate Cathode-Ray Oscillograph With Extremely Linear Time Scale," Wireless Eng., vol. 14, pp. 5-12; January, (1937).

[28] H. Hinterberger, "On the Behavior of a Cathode-Ray Tube at Ultra-High Frequencies," Zeit. fur tech. Phys., vol. 18, no. 9, pp. 256-259, (1937).

[29] A. L. Samuel, "Negative Grid Triode Oscillator and Amplifier For Ultra-High Frequencies," Proc. I.R.E., vol. 25, pp. 1243-1252; October, (1937).

[30] "Radio Progress During 1936," Proc. I.R.E., vol. 25, p. 179; February, (1937).

[31] W. G. Wagener, "Developmental Problems and Operating Characteristics, of Two New Ultra-High-Frequency Triodes." Proc. I.R.E., vol. 25, p. 928; August, (1937). (Abstract only).

[32] "High-Frequency Tube," Comm. and Broad. Eng., vol. 4, p. 19; August, (1937).

[33] W. G. Wagener, "The Requirements and Performance of a New Ultra-High-Frequency Power Tube," RCA Rev., vol. 2, pp. 258-264; October, (1937).

[34] K. Posthumus, "The Water-Cooled Pentode Types PA 12/15 at Ultra Short Wavelengths," Philips Trans. News, vol. 4, pp. 1-12; July, (1937). (In English and German.)

[35] K. Okabe, "The Electron-Beam Magnetron," Electrotech. Jour. (Japan), vol. 1, pp. 29-30; June, (1937). (In English.)

[36] Adolph Helbig, "Grid-Controlled Magnetron With Cathode Outside of Anode Cylinder," Hochfrequenz. und Elektroakustik, vol. 50, pp. 96-98; September, (1937).

[37] T. V. Ionescu, "Short-Wave Oscillator," Comptes Rendus, vol. 204, pp. 1411-1413; May 10, (1937).

[38] H. E. Hollman and A. Thoma, "Dynamics of Transversely and Longitudinally Controlled Electron Beams. Part I: Static and Dynamic Relationships," Hochfrequenz. und Elektroakustik, vol. 49, pp. 109-123; April, (1937). Part II: "Ultra-Dynamic Conditions," vol. 49, pp. 145-160; Supplement, pp. 161-162; May, (1937).

[39] W. Kleen and H. Rothe, "Space-Charge Equation For Electrons with Initial Velocity," Part II, Zeit. fur Phys., vol. 104, pp. 711-723; (1937).

[40] W. Kleen, "Investigation of the Space-Charge Law," Die telefunken-Rohre, pp. 66-75, April, (1937).

[41] B. Salzberg and A. V. Haeff, "Effects of Space Charge in the Grid-Anode Region of Vacuum Tubes," Proc. I.R.E., vol. 25, p. 546; May, (1937). (Abstract.) RCA Rev., vol. 2, pp. 336-374; January, (1938).

[42] W. Schottky, "The Space-Charge Reduction of Shot Effect," Wiss. Veroff. di. Siemens Werken, vol. 16, pp. 1-41, (1937).

[43] M. J. O. Strutt, "The performances of Certain Types of Frequency-Changing Tubes in All-Wave Receivers," L'Onde Elec.. vol. 16 pp. 29-44; January, (1937).

[44] M. J. O. Strutt, "Frequency Changers in All-Wave Receivers," Wireless Eng., vol. 14, pp. 184-192; April, (1937).

[45] M. S. Krauthamer, "Some Numerical Data on Converter Tubes With Two Control Grids," L'Onde Elec., vol. 16, pp. 114-131; February, (1937).

[46] E. W. Herold, "Frequency Changers in All-Wave Receivers," Wireless Eng., vol. 14, pp. 488-489; September, (1937). A note on reference 44.

[47] T. E. Goldup, "Frequency Changers," Wireless Eng., vol. 14, p. 318; June, (1937). A note on reference 44.

[48] H. Rothe and W. Kleen, "Electron Optics in the Technics of Amplifier Tubes," Zeit. fur Tech. Phys., vol 17, pp. 635-642, (1936).

[49] E. P. Rudkin, "The Deflection Amplifier as Amplifier, Rectifier and Generator," Wireless World, vol. 40, pp. 299-301; March 26, (1937).

[50] E. A. Lederer and D. H. Womsley, "'Batalum,' a Barium Getter For Metal Tubes," RCA Rev., vol. 2, pp. 117-123; July, (1937).

[51] L. C. Hollands and A. M. Glover, "Vacuum Tube Engineering For Motion Pictures." Jour. Soc. Mot. Pic. Eng., vol. 30, pp. 38-57; January, (1938).

[52] E. A. Lederer, D. H. Womsley, and E. G. Widell, Studies of Changes of Contact

Potential," Presented before Silver Anniversary Convention, New York City, May 11, 1937. Proc. I.R.E., vol. 25, p. 545; May, (1937). (Abstract.)

53J. H. Cox and D. E. Marshall, "Mercury-Arc Rectifiers and Ignitrons," Electrochemical Society preprint 72-24, pp. 359-375, (1937).

54A. H. Toepher, "Low Current Ignitors," Elec. Eng., vol. 56, pp. 810-812; July, (1937).

55G. H. Rockwood, "Thyratrons For Grid-Controlled Rectifier Service," Electrochemical Society, preprint 71-11, pp. 161-171. (1937).

56S. B. Ingram, "The 313A Vacuum Tube," Bell Lab. Rec., vol. 15, pp. 114-116; December, (1936).

57K. J. Germeshausen and H. E. Edgerton, "The Strobotron," Electronics, vol. 10, pp. 12-14; February, (1937).

58A. B. White, W. B. Nottingham, H. E. Edgerton, and K. J. Germeshausen, "The Strobotron—II," Electronics, vol. 10, pp. 18-21; March, (1937).

59H. C. Rentschler and D. E. Henry, "Photoelectric Emission," Jour. Frank. Inst., vol. 223, pp. 135-145; February, (1937).

60H. Mayer, "Photoelectric Properties of Atomic Layers of Potassium on Platinum," Ann. der Phys., series 5, vol. 29, pp. 129-159, (1937).

Liquid Soldering Flux

A CHEMICAL action that is frequently set up between ordinary soldering flux and metal tends, after a time, to cause the introduction of resistance at the joint. This action is particularly harmful where the connecting metal surfaces are quite small, as in radio and other delicate electrical work. The possibility of this chemical action may be lessened by swabbing the joint with alcohol as quickly as possible after the soldering flux is used. But even that is not a certain precaution.

The slow chemical deterioration of the connection does not take place when rosin is used as the flux, and for that reason rosin-core solder is used almost exclusively for all fine soldering work. But since often too much rosin runs onto the connection being soldered and must be scraped away if a neat joint is to be made, a liquid rosin soldering flux such as described here will be found extremely convenient.

This liquid flux is formed by adding rosin to denatured alcohol until no more will dissolve, thus creating a saturated solution. After the joint to be soldered has been carefully cleaned, it is painted with this alcohol-rosin solution, using a small paint brush. The joint may be soldered easily then if a clean and well-tinned soldering iron is used. This solution should be kept in a tightly-corked jar when not in use, to prevent evaporation. Since the alcohol is used up more quickly than the rosin, a little alcohol should be added occasionally as needed to dissolve lumps. This flux is not only extremely easy to use but it is economical, since inexpensive solid wire solder is used with it.—Radio.

THE TECHNICAL FIELD

In Quick Review

●

RADIO DIGEST briefly summarizes for its readers the contents of leading radio articles in current technical publications, some of which may appear later in RADIO DIGEST.

All-Wave Radio

MARCH, 1938
Manson Publications Corp.
16 E. 43 St., N.Y.C.
25c a copy—$2.50 yearly

STAGED IN THE WOOD, *by E. T. Turney, Jr.*—A complete constructional and layout description of a 500-600-watt phone and 800-900-watt c.w. rig, mounted upon a combination wooden baseboard and wooden cabinet. The final amplifier uses a pair of HF200's operating at 2000 volts for either phone or c.w; this stage is plate modulated by a pair of ZB120's for radiotelephony. The rig operates on 3.5, 7.0, 14 and 28 Mc.

THE FREQUENCY QUINTUPLER, *by S. T. Carter.*—A description of a two-tube exciter using Pierce and Jones oscillators. A combination of a 6L6 Pierce crystal oscillator, capacity coupled to another 6L6 or 807, the latter tube to be operated as a frequency multiplier in a circuit very similar to that used in the new Jones harmonic oscillator as described in recent issues of RADIO.

A VERSATILE 5-METER TRANSMITTER-RECEIVER, *by Irwin Wolfe.* The transmitter uses a t.n.t. 6E6 oscillator, running with about 15-18 watts input, modulated by a single 6L6 fed from a single button mike. The receiver uses an 89 detector coupled into a 6V6 audio and is designed to feed a loudspeaker with good volume. The whole outfit runs from a single Mallory 300-volt 100-ma. Vibrapack.

APRIL, 1938

ADVANCED DESIGN E.O.C. UNIT, *by John P. Taylor.*—A transmitter exciter design using an electron-coupled 807 oscillator with an untuned plate circuit capacitively-coupled to another 807 used as amplifier-doubler. As the effects of temperature variation, plate voltage variation and load reaction are the main causes of frequency change in self-excited oscillators, each of these factors is considered and the design is such that each is eliminated or minimized. Due to the use of beam power tubes, very little excitation is needed and a good deal more output is available than is usual with similar compact units. Since portable or emergency use as a low-powered transmitter was desired, provision is made for power also being supplied by a vibrator plate supply and storage battery. The oscillator covers the 160-meter amateur band; the amplifier is tunable to frequencies in the 80-meter or 160-meter bands with the same plate tank circuit with nearly 15 watts output in either frequency range. As for stability, tests showed that after about 5 minutes' filament-warming the total drift decreased with time and reached a maximum in one hour of about 300 cycles.

A PUSH-PULL 5-METER SUPER-REGENERATIVE RECEIVER, *by R. J. Hagerty.*—The writer disliked the susceptibility of the ordinary 5-meter superheterodyne to automobile QRM and desired a portable-mobile receiver. He describes the receiver which resulted from a design pointing to the improvement of the super-regenerative circuit. Shown by photos and circuit diagram is a receiver consisting of push-pull 6D6's for r.f. amplification, a push-pull series-fed Hartley detector circuit using 6J5G's with a 76 furnishing low frequency quenching and a 41 audio amplification. Exceptionally good results, with more signal strength and lower hiss level, are claimed.

COMMUNICATIONS

Bryan Davis Pub. Co., Inc.
19 E. 47 St., N.Y.C.
25c a copy—$2.00 yearly

APRIL, 1938

SELECTING SPEECH-INPUT UNITS, *by John P. Taylor.*—An intelligent analysis of the problem of selecting speech-input equipment for broadcast station use. The main factors to be considered in selecting the equipment can be classified under three headings: constructional and appearance features, electrical design features, and performance. Ample analyses, with many illustrative charts, are given to help in evaluating each of these considerations.

CONTROL-ROOM SWITCHING, *by J. G. Sperling.*—An article discussing how general operation of the broadcasting station can be improved and simplified by intelligent layout of the speech-input equipment and by proper installation of the switching facilities. A number of suggested improvements and simplifications in design are indicated and diagrammed.

ELECTROLYTIC CAPACITORS IN FILTER DESIGN, by Paul MacKnight Deeley.—The effect of power factor on operating characteristics of electrolytic capacitors used in vacuum-tube rectifier filter networks is completely discussed and analysed.

REAL VS. APPARENT STATION COVERAGE, *by R. L. Haskins and C. W. Metcalf.*—A discussion of the influence of man-made static and interference on the actual service coverage of a station as contrasted with the measured field strength.

MARCH, 1938

SELENIUM RECTIFIERS.—Recent developments of the selenium rectifier in communications and other fields of electricity make this article of interest to many. Although short, it is amply illustrated with performance charts and dimensional photographs and deals quite completely with the characteristics of these metal disc rectifiers.

CATHODE-RAY BALLISTICS, *by F. Malcolm Gager.*—"Hollman and subsequently Libby have indicated that high-frequency cathode-ray deflections as a function of frequency for sinusoidal charge forces on the electron stream are accounted for by a single correction factor and constants. The substance of this paper reveals a generalized correction chart for any cathode-ray tube of known geometry and applied potentials when deflected magnetically or electrostatically by sinusoidal or nonsinusoidal forces. In addition, the treatment calls for a recognition of two dissimilar constants and a more logical reference point for deflection expressions which is more in line with recognized differences between theoretical and experimental deflections."

SOME NOTES ON SNOW STATIC, *by Dr. Victor J. Andrew.*—Some information has previously been published on this type of interference which is particularly noticeable and troublesome to operation of aircraft communications. Here several forms are discussed, some of which are the results of known phenomena while others are still the subjects of laboratory experimentation.

HIGH-FREQUENCY TRIODE OSCILLATORS, *by Grote Reber.*—A mathematical discussion of the operation of triode oscillators dealing with such factors as transit time effects, power output, grid temperature and efficiency. It is illustrated by tables and curves.

electronics

50c a copy—$5.00 yearly
McGraw-Hill Pub. Co., Inc.
330 W. 42 St., N.Y.C.

APRIL, 1938

NEW YORK CITY'S FIRE BOAT COMMUNICATION SYSTEM, *by Frank Borsody.*—A complete description of the design considerations, the equipment and the method of operation of the N. Y. fire boat communication system.

A PRACTICAL METAL DETECTOR, *by W. C. Broekhuysen.*—Originally developed for detecting metallic bits in cigars during manufacture, the tuned-bridge detector described in this article can be applied to a variety of industrial applications and can be built readily from standard parts.

CBS BUILDS NEW HOME FOR KNX.—A well-illustrated article concerning the design of the buildings and studios being used at the new CBS "Columbia Square" studios in Hollywood. Layout drawings, blueprints and photographs clearly illustrate the new and extremely modern installation. Both acoustic and electrical considerations in the design of studios and their equipment are completely covered.

TELEVISION RECEIVERS, *by E. W. Engstrom and R. S. Holmes.*— The time is rapidly approaching when the radio engineer will be confronted with design problems in television receivers and the radio serviceman will be confronted with problems in servicing them. This, the first article of a series, considers some of the general problems and begins the analysis of the receiver.

CATHODE-RAY SCREEN PHOTOGRAPHY.—Choice of film and development procedure for obtaining maximum sensitivity and contrast from each of the commonly used cathode-ray screen materials, abstracted from data compiled by R. S. Morse of the Eastman Kodak Company.

MARCH, 1938

HP6A: A RADICAL DEPARTURE IN PHONOGRAPH PICK-UP DESIGN, *by F. V. Hunt and J. A. Pierce.*—Unbelievable response, flat within plus or minus 3 db from 30 to 18,000 cycles, with a needle pressure of 0.17 ounces, has been achieved by applying velocity microphone principles to disc record pick-up design.

MEASUREMENT OF MINUTE CHANGES OF CAPACITANCE AND INDUCTANCE, *by S. C. Leonard.*—Determining changes in L and C of the order of 0.0005%, and temperature coefficients of the order of 0.0001% by beat frequency methods. Suitable for measuring the effect of temperature changes on radio components.

Direct Disc Recording, *by C. J. Lebel.*—In producing "immediate playback" records, careful attention must be paid to turntable, cutter head, record blanks, and reproduction facilities. The second article in a series on practical recording problems.

Distortion Limiter for Radio Receivers, *by M. L. Levy.*—A discussion of methods of preventing distortion at the first audio or power audio grids from appearing in the output of receivers operating at high volume levels.

Distributed Capacitance Chart, *by P. H. Massaut.*—An alignment chart, based on the Palermo equation, for determining the distributed capacitance of single layer coils in terms of wire size, spacing, and coil diameter.

QST devoted entirely to
AMATEUR RADIO

25c a copy—$2.50 yearly
American Radio Relay League
West Hartford, Conn.

May, 1938

Applying Band-Pass Couplers to Amateur Transmitters, *by Clinton B. DeSoto.*—An analytic discussion of a continuous-coverage transmitter with 100 watts output on four bands. Over-coupled resonant circuits are employed to obtain the band-pass characteristics.

Simple Directional Arrays Using Half-Wave Elements, *by Nick C. Stavrou.*—A resume of previously published material on gain variation with spacing of close-spacing arrays. Tables are given on the theoretical gain of two half-wave antennas with different spacings, and on the theoretical gain of colinear half-wave antennas.

Intra-Band Quick Frequency Change for Transmitters, *by Byron Goodman.*—A description of a one-kilowatt c.w. transmitter, using 250TH's and combining band-pass action with relay controlled padders for frequency shift without manual tuning.

5-, 10-, and 20-Meter Converter, *by T. M. Ferrill, Jr.*—A converter giving band-spread tuning, effective preselection and stable operation with only two tubes. A 6K7 is used as an r.f. amplifier and a 6K8 (one of the new h.f. oscillator mixer tubes) as converter. Plug-in coils are used to cover the three h.f. amateur bands.

A Desk-Type Push-Button Frequency Control Unit, *by Clark C. Rodimon.*—A flexible unit allowing finger-tip selection of crystals or electron-coupled oscillator operation from the operating table. One of the new Yaxley push-buttons as designed for b.c.l. use is employed to accomplish the switching operations.

A Portable-Mobile Crystal-Controlled U.H.F. Transmitter, *by Louis R. Padberg.*—A 15-watt output unit which can be adapted to 28- and 56-Mc. work. A 6N7 Jones oscillator operating from a 40- or 36-meter crystal excites an 807 in the modulated amplifier for either amateur-band or mobile-police usage. A 6N7 drives another as a class-B modulator for the 807, while a 6C5 audio oscillator is available to be used as a call tone.

Construction of Television Receivers, *by Marshall P. Wilder.*—Circuit details of the experimental superhet model together with suggestions for its adjustment and for the adjustment of the previously described receiver. The sixth and final article of a series by Mr. Wilder dealing with television theory and constructional practice.

April, 1938

A Tuned Loop for 80- and 160-Meter Reception, *by John P. Tynes.*—The writer describes several experimental loops that were constructed during a search for a means of cutting down the QRM as an aid toward better reception for an emergency network. The loop which finally provided a satisfactory solution to the problem is herein fully described. It is shielded and is rotatable in both vertical and horizontal planes. A single turn coupled to the tuned loop and fed in link-fashion through a shielded cable to the regular receiver provided the necessary signal strength and eliminated the interfering stations in a satisfactory manner on the 160- and 80-meter bands.

PUTTING THE HARMONIC GENERATOR TO WORK, *by John L. Reinartz.*—The author describes use of the "harmonic generator" for exciting an 814 final amplifier stage. The harmonic generator uses a 6L6 crystal oscillator coupled with another 6L6 in such a manner that a number of output frequencies are available at the output of the 6L6, furnishing a flexible method of driving a tube which requires low driving power. With the described set-up, about 130 watts of output are available from the 814 with only two crystals, one in the 3.5-Mc. and one in the 7-Mc. band, with output in all bands from 3.5 Mc. to 28 Mc. inclusive.

CONSTRUCTION OF TELEVISION RECEIVERS, *by Marshall P. Wilder.*—The author herein describes the basic circuit details and preliminary outline of two experimental models as a continuation of the television articles which he has presented in the past few months. To quote, "After an extended period of experiment, Mr. Wilder presents us with preliminary details of two very practical television receivers. It must be admitted that even the simpler circuit is quite a fearsome affair, and it is obvious that a full understanding of the function of the various components will be possible only after careful study. The material has been prepared on the assumption that the interested reader has already made a close study of the previous articles in this series and that he is familiar with modern high-frequency receiver practice.—*Editor.*"

DELUXE BATTERY-OPERATED PORTABLE STATION, *by R. D. Waterhouse and W. C. Hilgedick.*—The small battery-operated pack transmitter-receiver described in this article is not designed for use in the amateur bands, as it is one of the units used in the National Park Service for fire communications and emergency use, but the ideas and layout can be followed for the construction of a truly portable station for amateur use. The transmitter consists of a 19 used as crystal oscillator and buffer, another 19 with paralleled elements for class-C amplifier which is modulated by a 19 class B driven by a 1F4 speech amplifier from a carbon microphone. Receiver is a superheterodyne, 1A6 frequency converter, 2 1A4's for I.F. stages and a 1B5 as diode rectifier a.v.c. supply and audio amplifier. Both of these units are built on one chassis, which also includes the antenna reel and a battery compartment for use when the need is imperative for lightweight battery supply. The microphone and headphone are combined in one of the well-known handset units.

SHOCK-PROOFING THE TRANSMITTER, *by L. C. Waller.*—"A Novel Tank-Circuit Arrangement and Miscellaneous Suggestions for Reducing Danger of Injury from High Voltages." Further stressing of this subject is always in order even though several articles are published every year on the subject. The tank-circuit arrangement mentioned above is the use of concentric feed to amplifier tubes, providing the advantages of series-feed but with the safety of parallel-feed as far as the lack of d.c. on the amplifier plate tank is concerned. Other components of a phone transmitter are treated in turn, with suggestions for making them safe to the operator.

RADIO

30c a copy—$2.50 yearly
RADIO, Ltd.
7460 Beverly, Los Angeles

MAY, 1938

SPEECH-MODULATOR OF MODERN DESIGN, *by Ray L. Dawley.*—A theoretical and constructional description of a combination speech amplifier and modulator using a pair of TZ40's and designed to modulate 500 volts input to the class-C stage. Automatic modulation control is incorporated to limit the peak modulation percentage, and degenerative audio feedback is employed between the drivers and the class-B stage to reduce distortion arising from this source.

DIVERSITY RECEIVER FOR 20-METER PHONE, *by Raymond P. Adams.*—A two-channel diversity receiver especially designed for one or possibly two-band operation, either on 14 or 28 Mc. The unit is built up in a two-deck rack with the two r.f. sections and the common oscillator on the bottom deck, and with the two i.f. channels and the detectors and the audio stage on the upper deck.

MODULATION TRANSFORMER DESIGN, *by Lloyd W. Root.*—An extensive analysis of the considerations in the design of high-level modulation transformers for class-B use where the secondary is required to carry the class-C plate current. Complete design information, to indicate the method of application of the formulas given, is shown for both a 100-watt and a 250-watt universal impedance output transformer.

AN ECONOMICAL CATHODE RAY MODULATION INDICATOR, *by H. F. Folkerts.*—An inexpensive oscilloscope designed to operate from one of the medium voltage plate supplies of the transmitter, to give continuous indications of the modulation conditions existing within the transmitter. A 913 tube is used in the monitor.

A FIVE-METER SUPER GAINER RECEIVER, *by Frank C. Jones.*—A description of a simple five meter superheterodyne receiver suitable for c.w. or phone reception in the u.h.f. region and incorporating a simple and new noise-limiting circuit. One of the new 6J8G tubes is used as combination oscillator mixer, a 6D6 as the i.f. amplifier, a 6A6 as second detector audio amplifier, and a 6H6 as the noise silencer.

THE "FLEXTAL" EXCITER, *by Leigh Norton.*—A simplified conversion exciter using a 76 Pierce crystal oscillator, a triode-connected 42 as low frequency oscillator, and an 802 as mixer and output amplifier. The unit is designed to cover a 150 kc. range in the 3.5 Mc. band to give complete coverage of the higher frequency amateur bands. Optional use of "edge marker" crystals is obtained by simply throwing a multi-position selector switch.

A NEAT H.F. KILOWATT AMPLIFIER, *by Faust R. Gonsett.*—A description of a rack mounted push-pull amplifier using a pair of the new Gammatron 254 triodes. The unit is designed to operate from a 2000-volt plate supply for radiotelephony and a 2500 to 3000 volt supply for c.w.

APRIL, 1938

AN INEXPENSIVE FIELD STRENGTH METER, *by Ray L. Dawley.*—A short constructional description of a sensitive f.s. meter using a small dry battery tube, a 1B4. Only this one low-drain tube is used, the circuit is sensitive, and only a very small amount of power is required to produce a comparatively large plate current change. The arrangement is stable and none of the energy picked up in the antenna is used to actuate the indicating meter. The meter is quite linear and a "life size" scale calibrated in db's, which can be fitted to the meter described in the article, can be cut out from the magazine and used if desired.

WHAT HAPPENS IN A SUPER-REGEN

ERATIVE RECEIVER, *by Frederick W. Frink.*—Continuing last month's discussion, adapted from an article appearing in January, 1938, *I.R.E. Proceedings*, the author dispels some of the atmosphere of mystery which, in the minds of many persons, seems to surround the super-regenerative circuit.

DETERMINATION OF SKIP DISTANCE. *by E. H. Conklin.*—The fact that many amateurs do not have a clear conception of skip distance and are, therefore, not familiar with the relationship between conditions occurring on two different bands leads the writer to give this data which may clear up some of the hazy points. A chart showing simultaneous behavior of frequencies above 15 Mc. at distances up to 8 or 9 thousand miles and another depicting a sample of reflection by the different layers of the ionosphere, plus two tables showing usable frequencies and distances, illustrate the article.

A ROTATABLE MAST FOR BEAM ANTENNAS. *by W. van B. Roberts.*—Another approach to the problem of aiming the antenna from point to point is discussed in this article about a system used at the author's amateur station. A lightweight mast is rotated by a small driving motor with the mast itself supported by an especially-made ball bearing ring. Provision is made for quick lowering of the whole mast for making adjustments.

DIRECTING STUFF AT THINGS, *by Jules Herbuveaux.*—Still another method of furnishing a rotating support for the antenna pole. In this case the rotating mechanism is furnished by a differential and rear axle from a junked "Model T". Directions are given for re-vamping the gear. Total cost of this very sturdy arrangement is about $2.50.

THE WHY OF HARMONICS. *by C. B. Stafford.*—In the minds of the majority of radio amateurs (and in those of a goodly number of radio professionals as well), the reason for the generation of harmonics by a non-linear impedance such as a vacuum tube is a bit indistinct. The fact that the distorted wave shape that is emitted from a tube can be resolved into a certain percentage of fundamental, plus additional percentages of second, third, and higher order sinewave harmonic components, is also unclear to most of them.

Any distorted wave form may be resolved into its exact composition of fundamental and integral harmonic frequencies by a method of graphical analysis commonly known as the Fourier analysis. In this article, Mr. Stafford discusses the reasons for the generation of harmonics and the method whereby the various sine-wive harmonic components, as found by a Fourier analysis, can be super-imposed upon the fundamental to produce the original distorted wave shape.

THE BI-SQUARE DIRECTABLE ARRAY. *by W. W. Smith.*—Describing a new array, with reversible directivity, that requires but one pole, and will cover the compass with low-angle, horizontally-polarized radiation. It consists of two separate broadside arrays mounted on the same pole at right angles to each other, each with its own quarter-wave stub. The transfer from one to the other is effected by a d.p.d.t. relay mounted on the base of the pole. Because of the shape, each antenna serves as part of the guying system, thus minimizing space requirements.

THE HAMSET RECEIVER, *by J. W. Birdwell.*—The most popular amateur receiving circuit ever devised, the tuned r.f. detector, and audio arrangement, is herein given another play in the way of circuit refinements and additions to form a design that is flexible and easy to build for good results. Modern metal tubes are used with a 6J7 regenerative r.f. stage added ahead of the usual r.f. amplifier. The article is also constructional and directions are given for making the metal chassis.

A "SURE-FIRE" CRYSTAL OSCILLATOR. *by Frank C. Jones.*—The well-known radio engineer-author describes experiments on various oscillators and analyzes the actions of the several arrangements. A particularly good arrangement is arrived at and is shown by diagrams for triode tubes and for pentodes.

MORE SPEECH POWER FROM CLASS-B MODULATORS, *by Douglas Fortune.*—The writer, who is an engineer for a large transformer company, shows why the average class-B modulator is the most conservatively operated section of an amateur transmitter. Starting with a discussion of power relations in speech waveforms, he shows how peak power calculations are made and how to increase the peak power output. Dealing largely with the new 809's, plate characteristics are shown, as well as a circuit for checking plate dissipation with a thermo-couple.

"LET'S SEE", TWO EXCELLENT 'SCOPES THAT ARE EASY TO BUILD, *by Jay C. Boyd.*—A fairly long and rather complete article dealing with construction of two oscilloscopes, one using the 913 tube and the other a 2-inch tube. Designed for numerous types of measurements, each of the 'scopes uses 5 other receiving type tubes for rectifiers and voltage amplifiers. Photos and diagrams detail the construction of the 2 'scopes; much of the article is given over to a discussion of the various patterns shown on the screen under different conditions with drawings of 15 separate tracings.

A 20-WATT MIDGET PORTABLE, *by L. V. Broderson.*—A short constructional article dealing with the popular single 6L6G crystal oscillator circuit arranged for operation on several bands and built into a 6-inch by 6-inch metal box, complete with power supply and antenna tuning condenser. Drawings show the exact dimensions and placement of parts as well as the circuit diagram. Provision is made for several kinds of antenna coupling.

RADIO NEWS AND SHORT WAVE RADIO

25c a copy—$2.50 yearly
Ziff-Davis Pub. Co.
608 S. Dearborn St., Chicago

APRIL, 1938

HAS YOUR VOICE GOT "UMPH?", *by Doc Schnurmacher.*—This is the first article in an entirely new and more diversified *Radio News* with its new technical and editorial staff. Written in the popular vein, this article deals with oscillogram records of the speaking voice and analyzations thereof.

BROADCASTING LINGO, *by Ted Leitzell.*—Preface: "Broadcasters have a picturesque flow of slang. The author has gathered a few of the thousands of words, now in general use. When put together, broadcast lingo seems like a foreign language."

IS TELEVISION HERE?—The above is the general title of this article with opposite opinions voiced by two well-known radio engineers, U. A. Sanabria and Commander E. F. McDonald. Mr. Sanabria supports the affirmative side of the question and Commander McDonald the negative.

WANT A JOB AS RADIO ANNOUNCER?, *by Wally Rodda.*—If you can't attend the school for announcers, this article will help you materially towards being an announcer.

AN AMATEUR'S TELEVISION TRANSMITTER, *by Anthony Kowalewski.*—A description of an ingeniously-designed amateur television transmitter installation. Most interesting part of the design is the scanning arrangement whereby a standard cathode-ray tube is used in conjunction with an Eby photo cell to televise the film. The moving spot that is formed on the flourescent screen of the cathode-ray tube is used to scan the film placed between this tube and the Eby cell. By placing a negative in this position, a positive image is obtained at the output of the transmitter.

SERVICE

A Monthly Digest of Radio and Allied Maintenance

25c a copy—$3.00 yearly
Bryan Davis Pub. Co., Inc.
19 E. 47 St., N.Y.C.

APRIL, 1938

TEST IT THOROUGHLY!, *by W. Robert Schoppe.*—An informative article designed to influence the serviceman who is interested in building up an enviable reputation in the community (and, incidentally, who is interested in making the most profitable service calls) into thoroughly testing the receiver that has come in for repairs. The receiver should be intelligently tested with the age of the set, the personality of the owner, and the set's ultimate capabilities in mind.

PROFIT OR LOSS, *by Leland S. Hicks.*—An article discussing the fact that any successful service shop must have at least an elementary system of bookkeeping to tell the value of the business, the amount that should be charged for each service job, the amount that must be charged to overhead, and to indicate the daily, weekly, monthly and yearly profit or loss.

MARCH, 1938

FADING, *by James J. Reeves.*—Probably the most annoying time killer for the radio service man is the receiver that operates intermittently. Well known to all, one of this class is the receiver that performs all right in the shop but falls again into intermittent fades after being delivered to the customer. The use of a vacuum tube voltmeter in remedying this and related conditions is shown, as well as a satisfactory vacuum tube voltmeter to be used and the methods to be followed in localizing the trouble, by working through the various portions of the receiver.

A "BREAK" FOR SERVICE MEN.—"Service men in areas covered by the REA (Rural Electrification Administration) are being given the opportunity to cooperate in getting radios into farm homes. Aside from participating in the initial sales, the increased servicing possibilities add an element of interest."

SOME ACOUSTIC PROPERTIES OF THE VELOCITY MICROPHONE, *by A. Barbieri.*—The author, a manufacturer of velocity "mikes", discusses their action and shows by means of diagrams of wave-trains, their response frequencies and the reasons therefore.

THE T & R BULLETIN

A JOURNAL FOR RADIO EXPERIMENTERS

1/6 a copy
Radio Society of Gt. Brit.
53, Victoria St., London

APRIL, 1938

AN ULTRA-MODERN 56-MC. TRANSMITTER *by J. N. Walker.*—A quite complete description of a crystal-controlled 56-Mc. transmitter with a power output capability of about 20-30 watts. A dual triode similar to the 6E6 is used as a combined crystal oscillator on 28 Mc. and doubler to 56 Mc. This tube is followed by a 316A u.h.f. (mud turtle) tube which acts as a class-C amplifier on 56 Mc. 30 to 50 watts input at 450 volts can be run on the final stage.

A 56-MC. TRANSCEIVER OF PROVEN RELIABILITY, *by G. McLean Wilford.* A simple transceiver using a 41 oscillator-detector, a 42 modulator and a 76 speech amplifier. It is designed to operate from a 6-volt filament supply and 200 to 300 volts of plate voltage.

AN ALL-METAL PORTABLE, *by M. Buckwell.*—A description of a low-power complete station mounted in a metal rack for easy portability. The transmitter is crystal controlled and uses a 6L6 oscillator to feed the antenna. The receiver is a conventional t.r.f.

Oh yes......
Your Subscription to 'Radio Digest'

☆

☆

☆

☆

Radio Digest
7460 Beverly Blvd.
Los Angeles, Calif.

I want 12 issues of 'Radio Digest'. Here is my $2.50.

Name________________________________

Street________________________________

City________________________________

(Foreign: $3.00 or 12s. 6d.)

ANOTHER
RADIO
PUBLICATION