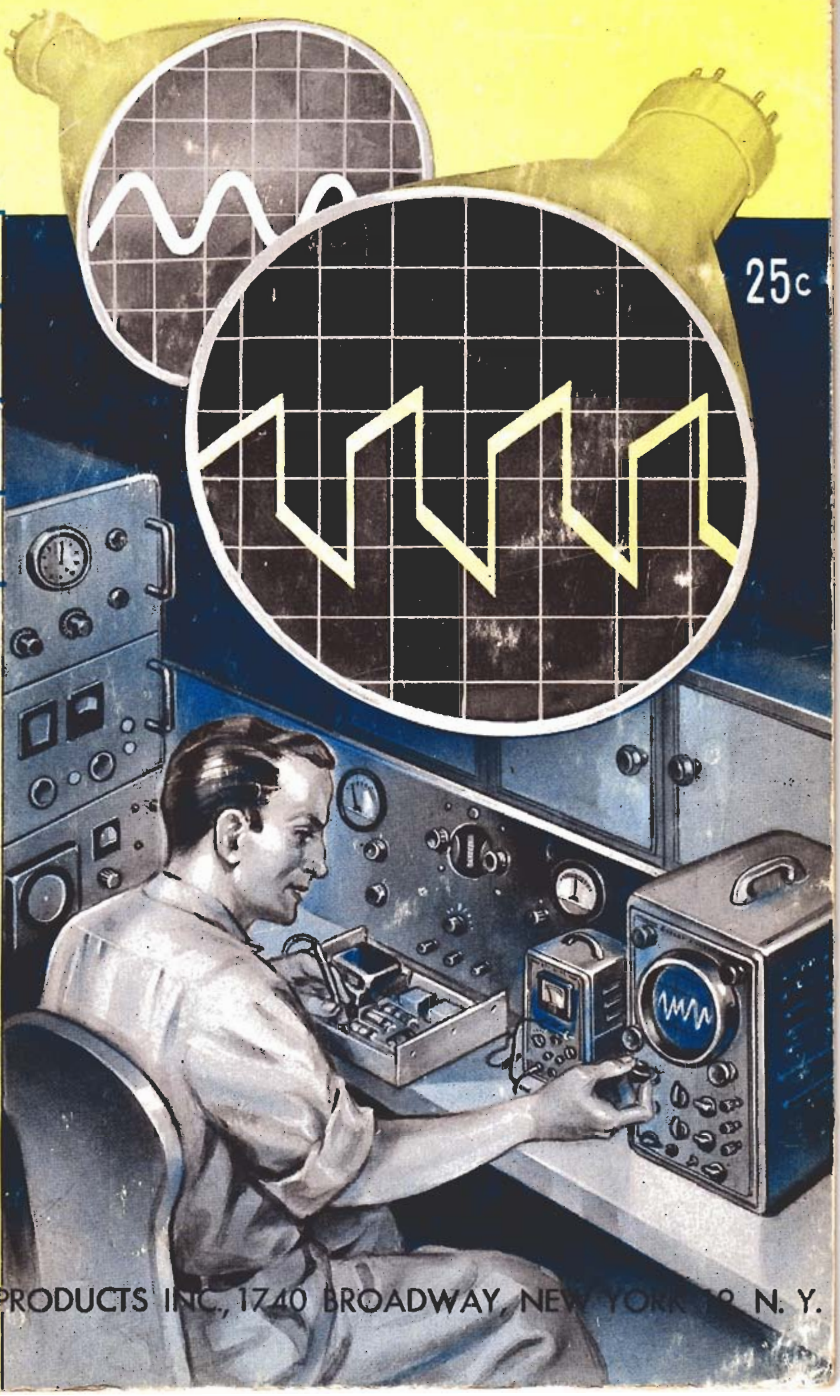
Crystal Diode CIRCUIT KINKS

MORE NEW USES FOR GERMANIUM DIODES



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SYLVANIA ELECTRIC PRODUCTS INC., 1740 BROADWAY, NEW YORK 19 N. Y.

CRYSTAL DIODE

Circuit Kinks

MORE NEW USES
FOR GERMANIUM
DIODES

Sylvania Electric Products Inc. 1740 Broadway, New York 19, N. Y.

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SYLVANIA ELECTRIC PRODUCTS INC.

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INTRODUCTION

In this booklet, we present 40 germanium diode applications, tried and proven, which did not appear in the several crystal booklets published previously by our Company. We believe the engineer, service technician, transmitting radio amateur, and hobbyist all will find items of interest in this new collection of circuits and data. It is believed further that the items contained in this booklet will provoke further thought and experimentation on the part of readers—activity which will lead to development of even more applications of the already prolific germanium diode.

In recent years, the crystal voltmeter and miscellaneous crystal meters have attained an identity of their own. For this reason, a separate chapter has been devoted to meters. Increasing acceptance of the germanium diode in TV reception likewise has occurred, and a description of successful circuits in this category appear in Chapter 3.

This booklet is offered with the earnest wish that it will bring practical ideas to radio-television technicians everywhere.

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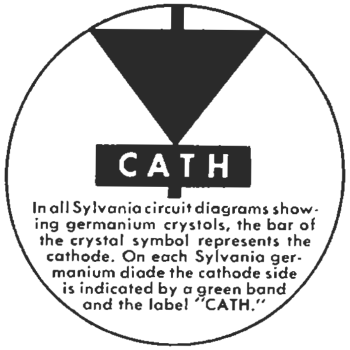
TABLE OF CONTENTS

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV



In all Sylvania circuit diagrams showing germanium crystals, the bar of the crystal symbol represents the cathode. On each Sylvania germanium diode the cathode side is indicated by a green band and the label "CATH."

LIST OF ILLUSTRATIONS

CHAPTER 1

CRYSTAL METERS AND METER ACCESSORIES

1.1 LINEAR VOLTMETER FOR BUILT-IN INSTRUMENTATION

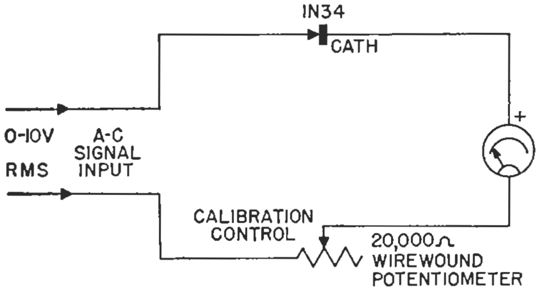
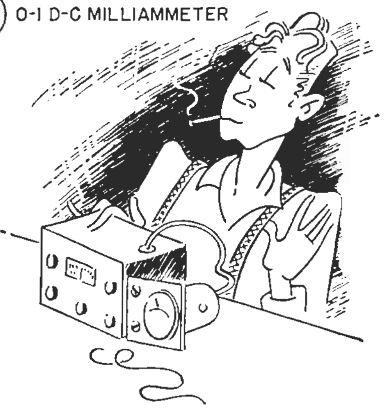


Figure 1-1. Series-type Linear Voltmeter for Built-in Instrumentation.



A small, wide-frequency voltmeter is useful on the panel of another instrument, such as a radio-frequency or audio-frequency oscillator, for continuous monitoring of signal output. A built-in meter of this type eliminates necessity for an external voltmeter.

The simple series-diode crystal voltmeter circuit of Figure 1-1 is suitable for such built-in instrumentation. The 0-1 d. c. milliammeter indicates 0-10 volts r. m. s. directly. This voltage range is satisfactory for most audio oscillator applications. If the output circuit of the oscillator is reasonably low impedance, response of the voltmeter circuit will be perfectly linear down to 0.1 volt (1/100 of full-scale deflection of the milliammeter).

The voltmeter input leads may be connected directly across the oscillator output terminals when the output voltage will not exceed a maximum of 10 volts r. m. s. For higher output values, the resistance of the calibration control potentiometer may be increased as required. At lower full-scale voltages than 10, the meter will not be linear, therefore the builder must not aim for low full-scale deflections unless he is willing to draw a special scale for the meter. In r. f. signal generators and in audio oscillators, the voltmeter also may be connected to the input terminals of the output attenuator in the instrument. This will permit standardization of the signal to a prescribed value at the attenuator input.

The d. c. return necessary for proper operation of the crystal diode must be completed by the output circuit of the instrument to which the voltmeter is attached. Ordinarily this return will be obtained through the secondary winding of the output transformer. No d. c. component must be present in the instrument output, otherwise the meter

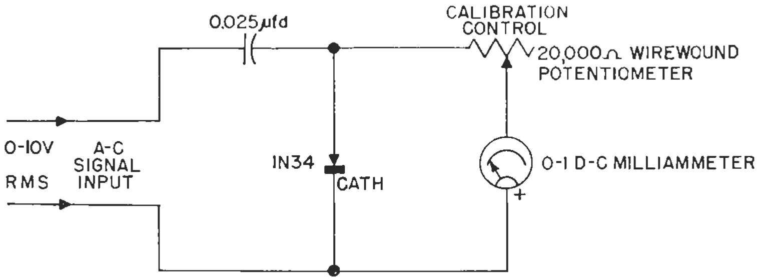


Figure 1-2. Shunt-type Linear Voltmeter for Built-in Instrumentation.

will be deflected erroneously and the diode and meter may be damaged.

If d. c. is present in the instrument output, or if no d. c. return path for the diode is provided by the instrument output circuit, the shunt voltmeter circuit shown in Figure 1-2 must be used. While this circuit is somewhat less desirable, from a loading standpoint, than the one given in Figure 1-1, its calibration is the same as the former circuit.

A single-point calibration of the voltmeter will suffice, since response is linear. The full-scale point is the most desirable. Apply a known 10-volt r. m. s. signal to the input leads of the meter circuit (the power-line frequency will be satisfactory) and adjust the calibration control potentiometer to bring the pointer exactly to the 1-milliampere point on the meter scale.

1.2 TUBE-DRIVEN LINEAR CRYSTAL VOLTMETERS

Sensitive a. c. voltmeters combine a high-gain, wide-band signal amplifier with a rectifier-type meter indicator circuit. Such meters are widely used in laboratories for the measurement of audio signal levels down to millivolt ranges. The experimenter may construct a simple, sensitive a. f. voltmeter of this type by connecting a high-gain audio amplifier ahead of a suitable linear crystal voltmeter. Linearity within the amplifier may be improved by means of suitable negative feedback. The sensitivity of this arrangement is a function of the overall gain of the amplifier. The crystal voltmeter circuit is operated at a voltage high enough to insure good linearity. This latter feature allows use of a common meter, such as a 0-1 d. c. milliammeter, without a special scale.

Figures 1-3 and 1-4 show tested circuits for amplifier-rectifier type meters. In each case, the full-wave crystal voltmeter circuit is capacitance-coupled to the amplifier output stage. A full bridge (4 diodes) is employed in Figure 1-3, and a half-bridge (2 diodes) in Figure 1-4. The full bridge meter has approximately twice the sensitivity of the half-bridge; however it requires four diodes which (for best results) should have matched characteristics. A Type 1N35 dual diode may be used in the half bridge (Figure 1-4) with two matched 100-ohm resistors.

The output stage may be the power tube normally employed in the amplifier. In most amplifiers built especially for audio voltmeter use, however, the output tube usually is a triode-connected 6AK5 or 6AQ5 in a. c.-operated units, or a triode-connected 3S4 in battery-operated models.

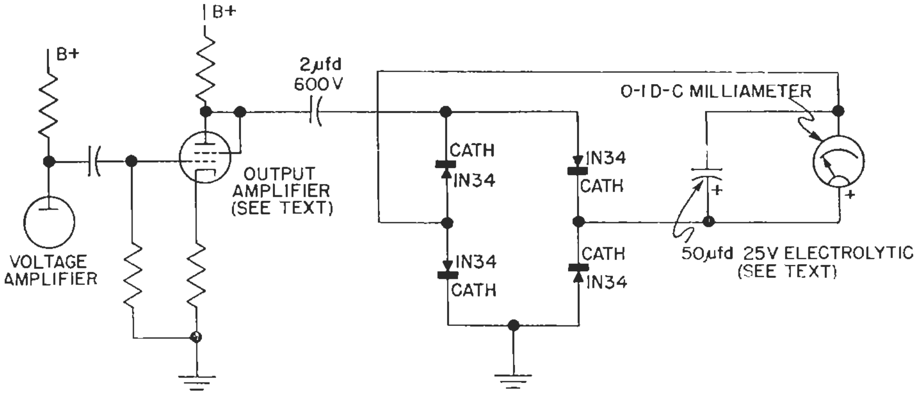


Figure 1-3. Full-bridge Tube-driven Voltmeter for Sensitive A.F. Measurements.

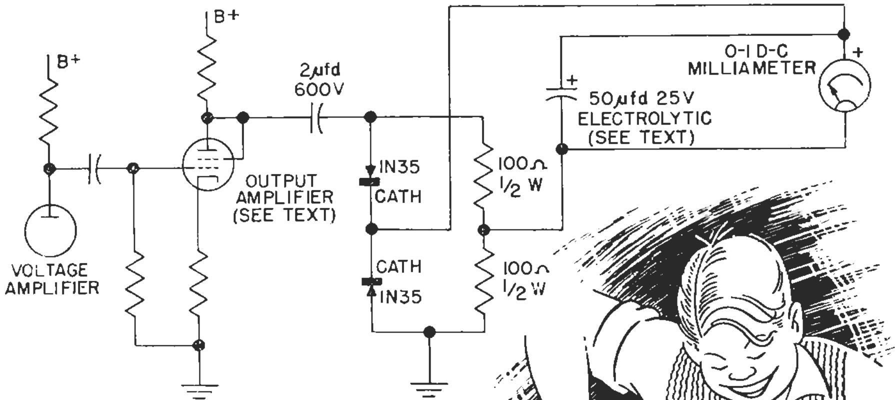
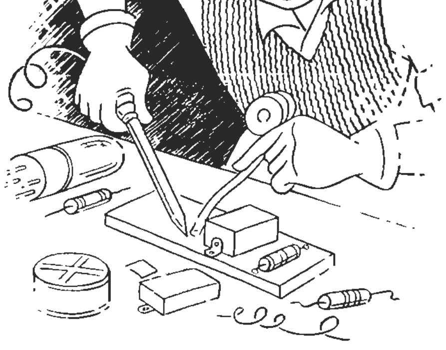


Figure 1-4. Half-bridge Tube-driven Voltmeter for Sensitive A. F. Measurements.

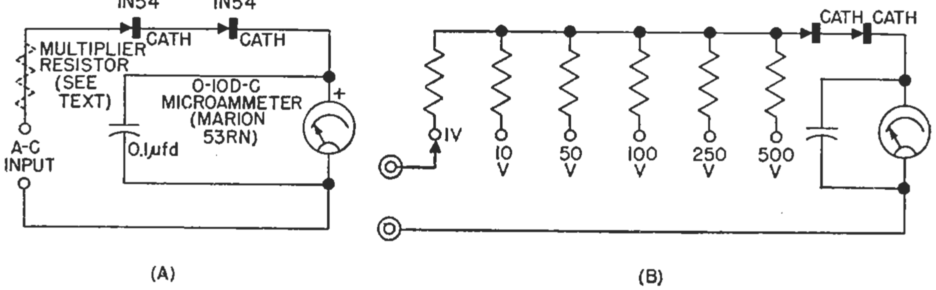


In each circuit (Figures 1-3 and 1-4), the electrolytic condenser shown in parallel with the meter may be used or omitted. If it is used, deflection of the voltmeter will be proportional to the *peak* value of the applied signal voltage. If it is omitted, the deflection of the voltmeter will be proportional to the *average* value of the signal voltage.

To calibrate a tube-driven crystal voltmeter, apply an accurately-known a. c. voltage to the amplifier input and set the amplifier gain control for desired meter deflection. For example, a 10-millivolt signal may be applied to the amplifier, and the gain set for full scale deflection of the 0-1 milliammeter. The meter then will read 0-10 millivolts. The procedure then is repeated for each desired range of the meter. To switch ranges at will, range resistors are installed which correspond in value to the resistance settings of the gain control thus determined

1.3 HIGH-RESISTANCE CRYSTAL VOLTMETER

A common objection to the ordinary crystal-type a. c. voltmeter is its relatively low input resistance. This characteristic limits the instrument to measurements in low-impedance circuits if calibration accuracy is to be maintained.



(A) (B)

Figure 1-5. High-resistance Crystal Voltmeter.

The instrument resistance can be increased advantageously by use of a low-range current meter. The most sensitive microammeter obtainable in the conventional panel-type case has a range of 0-10 microamperes (Marion 53RN). This meter permits a voltmeter sensitivity of approximately 100,000 ohms per volt. Figure 1-5(A) shows the circuit of a crystal voltmeter with such a desirable high input-resistance characteristic. Two high-back-resistance diodes (Type 1N54) are connected in series to provide the high order of reverse resistance required when high-resistance multiplier resistors are to be used in a voltmeter circuit. The basic circuit, as shown in the sketch, gives full-scale deflection of the microammeter with ¼ volt r. m. s. input. Because of the unusually low current density, response of the circuit is not linear and a special meter scale or calibration chart must be prepared.

The multiplier resistors required for various voltage ranges must be worked out experimentally by the builder, since their exact values will depend upon the individual germanium diodes used. The multiplier for the 1-volt range will be close to 88,000 ohms; 988,000 ohms for 10 volts; 4.9 megohms for 50 volts; 9.9 megohms for 100 volts; 24.9 megohms for 250 volts; and 49.9 megohms for 500 volts. Because of the extremely high values of multiplier resistors required beyond 500 volts, it is not advisable to extend the instrument range beyond that full-scale voltage. In a multi-range instrument, the multipliers may be switched in the conventional manner successively into the circuit, as shown in Figure 1-5(B).

The high-resistance voltmeter may be used at radio frequencies, as well as at audio and power-line frequencies. The voltage source under test must supply a d. c. return for the voltmeter circuit to allow the flow of d. c. current through the meter.

1.4 SQUARE-LAW D. C. VOLTMETER

Square-law a. c. voltmeters have been available for sometime. Similar instruments for experimental d. c. operation are not readily obtainable. A square-law d. c. voltmeter, in which meter deflection varies approximately as the square of the applied voltage, is useful for checking accurately small voltage *changes* on a single meter scale. Voltage changes, of important interest in certain types of experimental work, thus become more readable than on the common linear d. c. voltmeter scale.

The non-linear response of a germanium diode at low current densities may be utilized in the development of a square-law d. c. voltmeter by employing the diode as a series resistor in a simple meter circuit. The diode is connected to pass current in the forward direction. Type 1N34 gives approximately square-law response in the forward voltage range 0.1 to 0.2 volt. It is necessary, therefore, to bias the diode positively to 0.1 v. and then to apply the unknown d. c. voltage in series with this bias. The response curve may be corrected to square law by means of a low value of linear series resistance.

Figure 1-6 is the circuit of a complete square-law d. c. voltmeter. The 1N34 is biased to 0.1 volt positive, the point at which square-law operation starts, by means of the voltage divider R_2-R_3. Close adjustment of this voltage is obtained by means of the BIAS CONTROL rheostat, R_2. In order to keep the circuit resistance low, so as not to reduce the steepness of the diode response curve, the 0.1-volt bias is developed across a 1-ohm resistor, R_3. Also in order to keep the circuit resistance low, a low-resistance indicating microammeter is necessary (100 ohms or less internal resistance). Since the 1N34 curve is somewhat steeper than square law in the 0-100 microampere operating range, a small amount of series corrective resistance is provided in the circuit by the CURVE CONTROL rheostat, R_1.

The circuit is adjusted in the following manner: (1) Short-circuit temporarily the D. C. INPUT terminals. (2) Set rheostat R_1 to zero ohms. (3) Connect a low-range d. c. vacuum-tube voltmeter or a 20,000 ohms-per-volt d. c. voltmeter across resistor R_3. (4) Set rheostat R_2 for a 0.1-volt deflection of the test voltmeter. (5) The microammeter will indicate approximately 20 microamperes at this point. This is the "false zero" of the crystal voltmeter (6) Remove the short circuit and apply an accurately-known 0.1-volt d. c. potential to the D. C. INPUT terminals. Observe the correct polarity. (7) Note the meter deflection. If this reading is not 80 microamperes (four times the false-zero reading); increase the resistance setting of rheostat R_1, short-circuit the D. C. INPUT terminals, and reset rheostat R_2 for 0.1 volt deflection of the test voltmeter. Note new false-

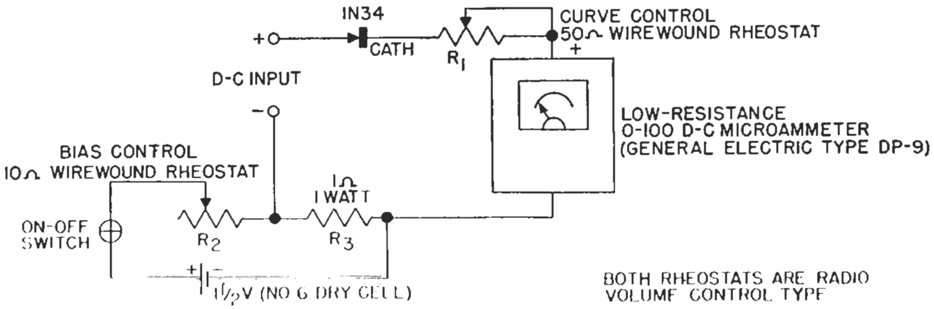


Figure 1-6. Square Law D.C. Voltmeter.

zero reading. (8) Again, remove the short circuit and apply the 0.1-volt signal to the INPUT terminals, noting new microammeter reading. (9) When CURVE CONTROL rheostat R_1 is set properly, and BIAS CONTROL rheostat R_2 adjusted for 0-1-volt bias, the application of a 0.1-volt input potential (representing a 2-to-1 increase in diode voltage) will produce a 4-to-1 increase in microammeter deflection. The test voltmeter then may be disconnected from across R_3. If the operator prefers that meter deflection start from meter zero rather than from a false-zero level, he may buck out the false-zero current by means of a dry cell and rheostat.

Voltages in excess of 0.1 may be checked readily by means of a voltage divider with 0.1-volt output taps. Whenever the instrument is not in use, open the ON-OFF switch, since the bias current drain through resistors R_2 and R_3 is 100 milliamperes. A No. 6 dry cell is necessary to supply this amount of current reliably and economically.

1.5 BALLISTIC METER FOR SINGLE TRANSIENTS

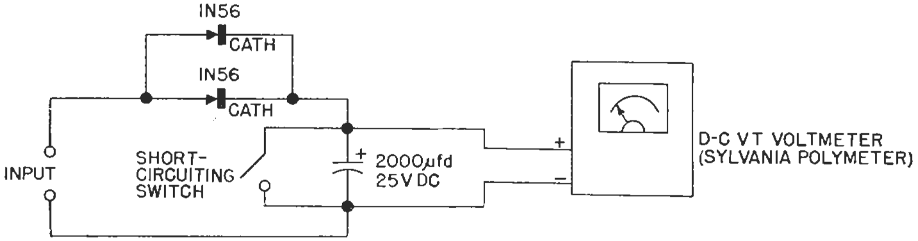


Figure 1-7. Ballistic Meter for Single Transients.

Figure 1-7 shows the circuit of a simple rectifier-storage capacitor "front end" for use ahead of a d. c. vacuum-tube voltmeter, such as the Sylvania Polymeter, to "catch" rapid, one-shot transients. The arrangement shown will indicate approximately the peak value of positive, non-repetitive pulses. Negative pulses can be checked by reversing the polarities of both the germanium diode and the electrolytic capacitor.

A fast, non-repetitive pulse charges the 2000-microfarad capacitor approximately to the pulse peak voltage. The large capacitor holds the charge due to this voltage for an interval long enough to enable the operator to read the meter. After the reading is taken, the short-circuiting switch is closed momentarily to discharge the capacitor and return the meter to zero. The instrument may be calibrated for fast transients initially by means of an oscilloscope having a voltage-calibrated screen.

1.6 SIMPLE A. C. MILLIVOLTMETER

A simple a. c. millivoltmeter circuit for a. f. and r. f. measurements is shown in Figure 1-8. The basic range of this circuit is 0-10 millivolts r. m. s. and a special feature of the circuit is its linearity. This sensitive range may be extended by means of suitable multiplier resistors connected in series with the negative terminal of the microammeter. Multiplier resistance values must be worked out experimentally, since their exact values will depend upon individual germanium diodes.

Approximately twice the specified sensitivity of 10 mv. may be obtained by employing a 4-diode bridge rectifier instead of the single diode shown in Figure 1-8. It is important that the microammeter have low internal resistance; that is, 100 ohms or less. The laboratory-type General Electric meter specified affords a sensitivity of 100 microvolts per scale division.

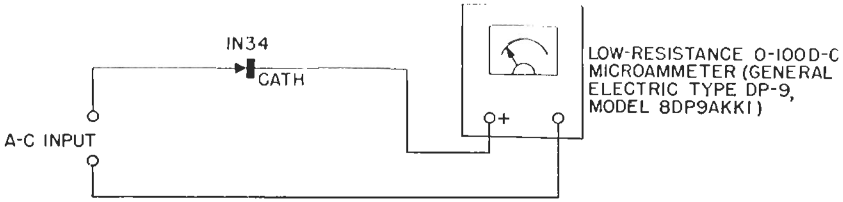


Figure 1-8. Series-type A.C. Millivoltmeter.

This is a relatively low-impedance circuit. The output circuit of the voltage source under test must supply a d. c. return for the millivoltmeter circuit, otherwise the flow of d. c. from the diode and through the microammeter will be blocked. No d. c. may be present in the signal under measurement, otherwise erroneous deflection of the meter will occur and the meter and diode may be damaged.

When a high-impedance input is required, the millivoltmeter circuit may be preceded by a simple cathode follower stage.

1.7 TRANSFORMER COUPLED A. F. MILLIVOLTMETER

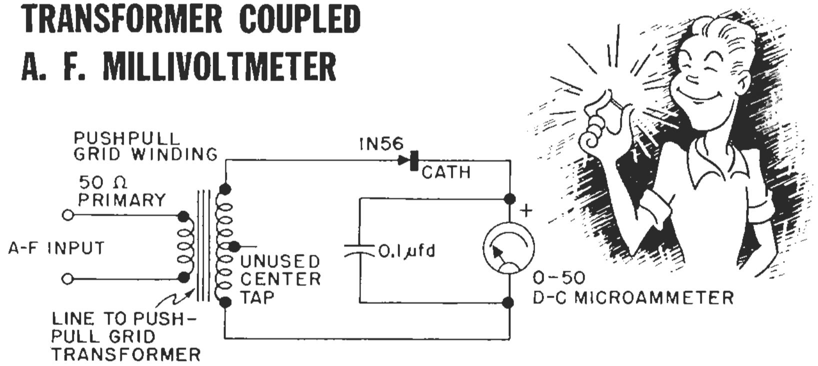


Figure 1-9. Transformer-coupled A.F. Millivoltmeter.

Audio-frequency millivolts may be measured in low-impedance circuits with the millivoltmeter circuit shown in Figure 1-9. This arrangement employs the high turns ratio of a line-to-pushpull grid transformer to step the low voltages up to values high enough to actuate the diode and microammeter. A standard, panel-mounting 0-50 d. c. microammeter is used. The Type 1N56 germanium diode provides maximum rectified current for a given signal input voltage.

Full-scale deflection of the meter is obtained with an input signal of 10 to 15 millivolts r. m. s. An individual calibration must be made. The response is not linear although it is very nearly so. The transformer must be a high-quality audio component having wide frequency response if the instrument calibration is to hold throughout the audio spectrum.

The basic range of the instrument (10 to 15 mv. full-scale) may be extended by means of appropriate multipliers connected in series with the negative terminal of the meter. The resistance values of these multipliers must be worked out experimentally for the particular diode and meter used.

Use of the transformer-coupled millivoltmeter shown here will be restricted to low-impedance voltage sources (50 ohms or less). When high-impedance input is required, the millivoltmeter circuit may be preceded with a simple cathode follower.

1.8 AUDIO-FREQUENCY MICROVOLTER

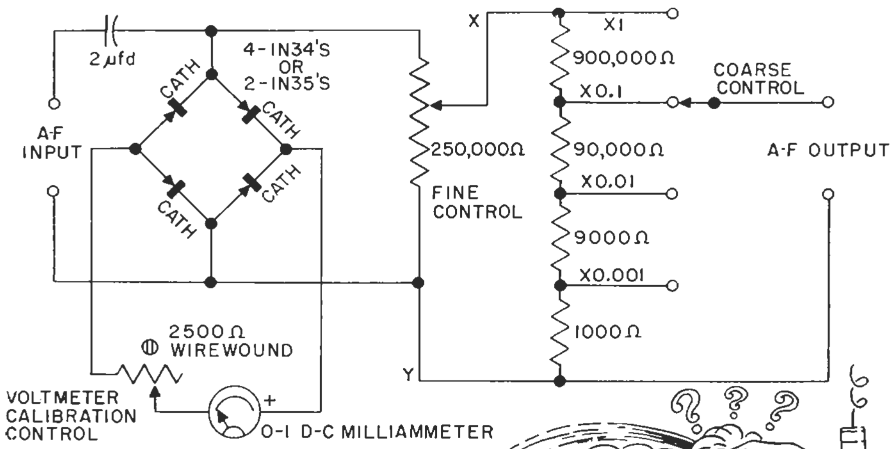
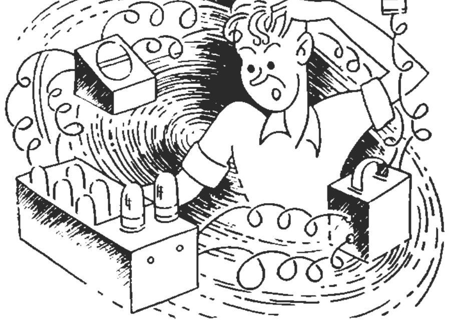


Figure 1-10. Audio-frequency Microvolter, Simplified Circuit.



This instrument is used to obtain known output voltages from an audio oscillator and is useful for checking gain and other characteristics of amplifiers and associated equipment. A COARSE CONTROL rotary switch selects either of four output ranges: 0-1 millivolt, 0-10 mv., 0-100 mv., or 0-1 volt. A FINE CONTROL potentiometer allows smooth, continuous variation of the output in any of the selected ranges. The microvolter calibration is standardized by feeding a 1-volt signal into the A. F. INPUT terminals. This 1-volt reference level is indicated by a bridge-type crystal voltmeter.

The crystal voltmeter consists of a 0-1 d. c. milliammeter, four matched 1N34 diodes (or two 1N35 dual diodes), and a screw-driver-adjusted meter calibration rheostat. To adjust the microvolter initially: (1) Feed a 1000-cycle signal into the A. F. INPUT terminals. (2) Set the FINE CONTROL potentiometer to its top (high-resistance) position. (3) Connect a high-resistance a. c. vacuum-tube voltmeter between circuit points X and Y. (4) Adjust the output of the 1000-cycle source for a 1-volt deflection of the v. t. voltmeter. (5) Adjust the VOLTMETER CALIBRATION CONTROL rheostat for exact center-scale deflection of the milliammeter. (6) Mark the FINE CONTROL dial 1 at this point. (7) Reduce the setting of the FINE CONTROL until the v. t. voltmeter reads 0.9 volt. (8) Mark this point 0.9 on the FINE CONTROL dial. (9) Repeat the procedure at each lower 1/10 volt step down to 0.1 volt deflection of the v. t. voltmeter, and mark each dial point accordingly. (10) Remove the v. t. voltmeter from the circuit.

To use the microvolter, feed the test signal into the A. F. INPUT terminals and adjust the output of the signal source for center-scale deflection of the milliammeter in the microvolter. A desired output signal level then may be obtained by proper settings of the COARSE and FINE controls. For example, 5 millivolts output is obtained by setting the FINE CONTROL to 0.5 and the COARSE control to X 0.01. (This corresponds to 0.5 of 0.01 of 1 volt or 0.005 v., which is 5 mv.).

1.9 D. C. METER COMPRESSOR

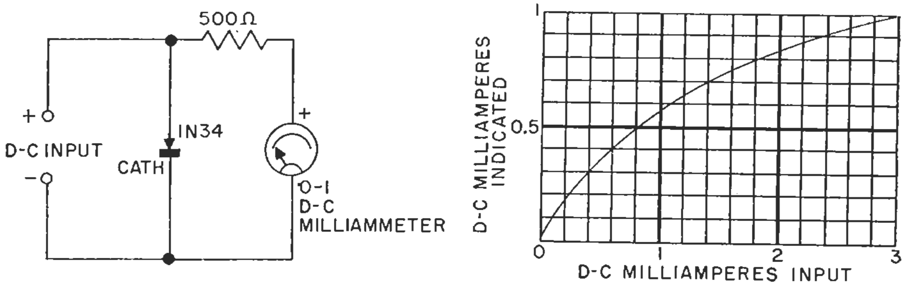


Figure 1-11. D.C. Meter Compressor.

The simple compression circuit shown in Figure 1-11 alters the normally linear response curve of a d. c. milliammeter in such a way that a small applied current produces a relatively large change in meter deflection, while larger current changes produce progressively smaller differences in deflection. One application of a compressed meter of this type is as the null detector in a d. c. resistance bridge. In this application, the meter sensitivity to changes in current level *increases* as the null point is approached—a desirable feature in bridge balancing. The "slowing down" of the meter response curve at high current levels also protects the meter against slamming when the bridge is unbalanced.

The response curve in Figure 1-11 illustrates circuit behavior with a typical 1N34 diode and 0-1 d. c. milliammeter. Response of more sensitive current meters, such as d. c. microammeters, may be compressed in the same manner. However, the meter series resistor (shown as 500 ohms for the 0-1 milliammeter in Figure 1-11) must be determined experimentally for the particular microammeter used. The value of this resistor must be such that exact full-scale deflection of the meter is obtained at the maximum current input which will be encountered.

1.10 PEAK-TO-PEAK TELEVISION VOLTMETER PROBE

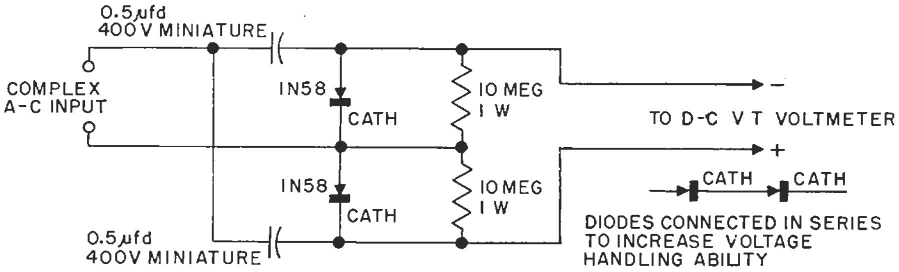


Figure 1-12. Peak-to-peak Television Voltmeter Probe.

The amplitude of the complex waveforms found in television receivers may be checked successfully with a voltmeter only when the meter responds to and indicates *peak-to-peak* voltages.

Figure 1-12 shows a typical crystal probe which can be connected ahead of a d. c. vacuum-tube voltmeter, such as the Sylvania Polymeter. With this probe, peak-to-peak values are indicated by the d. c. scales of the meter.

All values above 5 volts peak-to-peak may be read directly from the meter. Below 5 volts p-p, however, a special calibration must be made, since low-voltage non-linearity of the crystal diodes in this circuit causes the indications to be somewhat lower than true peak-to-peak values.

The probe circuit consists of two shunt-type peak rectifiers with their inputs in parallel. One rectifier responds to the positive half-cycle of applied voltage; the other to the negative half-cycle. The d. c. output of each is equal to the peak value of the corresponding half-cycle. The d. c. output circuits of the two rectifiers are in series and thus are additive. Type 1N58 diodes, as shown in Figure 1-12, permit measurement of a maximum input voltage of 200 volts peak-to-peak (70 volts r. m. s., for a sine wave voltage). This maximum may be doubled by employing two series-connected 1N58's in place of each single diode shown. The insert in Figure 1-12 shows proper polarity of connections for series diodes.

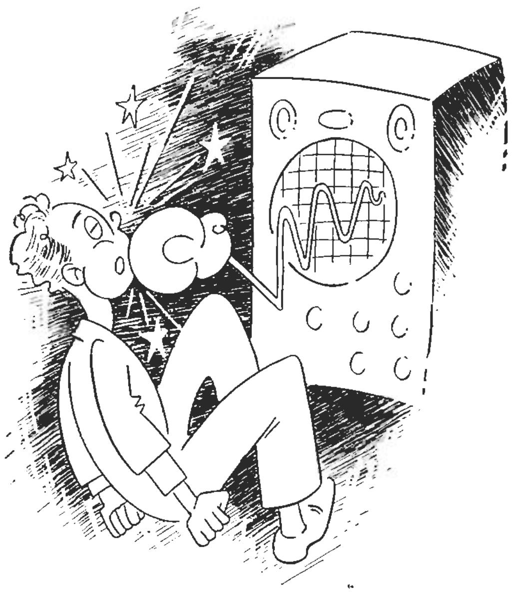
The peak-to-peak probe may be built into a small test prod with shielded container and shielded output cable. The terminal marked "x," should be connected to the tip of the probe. All waveforms, including sinusoidal, may be measured with the probe and a high resistance d. c. vacuum-tube voltmeter.

1.11 FULL-WAVE CURRENT METERS

Crystal-type a. c. milliammeters and microammeters, like crystal voltmeters, have the advantage of wide frequency response. Full wave current meters give the greatest sensitivity, since they utilize both cycles of the measured current wave. Several circuit arrangements are available for basic full-wave current meters. Figure 1-13 shows the four most satisfactory circuits; full bridge, ¾ bridge, ½ bridge, and ¼ bridge. Response of each of these circuits is non-linear, requiring a special meter scale or calibration chart. A brief description of each circuit follows.

Full Bridge. This circuit appears in Figure 1-13(A). At full-scale deflection of the meter, the a. c. input current is approximately 1.11 times the current value indicated by the d. c. meter. For best results, the four diodes must have matched characteristics, such as a 1N71.

¾ *Bridge.* See Figure 1-13(B). At full-scale deflection of the meter, the a. c. input current is approximately 1.19 times the current value indicated by the meter. For best results, the three diodes must have matched characteristics. In the absence of perfect matching of diodes, however, resistance R may be adjusted for equal-amplitude pulses, as viewed on the screen of an oscilloscope connected across the d. c. meter terminals.



½ *Bridge.* See Figure 1-13(C). At full scale deflection of the meter, the a. c. input current is approximately 1.39 times the current value indicated by the meter. For best results, the two diodes must have matched characteristics; although, in the absence of perfect diode matching, one of the resistors may be adjusted for equal-amplitude pulses, as viewed on the screen of an oscilloscope connected across the d. c. meter terminals.

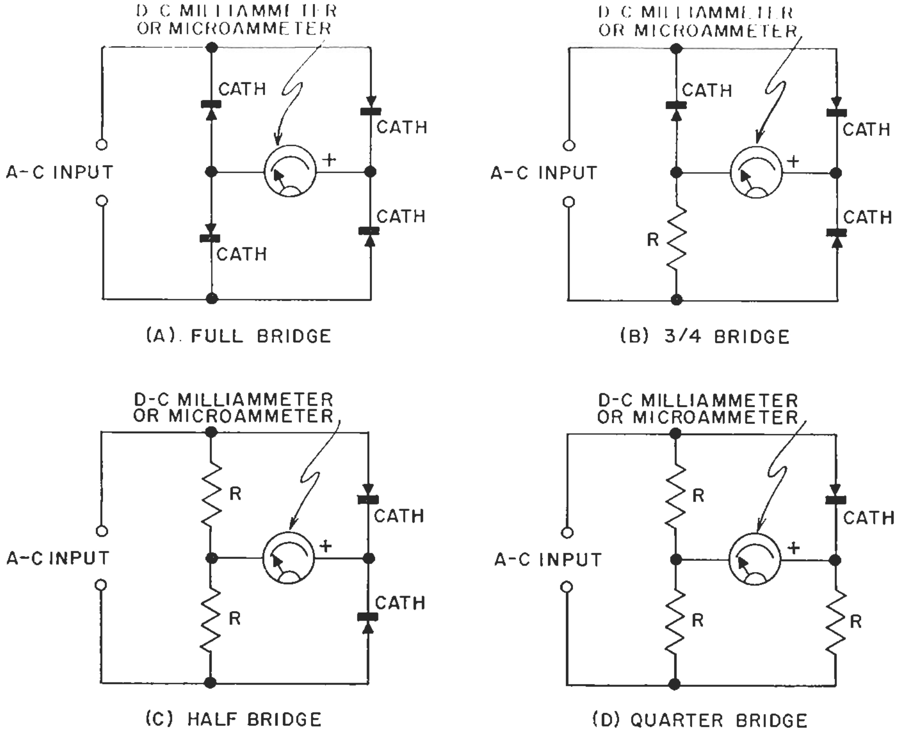


Figure 1-13. Full-wave Current Meter Circuits.

¼ *Bridge.* See Figure 1-13(D). This circuit is unique in that it provides full-wave rectification with a single diode. However, it has the lowest efficiency of any of the circuits given. In spite of its low output; economy simplicity, and compactness often will dictate its use. At full-scale deflection of the meter, the a. c. input current is approximately 2.78 times the current value indicated by the meter. One of the input resistors must be adjusted for equal-amplitude pulses, as viewed on the screen of an oscilloscope connected across the d. c. meter terminals.

Resistors. The resistors shown at (B), (C), and (D) in Figure 1-13 replace diodes in the 4-arm bridge circuits. In (C) and (D), these resistors are equal in value, except where one resistor is adjusted as described in the three preceding paragraphs. The following Table shows the maximum value which each resistor can have.

D. C. METER	MAXIMUM *R* RESISTANCE
0-1 ma.	5,000 ohms
0-500 ua.	10,000 "
0-200 "	25,000 "
0-100 "	50,000 "
0-50 "	100,000 "
0-20 "	250,000 "

Multiplied Ranges. Higher ranges may be provided for the crystal-type current meters by connecting an appropriate shunt resistor for each desired range across the A. C. INPUT terminals. The resistance of the shunt must be such that the current flowing through it will be the difference between the total current to be measured and the a. c. current normally flowing into the crystal-meter circuit.

1.12 SERIES-CONNECTED DIODES FOR HIGH-VOLTAGE A. C. METERS

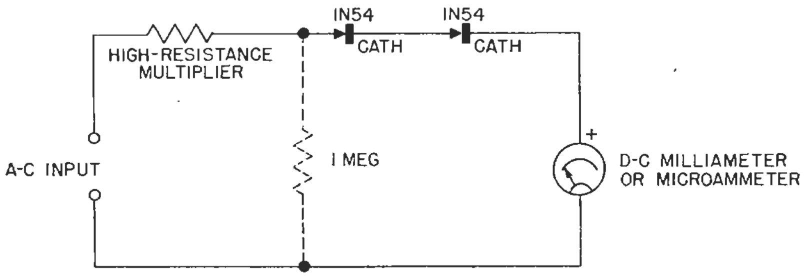


Figure 1-14. Series-diode Arrangement for High-voltage A.C. Voltmeters.

In simple, half-wave a. c. voltmeters for all voltages higher than 50 v. r. m. s., it is advisable to connect two germanium diodes in series for rectification (See Figure 1-14). There are two reasons for this. First; high-voltage multipliers have high resistance values, and when this resistance is comparable to the back resistance of a single diode in a voltmeter circuit, rectification efficiency is reduced. Second, the two diodes in series are better able to withstand the high peak inverse voltages encountered. In a series-diode circuit, such as Figure 1-14, the increased forward resistance due to the second diode is negligible compared to the high resistance of the multiplier, and does not detract from the advantage of increased back resistance. The 1 megohm resistor (shown in dotted lines) may be used to provide a better return path for the meter circuit when the multiplier resistor is an extremely high value for measuring high a. c. voltages.

Type 1N54 is a special high-back-resistance diode. This type has a resistance of at least 1 megohm at -10 v. and is especially suitable for the circuit of Figure 1-14. Each diode in the Type 1N35 dual unit likewise has at least 1 megohm resistance at -10 v. and this type provides both diodes for the series connection.

GERMANIUM DIODE INSTALLATION HINTS

1. Use the type of diode specified in the circuit diagrams. These types have been selected carefully to withstand circuit voltages and other operating conditions.
2. When soldering the diode into the circuit, hold the pigtail leads with a pair of long-nosed pliers. This will prevent heat from the soldering iron from entering and possibly damaging the crystal unit.
3. In all installations, use as much of the pigtail lead length as possible.
4. While the Germanium Diode is a rugged component, the user is cautioned against deliberately dropping the diode to the floor, tapping on it, or otherwise handling it in a rough manner so as to expose it unnecessarily to mechanical shock.
5. Mount the crystal diode so that it is reasonably free from severe mechanical vibration.
6. Keep the crystal diode as far as possible from heated objects.
7. Observe the diode polarity shown in the diagrams. The cathode terminal is plainly marked with the abbreviation "CATH" and with a wide band.

CHAPTER II

COMMUNICATION APPLICATIONS

2.1 IMPROVED LOW-LEVEL FREQUENCY MULTIPLIER

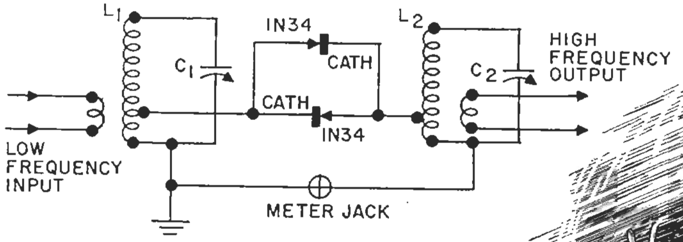
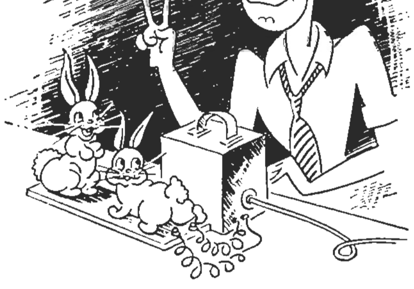


Figure 2-1. Improved Low-level Frequency Multiplier.



Several germanium diode radio-frequency multiplier circuits have been published in previous literature. Figure 2-1 shows an improved arrangement for multiplication at low power levels. In this circuit, two germanium diodes are connected in parallel with reversed polarity to pass current on both halves of an *unmodulated* r. f. cycle, and are tapped down the input and output tank coils for improved impedance matching. This circuit utilizes to the fullest advantage the non-linear (distorting) characteristic of the diode response curve to produce harmonics of the input frequency.

The input tank, L_1C_1, is tuned to the frequency of the input signal. The output tank, L_2C_2, is tuned to the desired harmonic. The diodes are tapped from 1/2 to 1/3 the way up from the grounded end of each tank coil. A radio-frequency milliammeter may be inserted at the meter jack to check current through the diodes. This current must not exceed *twice* the average anode current recommended for the type of diode used. This current value, for example, would be 100 ma. for two Type 1N34's, 120 ma. for 1N56's, etc. Maximum frequency multiplying efficiency will be obtained at low current levels (meter readings of ¼ milliampere and under), the region in which diode non-linearity is greatest. The two diodes need not be matched; in fact multiplying action is enhanced somewhat by mismatch.

While the germanium diode frequency multiplier is a low-power device, it nevertheless will find application in high-sensitivity transmitter exciters and in other experimental equipment where frequency multiplication can be carried out at low power levels ahead of high-gain pentode or beam power amplifiers.

2.2 HARMONIC ACCENTUATOR FOR EXCITERS

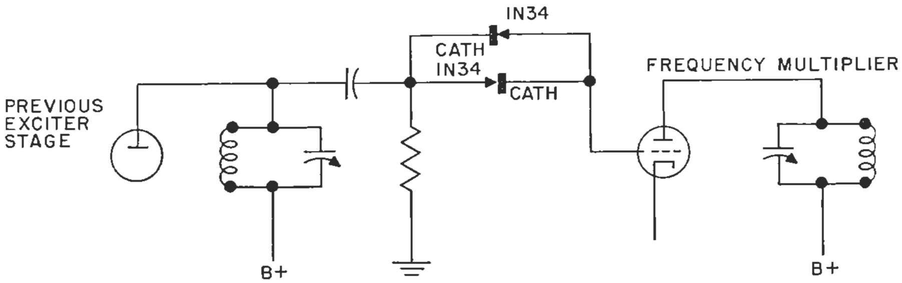


Figure 2-2. Harmonic Accentuator for Exciters.

Figure 2-2 shows how a pair of germanium diodes may be connected in the grid circuit of a frequency multiplier stage in a transmitter to raise harmonic output. By distorting the grid current fluctuations and thus emphasizing harmonics in the r. f. excitation voltage, the effectiveness of the multiplier stage is increased. This arrangement is particularly favorable to odd harmonics (3rd, 5th, etc.). Grid resistor bias is shown in Figure 2-2, but the scheme may be employed also in multiplier stages which employ bias-voltage supplies or cathode resistor bias.

2.3 SIMPLE CUEING RECEIVER

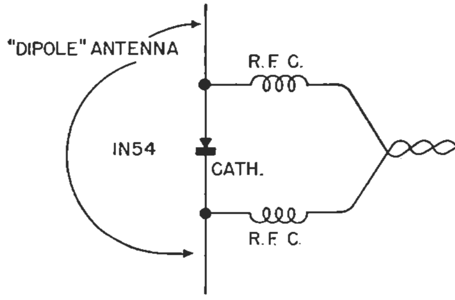
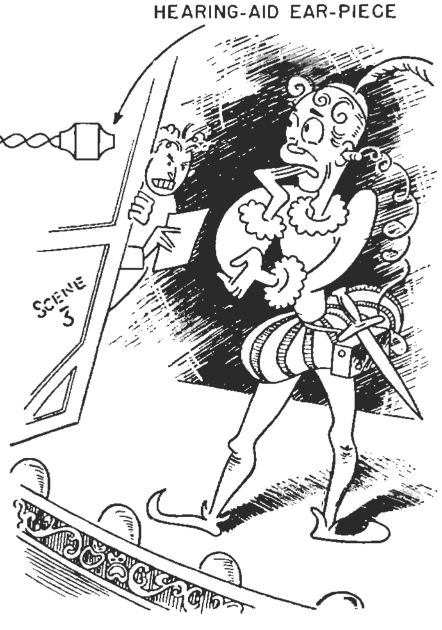


Figure 2-3. Simple Cueing Receiver.



Where the surrounding noise level is not excessive, a stage manager or program director on the sidelines with a portable u. h. f. radiotelephone transmitter can "cue" actors or announcers through simple personal receivers of the type shown in Figure 2-3. The receiver may be carried in a pocket or hidden in some convenient part of a costume, need not be any larger than a book of safety matches, and the two short lengths of flexible insulated wire which comprise the "dipole" antenna may be stretched by stitching conveniently into the costume. The antenna length is not particularly critical, a useful amount of energy being picked up by brute force from the nearby transmitter. A foot or so of length in each section usually will suffice. The number of turns in the r. f. chokes will depend upon the transmitter frequency. A rule of the thumb is to measure off (for each choke) ¼ wavelength of No. 30 cotton covered wire and wind two closewound coils on insulated rods or sticks about the same diameter as the germanium diode.

At noisy locations, output of the crystal cueing receiver may be fed into a conventional hearing aid as a booster audio amplifier.

The information in this book is furnished without assuming any obligations.

2.4 AMPLIFIER PROTECTIVE RELAY

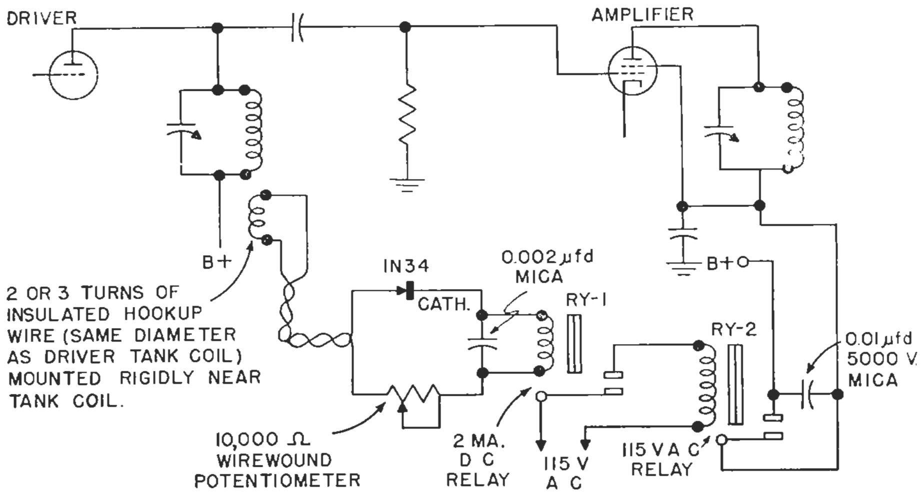


Figure 2-4. Amplifier Protective Relay.

The scheme shown in Figure 2-4 protects a grid resistor-biased beam power amplifier in a transmitter against damage due to loss of bias when excitation fails or drops to a low level. Since the protective circuit is operated by r. f. energy from the exciter, it is controlled directly by excitation level. This arrangement allows the advantages of resistor bias to be utilized with complete protection.

A small amount of r. f. energy is picked up by the coupling coil mounted rigidly near the driver plate tank coil. This energy is rectified by the 1N34 diode and the resultant d. c. used to hold-in the sensitive d. c. relay, RY-1. The setting of the 10,000-ohm potentiometer and the coupling coil spacing both are adjusted by trial so that the relay RY-1 opens when the amplifier grid bias drops to the minimum permissible voltage level. Relay RY-1 in turn controls a 115-volt a. c. relay, RY-2, which removes plate and screen voltage from the amplifier whenever excitation falls to the level corresponding to minimum permissible grid bias. Both of the relays are normally open. Although a single-ended amplifier capacitance-coupled to the driver is shown in Figure 2-4, the protective relay scheme may be applied as well to pushpull amplifiers and to other methods of interstage coupling.

2.5 CARRIER-OPERATED RECEIVER MUTING SYSTEM

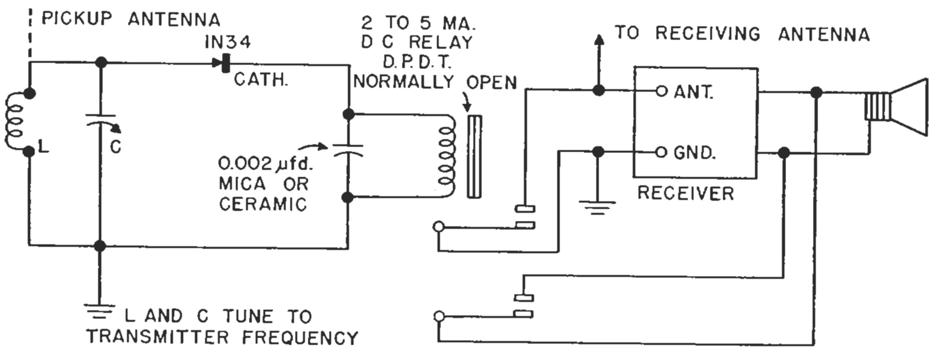


Figure 2-5. Transmitter (Carrier) Operated Receiver Muting System.

In Figure 2-5, the transmitter carrier is rectified by a 1N34 diode and the resultant d. c. applied to a sensitive relay. When the relay closes as a result of the carrier coming on, one pair of its contacts short-circuits the antenna input terminals of the receiver, while the other pair short-circuits the loudspeaker voice coil. This scheme eliminates the usually heavy-duty transmit-receive switch or relay system, and is particularly applicable to a receiver which must be located at some distance from the transmitter. Since this arrangement permits the receiver to operate continuously at its normal voltages. standby drift is eliminated. When the transmitted carrier is interrupted, the receiver automatically is recommissioned. Modulation does not affect the relay.

Coil L and capacitor C are chosen to resonate at the carrier frequency. In the neighborhood of a transmitter of reasonable power, sufficient energy may be picked up without an antenna. Farther away, a small pickup antenna will be required. This may be a random length of insulated wire or a short vertical rod.

2.6 VOICE (MODULATION) CONTROLLED RELAY

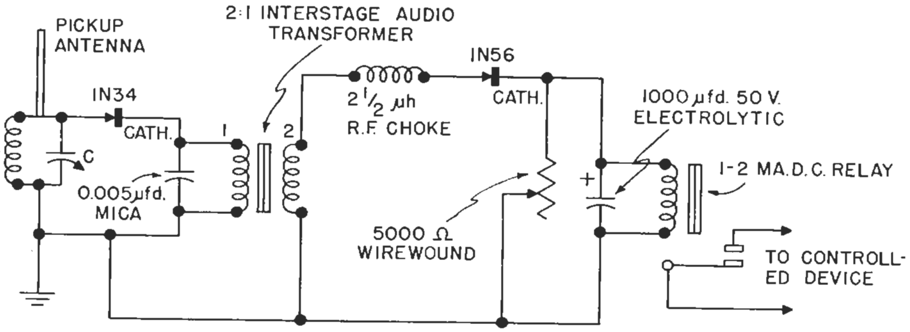


Figure 2-6. (Voice Modulation) Controlled Relay.

Voice-controlled systems depend upon control action obtained with the modulation component of energy picked up from a modulated transmitter. Such systems operate only while modulation is present and release in the absence of modulation. Presence of the carrier component has no effect. Typical applications are voice-controlled receivers, instruments, switching devices, etc. associated with the transmitting station.

Figure 2-6 shows a simple voice control receiver which is small enough to be built into an inconspicuous box. The coil-capacitor combination, L-C, is tuned to the transmitter carrier frequency. The 1N34 acts as a detector or demodulator. The modulation component obtained by means of the 1N34 is passed by the coupling transformer to the 1N56 which acts as a modulation rectifier. D. C. output of the 1N56 is applied to a 1- or 2-milliampere d. c. relay which accordingly is picked up as a result of presence of modulation.

The length of time the relay is held-in after modulation ceases may be controlled by the 5000-ohm potentiometer and 1000-microfarad electrolytic capacitator shunting the relay coil. The less resistance cut into the circuit by the potentiometer, the faster will be the relay dropout, and vice versa. Thus, the potentiometer may be set at one extreme to drop the relay out after each ordinary spoken word, or at the other extreme so that the relay holds-in for several seconds after speech modulation ceases.

2.7 MONITOR RECEIVER FOR BROADCAST TRANSMITTER LOCATION

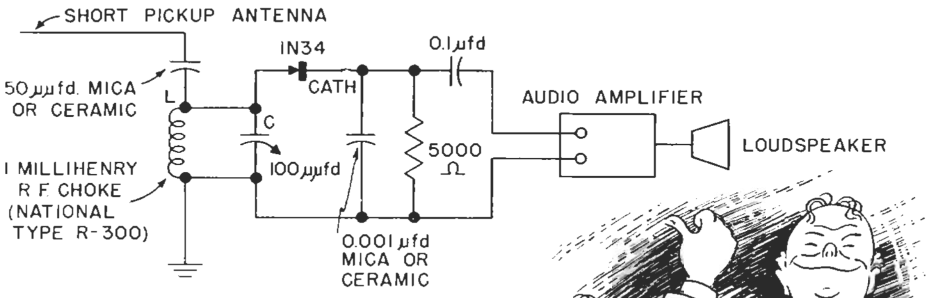


Figure 2-7. Monitoring Receiver for Broadcast Transmitter Location.

For continuous aural monitoring (via loudspeaker) of a broadcast station straight from the air, a simple crystal "front end" may be coupled to a small audio amplifier. Details of this arrangement are shown in Figure 2-7.

A short pickup antenna, consisting of a vertical rod or a random length of insulated wire, is all that is required with the receiver to deliver a husky audio signal to the amplifier input terminals. The L-C tuning combination specified in Figure 2-7 is designed to cover the 500-1600 kc. range. Tuning capacitator C can be a miniature air trimmer pre-set to the transmitter frequency. If frequencies higher than 1600 kc. must be reached, a few turns may be removed from the 1-millihenry. r. f. choke, L, to obtain resonance. The audio amplifier need not be bulky nor complicated, since the a. f. output of the diode detector will be high in the neighborhood of the transmitter. One voltage amplifier stage and a single power output stage usually will suffice. The amplifier can be of the AC-DC type if economy dictates.

Audio fidelity of the diode detector is good. Sensitivity of the receiver is low; but this is an advantage, since reduced sensitivity prevents pickup of interference from other stations on the same frequency and also from nearby "static" sources.

2.8 A. M. RECEIVER NOISE LIMITER

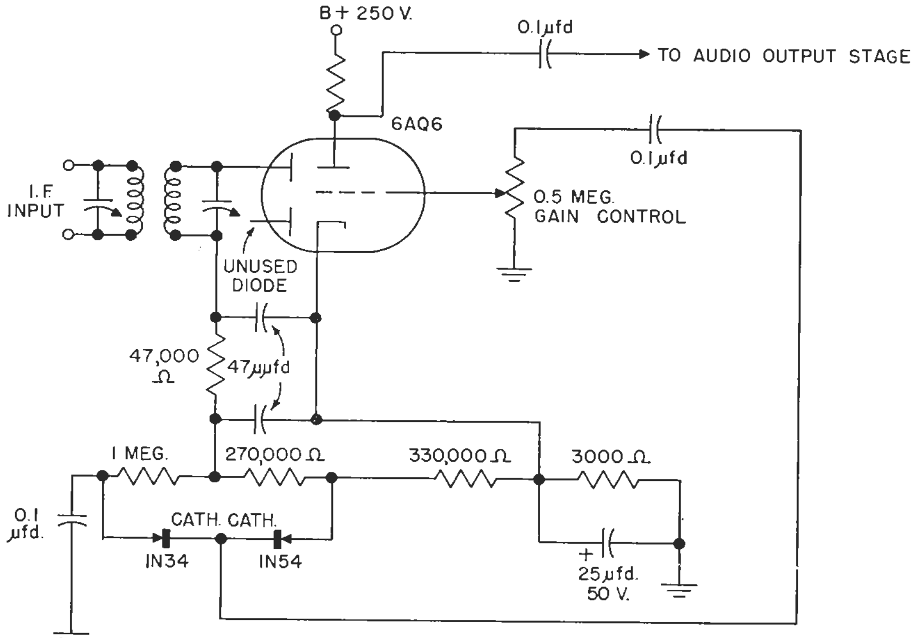


Figure 2-8. Impulse Noise Limiter.

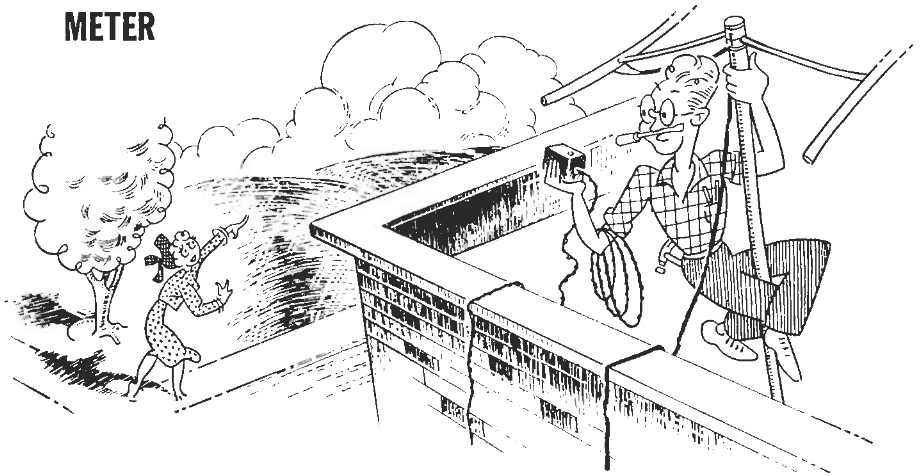
A combination series-shunt automatic impulse noise limiter for A. M. receivers is shown in Figure 2-8. This circuit is arranged around the combined 2nd detector-1st audio stage of the receiver, requires few parts, and is quite compact. The series clipper component is a 1N54 diode. This type has high back resistance which adapts it to this position in the circuit. The shunt clipper component is a standard 1N34 diode. The circuit is self-adjusting to the *average* level of the intermediate-frequency signal.

The information in this book is furnished without assuming any obligations.

CHAPTER III

T. V. AND RADIO SERVICE DEVICES

3.1 T. V. ANTENNA ORIENTATION METER



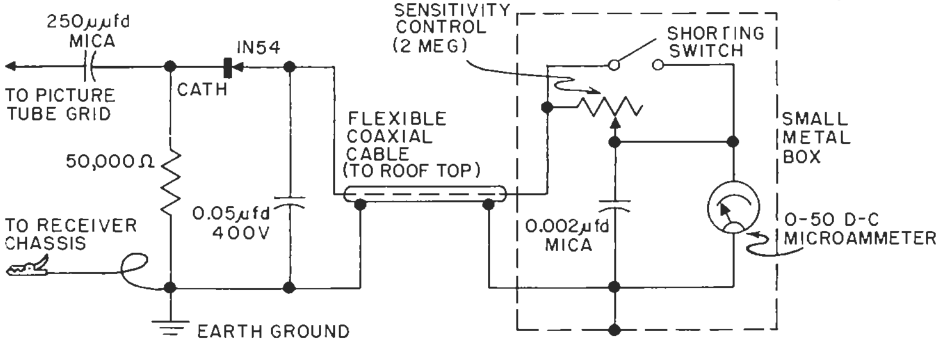


Figure 3-1. T.V. Antenna Orientation Meter.

A meter giving peak deflection when a television receiving antenna is lined up properly with the transmitting station is invaluable in antenna installation work. Figure 3-1 shows the circuit diagram of an antenna orientation meter of this type.

The 1N54 diode and the two capacitors and one resistor associated with it may be enclosed in a small probe. Connections from the diode pickup circuit are made to the receiver chassis and picture-tube grid. (The picture-tube cathode must be used if the video signal is applied to the cathode in the receiver used). D. C. output from the diode is fed through a flexible coaxial cable to the roof top where the antenna installation is being made. The receiver is switched-on and tuned carefully to a desired channel frequency.

As the antenna is rotated, the meter reading will increase as the antenna becomes aligned with the station, and will be maximum when the antenna points directly toward the signal source. Ghosts show up as double peaks as the antenna is rotated. The 2-megohm SENSITIVITY CONTROL rheostat allows the signal voltage to be cut down at will to prevent slamming of the meter. When the received signal is too weak for full-scale deflection, the rheostat may be cut out of the circuit by closing the short-circuiting switch.

3.2 SELF-CONTAINED FIELD STRENGTH METER

The antenna orientation meter described in Section 3.1 requires connection to a working television receiver. It also necessitates running a cable from inside the building to the roof. For the same purpose of antenna adjustment, self-contained field strength meters are available, but these instruments are 115-volt operated and have the disadvantage that a power line for their operation must be pulled to the roof.

A self-contained field strength meter operated free from the power line and requiring not even batteries may be made with a germanium diode detector. Such an instrument consists simply of a tuned circuit (tuneable to the desired t. v. channel frequency) connected to the crystal millivoltmeter described in Section 1.6, Chapter 1. The antenna is coupled into the coil of the tuned circuit by means of a small coil connected across the conductors of the feeder line. The feeders also may be connected across a few turns of the coil.

The tuning capacitor may be a 100-uufd. air variable Coils for the various channels may be wound from data on coil specifications found in the various radio handbooks.

3.3 DEMODULATOR PROBE FOR T. V. OSCILLOSCOPE

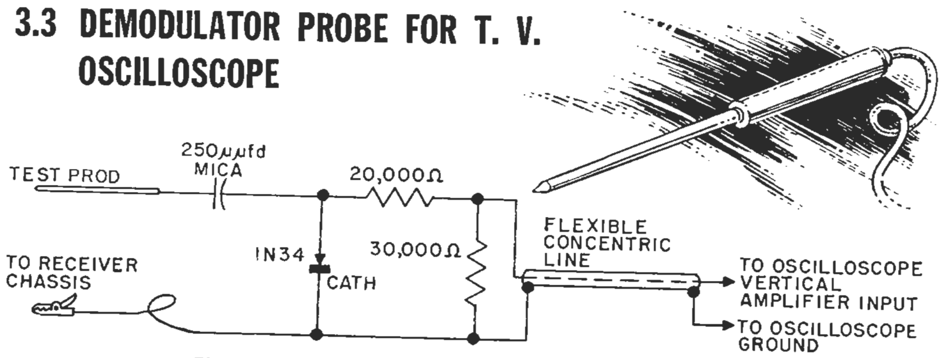
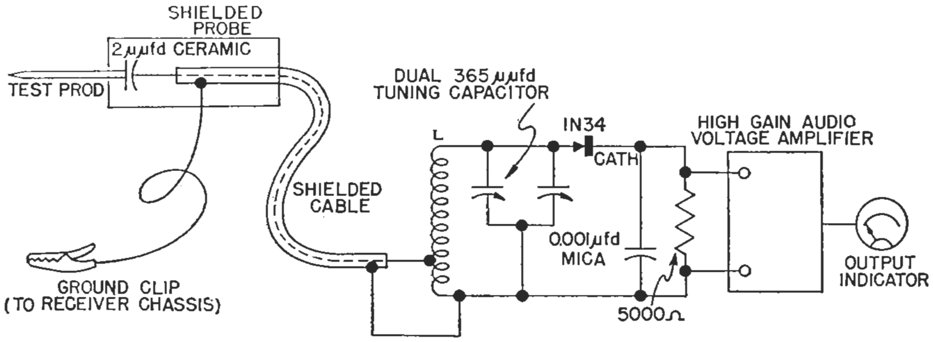


Figure 3-2. Demodulator Probe for Oscilloscope.

Visual alignment methods are required in television servicing. When an oscilloscope is used in the alignment and testing of television r. f., i. f., and sometimes video stages, the high-frequency signals must be demodulated before presentation to the vertical amplifier of the oscilloscope. A germanium diode probe circuit is employed for demodulation.

Figure 3-2 shows the circuit of a demodulator probe employing a Type 1N34 diode. All of the components may be enclosed in a shielded-handle test prod. The cable may be made up to 4 feet in length before shunting capacitance becomes objectionable, however, this cable should be kept as short as practicable.

3.4 TUNED CRYSTAL-TYPE SIGNAL TRACER



COIL (L) VALUES

400-1200 KC	90 TURNS NO 32 ENAMELLED WIRE CLOSEWOUND ON 1¼" DIAMETER FORM. TAP 18 TURNS FROM BOTTOM END.
1100-3200 KC	56 TURNS NO 30 ENAMELLED WIRE CLOSEWOUND ON 5/8" DIAMETER FORM. TAP 12 TURNS FROM BOTTOM END.
3-10 MC	20 TURNS NO 30 ENAMELLED WIRE ON 5/8"-DIAMETER FORM. SPACE TO WINDING LENGTH OF 1 3/16". TAP 4TH TURN FROM BOTTOM END.
8-30 MC	6 TURNS NO 24 ENAMELLED WIRE ON 5/8"-DIAMETER FORM. SPACE TO WINDING LENGTH OF 5/8". TAP 2ND TURN FROM BOTTOM END.

Figure 3-3. Tuned Signal Tracer.

Signal tracers are justifiably popular for tracking down trouble in radio receivers. An amplitude-modulated test signal is used in the signal tracing operation. Most simple signal tracers consist of a crystal-type demodulator probe connected to the input circuit of a high-gain audio voltage amplifier. An output indicator, such as an a. c. voltmeter, headphones, or magic eye tube, shows relative signal strength (or absence of signal) at various test points. Worthwhile improvement is obtained when the signal tracer can be tuned to the carrier frequency of the test signal, but conventional tuned signal tracers (channel analyzers) contain many tubes and are both complicated and expensive.

Figure 3-3 shows a simplified, tuneable signal tracer. The input stage embodies a single tuned circuit and 1N34 detector. This is, in effect, a crystal receiver. The exploring test prod is connected to the tuned circuit through a 2-uufd. capacitor which serves to isolate the instrument from the circuit under test and from the operator's fingers, thereby preventing detuning of tested circuit. Output of the diode detector is fed into a high-gain audio amplifier terminated by an output meter. For a. c. operation, the amplifier may consist of a resistance-coupled 6AU6-6AQ5 combination. For fully-portable battery operation, a 1U4-3S4 resistance-coupled lineup may be used.

Tuning of the signal tracer is accomplished by means of a dual 365-uufd. midget variable capacitor with its two sections connected in parallel. The complete tuning range is 400 kc. to 30 Mc. in four ranges: 400-1200 kc., 1100-3200 kc., 3-10 Mc., and 8-30 Mc. This range includes all i. f., r. f., and oscillator frequencies ordinarily encountered in the servicing of radio receivers. The coils may be wound from instructions given in Figure 3-3 or may be commercially available all-band coils. They may be made plug-in for range changing, or a rotary selector switch may be used with self-contained coils for band switching. The dial attached to the tuning capacitor may be calibrated by feeding-in modulated signals from a signal generator, and can be graduated directly in kilocycles and megacycles.

In addition to its intended use as a tuneable signal tracer, this instrument may be used also to check r. f. test oscillators and signal generators, transmitters, and carrier control equipment.

3.5 TELEVISION VIDEO DETECTOR

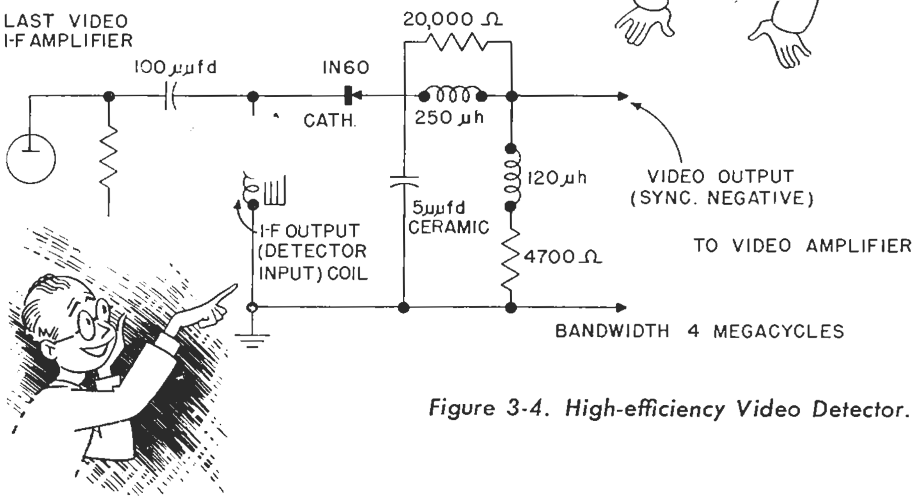


Figure 3-4. High-efficiency Video Detector.

The lower dynamic impedance and increased efficiency of the germanium diode recommend use of this component in a number of circuits in place of the usual diode tubes. Other advantages obtained at the same time are compactness, heatless operation, low shunt capacitance, simple wiring, and elimination of filaments. A typical application is the germanium diode video detector for television receivers.

In Figure 3-4, a video detector circuit is designed around the Type 1N60 which is a special video detector diode. Circuit constants are given for 4-megacycle bandwidth.

Improved receiver performance has been reported by service technicians and by experimenters who have incorporated this video detector into t. v. receivers.

TO OBTAIN ALL TYPES OF SYLVANIA GERMANIUM DIODES SEE THE SYLVANIA RADIO TUBE DISTRIBUTOR NEAREST YOU. YOU WILL FIND HIM LISTED IN THE YELLOW PAGES OF YOUR TELEPHONE DIRECTORY UNDER "RADIO SUPPLIES AND PARTS."

3.6 F. M. — T. V. DISCRIMINATOR

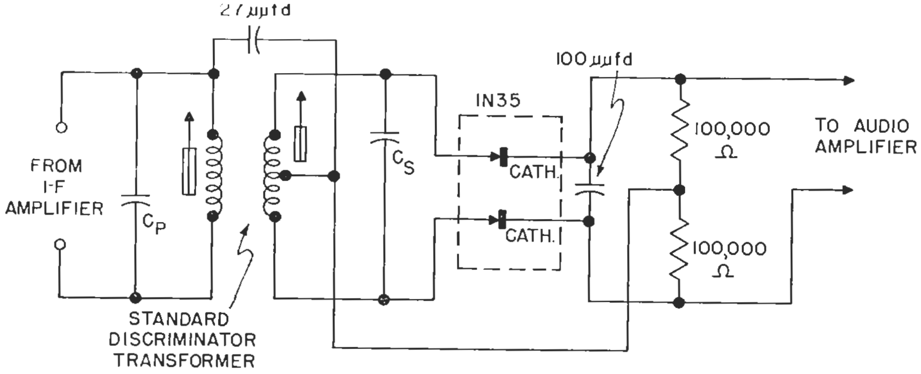


Figure 3-5. F.M.-T.V. Discriminator.

The improved forward and reverse characteristics of the two matched diodes in the Type 1N35 dual diode unit are exploited fully in the simplified discriminator circuit shown in Figure 3-5. The increased reverse resistance of the 1N35 allows the use of the high (100,000-ohm) load resistors for best circuit efficiency and without any improvising.

This discriminator may be employed in regular F. M. receivers, as well as in sound channels in television receivers. If a pair of matched 100,000-ohm resistors is used, no adjustments will be required beyond the usual alignment of the input transformer.

3.7 F. M. DYNAMIC LIMITER

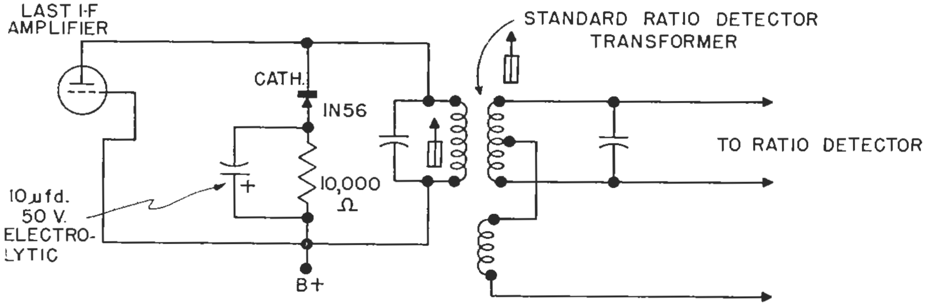


Figure 3-6. F.M. Dynamic Limiter.

Figure 3-6 shows a germanium-type dynamic limiter which has none of the complexity of tube-type stages of the same type. This circuit may be applied in F. M. receivers and t. v. sound channels. The threshold level is variable and reaches low signal levels. Interchannel background noise, as well as audio buzz in intercarrier-type television receivers, are quieted by this limiter circuit.

Chief feature of the limiter is the self biased Type 1N56 high conduction diode which is connected in parallel with the primary of the detector input transformer (ratio detector or discriminator). Diode bias is developed across the 10,000-ohm diode series resistor. The shunting capacitor is a 10-microfarad electrolytic. The time constant of this R-C combination is satisfactory for rejection of amplitude-modulated multipath interference components, 60-cycle blanking pulses, and similar phenomena.

3.8 T. V. CASCADE SYNC CLIPPER

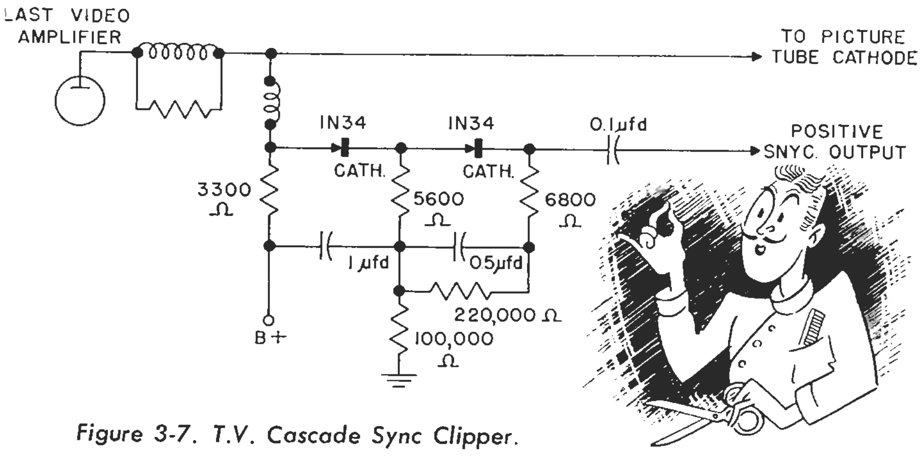


Figure 3-7. T.V. Cascade Sync Clipper.

A high-level sync clipper is shown in Figure 3-7. The two cascaded 1N34's in this circuit are supplied with fixed bias partially derived from the plate load resistor of the last video amplifier. The biasing network for each diode has a long time constant. The high-frequency compensation of the video output stage is unaffected by shunting the clipper circuit across this output, because of the low diode capacitance.

Stripping action of the two diodes is cumulative, since the clipping level of the second diode is determined by the partially separated sync pulse output of the first diode. Separation is sharp, and sync pulse output of the clipper is completely free of video information.

3.9 A. G. C. PEAK DETECTOR

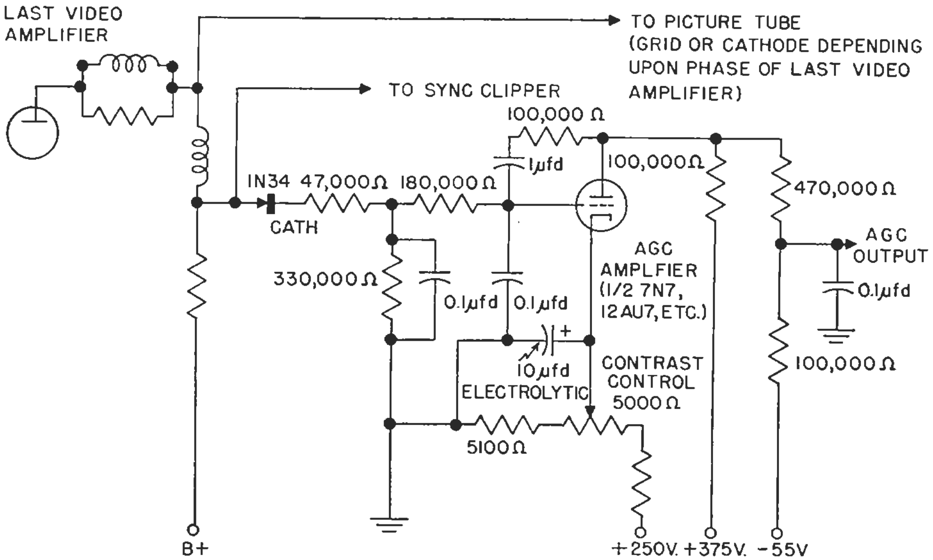


Figure 3-8. A.G.C. Peak Detector and Amplifier for T.V.

In the circuit of Figure 3-8, a 1N34, direct-coupled to the plate output of the last video amplifier, is used as an A. G. C. detector. This diode conducts only during the sync interval because of the lengthened discharge time constant of its load circuit. The positive d. c. voltage output of the diode detector is R-C filtered and presented to the control grid of the A. G. C. amplifier tube.

The control rate of the circuit takes care of all but very fast fading; however the receiver gain does not alter appreciably during vertical blanking periods, so vertical sync pulses are not "pushed down."

3.10 T. V. VERTICAL PULSE SEPARATOR

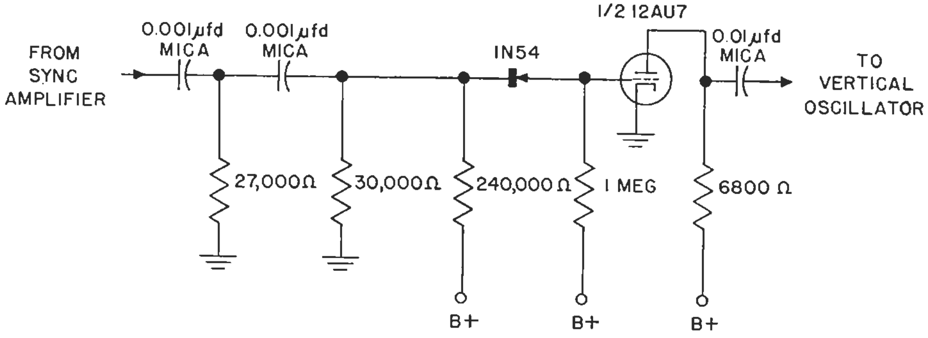


Figure 3-9. T.V. Vertical Pulse Separator with Limiter-Inverter.

A biased 1N54 diode in the circuit shown in Figure 3-9 follows a 2-stage differentiating network, and clips horizontal components from the applied sync signal. The negative vertical pulses in the diode output then are applied to the grid of a triode which amplifies, squares, and inverts them. The output pulses are steep-fronted, of high amplitude, and positive in polarity. This circuit affords stable vertical sync minus interlace jitter and line pairing. The low interelectrode capacitance of the 1N54 improves pulse discrimination.

GERMANIUM DIODE INSTALLATION HINTS

1. Use the type of diode specified in the circuit diagrams. These types have been selected carefully to withstand circuit voltages and other operating conditions.

2. When soldering the diode into the circuit, hold the pigtail leads with a pair of long-nosed pliers. This will prevent heat from the soldering iron from entering and possibly damaging the crystal unit.

3. In all installations, use as much of the pigtail lead length as possible.

4. While the Germanium Diode is a rugged component, the user is cautioned against deliberately dropping the diode to the floor, tapping on it, or otherwise handling it in a rough manner so as to expose it unnecessarily to mechanical shock.

5. Mount the crystal diode so that it is reasonably free from severe mechanical vibration.

6. Keep the crystal diode as far as possible from heated objects.

7. Observe the diode polarity shown in the diagrams. The cathode terminal is plainly marked with the abbreviation "CATH" and with a wide band.

CHAPTER IV

EXPERIMENTAL APPLICATIONS

4.1 AMPLITUDE MODULATOR

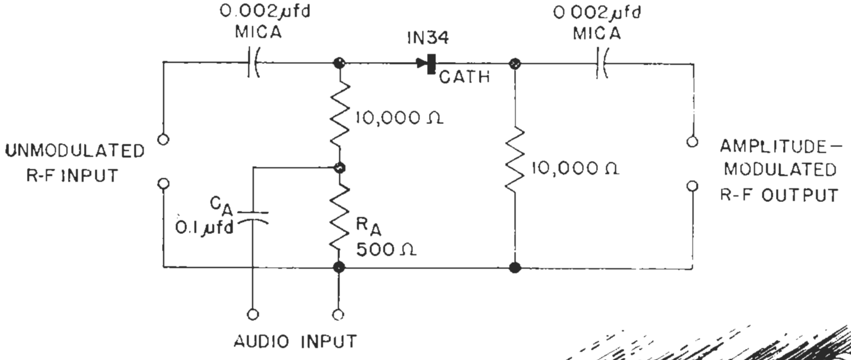
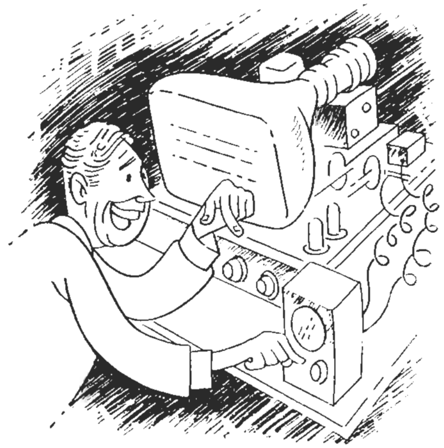


Figure 4-1. Germanium Diode Amplitude Modulator.

A simple amplitude modulator with a host of applications in test instruments and electronic control gear is shown in Figure 4-1. With a minimum of components, this circuit utilizes the ability of a non-linear component such as the 1N34 germanium diode to accomplish modulation.

In a typical application, unmodulated r. f. from an oscillator or signal generator is fed into one pair of input terminals, and an audio modulating signal into the second pair of input terminals. Amplitude-modulated r. f. then is available at the output terminals. The wide frequency range afforded by the germanium diode also permits the modulation of one r. f. signal by another r. f. signal, or modulation of one audio signal by another audio signal.



The diode modulator may be employed for externally modulating a signal generator, for producing amplitude modulation at low power levels in radio and carrier-current transmitters, tone-modulating received signals (by inserting the modulator in the i. f. amplifier of a receiver), and for producing a modulated ("two-tone") audio test signal for special amplifier checking. Since no coupling transformer is present in the modulation input circuit, high modulating frequencies extending far into the r. f. spectrum may be used with ease. The diode modulator can be operated at ultra-high frequencies, if desired.

One application of the diode modulator of interest to television receiver technicians is its use as a bar generator for t. v. linearity alignment patterns. For this application (1) connect an unmodulated r. f. test oscillator or signal generator tuned to a desired t. v. channel to the modulator r. f. input terminals. (2) Connect the antenna input of the receiver to the modulator output terminals. (3) Connect a modulating signal generator to the audio input terminals of the modulator. When the frequency of the modulating generator is in the audio range (up to about 20,000 cycles), horizontal parallel bars will appear on the picture tube screen. When the modulating frequency is in the r. f. spectrum (100 kc. and higher), vertical parallel bars will appear on the screen. In each case, the number of bars increases as the modulating frequency is increased.

When the waveform of the modulating voltage is non-sinusoidal, such as square waves or pulses, the values of capacitor Ca and resistor Ra may have to be changed to prevent distortion of the modulation waveform.

4.2 BRIDGED-T PHASE MODULATOR

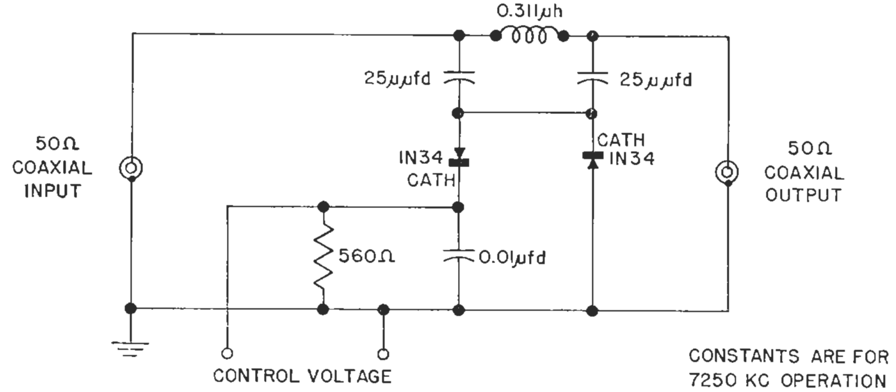


Figure 4-2. Bridged-T Germanium Phase Modulator.

Figure 4-2 shows an ingenious bridged-T circuit in which a pair of germanium diodes replaces the usual resistance arm of the conventional bridged-T network. The resistance of the diodes, and therefore the network transmission characteristic, is varied by means of a control voltage applied to the diodes. This circuit was developed by Dr. M. G. Pawley of the National Bureau of Standards.

An important property of this circuit is its ability to give an appreciable phase shift between input and output voltages with negligible amplitude attenuation. 90-degree phase shifts have been obtained. Another important property is ability of the circuit to function as a simple phase modulator. For this application, the modulator may be inserted in the coaxial line between two low-level stages of a phase-modulated transmitter.

Circuit constants in Figure 4-2 are those given by Dr. Pawley for 7250-kc. operation with 50-ohm input and output impedances. Constants for operation at other frequencies, audio and radio, may be obtained by means of standard bridged-T calculations.

The information in this book is furnished without assuming any obligations.

4.3 SPIKE GENERATOR

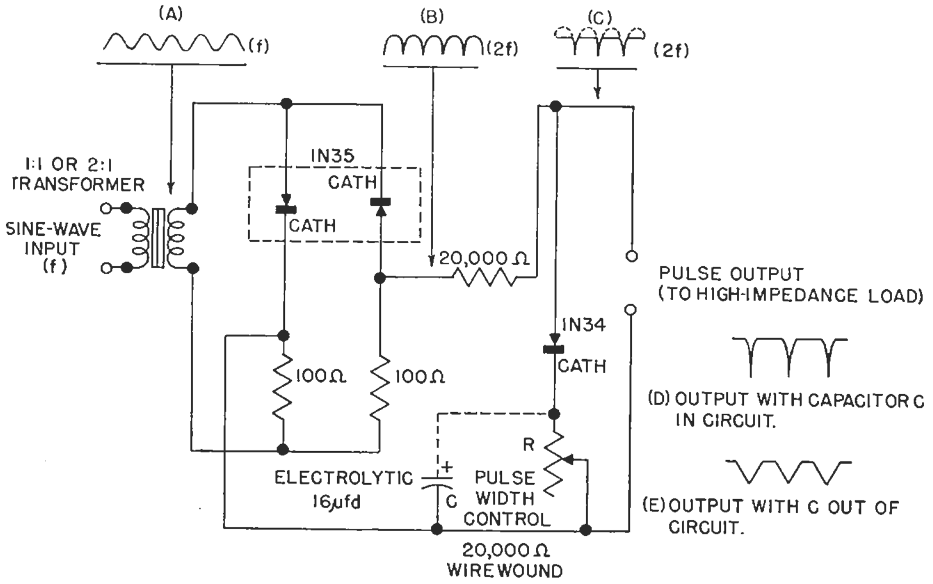


Figure 4-3. Spike Generator.

Sharp spike-type pulses for marking, timing, and blanking in oscilloscope measurements and for special modulation are produced by the circuit shown in Figure 4-3.

A sine-wave input voltage is applied through the input transformer to a 1N35 full-wave rectifier. Output of this rectifier consists of continuous, joined positive pulses only, as shown in Pattern B. A 1N34 diode clipper removes the upper rounded portions of these pulses (See Pattern C), leaving only the lower pointed portions. The clipping level, and thus the spike width and amplitude, is governed by the setting of rheostat R. The pulses are narrow and spiked when capacitor C is included in the circuit (See Pattern D) and are approximately triangular (See Pattern E) when C is omitted.

Because of full-wave rectification at the input, the spike repetition rate is twice the frequency of the input sine wave. The circuit as shown produces negative pulses. Positive pulses may be obtained by reversing the polarity of each of the three diodes.

4.4 PULSE GENERATOR

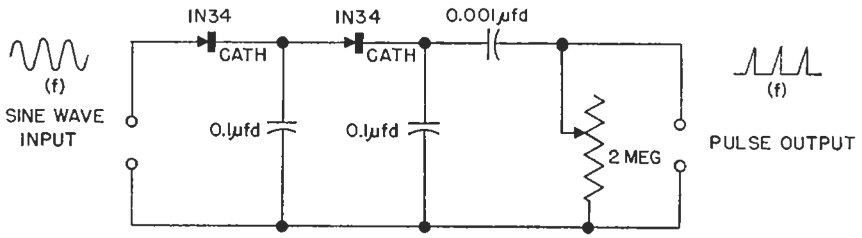


Figure 4-4. Pulse Generator.

A somewhat simpler sharp-pulse generator is shown in Figure 4-4. This circuit resembles a low-pass R-C filter in which germanium diodes take the place of the usual resistors. Unlike the arrangement described in Section 4.3, this circuit gives a pulse repetition rate equal to the frequency of the applied sine wave. The circuit may be used throughout the audio spectrum with the capacitor values shown. At radio frequencies, smaller capacitors and shielding between components will be required.

The 2-megohm rheostat is adjusted to give the best pulse shape, as viewed with a wide-band oscilloscope. Negative pulses may be obtained by reversing the polarity of each of the diodes.

4.5 SAWTOOTH GENERATOR

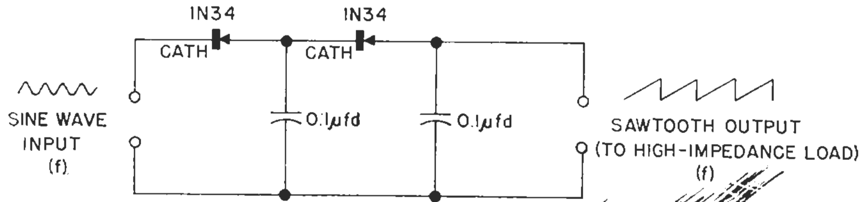
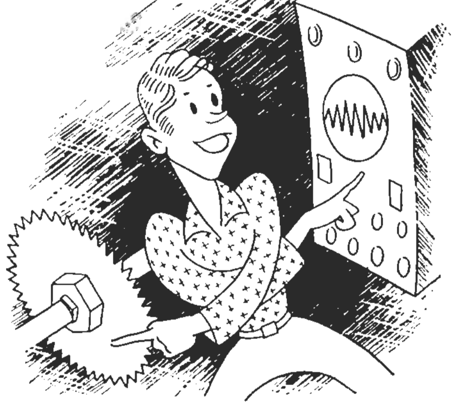


Figure 4-5. Sawtooth Generator.

The circuit of Figure 4-5 converts a sine-wave input signal into a sawtooth wave. At 10 volts r. m. s. input, this sawtooth waveform was found to be linear enough for use as an oscilloscope sweep up to 50 kc.

With the diode polarity shown in Figure 4-5, positive-going sawteeth are obtained. Reverse the polarity of each diode to obtain negative-going sawteeth.



4.6 GERMANIUM TRIODE POWER SUPPLY

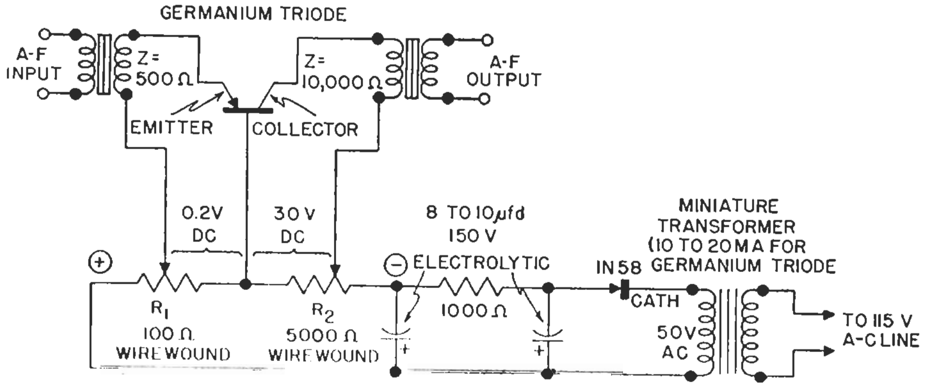
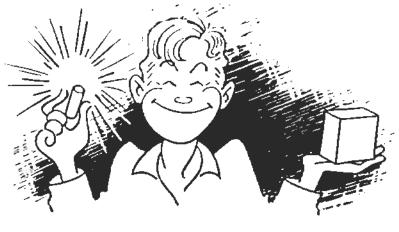


Figure 4-6. Germanium Triode Power Supply.

Germanium crystal triodes (transistors) are small-sized components. Often, the power supply components for furnishing d. c. operating voltages to germanium triode amplifiers and oscillators are many times the size of the germanium triodes themselves. Even selenium rectifiers, used for this purpose, are enormous in comparison with germanium triodes.



The ideal miniaturization afforded by the germanium triode can be pursued by using a high back-voltage germanium diode as the rectifier in the low-current germanium triode d. c. power supply. Figure 4-6 shows a power supply of this type, in conjunction with a single-stage germanium triode amplifier. With a 50-volt-output miniature (10 to 20 ma.) power transformer and 1N58 diode; potentiometer R_1 allows a positive voltage of approximately 0.2 v. to be selected closely for the emitter ("grid") electrode of the germanium triode, while potentiometer R_2 allows close selection of a negative voltage of approximately 30 v. for the collector ("plate") electrode. Note the apparent backward connection of the diode and of the miniature electrolytic filter capacitors. These polarities are very important since, unlike vacuum tubes, the germanium triode "grid bias" must be positive and its "plate voltage" negative.

4.7 MINIATURE LIGHT-INTENSITY METER

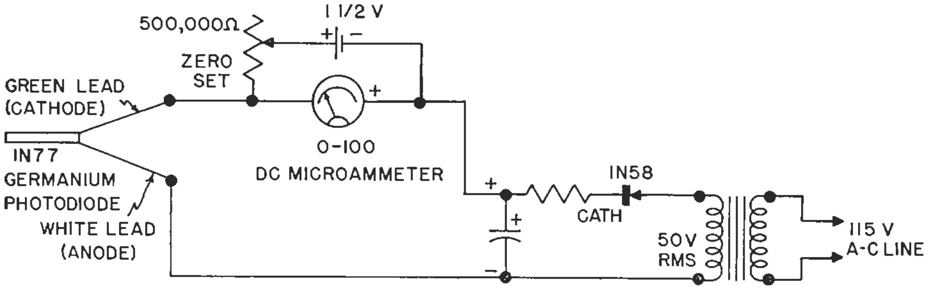


Figure 4-7. Miniature Light-intensity Meter.

In the circuit shown in Figure 4-7, a 1N77 subminiature germanium photodiode is employed as the light-sensitive pickup device and a 1N58 diode as the power supply rectifier. This instrument may be used to examine the brightness of small illuminated areas, such as sections of photographic negatives, illuminated dials, etc. The 1N77 photodiode is tiny enough to be mounted in the tip of a thin pencil-type exploring probe. The 1N77 is especially sensitive to red and infra-red illumination.

This light-intensity meter has good sensitivity and may be calibrated with the aid of a foot-candle meter or other brightness standard. To prepare the circuit for use, simply darken the 1N77 and adjust the ZERO-SET rheostat for zero reading of the microammeter.

4.8 INDICATING AUDIO FREQUENCY METER

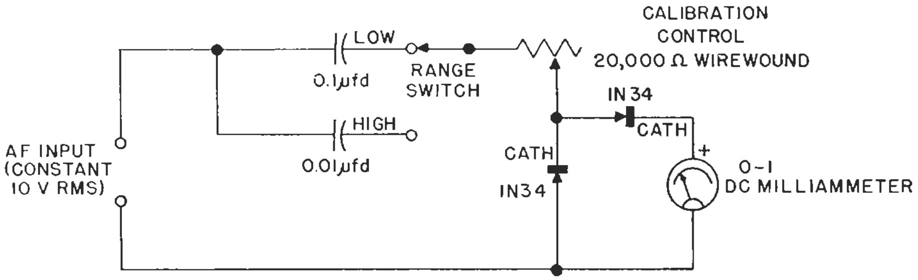


Figure 4-8. Indicating Audio Frequency Meter.

When conditions do not warrant or permit use of a more complicated electronic audio frequency meter, satisfactory frequency indications may be obtained with a simple circuit making use of the varying reactance of a capacitor. This scheme has been employed in the design of the instrument circuit shown in Figure 4-8. This arrangement is no more complicated than a rectifier-type a. c. voltmeter circuit.

The instrument has two overlapping frequency ranges: 20 to 500 cycles, and 100 to 5000 cycles. Sample calibration charts are given in Figure 4-9. From the charts, it will be seen that the frequency curves are neither linear nor uniform. This requires the preparation of a calibration chart or the drawing of a special meter scale. The input signal voltage must be maintained constant at 10 volts r. m. s., but in most instances, this requirement will impose little hardship. The 0.1- and 0.01-microfarad capacitors must have exact specified values and should be of good quality.

The frequency meter may be calibrated with an audio oscillator. Set the oscillator to 500 cycles, and the frequency meter to its low-frequency range. Adjust the signal input voltage to 10 volts r. m. s. and set the 20,000-ohm CALIBRATION CONTROL rheostat to bring the meter pointer exactly to full scale. If the two capacitors have exact values, no further adjustment of the control will be necessary. The meter then may be calibrated at as many frequency points as desired, being careful each time the frequency is changed to keep the input voltage at 10 v.

Signal voltages higher than 10 v. can be accommodated by stepping them down to 10 either through a transformer or with a resistance-type voltage divider.

A. Low-Frequency Range

FREQUENCY (cycles)	METER READING (milliamperes)
20	0.22
30	0.28
40	0.33
50	0.38
60	0.43
70	0.48
80	0.52
90	0.55
100	0.58
200	0.81
300	0.92
400	0.97
500	1.00

B. High-Frequency Range

FREQUENCY (cycles)	METER READING (milliamperes)
100	0.14
200	0.23
500	0.41
1000	0.61
2000	0.84
3000	0.92
4000	0.98
5000	1.00

Figure 4-9. Calibration Data for the Audio Frequency Meter.

4.9 VOLTAGE-SELECTIVE CIRCUIT

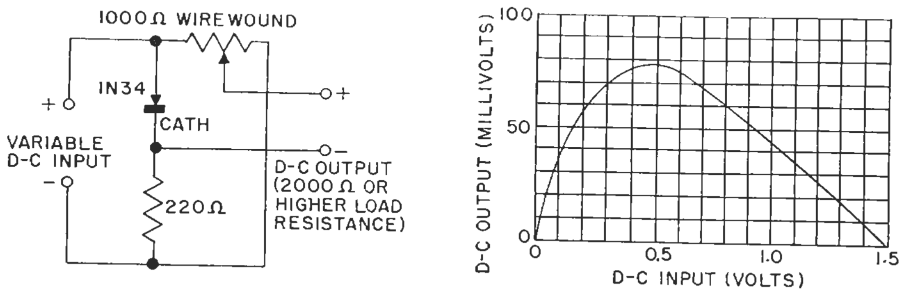


Figure 4-10. Voltage-selective Circuit.

It is convenient in a number of electrical control operations to have a control voltage rise to some peak value as an applied voltage increases in value, and then fall back to zero as the applied voltage continues to increase. Few circuits have been available for this purpose.

Figure 4-10 shows a simple germanium diode circuit in which d. c. output voltage rises from zero to approximately 79 millivolts as the input voltage rises from zero to approximately ½ volt, and then decreases as the input voltage increases further, eventually again reaching zero when the applied voltage has risen to 1½ volts. Action of this circuit, which is a 4-arm bridge, is based upon the fact that one bridge arm (the germanium diode) is a nonlinear element. The bridge therefore can be balanced at only one input voltage value, and unbalances in one direction or the other depending upon the level of applied voltage.

While the nose of the output voltage curve is relatively blunt, there is sufficient "selectivity" to pick up a sensitive meter-type d. c. relay at 0.5 volt input and to drop the relay out at points slightly higher and lower than 0.5 v. Where higher output voltage is required, the output may be fed into a d. c. amplifier.

The 1000-ohm potentiometer is set at about half-range (500 ohms each side), but its exact setting will depend upon forward current characteristics of the individual diode used. When this control is set correctly, the output voltage (as read with a 100- or 200-millivolt 200-ohm or higher meter, the 100-microampere d. c. range of a Simpson Model 260 volt-ohm-milliammeter will suffice), the output voltage will fall to zero but will never go *negative* as the input voltage is varied.

4.10 GERMANIUM DIODES AS CURVE STRAIGHTENERS

In a circuit in which direct current flow is non-linear with respect to voltage variation, a germanium diode often may be employed to straighten-out or linearize the current curve. The diode simply is connected in the current-carrying arm of the circuit with its anode connected to positive. Best success is obtained when the curve to be corrected is somewhat less than linearity. The circuit current must not exceed the average continuous forward current rating of the diode used.

In some instances, a variable resistance must be connected either in series or parallel with the diode to obtain the desired amount of curve correction.

RATINGS AND CHARACTERISTICS OF SYLVANIA GERMANIUM CRYSTAL DIODES

Sylvania's line of germanium crystal components include fourteen diode types, a duo-diode and four varistor networks. All are lightweight, compact, rugged circuit elements having low shunt capacity, no contact potential and require no heater supply or mounting hardware. They have exceptional electrical stability and are strongly resistant to thermal shock.

Among the 14 germanium diodes are types designed to withstand working voltages up to 50, 60, 100, 150 or 200 volts in the reverse direction, to exhibit exceptionally high back resistance or to possess a high forward conduction characteristic.

Six types are now available in either the ceramic or glass construction type. The glass types are made moisture proof by the unique hermetically sealed glass cartridge. They are smaller and lighter than the ceramic types and have been designed with terminals smaller in diameter than the glass body to eliminate risk of accidental contact in side-by-side mounting.

The duo-diode Type 1N35 is a mounted pair of 1N34 diodes carefully matched for use in balanced circuits, for full-wave rectification, modulation or demodulation.

Sylvania Varistor Types 1N40, 1N41, 1N42 and 1N71 are networks of four carefully selected and matched diodes especially designed for use as ring modulators in carrier suppression or carrier transmission circuits. In the plug-in units, Types 1N40, 1N42 and 1N71, the crystals are mounted in a compact metal radio tube shell. In Type 1N41, the crystals are assembled in a rectangular metal can equipped with eight soldering lugs and adapted for top or sub-panel mounting.

All Sylvania Germanium Diodes have a nominal shunt capacitance of 1 μμf., tolerate an ambient temperature range of −50° to +75° C and have an average life of more than 10,000 hours.

The principal electrical ratings for each diode and the duo-diode and varistor types are shown on the accompanying table.

SYLVANIA
Germanium Diodes

RATINGS AND CHARACTERISTICS

TYPE	DESCRIPTION	CONSTRUCTION	CONTINUOUS REVERSE WORKING VOLTAGE (volts Max.)	REVERSE VOLTAGE For Zero Dynamic Resistance (volts Min.)	FORWARD CURRENT @ +1 volt (ma. Min.)	AVERAGE ANODE CURRENT (ma. Max.)	RECURRENT PEAK ANODE CURRENT (ma. Max.)	INSTANTANEOUS SURGE CURRENT (ma. Max., 1 sec.)	REVERSE CURRENT (μa Max.)
1N34	General Purpose Diode	Ceramic	60	75	5.0	50	150	500	50@−10v, 800@−50v
1N34A	General Purpose Diode	Glass	60	75	5.0	50	150	500	30@−10v, 500@−50v
1N35*	Matched Duo-Diode	Ceramic Duo-Diode	50	75	7.5	22.5	60	100	10@−10v
1N38	100-Volt Diode	Ceramic	100	120	3.0	50	150	500	6@−3v, 625@−100v
1N38A	100-Volt Diode	Glass	100	120	4.0	50	150	500	5@−3v, 500@−100v
1N39	200-Volt Diode	Ceramic	200	225	1.5	50	150	500	200@−100v, 800@−200v
1N40**	Varistor	Plug-In	25	75	2.75 (@ 1.5 volts)	22.5	60	100	40@−10v
1N41**	Varistor	Lug-Type	25	75	2.75 (@ 1.5 volts)	22.5	60	100	40@−10v
1N42**	100-Volt Varistor	Plug-In	50	120	2.75 (@ 1.5 volts)	22.5	60	100	6@−3v, 625@−100v
1N54	High Back Resistance Diode	Ceramic	35	75	5.0	50	150	500	10@−10v
1N54A	High Back Resistance Diode	Glass	50	75	5.0	50	150	500	7@−10v, 100@−50v
1N55	150-Volt Diode	Ceramic	150	170	3.0	50	150	500	300@−100v, 800@−150v
1N55A	150-Volt Diode	Glass	150	170	4.0	50	150	500	500@−150v
1N56	High Conduction Diode	Ceramic	40	50	15.0	60	200	1000	300@−30v
1N56A	High Conduction Diode	Glass	40	50	15.0	60	200	1000	300@−30v
1N58	100-Volt Diode	Ceramic	100	120	4.0	50	150	500	800@−100v
1N58A	100-Volt Diode	Glass	100	120	4.0	50	150	500	600@−100v
1N60	Video-Detector Diode	Ceramic	25	30	†	50	150	500	†
1N71***	Low Impedance Varistor	Plug-In	40	50	15.0	60	200	1000	300@−30v

*Units are matched in the forward direction at +1 volt so that the current flowing through the lower resistance unit is within 10% of that in the higher resistance unit. Ratings shown are for each diode.

**Consists of four specially selected and matched germanium diodes whose resistances are balanced within ±2.5% in the forward direction at 1.5 volts. For additional balance, the forward resistance of each pair of varistor crystals are matched within three ohms. Ratings shown are for each diode.

***Consists of four specially selected diodes whose forward currents are within a range of 1 ma with +1 volt applied. Ratings shown are for each diode.

†Units are tested in a circuit employing an input of 1.8 volts rms at 40 mc, 70% modulated at 400 cycles. Demodulated output across a 4700 ohm resistor shunted by a 5 μμfd capacitor is a minimum of 1.4 volts peak to peak.

TO OBTAIN ALL TYPES OF SYLVANIA GERMANIUM DIODES SEE THE SYLVANIA RADIO TUBE DISTRIBUTOR NEAREST YOU. YOU WILL FIND HIM LISTED IN THE YELLOW PAGES OF YOUR TELEPHONE DIRECTORY UNDER "RADIO SUPPLIES AND PARTS."

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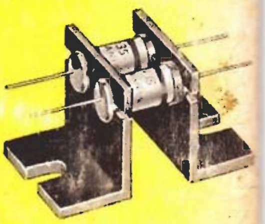
1N34A, 1N38A, 1N54A
1N55A, 1N56A, 1N58A
1N32

1N34, 1N36, 1N38
1N54, 1N55, 1N56
1N57, 1N58, 1N60



1N35

1N41

1N71

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