The RADIO ENGINEERS' DIGEST

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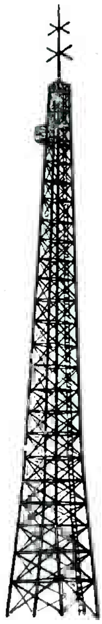

THE RADIO ENGINEERS' DIGEST

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RADIO-AND-ELECTRONIC ENGINEERS IN WAR AND PEACE

Reprinted from Proceedings of the I.R.E.

By Major General Harry C. Ingles

WHEN the history of World War II is written, it will be found that although little publicity was given to the work engaged in during hostilities by radio and electronic engineers, it was the painstaking research activities and patriotic devotion to duty of these brilliant scientists which materially hastened the final Allied victory.

Following on the heels of the Pearl Harbor attack, our country called for help, and many leading radio-and-electronic engineers, most of them members of The Institute of Radio Engineers, were prompt in their response. Today the United States is the communications center of the world and much of the credit must go to the excellent co-operation of these men of science.

In these days of whirlwind warfare, with entire armies moving at unbelievable speed, signal communications are of paramount importance in directing our gigantic offensives. The Signal Corps, whose principal mission is to insure swift and reliable communication among all elements of the Army from the high command in Washington to the most advanced outpost, employs every serviceable means to achieve that accomplishment.

But is in the field of radio and electronics that the Signal Corps has attained pre-eminence in signal communications. Many amazing items of signal communications equipment have resulted from the research activities of radio-and-electronic engineers in co-operation with Signal Corps engineers. For the time being much of this equipment must remain a military secret. However, members of The Institute of Radio Engineers may well feel proud of their contribution to the successful performance of this equipment on battlefields in every quarter of the globe, and to the winning of the great conflict now raging. Without their scientfic aid, the magnificent victories now being won by our forces might not have been possible.

The Signal Corps has trained thousands of men in the basic principles of radio-and-electronic engineering in order to provide personnel to operate and repair the intricate and astounding signal equipment now helping our men to win victories all over the world. Radio-and-electronic engineers, by lending their knowledge of this vital science, helped to improve and perfect this vast training program.

Thus the radio industry will have a large reservoir of trained personnel upon which to draw for its postwar expansion, which will eclipse anything it had attained prior to the opening of hostilities in the Far East.

Radio-and-electronic engineers now have a big job in helping us to win the war. But they will also have a job after victory in helping to set up new applications of the devices they aided in developing for military purposes. But what is more important, members of The Institute of Radio Engineers, when peacetime comes, can render a patriotic service to our country by helping it to grow even stronger, through science, so that no aggressor, or combination of them, may ever again threaten our security.

MODERNIZE YOUR OSCILLOSCOPE

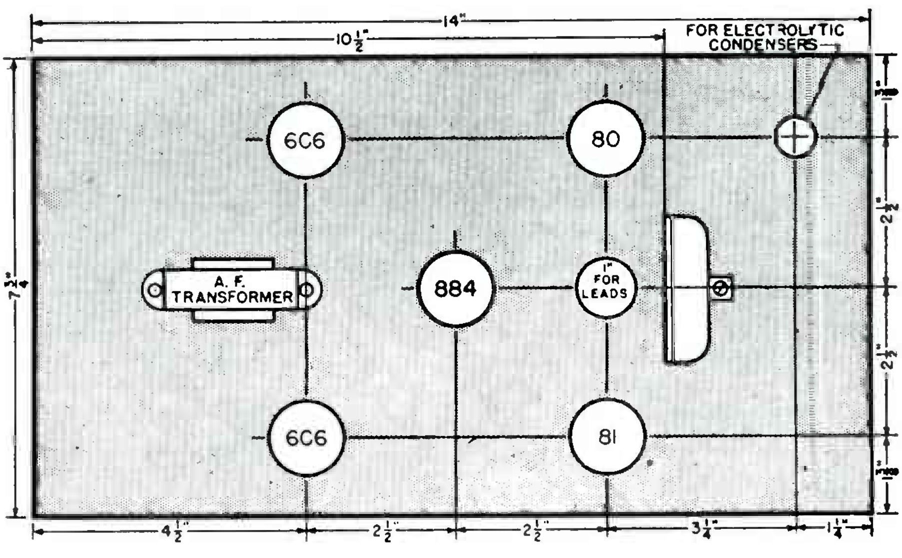
Reprinted from Radio News

By A. D. MAYO

ANYONE who has tried to buy a complete oscilloscope recently will know that it is very difficult to get one either with or without a priority rating. On the other hand, it is possible to find a number of the earlier models which can be bought. The so-called "basic" oscilloscopes, consisting of only a tube and power supply without amplifiers or sweep circuits, were once quite popular for use in "ham" stations to produce trapezoidal modulation patterns. This is, incidentally, about all these oscilloscopes were ever any good for.

Here are the details relating to the reconstruction of one of the National 3-inch scopes. The original oscilloscope had a 906 tube mounted in a case with a power transformer, rectifier tube and little else. There was an intensity control and a switch to change from 60-cycle sweep to an external sweep circuit. There were no controls to position the spot on the screen.

In the new model it was deemed advisable to have centering, intensity, focus, vertical and horizontal gain controls, as well as switches to select various input combinations and to vary the frequency of the sweep circuit. An 884 thyratron



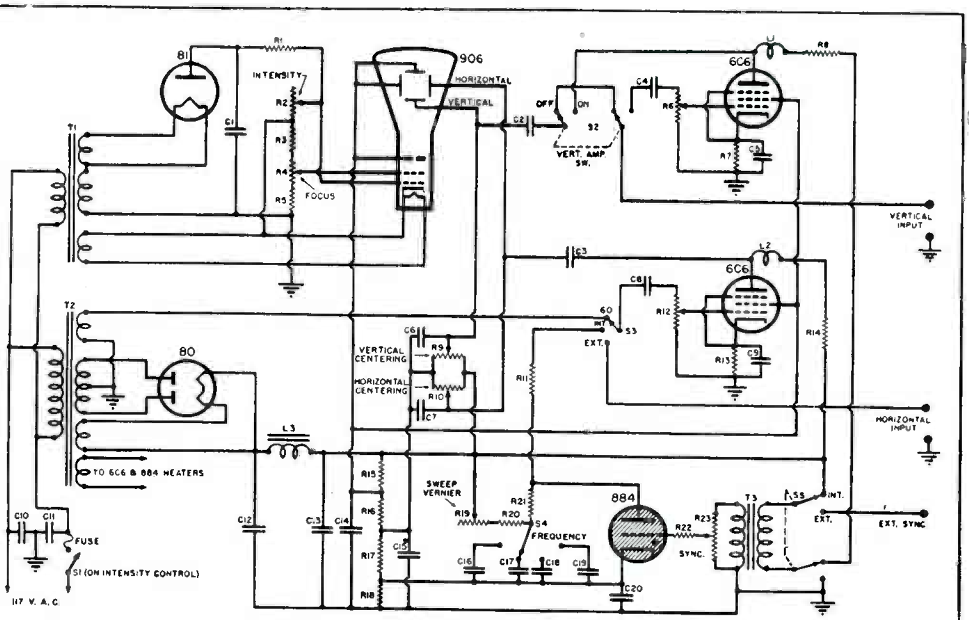
Chassis layout showing placement of various component parts.

tube was used as an oscillator to produce a saw-tooth wave for the sweep circuit. 6C6 tubes were used for vertical and horizontal amplifiers. These particular tubes were used because they were on hand and their characteristics are entirely satisfactory for this use.

The original power supply consisted of a half-wave rectifier, a type 81 tube, fed by the power transformer which also had two filament windings to supply the rectifier and the 906. Another winding was included which was used originally to supply the 60-cycle sweep voltage to the 906. This latter winding was not used in the present design. Filter for this power supply consisted of a .5μfd oil-type condenser rated at 1500 volts. This small amount of filter was sufficient considering the small amount of current drain of the cathode-ray tube.

In order to operate the various accessory circuits to be affixed, a separate power supply was added. This consisted of a midget 5-tube transformer with an 80 rectifier and condenser input filter. One of the things to watch out for in a job of this type is magnetic coupling from the power transformer to the cathode-ray tube. There is a magnetic field around the outside of a power transformer and if the transformer is mounted near the tube it will be impossible to get the spot steady on the screen. The magnetic field will deflect the electron beam, and therefore the spot, at a 60 cycle rate and in a direction depending on the axis of the magnetic field.

To minimize the above effects the power transformers were both mounted underneath the chassis. The National transformer was all right from this standpoint since it was totally enclosed inside an iron case in the first place and no doubt originally was designed with the idea of keeping the flux density down to a low level. The first one of the midget broadcast transformers tried in this



C_1—.5 μfd. @ 1500 v. cond.
C_2, C_3, C_4, C_6, C_7, C_8, C_{16}—.25 μfd. @ 400 v. cond.
C_5, C_9—.004 μfd. @ 200 v. cond.
C_{10}, C_{11}—.01 μfd. @ 400 v. cond.
C_{12}—2 μfd. @ 200 v. elec. cond.
C_{13}, C_{14}—16 μfd. @ 400 v. elec. cond.
C_{15}—8 μfd. @ 400 v. elec. cond.
C_{17}—.03 μfd. @ 400 v. cond.
C_{18}—.005 μfd. @ 400 v. cond.
C_{19}—.0015 μfd. @ 400 v. cond.
C_{20}—.001 μfd. @ 400 v. cond.
R_1—40,000-ohm, 1-w. res
R_2—50,000-ohm pot.
R_3, R_8, R_{11}, R_{14}, R_{20}, R_{22}—100,000-ohm, ½-w. res.
R_4, R_9, R_{10}—250,000-ohm pot.
R_5—250,000-ohm, ½-w. res.
R_6, R_{12}, R_{23}—1-megohm pot.
R_7—1250-ohm, 1-w. res.
R_{13}—1500-ohm, 1-w. res.
R_{15}, R_{16}—20,000-ohm, 2-w. res.
R_{17}—10,000-ohm, 1-w. res.
R_{18}—1200-ohm, ½-w. res.
R_{19}—9-megohm pot.
R_{21}—200-ohm, ½-w. res.
T_1—Power trans.—National
T_2—Power trans.—5-tube BC rec. type
T_3—Audio freq. trans. (1:1)
S_1—S.p.s.t. switch
S_2, S_5—D.p.d.t. switch
S_3—S.p.3.p. switch
S_4—S.p.4.p. switch
L_1, L_2—60-millihenry r.f. choke
L_3—40-hy. 25-ma. filter choke
1—81 tube
1—80 tube
1—906 cathode-ray tube, 3-inch
1—884 tube
2—6C6 tubes

Wiring diagram of the oscilloscope. Sufficient controls have been added to conform with present-day professional units.

spot was a new one with only a half-shell shield on it. This transformer had considerable effect on the electron beam and it was replaced with a completely shielded transformer taken from an old broadcast receiver of reliable make, about 10 years old. The transformers in older receivers were considerably better made than the present ones from several angles. It is important to select a transformer which is not only well shielded but which has a relatively large number of primary turns for the core size. If it is possible to select a transformer out of a group for this use one should be selected which has a low exciting current when the primary is energized.

Sometimes it is possible to minimize any movement of the spot by rotation of the power transformer when it is mounted. The beam can be noted as the transformer is turned to various positions. If it is absolutely necessary to use a transformer which reacts on the electron beam, as a last resort a section of fairly thin walled steel pipe can be mounted around the cathode-ray tube as a magnetic shield.

Inspection of the circuit diagram will show that a part of the voltage from the added power supply is used in series with the old power supply to operate the cathode-ray tube. Since controls were added for centering, focusing and controlling the intensity of the beam, a little higher voltage than optimum was necessary to give some leeway on the controls. It was easy to add these voltages since the positive side of the cathode-ray tube power supply is operated grounded while the negative of the conventional power supply is grounded.

The 6C6 amplifiers are ordinary pentode voltage amplifiers similar to those in the input stage of a speech amplifier. Since they are sometimes used at frequencies in the upper audio range the plate loads consist of chokes in series with 100,000-ohm resistors. This combination insures better response to higher frequencies. The cathode by-pass codensers are small for the same reason. Both stages are working into fairly high capacitive loads presented by the necessarily long leads and the input capacitance of the cathode-ray tube. The saw-tooth sweep wave contains considerably higher frequency components and it is desirable to have good-high-frequency response.

Without the amplifiers, full deflection on the screen of the 906 will be secured with about 90 volts peak on the deflecting plates. The amplifiers have a voltage gain of about 60 and with them in the circuit full deflection will be secured with an input voltage of only 1.5-volts peak. This is desirable for both vertical and horizontal input circuits. Vertical deflection becomes very sensitive, allowing waveforms to be examined in low-level audio stages. An amplifier following the sweep oscillator is necessary since its output is kept low to insure good waveform.

A switch is provided to switch the vertical amplifier out of the circuit when it is desired to put r.f. or other very-high frequency on the vertical plates. There is also a switch to throw the grid circuit of the 884 to an external binding post for external synchronizing voltage.

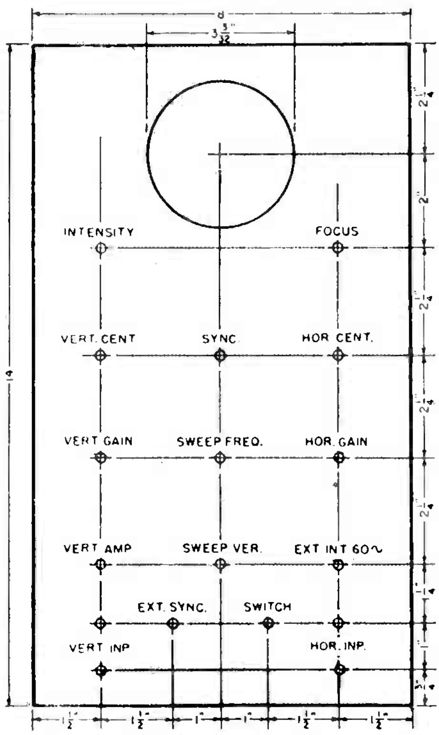
A third switch selects any one of three types of sweep voltage: 60 cycle, internal saw-tooth, and external. The horizontal amplifier is left in the circuit at all times. For 60-cycle sweep it is only necessary to feed a little a.c. from the filament supply into the amplifier. For saw-tooth sweep the amplifier grid is connected to the output of the 884 oscillator. For external sweep the amplifier grid is switched to the horizontal input binding post and the external voltage connected to this post. The horizontal gain control, being in the grid circuit of the horizontal amplifier, is left in the circuit at all times. Therefore, the length of the pattern in a horizontal direction is adjustable under all conditions.

The original case was not large enough to contain all the necessary parts and controls. Therefore a new case and chassis were made. Considering the fact that ordinary scrap sheet metal was used for the new case, the whole assembly is very strong. The sheet metal was laid out and marked. Then it was taken to a tin shop and bent to shape on a brake.

The chassis is 4-inches high, greater than the average chassis height but necessary to contain the power transformers and other parts. The front panel is secured to the chassis and the two pieces become one unit. A flange, consisting of a piece of sheet steel bent to a cylindrical shape, is soldered in the hole for the window of the cathode-ray tube. The inside is lined with thin felt to cushion the tube. Black felt is used to cut down reflected light coming in from the side.

The rear end of the cathode-ray tube is supported in a 7-prong socket, the old one, and the socket is held in place with a bracket fashioned from sheet metal. The bracket was made up and the proper height for positioning the socket on it was determined by holding the tube in place. The cover slips on from the back. Since the back of the cover comes up to the back of the chassis there is a hole in the cover to allow the line plug to pass.

When first turning the unit on it is best to leave all of the tubes out except the two rectifier tubes. Check both power supplies for d.c. voltage and make sure that the filter condensers and circuit are all right. The unorthodox connections used in the power supply connections, that is, a 1000-volt supply with the positive ground and the interconnections between the two, will give rise to the possibility of surges and other troubles. The filter condensers are subjected



Panel layout, showing the placement of various operating controls.

to higher peaks than they would be in broadcast receiver operation. It is important that their leakage be fairly low in this application due to the small current drain on the power supply.

It should be possible to center the beam with the two horizontal and vertical centering controls if the values of divider resistors and controls shown in the circuit diagram have been used. The spot probably will not be small and well defined on the initial try. In this case it can be adjusted to a small, sharp spot by manipulating the focus and intensity controls. The focus and intensity controls interlock to some extent so that it is necessary to alternately adjust one and then the other until the desired shape of spot is obtained. When the spot is once adjusted and centered, its brilliance probably can be controlled by the intensity control alone. Since the line switch is on the intensity control, this control always will need to be readjusted when the unit is turned off and back on.

When adjusting the size of the spot be sure there is no voltage being fed into either the horizontal or vertical deflection plates. Without the 6C6 tubes in place there should be no deflection of the spot. Any deviation from a sharp spot on the screen indicates that there is either a voltage being fed onto the deflection plates or else there is a magnetic field acting on the beam. When the 6C6 tubes are put in place the vertical and horizontal gain controls should be returned to the minimum setting.

With the amplifier tubes in place, turn the sweep selector to 60 cycles. It should be possible to get a horizontal line on the screen by gradually turning up the horizontal gain control. It should also be possible to get a similar line by turning up the control with the sweep turned to "internal" and with the 884 in place. If horizontal sweep can not be obtained in either one of the above cases there is probably something wrong with the horizontal amplifier stage.

Next, check up on the vertical deflection. Feed a little a.c. voltage into the vertical input binding posts and increase the vertical gain contral setting. There should be deflection of the beam vertically, and the deflection should increase as the control is increased. With the amplifier switch thrown to the "off" position the deflection should be much less and the voltage input will have to be increased greatly to get full deflection on the screen.

With 60-cycle input on the vertical plates, turn the sweep to "internal" and set the sweep frequency-selector switch to the first position. With the vernier sweep control knob it should be possible to get one, two, or three sine waves on the screen. Try the sweep lock control with the switch on "internal" indicating internal synchronization control. By advancing the lock control it should be easy to lock the sweep oscillator in with the 60-cycle input and make the traces stand still on the screen.

If the finished oscilloscope stands all the above tests satisfactorily it will be useful for many different testing applications.

Probably the most common use of the oscilloscope is in the testing of audio amplifiers and equipment. Most a.c. power mains supply a wave shape that is almost pure sine wave. By observation of this wave shape on the screen of the oscilloscope it is easy for one to fix in his mind the approximate shape of the desired sine wave. It is useful for testing an amplifier which is operating with a sine wave input. If any distortion of the sine wave shape is noted in any amplifier stage one will know that something is haywire in that stage. With the 'scope left attached and the wave shape under observation changes can be made in the particular stage in question and its response characteristics improved. By this method the signal can be traced visually through the amplifier and the performance of each stage studied.

The input terminals of the oscilloscope will load the circuits to which it is attached, capacitively, to a degree ranging from negligible on power stages to a considerable amount on high-gain input stages. In order to prevent leakage of high voltage from the scope into input stages under observation, it is important that the ground terminals of the amplifier and the scope be tied firmly together and grounded.

Waves appearing on the screen of the scope from a stage under observation, which do not check with the input wave shape, can be identified and their source determined. For instance, if an amplifier is being checked with a 400-cycle audio tone and a 60-cycle wave appears modulating the 400 cycle, it will indicate that hum is entering the stage from some cause. If a 120-cycle wave appears it usually will indicate power supply ripple due to insufficient filter. 60- and 120-cycle waves are easily identified by turning the sweep to 60 cycle. A single loop of almost any shape (depending upon the phase relations of the vertical and horizontal voltages) will indicate 60-cycle hum. A double loop of a figure 8 shape, either elongated or squashed down, will indicate 120 cycle. It is possible to get straight lines in both of the above cases if phasing is exactly such as to give such a pattern but usually there will be enough of a loop to identify the frequency.

Voltages can be measured with the oscilloscope if the vertical gain control is calibrated in terms of volts necessary to produce a certain deflection on the screen. For instance, if 1-volt peak input voltage will produce ½" deflection on the screen, a ¾" deflection will correspond to about 1.5-volts input. By employing the oscillograph in measuring the voltage at the input and output terminals of an audio stage, the stage gain can be determined wth a fair degree of accuracy.

You will find that from a practical standpoint if an audio amplifier will pass a sine wave which looks good on the scope at the output terminals you can be fairly sure that the harmonic distortion in that amplifier hardly can be heard. The mere visual inspection of the output wave will reveal distortion more quickly than the ear.

Electronic Boiler Control

Electronics has taken on still another job. It controls the water-level of boilers, automatically shutting off the fuel supply if the water drops below the safety level.

BROADCASTING'S POST-WAR EQUIPMENT PLANS

Reprinted from Electronics

Standard a-m stations indicate what gear they will need for modernization of existing plants, and replacements. Proposed increases in power are reported. Intentions relative to other services such as f-m and television are revealed. Electronics' survey emphasizes importance of market offered by one branch of the communications field.

WHEN the war ends and transmitting equipment once more becomes readily available there will be a substantial backlog of demand for it among standard a-m broadcast stations. Fully 34.2 percent of the stations now n operation hope to increase power and 26.1 percent of this group proposing to crack on more kilowatts have already filed application with the FCC for permission to do so.

These and other facts indicative of the post-war market for electronic gear in one of the most important branches of the communications field are revealed in a survey just completed by ELECTRONICS. The editors contacted chief engineers of 64.8 percent of all standard a-m broadcast stations in the country. Only 8.9 percent said they have no plans.

Complete New Transmitters

In addition to the need for new equipment where power increases are proposed, there are many reasons why stations want to purchase new gear. Chief among these, in order of importance, are:

Obsolescence of equipment
Worn-out equipment
General inadequacy
Poor quality
Desire to standardize

Thus 7.4 percent of all the stations contacted plan to buy complete new a-m transmitters soon after V-E (Victory-in-Europe) day or after Japan collapses. Architects, builders and suppliers of materials such as sound-proofing and lighting in particular will be interested to know that 3.9 percent of all the standard a-m broadcast stations contacted hope to have new studios, and 1.3 percent say they are already dickering for new transmitter building sites.

Component Parts and Accessories

Partial replacement of existing equipment, or addition of duplicate equipment, is contemplated by 69.4 percent of all stations. Reasons given are the same as

PLANS FOR PEOPLE

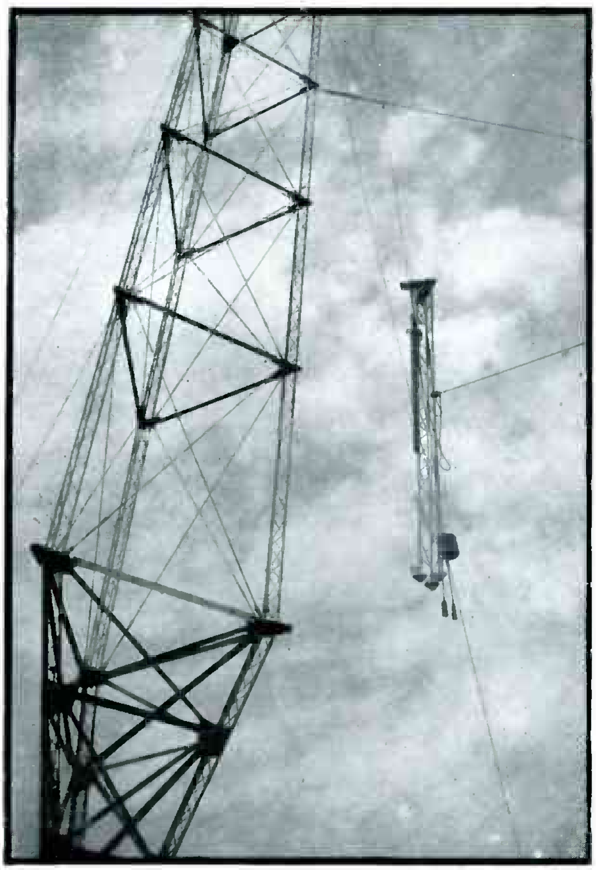
Technical Personnel per Station

	Pre-War	Today	Post-War
MEN	7.4	6.7	11.7
WOMEN	0.4	1.6	0.8
	7.8	8.3	12.5

those noted in connection with complete new transmitters. The following list indicates the number of stations apparently waiting to buy or build specific items:

Transcription equipment	44.0%
Recording devices	43.4
Microphones	40.8
Studio audio systems	29.9
Field amplifiers	29.7
Audio and modulation monitors	25.8
Antenna systems	12.6
Transmission Lines	12.3
Frequency monitors	4.3
R-F units	1.9
Power supplies	1.9
Modulators	1.3

Other indicated items include mobile units, auxiliary transmitters, emergency power systems, ground systems, master controls, attenuation panels, miscellaneous amplifiers, level indicators, overload equipment, phasing and coupling devices.



There will be much new construction among standard a-m broadcast stations, aside from their plans for other services.

Post-war plans are not yet sufficiently far along to permit determination of the number of individual items the average station proposes to acquire. However, in the case of microphones, sufficient information is at hand to indicate that purchases should average better than one per station.

Tubes and Test Equipment

Regarding replacement tubes, 1.9 percent of the stations surveyed say they use more or less standard types readily available even in war-time and have ample stocks on hand, while 62.3 percent are apparently obtaining a sufficient number of harder-to-get types of tubes to keep things going and perhaps avoid the need to place abnormally heavy orders when the dam breaks. The remaining 35.8 percent are, to some extent, tube starved. It looks as though a-m broadcast stations will lay an average of $315 on the line for replacement tubes the instant these become available.

Purchase of new test and measurement equipment is planned by 51.6 percent of all stations contacted. Specifically, the items rank in this order of interest:

Signal generators	*17.4%*
Field strength meters	*15.1*
Noise and distortion meters	*14.7*
R-F bridges	*9.1*
Oscilloscopes	*8.0*
Tube testers	*4.5*
Vacuum-tube voltmeters	*3.2*
Phase monitors	*2.6*
Square-wave generators	*2.2*
Multimeters	*1.5*
Capacitance bridges	*1.3*
Circuit analyzers	*1.1*

Interest was also exhibited in impedance bridges, Q meters, and miscellaneous instruments. Dollar value of proposed purchases cannot be estimated owing to the probable duplication of individual items and to the unknown factor of price on post-war gear.

Other Services, S-T Links

Immediate post-war operation of frequency-modulation stations, in addition to present a-m facilities, is planned by 66.8 percent of the stations contacted. Of those planning such additional services 40.6 percent say they have already filed applications with the FCC. Average power requested appears to be in the neighborhood of 10 kw. Eventual operation of television transmitters is planned by 17.8 percent and 38.5 percent of this group have filed applications in Washington. Average power requested is 6 kw.

Plans for studio-transmitter links among standard a-m stations proposing to operate f-m and television stations after the war are highly speculative and dependent upon some factors over which the stations themselves have little control. Of the stations surveyed, however, 67.8 percent presented some tentative plans. Of this group 2.7 percent will need no s-t links at all, since studios and stations are to be at the same location. Among stations proposing f-m service, 40.3 percent hope to use radio links, 35.4 percent plan wire links, and 12.9 percent would like to use coaxial cables. In the television picture, 11.2 percent plump for radio links, 4.4 percent expect to use coaxial cables, and 1.1 percent hope wire lines suitable for the job can be devised. These percentages total more than 100 percent because alternate proposals were given in a number of cases.

Considering the fact that all of the above figures deal with the proposed post-war plans of just one communication group . . . the existing standard a-m stations of the country . . . it is apparent that the potential market for transmitting equipment in the United States itself is indeed bright, without even considering export possibilities. For there are many f-m stations already operated by people not having a-m licenses, and therefore not covered in this survey, and several such television stations. More stations, operated by people not yet in the field, are obviously to come. There is also much additional business among present and potential operators of point-to-point commercial communications services, police, fire, forestry and other public-welfare services, and industrial services such as aviation and railroads that are clamoring for space on the airlines. — W. MacD.

Mobile Airport Light Unit

Mobile airport lighting units — the most powerful ever made — are illuminating new or captured landing strips in battle areas. A unit is equipped with four 3,000-watt flood lights. It is mounted on a truck, and is "self-powered" — carrying generators, transformers and controls.

ELECTRONIC ANALYZERS IN INDUSTRY

Reprinted From Service

By S. J. Murcek

MODERN production testing is a precision operation. This requirement is rendered complex when the permanence of the equipment calibration over long periods of time is taken under consideration. Fortunately, certain electronic testing circuits readily meet these requirements.

Generally, where precision in measurement is a factor, such electronic circuits are not of the dynamically coupled type, since, in most instances, the electrical characteristics of the product under control are most readily obtainable as d-c voltage or current characteristics. Again, where the end-circuit must have a considerable power capability, thyratron control assumes difficult proportions. Hence, where precision is a circuit requirement, production testing circuits incorporate directly-coupled tube systems together with d-c indicator circuits, such as are to be found in the *moisture content analyzer* and the *electronic precision guage*. These devices are intended for precision product control under modern mass production methods.

The Electronic Moisture Content Analyzer

During the course of manufacture of either paper or textile products, the material being processed is subjected to considerable immersion in various chemical mixtures containing a high percentage of water. Consequently, prior to the preparation of the finished product for storage or shipment, it must necessarily undergo a drying operation, in which the product moisture content is reduced to an acceptable minimum. Since the prime requisite of mass-production processing is rapidity of completion, it is necessary to provide a means capable of determining the maximum speed at which the drying operation may be accomplished. Further, since the drying speed is dependent, in appreciable measure, on the minimum acceptable moisture level in the finished product before shipment, the drying operation might readily be controlled automatically by an electronic device responsive to the product moisture content.

It is an established fact that water, if impure, is a condutcor of electricity, its resistivity being inversely proportional to the content of impurities. Therefore, the processing and dyeing baths utilized in the manufacture of paper and textiles are electroconductive, and the moisture content of the cloth or paper is inversely proportional to the product resistivity. Thus, if the resistance, taken transversely through the cloth or paper, is high, the moisture content is obviously very low. It is this principle which determines the operation of the *moisture content analyzer*.

The electrical circuit of the moisture content analyzer is shown in the diagram given in Fig. 1. In this device, the d-c voltage obtained from an industrial type of power filter-rectifier system is impressed across a measuring circuit consisting of a pair of electrodes, which are in contact with product under analysis, and an electrical measuring shunt having a relatively high resistance. The small voltage developed across this resistance by the product leakage current functions to control an electronic system which, in turn, automatically controls the speed of the product drive-roll motor.

In Fig. 1, the industrial type of power supply comprises a source of a-c power. This is the winding 32 on the main power transformer 20 core, the industrial rectifier tube 31, together with a suitable filtering circuit consisting of the smoothing reactor 30 and two capacitors 29 and 33. The d-c voltage developed by this circuit is impressed across *bleeder* resistor 28, as well as the product analyzer circuit and the motor main shunt field 27. The principal function of resistor 28 involves the discharge of the filtering capacitors 29 and 33, should the d-c circuit load be disconnected before the a-c power supply connected to the terminals 22 and 23 of the power transformer is opened. It also serves to suppress the rise of high voltages across the terminals of field winding 27 in event of an abrupt change in the motor operating conditions.

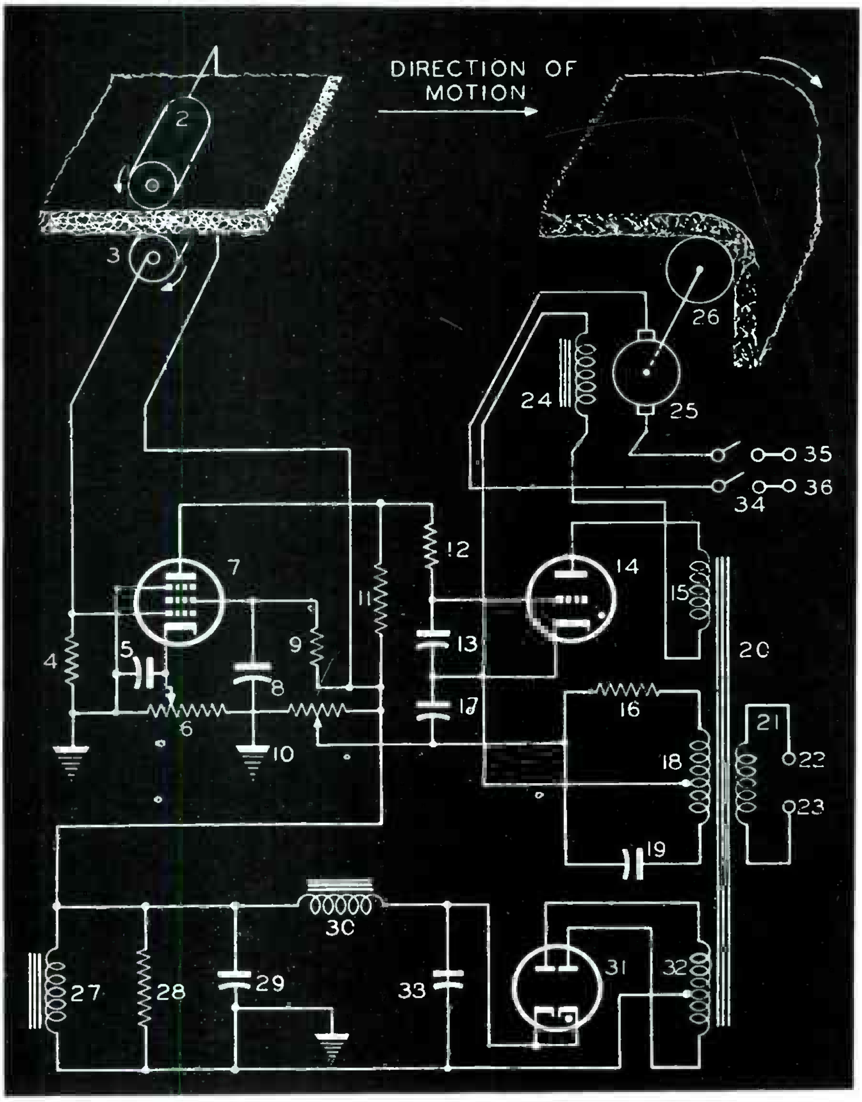


Fig. 1, a production moisture analyzer applying electronic principles. An increase in the moisture content of the processed material 1 results in increases of the current through and voltage developed across the grid input resistor 4, together with accompanying decreases in the thyratron 14 rectified a-c and the drive-roll motor 25 shaft speed, permitting the material to remain in the drying oven for a greater length of time.

The necessary processing motion is imparted to the product by drive-roll 26. The product 1 is thereby drawn between the measuring electrodes 2 and 3 which are in contact with this material. Since the product is then effectively connected in series with the d-c power supply and the resistor or shunt 4, a leakage current which is propotional in magnitude to the moisture content of the product flows through the resistor 4. It is further evident, that the voltage thus developed across this resistor is also proportional to the moisture content of the product. This voltage tends to drive the control grid of the amplifier pentode 7, positive, with respect to the cathode.

The cathode of pentode 7, in Fig. 1, is maintained slightly positive with respect to the grounded or negative terminal of the d-c power supply by means of a bias control potentiometer, 6. The resistance element of this potentiometer, together with that of the potentiometer 10, comprise a voltage divider which is connected in parallel with the d-c power supply. Since a fixed, constant potential is thus established across the resistance element of the control potentiometer, variation of the potentiometer slider arm position determines effectively the voltage which prevails across resistor 4 to drive the control grid of the amplifier pentode positive with respect to the cathode.

When the voltage developed across resistor 4 tends to drive the control grid of the amplifier pentode positive with respect to its cathode, the pentode plate current increases, and the plate-cathode voltage present here decreases proportionately. This is due to the increased voltage drop developed across the pentode plate loading resistor 11. As a result, the control grid of thyratron 14, which is effectively connected to the plate of the amplifier pentode in series with the grid current series limiting resistor 12, swings negative with respect to its cathode. The latter condition is self-evident when it is taken into account that the cathode of the thyratron is held positive with respect to the grounded or negative terminal of the d-c power supply by a voltage approximately one-half that present across the output terminals of the d-c power supply. This condition is obtained by means of a thyratron bias control potentiometer 10. The slider arm of this potentiometer is so adjusted that the potential existing between the cathode of the thyratron and the negative terminal of the d-c power supply meets these conditions.

Since it is required that the motor-speed control be continuously variable, thyratron tube 14 is operated as a phase-controlled rectifier. To obtain phase-shift control over the thyratron anode current, the grid-cathode voltage applied to this tube is modulated by a voltage wave which is displaced by 90°, with respect to the plate voltage wave. The plate voltage is obtained from the main power supply transformer winding 15, in Fig. 1. This is shown as E_1 in Fig. 2. A phase-shifting circuit, comprising the transformer winding 18, the resistor 16, and the phase-shift capacitor 19, in Fig. 1, functions to produce a grid-cathode voltage component which is 90° late in phase with respect to the plate-cathode voltage wave E_1 in Fig. 2. The grid-cathode voltage component is given as E_2, E_{2a}, and E_{2b}, respectively, for various magnitudes of amplifier pentode plate - cathode potentials, which are shown as E_3, E_{3a}, and E_{3b}, respectively.

An increase in the plate-cathode voltage present across these electrodes of the pentode amplifier results in a proportionate increase or phase-advance in the positive a-c half-cycle which the thyratron 14 conducts. Hence, an increase in the pentode amplifier plate-cathode voltage results in an increase in the *average* current conducted by the thyratron.

The current conducted by the phase-controlled thyratron rectifier passes through the auxiliary field winding 24 of the roll-drive motor. This auxiliary shunt field is wound in a direction opposed to that of the main winding 27, and therefore, their magnetomotive forces or magnetic fields are opposed. In consequence, an *increase* in the current conducted by the thyratron rectifier results in a decrease of the drive-roll motor field strength, and an *increase* in the motor shaft speed, the latter operation being characteristic of a d-c motor having separately excited fields.

In Fig. 1, the roll-drive motor is shown to impart motion to the product under analysis. Here, the product 1 is drawn between the analyzer electrodes 2 and 3 by the drive-roll 26. The shaft of the drive-roll is shown directly-coupled to the controlled d-c motor. The armature of the drive-roll motor obtains its power supply from a separate d-c power source, 35 and 36, in series with the disconnect switch 34. As a direct result of this arrangement, the electronic analyzer device is small, since it functions to supply only a small portion of the power required for the motor operation.

Under normal operating conditions, the amplifier pentode bias-control potentiometer 6 functions as the moisture level control. It is so adjusted that the product moves at a speed which produces or results in satisfactory drying of the material after which adjustment the device functions to control the speed of the product in accordance with the percentage of moisture present in the material.

A rise in the product-moisture content results in a greater positive swing of the pentode grid with respect to its cathode, increasing the tube plate current. The resultant decrease in the pentode plate-cathode voltage causes the grid of the thyratron to swing negatively with respect to its cathode, the thyratron plate current decreasing as a result.

Since a decrease in the motor auxiliary field current, which is supplied by the thyratron rectifier, results in a decrease of the motor shaft speed, the product rate of motion also decreases, and the drying time increases proportionately.

Conversely, a decrease in the product-moisture content results in an increase in the amplifier pentode plate-cathode voltage. This is accompanied by a rise in the average auxiliary field current conducted by the thyratron. Since the motor field strength is thereby decreased, the motor shaft speed, as also the product rate of motion, increases, decreasing the product drying time.

Maintenance and Servicing Requirements

Since the *electronic moisture content analyzer* is essentially *a production* testing device, speed in its servicing and repair are imperative. However, adequate service or repair are not readily carried out properly when these operations must be carried out hurriedly. The only way in which both may be accomplished without serious loss is the substitution of a spare or emergency unit for the defective device.

Where incorrect operation cannot be readily corrected, the substitution of the spare *analyzer unit* quickly determines whether the defect lies in the electronic device or in the customer's controlled apparatus, which includes the roll-drive motor. Inoperative motor equipment is usually quickly replaced by the manufacturer's own repair staff, again resulting in a further general localization of possible defective equipment. Through application of this substitution method as a means of trouble diagnosis, any continued defect would be rapidly traced to the analyzer electrodes and the associated electrode wiring.

In the event that troublesome operation is due to leaky electrode supports to electrode wiring, as determined with a suitable high-voltage megohmmeter, the most rapid progress in correction of the defect may be effected through replacement of the defective wiring, and thorough cleaning of the electrode supports. Carbon tetrachloride or pentachloride should be used as the cleansing agent, in order to leave a minimum thickness of residual grease film.

Repair of the *analyzer unit* proper, which consists of the electronic portion of the system mounted in its own integral housing, involves the replacement of defective components, much in the same manner as with public address equipment. Defective tubes, especially thyratrons and gaseous diodes, account for the greatest number of equipment failures. Hence, tube testing is an important phase of the repair or maintenance operation.

The moisture level control potentiometer 6, in Fig. 1, is of the wirewound type. Since the *moisture analyzer* is unavoidably in close proximity with a *wet* atmosphere, this potentiometer is subject to corrosion and oxidation. It should be carefully tested and inspected, and subsequently replaced if it shows considerable evidence of rusting. The same proceedure applies to the *bleeder* resistor 28, even though this resistor is coated with a vitreous enamel layer.

Condenser failures are few in equipment of the instrument nature, since these are all of the *wet* impregnated types. In event a condenser should fail, however, instrumentation for the defective capacitor is carried out in the manner familiar to radio servicing. Resistors incorporated into the *moisture analyzer* circuit system, other than the moisture level control potentiometer and *bleeder* resistor, are

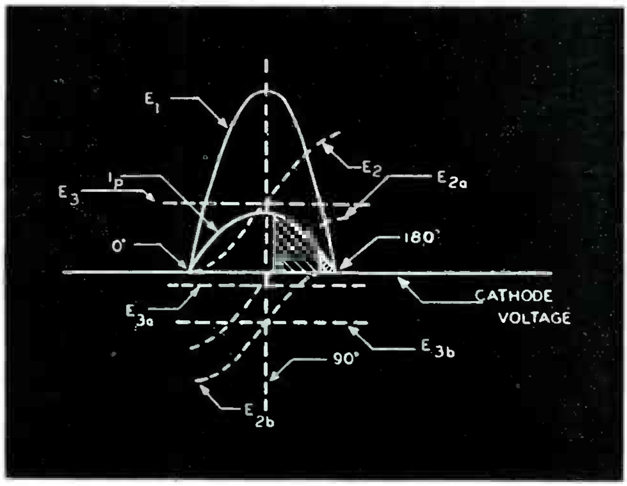


Fig. 2, Thyratron d-c grid control. Thyratron plate-cathode voltage, which is the positive half of the a-c cycle, is shown here as E_1, and the grid-cathode phase-shift a-c component as E_2. When the amplifier pentode plate-cathode voltage is such that the grid d-c component is positive with respect to the cathode, E_3, the thyratron conducts the entire half cycle I_a from angle 0° to 180°.

molded-resistance compound units which exhibit no tendency to cause equipment failures. In general, it is evident that the maintenance and repair of precision electronic equipment of instrument grade need present no barrier to the Service Man.

Among the various production testing devices of this nature, the *photoelectronic precision guage* is of particular interest to the Service Man. This device incorporates nearly all of the principles conventionally applied to electronic production testing devices.

The Photoelectronic Precision Guage

One of the most difficult operations arising in the mass production of machined or turned plastic or metal machine components involves the inspection of the finished pieces. This inspection must be rapid, yet precise. Prior to the advent of electronic testing devices, various types of fixed mechanical guages were employed to determine whether the inspected part adhered to the desired specifications. However, these fixed guages were subject to considerable wear, in addition to the cumbersome nature of their application.

The *photoelectronic guage* avoids all of the difficulties met in mechanical guages, since the part under measurement partially intercepts only a narrow beam of light while under inspection. Once this device is calibrated, therefore, it provides unerring measurements over considerable periods of time without further attention. Further, these measurements are accurately made even by unskilled personnel because of the simple nature of this operation. In isolated instances, such as those incident to the inspection of numerous similar pieces, the measurement operation is carried out automatically. Under these conditions, the *photoelectronic guage* functions to remove from the production line all processed pieces which do not adhere to the specified tolerances.

Usually, the *photoelectronic guage* is a relatively simple device, and is so designed as to be utilized in multiple arrays. Here, one of the basic guage units is adjusted to reject measurements having less than a given minimum tolerance, and another rejects, of the remainder, those items which exceed the given maximum tolerance. When these two inspections are completed, the processed pieces which were inspected without causing either unit of the inspection array to operate are obviously within the specified limits, and therefore acceptable. Such an inspection arrangement is known as a *go-no-go array*.

An interesting electronic circuit is used in the *photoelectronic guaging* unit. A departure from conventional *industrial* electronic system practice is here represented in the thyratron control of signal lamps as a means of measurement tolerance indication.

In order that the measurements accomplished with the aid of this device be precise, it is necessary that the light beam focus, above the inspected item 1, be concentrated to the minimum diameter possible. This diameter is, however, dependent on the dimensions of the light source filament. Lamps intended for photoelectronic applications are usually provided with filaments having a small overall area. Despite this design precaution, the filament area is still too great for accurate light beam guage systems, and added care must be taken in the selection of the light source lamp.

The light source is a special form of the incandescent lamp, known as the *Point-O-Lite*. Its glass envelope contains, in addition to a filament which has a low operating temperature, a small tungsten sphere and a rarefied inert gas atmosphere. A detailed illustration of the construction of this lamp is given in Fig. 3.

When the *Point-O-Lite* lamp is in operation, an ionized arc path is developed between the filament and the second electrode which is actually an anode, or *plate*. Due to the intensity of the current in the arc path, the temperature of the plate sphere is raised to incandescence. However, since the lamp filament operates at a relatively low temperature, serving merely to provide an electron stream required for the ionization of the gas atmosphere, the actual source of illumination in the lamp is the plate sphere. Thus, in the *Point-O-Lite*, the actual area of the light source proper, which is the anode sphere, is comparatively small.

Since, in any tightly-focussed light projection system, comprising a light source and a suitable lens, such as the convex lens, the cross-section of the light beam at the point of focus is directly dependent on the area of the source of light. Hence, in the system employing the *Point-O-Lite*, the cross-section of th beam at this point is very small.

The transmitted light is arranged to fall, if it is unobstructed, on the photoelectronic camera lens in such a manner that a considerable portion of the phototube cathode is illuminated. If the height of the measured part, inclusive of that introduced by the interposition of the guage cradle, above the true surface, is such that a portion of the light beam is obstructed, the illumination falling on the phototube cathode is proportionately decreased. As a result of these conditions, a small change in the height of the measured component above the true surface affects a considerable change in the illumination incident on the phototube cathode.

Inasmuch as the phototube anode-cathode resistance is inversely proportional to the illumination incident on the phototube cathode, a change in the illumination of the phototube cathode results in a proportionate change in the flow of the tube plate current.

Then the voltage appearing across the phototube plate-loading resistor is directly proportionanal to, and varies directly with, the phototube illumination. Consequently, an increase in the height of the measured object reduces the phototube illumination, and in consequence voltage apparent across the plate loading resistor.

The voltage appearing across the phototube plate loading resistor is, in the *precision electronic guage,* compared with a constant pilot or standard voltage. This voltage difference is subsequently amplified by a high-gain static voltage amplifier. The voltage standard is developed by the gaseous glow regulator tube under the control of the calibration potentiometer. That is, the calibration potentiometer is arranged as a voltage divider, connected in parallel with the regulator tube in such a manner that a suitable constant potential is secured between either of its resistance element terminals and the slider arm. Here, the voltage component existing between the positive terminal of this potentiometer

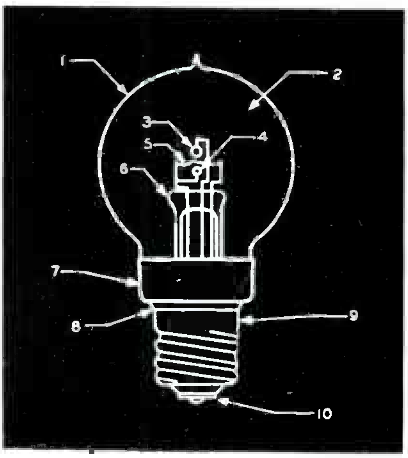


Fig. 3, Point-O-Lite, with a brilliant light source of small emitting area, plate sphere 3. The glass envelope 1 contains a rarefied inert gas atmosphere 2. An intense arc, developed between the filament 5 and the plate sphere, heats the latter to incandescense. The filament is connected to the plug shell 9 and solder knob 10, the sphere to auxiliary shell 7. An auxiliary sphere 4, directly connected with the filament leg serves to protect the filament in event of over-voltage surges.

and its slider arm is designated as the pilot or standard potential. The ohmage of the resistance element of this potentiometer is low in comparison to the series resistance of the phototube and the phototube plate loading resistor. This, together with the fact that the current in the phototube circuit at any time is small, effects a virtually negative change in the standard potential regardless of the phototube current variation.

It has been shown that an increase in the height of the measured object results in a decrease of the voltage appearing across the phototube plate loading resistor. As a result, the grid of the pentode static voltage amplifier pentode swings negatively with respect to the cathode, resulting in a reduction of the tube plate current. As a further result, the voltage drop across the pentode plate loading resistor decreases and the pentode plate-cathode voltage increases. Hence, an increase in the height of the measured machine part results in an increase in the plate-cathode voltage of the pentode.

The slider arm of the potentiometer is permanently adjusted in such a manner that the potential between the slider arm and the cathode of the pentode is exactly one-half that existing between the positive terminal of the d-c power supply and the cathode of this tube. If, therefore, the potential between the pentode anode and cathode is exactly one-half that existing between the positive terminal of the d-c voltage supply and the cathode of this tube, the grid-cathode potentials of the thyratron tubes are zero, and both tubes tend to conduct. These thyratrons, however, are tetrodes, and, as such, require that the control grid be positive with respect to the cathode on the order of several volts in order that the tube conduct.

Signal Lamp Assembly

A suitable signal-lamp assembly is connected in series with each thyratron anode. These lamp assemblies are provided with removable color lenses or caps, usaully red and green, depending on the position of the guage unit in the inspection array. The lamps may be provided with either a red or green lens, which will be discussed in a later paragraph. It should be observed here that the a-c voltage developed by the windings is slightly more than twice the normal lamp filament voltage. The excessive voltage across either of these windings is necessary since the illumination emitted by the filament of the signal lamp is directly proportional to the *temperature* of the filament. In addition, the thyratron tube is a *half-wave* rectifier, which indicates that the true power in the rectified output is slightly less than half the product of the a-c voltage and the normal lamp filament current.

Conventional Arrays

In the conventional *go-no-go array*, two of these inspection guage units are employed, the first having the red lens cap on the lamp assembly which indicates excessive height, and the second incorporating the red lens cap in the lamp assembly, which indicates a deficiency in the object height. In addition, the standard test object used to calibrate the first unit is machined to slightly less than the maximum desired tolerance, and the test object used in the calibration of the second unit is slightly more than the minimum desired value. Thus, if the objects to be measured are guaged in the cradle of the first unit, each lighting the red indicator lamp, they are rejected for excessive height. If neither, nor the green indicator lamp is illuminated, the objects are then guaged in the cradle of the second unit, wherein either lamp is dark or the green lamp is illuminated, if the objects are of the correct height. Such an inspection array may be operated in a rapid and correct manner by relatively unskilled hands, though the array is usually incorporated into an automatically-controlled inspection system when the number of objects to be measured is great.

The guage circuit is so adjusted, by means of a calibration potentiometer, that the indicator lamps are dark when the height of the measured unit is at the correct level. A subsequent decrease in height results in illumination of one of the lamps.

"STATION RIDING"

CROSS-MODULATIONS PRESENTS SERIOUS PROBLEMS TO THE SERVICEMAN

Reprinted from Radio-Craft

*By Leo G. Sands**

THE term "Station riding" was first heard by the writer in San Francisco in 1930. It was used by radio technicians of the Bay City to describe a type of radio interference very prevalent in that area. Station riding is the type of interference that allows an unwanted signal to "ride" the carrier of a wanted signal. When a signal is tuned in on a radio receiver and station riding is present, two or more signals are heard at the same time. When the receiver is detuned, neither the desired nor the undesired signals are heard. In the case of a broad tuning or non-selective receiver, interfering signals are usually heard between stations. Station riding affects highly selective radio receivers as well as receivers with poor selectivity.

To rid the receiver of this annoying interference, many schemes were tested. Changing the antenna, a better ground connection, wave traps, etc., were tried. These methods often reduced or eliminated the interferece. In other cases, the source of interfernce had to be located and the remedy appl.ed to the source.

The source of station riding is usually hard to locate unless a radio interference locating device or a sensitive portable radio receiver is used. Typical causes of station riding are poor electrical contact between sheets of metal on a metal roof. two pipes touching but not making good electrical contact, antenna touching metal drain pipe, poor electrical contact at splices on guy wires attached to antenna mast or metal chimney, or almost any mass of metal making poor electrical contact to another mass of metal. (Fig. 1). The theory that has been advanced on the cause of this station riding claims that rectification of strong radio signals takes place at the point of poor electrical contact. (See "Foxhole Emergency Radios" in September *Radio-Craft.*) When two or more radio signals are rectified at these points, their sum and difference frequencies are radiated by the metal objects. The more signals that are picked up and rectified, the larger is the number of radiated beats. When several signals are rectified in this fashion, nearby receivers may pick up jumbled signals every few kilocycles on the receiver tuning range.

In one instance, the writer was called to diagnose a case where the listener complained that the radio was unusable. It was found that half a dozen mixed signals were being received every ten kilocycles throughout the broadcast band. Every carrier, including the high power local stations, was accompanied by half a dozen interfering signals. Line filters and wave traps were tried to no avail. Being a loop antenna type receiver, an outdoor antenna and ground were tried. The owner felt that it must be the fault of the radio receiver. One of another make was tried and the results were found to be just as bad.

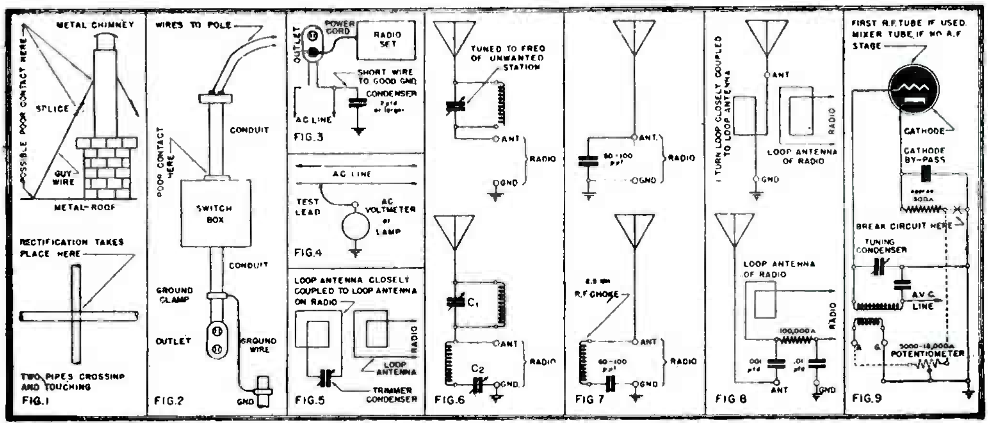
Tracking Down the Trouble

Armed with a portable receiver (which also suffered from the same interference), the writer followed the power lines in front of the house and found the interference strongest when directly under the wires. The power lines were followed to their termination in the next block at a construction company tool shack.

* Assoc. I. R. E.

A switch box was located on the wall of the shack. The wires were fed to the switch box through a vertical piece of conduit. From the bottom of the switch box, another short piece of conduit terminated in an outlet box. This lower piece of conduit was grounded. Upon examining the switch box, the writer slammed its door shut. The interference ceased. Moving the conduit caused the interference to reappear. Poor electrical contact between the top piece of conduit and the switch box apparently caused rectification of radio signals. (Fig.2.) Tightening the conduit to the box cleared the trouble.

Another case of severe station riding occurred with a popular brand multi-tube receiver which was normally quite selective. The receiver was located less than one quarter of a mile from a five-kilowatt broadcast station. This station did not cause interference, but a ten-kilowatt station fifteen miles away rode every signal that could be tuned in on the broadcast band. The writer tried every trick in the bag including a check of the house wiring. One peculiar condition of this



case was the fact that the interference ceased every day between the hours of noon and one P. M., apparently due to load changes on nearby power lines. Since the radio was one of a very popular brand, the distributor was anxious to keep the radio sold, so a factory engineer was dispatched to the scene. He too tried every trick he knew including the replacement of the built-in loop antenna with an antenna transformer and an outdoor vertical rod antenna. Nothing seemed to reduce the interference, so the dealer who had sold the radio exchanged it for one of another make. This receiver worked fine without a trace of station riding. The first receiver used variable capacitor tuning and the second receiver used permeability tuning. However, this proves nothing as in other locations receivers with permeability tuning suffered from station riding just as badly as those with capacitor tuning.

By-Passing the Line

Still another case. This radio receiver was one of good design with exceptionally good selectivity, but it too suffered from severe station riding. The writer found that running a short ground lead to the grounded side of the A.C. line at the outlet to which the radio was connected completely eliminated the trouble. (The reader should be cautioned not to try this unless he has definitely determined which side of the line is grounded. For safety reasons, a large paper dielectric condenser (2.0 mfd. or larger) should be used in series with the ground lead.) In this case, the cure did not work unless a sufficiently large condenser was used. (See Figs. 3 and 4.) Another word of warning to the reader is to be careful not to violate underwriter rulings.

In cases where the source of interference has been found to be caused by two pipes touching, insulate the pipes from each other or bond them together so that a better electrical contact is established. On buildings with metal roofs, it is suggested that the individual metal plates be bonded together and then grounded. Watch the antenna and lead-in, making sure they do not touch near-by metal objects. In the case of rusted guy wires, break them up with strain insulators or clean and solder the splices. Metal clothes lines terminated at rusty hooks or pulleys should be checked.

In cases where it is not practicable or economical to cure the station riding at its source, or where the source is too difficult to locate, other measures may be tried. In receivers using a loop antenna where only one interfering signal is present, a loop type wave trap should be tried. This consists of an extra loop antenna strapped to the loop antenna in the receiver, as shown in Fig. 5. This extra loop is shunted by a trimmer condenser of sufficient capacity to tune it to the frequency of the interfering signal. Adjust the trimmer condenser until the attenuation of the interfering signal is maximum.

For receivers designed for use with an external antenna and ground, wave traps of the resonant or anti-resonant types may be tried. A combination of both types may be used as shown in Fig. 6. Adjust both wave traps for maximum attenuation of the interfering signal. Where interference is general from stations at the high frequency end of the broadcast band, the interference may be reduced by shunting the antenna and ground connections with a small mica condenser of approximately 50 to 100 micro-microfarads capacity. If the receiver has short-wave bands and the listener uses these bands, and R.F. choke of approximately 2.5 millihenries should be used in series with the condenser (Fig. 7). The reactance of the choke will be so high on the short wave bands as to nullify the effect of the condenser, but still make it effective on the broadcast band.

A good ground connection often helps in reducing radio interference. (The writer has seen a nail driven into a flower pot used as a ground—this is *not* a good ground connection.) Use of a properly designed line filter aids materially, especially with A.C.-D.C. type receivers. Loop antenna type receivers often perform better when used with a vertical rod type outdoor antenna. See Fig. 8 on suggestions as to methods of connecting an outdoor antenna to loop antenna receivers. The one-turn loop coupled to the receiver's loop antenna works quite effectively, especially with receivers using two- or three-turn low impedance loop antennae.

When image interference is strong, a sensitivity control as shown in Fig. 9 will often make the receiver more usable. This control may be installed on the rear of the receiver chassis and adjusted to a position where reception is most satisfactory, then left that way.

The writer has wandered from the original discussion of station riding to other types of radio interference as their cures are closely related. There is no definite cure-all for all cases of station riding, and some cases will give that radio technician quite a tussle before the answer is found. It is hoped that some of the suggestions presented here will be of benefit in the quest for better radio reception.

SOUND CONDITIONING FOR POSTWAR HOMES

Reprinted from *FM* AND TELEVISION

Review of Techniques Which Will Enhance High-Fidelity Effects of FM Reception.

This article, prepared by the staff of Architectural Forum, September, 1944, reviews the application of sound conditioning to new and remodeled homes, with particular reference to enhancing the quality of FM reception. As the authors point out, "a $500 radio in a small, acoustically bad room is not heard to best advantage. But if the room is acoustically planned for its use, the room seems bigger, the tone much richer."

Another problem discussed is that which arises when "Mother plans to listen to a symphony concert on the radio, Father wants to go over some reports, and Junior has homework to do."

Consulting engineers who associate themselves with leading dealers and architects in their communities will find many problems of home sound conditioning presented for solution as radio listeners learn how their enjoyment of FM reception can be augmented by simple acoustic treatment of walls and ceilings.

WITH present advances in the science of acoustics, sound conditioning should at last get its share of attention in the planning of modern homes. Segregation of sound to provide quiet areas in different parts of the house, reduction of clatter within a room, and acoustical treatment for accurate sound reception would add much to family comfort and should be considered while design of a house is in progress.

PROGRESS OF SOUND CONDITIONING

Sound conditioning has already been applied with brilliant success to nonresidential interiors such as theaters, broadcasting studios, restaurants and hospitals—wherever noise reduction is a problem of prime importance. Sound control has become so accurate that acoustical engineers now can produce any desired auditory effect. The first attempts toward acoustical improvement by haphazard use of sound-absorptive materials have given way to architectural understanding of the problem, with quality and liveness of tone the paramount objective.

This may be observed in broadcasting studios which have gradually developed from conventional rectangular rooms equipped with sound-absorbent material on the ceiling alone. Today studio walls are tilted, never parallel, and broken surfaces jut into the room. Acoustical material is used sparingly on certain walls while others are paneled with plywood to reflect sound and afford resonance.

Sound-absorbing materials have also been used effectively in commercial spaces where the noise of typewriting or telephoning formerly reduced efficiency of workers. Under the pressure of war, factories, too, have found that sound conditioning boosts production and cuts down absenteeism.

APPLICATION TO PRIVATE HOMES

Because of this increase in the use of sound control, a great variety of good-looking and inexpensive acoustical materials are now on the market. They are the opening wedge for further expansion of sound conditioning. Although non-residential applications have been phenomenally successful, few people have ever thought of using acoustical tile, plaster, metal panels or wallboard in the home. Here noise is often only a minor annoyance, but it can have a direct effect on the nervous system, and it is always the unwanted noise which we hear. In the future, this situation will undoubtedly become more acute, because of the increased use of open plans, and the trend toward bare furnishings and no rugs which create sound problems in modern homes. A definite plan to control noise can contribute much toward increased comfort and livability in postwar construction and remodeling of the family dwelling. It should be possible, for instance, to provide quiet areas in the home which will be unaffected by noise in other portions of the house. With proper planning and the

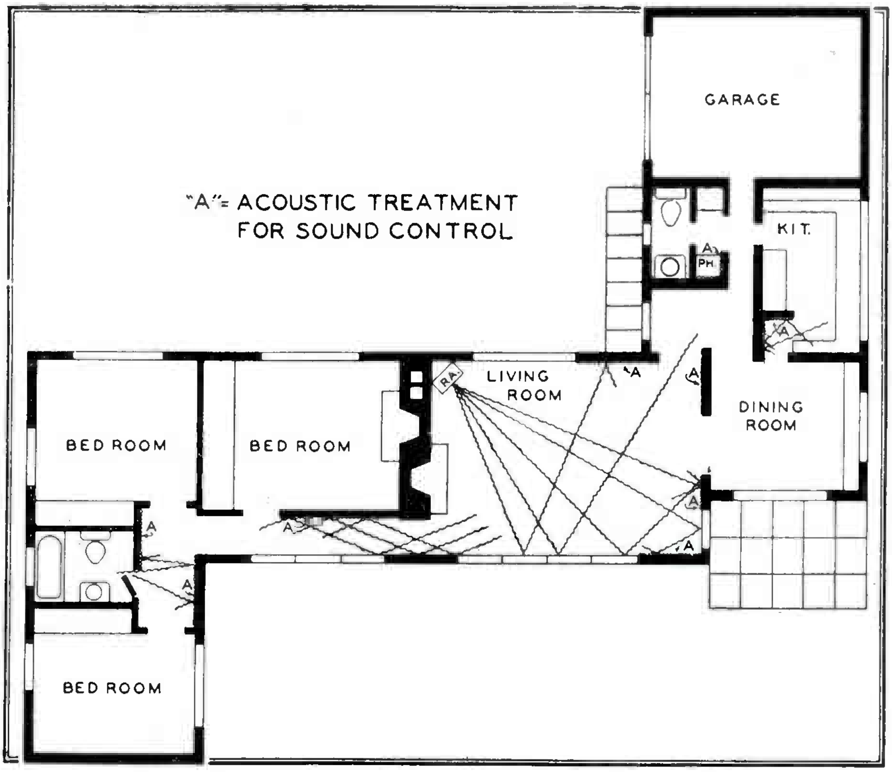


Fig. 1. Various sound-absorbing methods are illustrated here

wise use of sound-absorbent materials, this may even be accomplished in different parts of the same room. Better acoustical conditions could also provide greatly improved radio reception, whether for an inexpensive $50 set or for a sensitive $500 machine.

However, since home use of acoustical materials is still mainly in the idea stage, it is not yet certain what home-owners will want to accomplish with sound control. A sparing and experimental use of the materials will constitute no great loss even if results are not completely successful, for acoustical wall finishes cost only a little more than ordinary ones. A knowledge of the principles of sound transmission will eliminate much of the guessing in these experiments. To better understand how acoustics work, therefore, a brief explanation is necessary.

INSULATION AND ABSORPTION

There has always been a certain amount of confusion in this field because of the failure to distinguish clearly between sound insulation and sound absorption. The first deals with transmission of both airborne and impact noises from one space to another. Sound absorption on the other hand is concerned with reducing the general noise level within a space, and with providing more nearly ideal acoustical conditions. This type of sound control deals solely with airborne sound waves which, besides traveling through the air, bounce from any reflective surface.

Without realizing it, everyone knows that talking to a person outdoors and indoors are acoustically two different situations. Outdoors it is necessary to speak *at* a person, perhaps to turn your head towards him because the sound waves, unlimited, go off in all directions. Indoors, where sound is trapped and reflected, you instinctively know the sound will reach a person even if your face is turned away while speaking. When sound-absorbent material is used on a ceiling the acoustical result is almost as though the ceiling had been removed. If this sort of material is also used on walls, it might absorb too much sound, giving the uncomfortable, because unaccustomed, sensation that you are out of doors.

Too great reflection of sound waves, however, produces a booming effect during conversation. This is easily seen in the contrast between a furnished room and an unfurnished one. In an empty apartment, sound reverberates because the waves

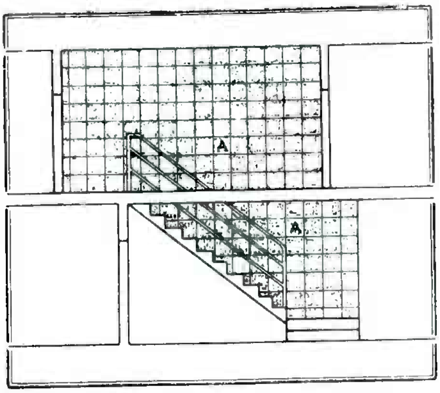


Fig. 2. Treatment of stair walls

bounce back and forth reflected by the bare walls, ceiling and floor. Upholstered furniture and rugs act as sound absorbers and produce the tones we are accustomed to hear.

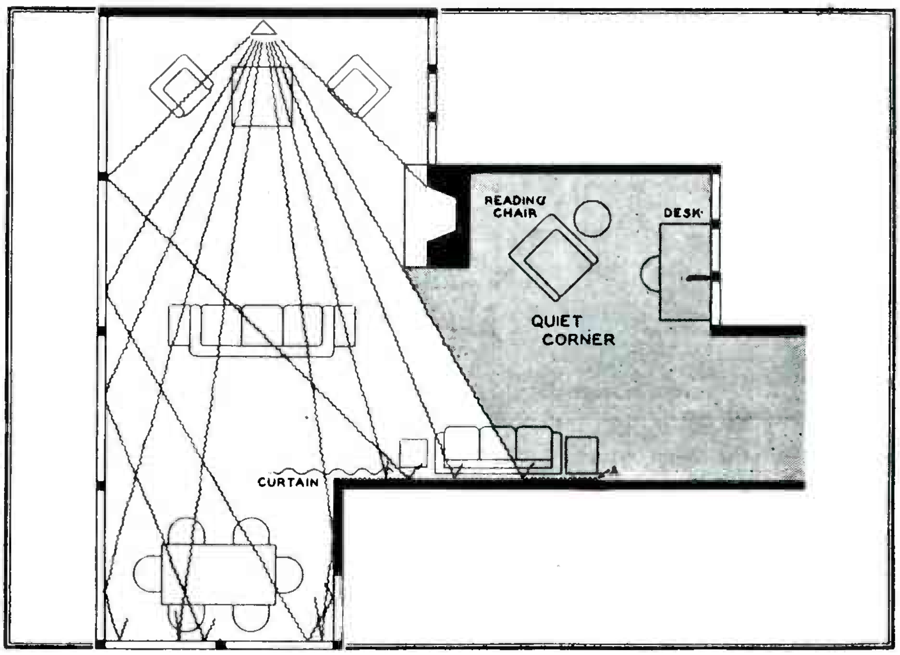
In sound insulation, which combats the transmission of noise from space to space, it must be remembered that airborne sounds can enter through windows, cracks under doors, flaws in masonry or plastering, cracks around ventilating ducts, even pipes and conduits. Careful workmanship, the elimination of cracks, and use of acoustical duct filters will help this situation.

In addition, airborne sounds may be transmitted directly through a building structure which acts as a diaphragm set in motion by the sound waves. This motion is translated back into sound on the other side of the structure. It can be most effectively reduced by heavy construction such as 4-in. to 6-in. masonry walls, non-homogenous walls, and by walls or ceiling of two or more layers with a sound-absorbing filler like mineral wool. According to tests conducted by the Bureau of Standards, a wall constructed of ½-in. insulating board and plaster on each side of 2- by 4-in. studs reduces noise better than walls made with either gypsum or wood lath as the plaster base. However, a heavy masonry wall is still better and is less expensive than double construction floating floors and ceilings and similar devices.

Impact noises, a completely different type of sound transmission, must also be considered if sound insulation is to be effective. They are caused by structural vibrations from one portion of a building to another. Walking, moving furniture, rattling of water pipes are all examples of impact sounds. They can be effectively reduced at the source by covering the floor with rugs or resilient floor tile, and by proper mounting of pipes and conduits.

Sound-absorptive material, used mainly to reduce noise within a space, can be applied to the problem of sound transmission in certain cases. A hallway down which sound travels from a living room to a bedroom may be treated in this way. Absorptive materials may also be used to reduce noise transmission from one part of an irregularly-shaped room to another.

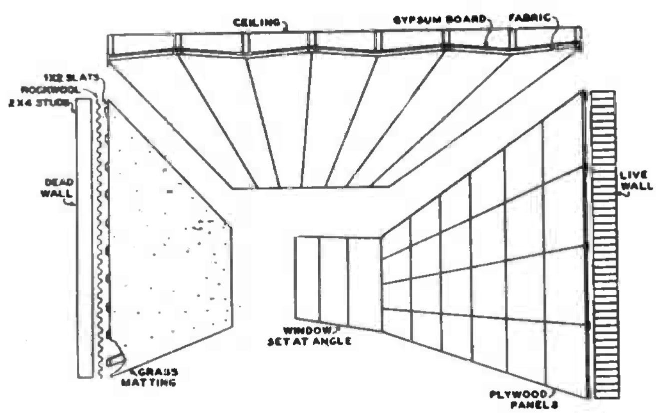
Fi. 3. Wall marked "A" absorbs sound to produce quiet corner



OBJECTIVES OF SOUND CONDITIONING

With the distinction clearly made between sound insulation and sound absorption, acoustical treatment of a house boils down to three objectives: preventing the passage of sound from one room to another, absorption of noise at the source, and sound control within rooms. To accomplish these ends, elaborate and expensive devices are unnecessary. Careful thought and the use of certain new design ideas make sound conditioning a relatively simple matter. Houses can be planned to maintain areas of complete quiet, or to accomplish at least a great reduction in sounds which travel from a noisy part of the house to quiet parts. For instance, houses may be planned and built in such a way that children will be able to sleep in the bedroom portion while their parents play the radio or have a party in another part of the house. This is illustrated in Fig. 1.

In a one-story home, this can be accomplished by planning for sound control at the design stage. A bank of fireplaces and chimney flues installed between living room and bedrooms, Fig. 1, make an excellent sound barrier for this purpose. If the fireplace is not wanted, a masonry wall can be used, finished in the ordinary way or left unfinished as a functional decoration suitable for both modern and traditional homes. Another excellent barrier device is a double row of closets, one row opening into the living room and hall, the other into the bedroom. Closets are particularly



Figs. 4 and 5. Arrangement and acoustic construction in the home of Sherman Fairchild

effective, since clothes are exceptional sound absorbers. If, in addition to the creation of an effective sound barrier, the hall connecting living room and bedrooms is treated with acoustical material, airborne sounds traveling through the corridor will be absorbed and considerable noise control achieved even when doors are left open.

In a two-story house this separation is more difficult because ordinary floor and ceiling construction does not constitute a good sound barrier. Nevertheless, treatment of the side wall of the stairway with sound-absorbent material as shown in Fig. 2, would partially isolate living and sleeping quarters. Living room noises and the sound of the radio would be prevented from going up, and upstairs noise, such as bathroom sounds, could not come down. Actually the noise would not be eliminated, but the substantial reduction in sound flow resulting from this treatment would probably make it worth while.

Similar to the bathroom problem is sound control within a kitchen. Both these rooms are particularly subject to reverberation because, unlike other parts of the house, they do not have sound-absorbent furnishings. Tile, metal, and plaster, the materials most commonly used, are brilliant sound reflectors. The clatter of dishes is therefore intensified and easily penetrates into the dining room as an unpleasant background to dinner. Harsh noises are also an annoyance to the housewife who spends much of her time in the kitchen.

Again the basic treatment should be the absorbing of sound at the source. An acoustical ceiling and resilient floor-covering deaden the noise, but additional reduction can be accomplished by the use of wooden or linoleum work surfaces instead of enameled metal drainboards and tables.

To prevent the transmission of sound from kitchen to dining room, a pantry or utility space between the two rooms can be used as a barrier. This still leaves the problem of noise entering through the door. If the door is placed next to the pantry, and the small section of wall leading into the dining room treated with sound-absorbent material, as indicated in Fig. 1, this problem should be considerably reduced. Sound waves must be reflected from that particular section of wall to go around such a barrier, and when they hit the acoustical material they are in the main absorbed.

ZONES OF QUIET

Conflicting activities in the same room or same part of the house is another problem which can be solved by a moderate use of acoustical material and wit. One of the most annoying sidelights to family living is the problem of using the telephone when everyone else is around. For convenience, the phone is usually located in a central spot. It can be answered quickly, but a conversation cannot be carried on unless other members of the family stop talking and the radio is turned down. Borrowing a trick from the open-front telephone booths in New York's newest subway will help solve the problem. Here acoustical tile lines the three sides of open-front booths, allowing conversation even during the rumble and crash of a passing subway. In the home, a small recess could be built into the wall and lined with a few acoustical tiles. This is also illustrated in Fig. 1. Such a device is needed anyway as a planned location for the telephone and although it might not be 100 per cent effective in isolating sound, it would be a vast improvement over the common variety of telephone table.

Another tricky problem in acoustics is presented by a family whose members all want to use the living room at once. Mother plans to listen to a symphony concert on the radio, Father wants to go over some reports and Junior has homework to do. An acoustically planned L-shaped room, Fig. 3, allows all these things to be done with a minimum of fuss. Mother sits beside the radio which is placed at the top of the "L". Sound waves traveling the length of the room would ordinarily bounce off the wall and into the alcove where father and son are seated. Acoustical material on the end wall, however, would absorb much of this sound, leaving the alcove relatively quiet while the radio plays. If the sound reduction from this treatment is not sufficient, extended bookcases can act as additional baffles.

IMPROVING RADIO QUALITY

Quite apart from segregation of sound in the living room is the problem of improving its acoustical quality for better radio reception. Since most living rooms are small, they never capture the true quality of a large orchestra which should be heard in a concert hall to be appreciated. A $500 radio in a small, acoustically bad room is not heard to best advantage. But if the room is acoustically planned for its use, the room seems bigger, the tone much richer.

This device was used to advantage in Sherman Fairchild's Manhattan town house.* Fig. 4 shows a view of the living room, while the acoustic treatment is diagrammed in Fig. 5. The long, low radio cabinet can be seen in Fig. 4, with a detailed sketch in Fig. 6. The loudspeaker is at the opposite end of the room in Fig. 4, and therefore does not appear in this view. Realizing that good radio sounds only as good as the room it is in, Mr. Fairchild demanded an acoustically perfect interior for his specially-built set. In addition to the radio, he had two grand pianos. To obtain the best possible tone from his instruments, the living room was treated to sound like a huge symphony hall. The ceiling was made of wood frames, some areas filled with broken pieces of wallboard, others with rock wool to produce irregular reflections of sound. A second cloth ceiling was stretched over this. Rock wool padded one wall behind a grass matting and the opposite wall was made of plywood. Glazed panels, one of which is set at an angle, formed the other two walls. The construction is shown in Fig. 5. The result in faithful reproduction of sound was extraordinary, and it seems plausible that this technique in varied form could be applied to many situations, although perhaps not in so elaborate a form.

This sort of construction will undoubtedly become more important as the demand for better home acoustics increases. Trends in modern architecture—the openness of design, lavish use of glass, bareness of furnishings and lack of rugs—will also tend to increase demand for acoustical planning where before one could take it or leave it alone. Modern houses will also present a sound transmission problem with

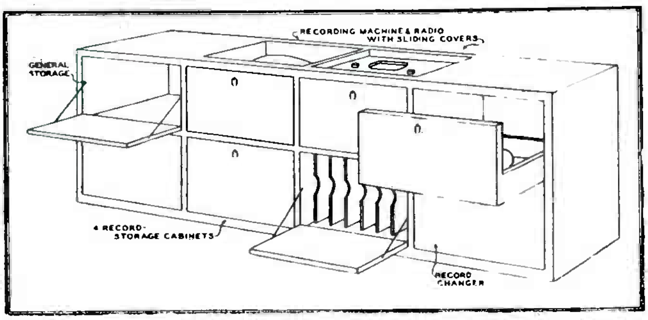


Fig. 6. Details of the radio, phonograph, records, and record cabinet shown in Fig. 4. Loudspeaker is mounted separately

their use of lighter materials in place of regular plaster partitions. On the other hand they will offer heretofore unknown acoustic opportunities because sound problems can be solved by the design itself. Walls need not be parallel, glazed panels may be tilted and acoustic materials placed to best advantage. With the development and perfection of such design, sound conditioning can be aimed not only towards remedying the faults of present construction, but towards creating new acoustical opportunities for future homeowners.

The consideration of acoustic treatment for modern homes is particularly appropriate at a time when broadcast engineers who would like to reduce the 15,000-cycle standard of FM fidelity complain that the acoustics in most homes are such that the high-frequency overtones are lost. It may very well be that sound-treatment of postwar homes will be featured along with quick-freeze units and air-conditioning. There is no reason why, with intelligent planning, modern living rooms cannot have the acoustic characteristics of small concert halls.

Since FM standards set now will prevail for years to come, it would be far better to set them high, even though they cannot be utilized to the fullest extent at this time. Eventually, if 15,000-cycle quality is available, progress in materials and home construction will afford its advantages to radio listeners.

RH-507 INVERTED TRIODE

Reprinted from Radio News
(Radio-Electronic Engineering Edition)

By W. A. Hayes, Electronics Eng., Westinghouse

USING PLATE AS CONTROL GRID MINIMIZES SPACE CHARGE EFFECT AND PERMITS ZERO GRID CURRENT

MEASUREMENT of currents as low as 10^{-15} ampere is made possible by the development of a new tube, called the inverted triode. In this tube the outer electrode, which is normally the plate in an ordinary vacuum tube, is used as the control grid. This inversion minimizes the space charge effect thereby making it possible to select a value of grid bias that will result in zero grid current,

The sensitivity of this tube is made possible by an extremely low grid current and a high grid-to-cathode resistance. In addition to measuring currents as low as 10^{-15} ampere, it will permit indication of currents as low as 10^{-16} ampere, which represents a flow of about 625 electrons a second. Direct potentials of 10^{-4} volts may be measured in circuits having up to 10^{12} ohms resistance.

Due to the small magnitude of the currents expected in the type of applications to which the tube is usually put, it is absolutely necessary that none of the minute quantities of current be absorbed in surface leakage. Therefore, the tube has been

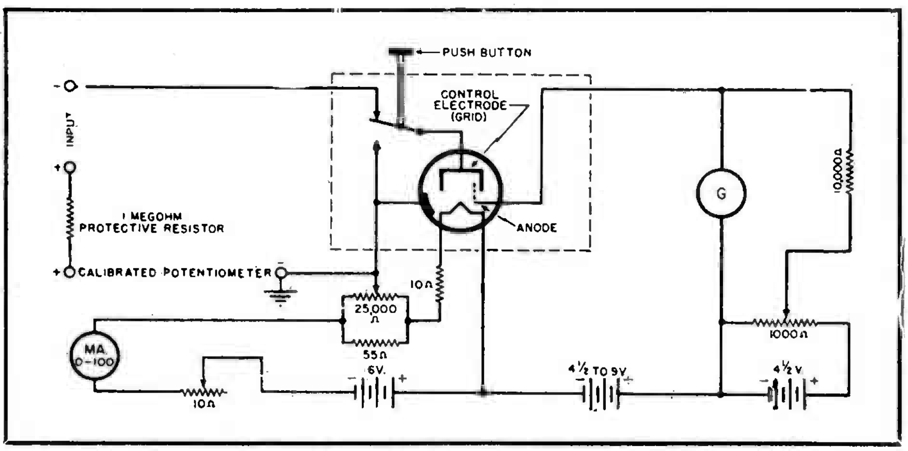


Fig. 1. Typical electrometer circuit using the inverted triode tube.

designed to eliminate leakage as far as possible. So-called "glass pant leg" supports, consisting of a glass sleeve surrounding a wire which acts as a support, provide the necessary insulation between electrodes so that practically no energy is absorbed from the source being measured.

Even a microscopic film of moisture on the bulb surface would provide a leakage path between the control electrode and the cathode. Consequently, it is advisable to mount the tube in a reasonably tight shielded can containing a drying agent. The outside of the bulb may also be treated with Silicone Resin or other suitable material, which helps break up the possible formation of moisture into tiny droplets, and so tends to prevent a continuous leakage path from forming through the moisture.

Electrostatic charges which might accumulate on the inner surface of the glass bulb can seriously affect the overall tube sensitivity. To eliminate this condition, a small piece of spring wire resembling a "cat's whisker" is mounted with a slight pressure against the inner wall of the glass bulb and brought out to a terminal for grounding. The tube and all leads from the voltage supply should be

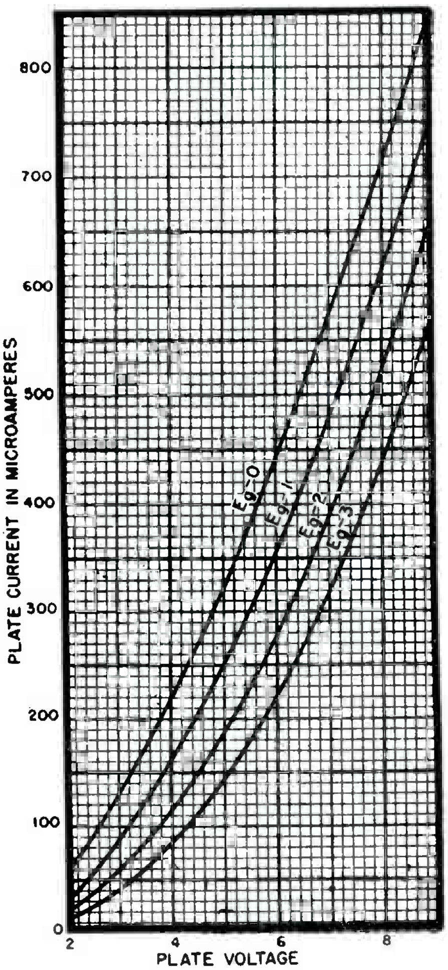


Fig. 2. E_p—I_p characteristic curves

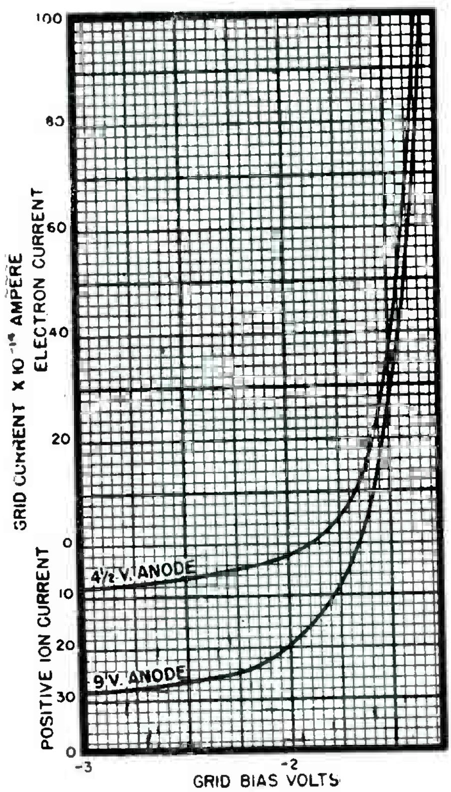


Fig. 3. E_g—I_g characteristic curves

shielded very carefully from any stray magnetic or electrostatic fields. It is also necessary to shield the tube from light as there may be some photoelectric effects while sensitive readings are being taken.

The filament is operated at a low temperature to minimize primary or photo emission from the grid. The electrodes are operated at rather low voltages and currents to reduce the possibility of ionizing residual gas in the tube. These low voltages require the use of a galvanometer or miroammeter for indicating purposes.

The output may also be fed into a suitable amplifier, in which case the RH-507 tube will serve as a coupling device between the source under measurement and the amplifier proper. In this way it is possible to use more rugged and cheaper instruments to obtain measurements previously requiring laboratory precision equipment. A typical electrometer circuit is shown in Fig. 1.

The characteristic curves shown are taken from readings of several tubes. The plate current curves (Fig. 2) therefore represent average values, although individual tubes should not vary greatly from the average.

The grid current curves also represent average values taken on several tubes but the readings on individual tubes may vary considerably from the figures shown. The curve in Fig. 3 with 4.5 volts on the anode shows that the grid current passes through zero at minus 1.8 volts. The important feature to notice is that the grid current of every tube crosses zero at some bias voltage near this value. It is therefore possible to select a value of grid bias such that the grid current is zero; hence extremely minute currents can be measured accurately. By adjusting the grid bias so that the grid current is zero it has been found practical to measure the grid currents as low as 10^{-15} amperes and to obtain indications of grid currents as low as 10^{-16} amperes. By providing a bias adjustment on either side of the "floating potential," reversal of control current is effected to advantage in electrochemical polarization studies.

The sensitivity of this tube makes several operations practical that were previously considered very difficult or impossible. It is used to measure:

1. Hydrogen ion concentrations.
2. Currents produced by phototubes when subjected to starlight.
3. Ion current in mass spectrometer.
4. Alloying constituents of steel.
5. Minute quantities which previously required an electrometer or its equivalent.

The tube filament may be operated from an Air Cell type battery or No. 6 dry cells. The filament current is very critical and must be held constant, so only seasoned batteries should be used. Good "C" batteries may be used for the grid and plate supplies.

Because of the extreme sensitivity of this tube, every precaution must be taken to insure that no electrical leakage is present in the circuit wiring. Whereever possible, all leads from the electrodes should be air insulated. Where construction requires "feed through" insulators, the finest grade of insulating material should be used, such as quartz glass or a material which offers extremely high resistance to surface leakage.

WHAT'S BEING READ THIS MONTH

Once again for the benefit of our readers we take pleasure in presenting a complete list of the feature articles which have appeared in the most recent issues of the leading trade and professional magazines. This month's list is as follows:

COMMUNICATIONS (January 1945)

POLICE COMMUNICATION SERVICES
Police communication problems facing engineers today .... *Lewis J. Boss*

TELEVISION ENGINEERING
A report on the Technical Panel Session at the TBA Conference .... *Lewis Winner*

AIRBORNE EQUIPMENT
British airborne communications equipment

CIRCUIT DEVELOPMENT
Coupled Circuit Design .... *A. J. Maynard*

TRANSMITTER TUBE DESIGN AND APPLICATION
External anode triodes (*characteristics and applications*) .... *A. James Ebel*

AERONAUTICAL COMMUNICATIONS
Aeronautical communications in the post-war era .... *McMurdo Silver*

SOUND ENGINEERING
Resistive attenuators, pads and network (*Part III*) .... *Paul B. Wright*

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Index to Communications, 1944

U-H-F LABORATORY RESEARCH
U-H-F Power Supply (*Part II*) .... *Iredell Eachus, Jr.*

ELECTRONICS (February 1945)

FIELDS IN WAVE GUIDE
Visual aid designed by Prof. Paul H. Nelson of Univ. of Conn. to show propagation in rectangular u-h-f guides

PLANNING AN F-M STATION
Discussion of problems confronting a-m stations considering the new service .... *P. B. Laeser*

DISK-SEAL TUBES
Union of wave circuit and electronic circuit increases the frequency limit of conventional vacuum tubes .... *E. D. McArthur*

MEASURING THE ELASTICITY OF SYNTHETIC YARNS
Dynamic method utilizing 10-kc sonic waves reduces errors due to plastic deformation .... *S. Silverman and J. W. Ballou*

CIRCULAR WAVE GUIDE FIELDS
Direction and relative magnitude of fields are plotted to facilitate exciter and filter design .... *George R. Cooper*

LOAD REMATCHING IN ELECTRONIC HEATING
Special auxiliary rematching circuits offset variations in load characteristics during heating cycle .... *Eugene Mittelmann*

THE CAA INSTRUMENT LANDING SYSTEM — PART I
Technical details of radio blind landing system recently adopted by CAA for civil aviation in U. S. .... *Peter Caporale*

PROCEEDINGS OF THE I.R.E. (February 1945)

BROWDER J. THOMPSON — 1903-1944
ELECTRONIC PAPERS .... *H. M. Turner*
THE INSTITUTE LOOKS TO THE FUTURE .... *W. L. Everitt*
RAYMOND F. GUY
ELECTRONICS IN INDUSTRY .... *W. C. White*
CAPE CHARLES-NORFOLK ULTRA-SHORT-WAVE MULTIPLEX SYSTEM .... *N. F. Schlaack and A. C. Dickieson*
CORRECTION TO "THE USE OF FIELD-INTENSITY MEASUREMENTS FOR COMMERCIAL-COVERAGE EVALUATION" .... *Edgar H Felix*
ULTRA-SHORT-WAVE MULTIPLEX .... *Charles R. Burrows and Alfred Decino*
ULTRA-SHORT-WAVE RECEIVER FOR THE CAPE CHARLES-NORFOLK MULTIPLE RADIOTELEPHONE CIRCUIT .... *D. M. Black, G. Rodwin and W. T Wintringham*
CORRECTION TO "ELECTRONIC APPARATUS FOR RECORDING AND MEASURING ELECTRICAL POTENTIALS IN NERVE AND MUSCLE," BY WILLIAM B. ROGERS AND HORACE O. PARRACK
ULTRA-SHORT-WAVE TRANSMITTER FOR THE CAPE CHARLES-NORFOLK MULTIPLEX SYSTEM .... *R. J. Kircher and R. W. Friis*
A NEW STUDIO-TO-TRANSMITTER ANTENNA .... *M. W. Scheldorf*
REFLEX OSCILLATORS .... *J. R. Pierce*
THE THEORY OF TRANSMISSION LINES .... *E. N. Dingley, Jr.*
DISCUSSION ON "NOISE FIGURES OF RADIO RECEIVERS" .... *Dwight O. North and H. T. Friis*

RADIO CRAFT (February 1945)

A PRIMER OF AVIATION RADIO .... *Raymond Lewis*
RADIO PILOT LANDS PLANES .... *S. R. Winters*
SUPER PHOTO-TIMER
PHOTOGRAPHING THE AIR
NEW FM RECEIVING SYSTEM
ELECTRONIC THICKNESS GAGE .... *Wesley S. Erwin*
LUMINESCENT RADIOS .... *M. A. Heikkila*
EARTHQUAKE RECORDER
USES FOR OA4-G GAS TUBE .... *Nathaniel Rhita*
RADIO-AUDIENCE METER .... *I. Queen*
CROSS-OVER NETWORKS .... *Jack King*
SPEECH AMPLIFIER, PART V .... *Robert F. Scott*
NOISELESS RECORDING .... *I. Queen*
CAPACITY PHONO PICKUP .... *Benjamin F. Miesner*
BROADCAST EQUIPMENT, PART VI .... *Don C. Hoefler*
AN ELECTRONIC ACCOMPANIST .... *Nathaniel Rhita*
RECORD CHANGERS .... *John Needre*
ULTRA RADIO .... *Bob White*
CAPACITY BRIDGES .... *Alfred Thomson*
INVERTED TRIODE .... *W. A. Hayes*

RADIO NEWS (February 1945)

ELECTRONIC FLIGHT RECORDER .... *Thomas B. Thompson and Willard C. North*
TRANSMISSION LINES AT 200 Mc. .... *Thos. A. Garretson*
ELECTRICAL COMPUTING AIRBORNE GUNSIGHT .... *Russell H. Lasche*
WACS AT WORK .... *Edgar F. G. Swasey*
"ELECTRONICALLY YOURS,—G.I. JOE" .... *William E. Taylor*
POWER SUPPLY FILTER DESIGN .... *Harold S. Renne*
BOMBER'S EARS
TONE CONTROL CIRCUITS FOR PHONOGRAPHS .... *F. E. Winter*
RADIO FOR TRANSIT UTILITIES .... *Joan David*
THE TELEVISION CHANNEL .... *Edward M. Noll*
MULTI-BAND 30 WATT TRANSMITTER .... *McMurdo Silver*
LET'S TALK SHOP .... *Joe Marty*
PRACTICAL RADIO COURSE .... *Alfred A. Ghirardi*
THE CATHODE FOLLOWER .... *G. Donald Hendricks*
THEORY AND APPLICATION OF U.H.F. .... *Milton S. Kiver*
FRENCH UNDERGROUND NETWORK DURING GERMAN OCCUPATION .... *Kenneth R. Porter*

RADIO NEWS Radio-Electronic Engineering Edition (February 1945)

MEASURING DIELECTRIC PROPERTIES AT U.H.F. .... *C. N. Works*
THE CYCLOTRON .... *Dr Bowen C. Dees*
POWER LINE CARRIER CURRENT TERMINAL EQUIPMENT .... *P. R. Crooker*
V.H.F. MEASUREMENTS .... *D Fidelman*
DYNAMIC RANGE IN BROADCAST TRANSMISSION .... *Harold E. Ennes*
ELECTRONIC EQUIPMENT IN MEDICINE .... *Howard A. Carter*

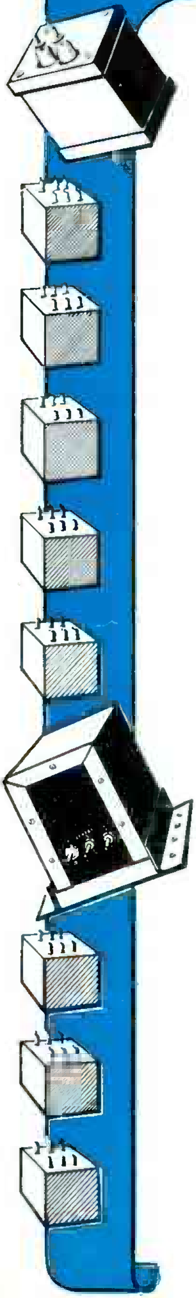
SERVICE (January 1945)

A DEALER IN BUZZ-BOMB ALLEY .... *A. W. Lines*
F-M ANTENNAS .... *Willard Moody*
INTERCOMMUNICATOR AMPLIFIERS AND SYSTEMS .... *A. Ghirardi*
LOUDSPEAKER MATCHING .... *E. B. Menzies*
OLD TIMER'S CORNER
SER-CUITS .... *Henry Howard*
TEST EQUIPMENT IN THE POST WAR ERA .... *L. A. Goodwin, Jr.*

TELEVISION (February 1945)

FCC ALLOCATIONS REPORT DOC. 6651 — ALL EXCERPTS ON TELEVISION
COMMISSIONER JETT SPEAKS OUT
ELECTRONIC EFFECTS
BUILDING A PROGRAM
5 YEARS OF TELEVISION — N. W. Ayer
WHAT'S WRONG WITH TELEVISION
PROGRAMMING
COMMERCIALS
TECHNICAL DIGEST
TELEVISION IN REVIEW
BRITISH TELEVISION
THEATRE TELEVISION
UNITY IN TELEVISION (UNIONS)

All Transformers are *Not* alike!



How many times have **YOU** heard someone who lacks technical knowledge say, "All transformers are alike"?

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