BABANI PRESS.. No.9

38 PRACTICAL TESTED DIODE CIRCUITS FOR THE HOME CONSTRUCTOR

by

B.B. BABANI

35p

Based on data supplied by

SYLVANIA ELECTRIC PRODUCTS INC.,

38 PRACTICAL TESTED DIODE CIRCUITS for the HOME CONSTRUCTOR

by

Bernard B. Babani

BABANI PRESS
The Publishing division of
Babani Trading and Finance Co. Ltd.
The Grampians
Western Gate, London W.6.

Babani Press Handbook No. 9

First Published April 1972

We invite all authors, whether new or well established, to submit manuscripts for publication. The manuscripts may deal with any facet of electronics but should always be practical. Any circuit diagrams that may be included should have been thoroughly checked by the author. If you are considering trying your hand at writing this type of book we suggest that you let us have a short summary of the subject you intend to cover. We will then be able to let you know the size of book required and perhaps give you some advice on presentation.

BERNARD B. BABANI

Printed by

Krisson Printing Limited, London.

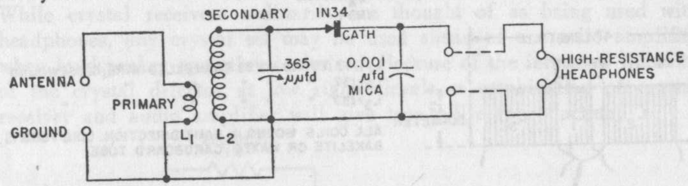
for Babani Press, The Publishing division of Babani Trading and Finance Co. Ltd., The Grampians, Western Gate, London, W.6

CONTENTS

RECEIVERS AND RECEIVER APPLICATIONS

1.1 SIMPLE CRYSTAL RECEIVER. The crystal receiver has had universal appeal to a multitude of radio experimenters since the early days of wireless. Its continued fascination, even at present when tubes are inexpensive, has been due to the fact that the crystal detector requires no power supply and gives remarkably clear and lifelike reproduction. Furthermore, a crystal set is simple in principle and easy to build.

The audio output of a crystal set is low. This means that a good, long, outside antenna and a good ground must be used in most localities for best results. These requirements do not detract from the popularity of this simple receiver, however, and thousands are built each year by hobbyists in all walks of life.



L_1 AND L_2 ARE THE PRIMARY AND SECONDARY OF ANTENNA COIL WITH FREQUENCY RANGE OF 540-1750 KC

Figure 1-1. SIMPLE CRYSTAL RECEIVER

Figure 1-1 shows one of the simplest circuits which may be employed to receive broadcast stations. A set of this type may be built in a single evening by an inexperienced person. While the reader might wind his own coils, the manufactured coil specified in Figure 1-1 is so low in price as to make the labor of making the coil at home unattractive.

The set covers the standard broadcast band. That is, 540 to 1750 kc which is actually a little more than the broadcast band limits. All tuning is done with the single 365-μfd variable capacitor.

Under ordinary conditions, the range of the receiver will not be greater than about 25 miles. Loudest signals will be picked up from the most powerful stations. Best signal strength will be obtained when the antenna is outside, between 40 and 100 feet long, and situated as high as practicable above the ground and other objects. A good ground, such as a tight connection to a *cold* water pipe, might be used.

1.2 PUSH-PULL CRYSTAL RECEIVER. The crystal receiver circuits shown in Figure 1-2 deliver somewhat louder signals than the simpler sets described in Section 1.1, and separates stations more effectively.

The improved operation of this circuit is obtained by use of double tuning (by means of tuning capacitors C_1 and C_2) and two crystal diodes in a full-wave detector circuit. If desired, a Sylvania Type 1N35 duo-diode unit may be used in place of the two separate 1N34's. Details of the special coupling coil, which can be built easily by the reader, are given in Figure 1-2.

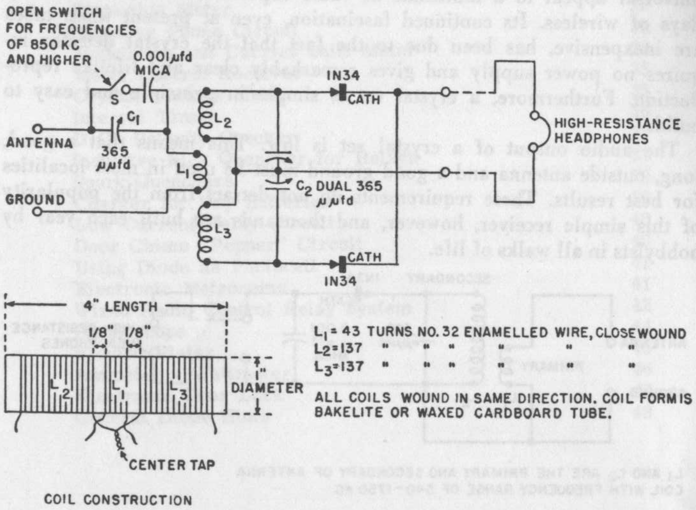


Figure 1-2. PUSHPULL CRYSTAL RECEIVER

Operation of the set is not complicated. (1) If the station to be received operates on a frequency lower than 850 kc, close switch S. If the station frequency is 850 kc or higher, open the switch. (2) Tune-in the station closely by adjusting capacitor C_2. (3) Finally, adjust capacitor C_1 to improve the headphone volume and to reduce at the same time interference from other stations.

1.3 BANDPASS CRYSTAL RECEIVER. A highly-selective crystal broadcast receiver circuit is shown in Figure 1-3. The ability of this circuit to separate stations more effectively than earlier sets is made possible by a tuned bandpass filter made up with manufactured coils. These coils are obtainable as a kit. Single-dial tuning is entirely by means of the dual 365-μfd variable capacitor.

The audio output of this circuit is somewhat lower than that afforded by the receivers described in Sections 1.1 and 1.2. However, the circuit was designed originally for use as a broadcast tuner to be used with a high-fidelity audio amplifier. The amplifier gain compensates for the low volume of the crystal detector output.

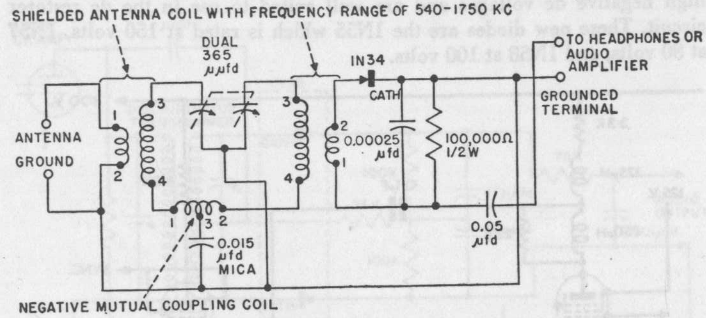


Figure 1-3. BAND PASS CRYSTAL RECEIVER

1.4 USE OF AUDIO AMPLIFIERS WITH CRYSTAL SETS. While crystal receivers ordinarily are thought of as being used with headphones, any crystal set may be used ahead of an audio amplifier when loudspeaker operation is desired. Because of the increased linearity of the crystal detector at low signal levels, a combination of crystal receiver and audio amplifier will give true-to-life reproduction.

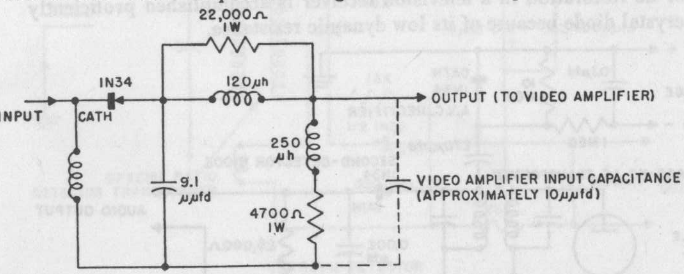


Figure 1-4. CRYSTAL VIDEO DETECTOR FOR TELEVISION

Figure 1-4 is the circuit of a video detector employing the 1N34. This circuit will be of interest to builders of home-made television receivers who wish to reduce the amount of tube space on the chassis, while at the same time taking advantage of the additional improvements offered by the crystal detector.

1.5 CRYSTAL VIDEO DETECTOR. Because the dynamic resistance of the germanium crystal diode is very low and the crystal capacitance also is low, the crystal diode offers improved operation in video second detector circuits in television receivers. The crystal diode also gives excellent linearity at low signal levels and is free from contact potential effects.

Figure 1-5 shows a typical dc restorer circuit. Several new crystal diodes developed by Sylvania have the ability to withstand relatively high negative dc voltages and are well suited to use in the dc restorer circuit. These new diodes are the 1N55 which is rated at 150 volts, 1N57 at 80 volts, and 1N58 at 100 volts.

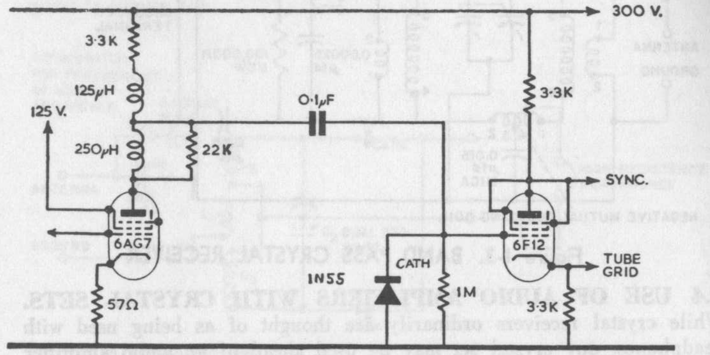


Figure 1-5. CRYSTAL DC RESTORER FOR TELEVISION

1.6 CRYSTAL DC RESTORER FOR TELEVISION.

The function of dc restoration in a television receiver is accomplished proficiently by a crystal diode because of its low dynamic resistance.

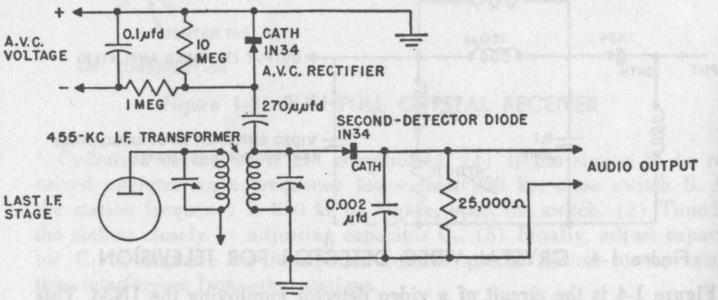


Figure 1-6. SECOND DETECTOR—A.V.C. CIRCUIT

1.7 SECOND DETECTOR—AVC CIRCUIT.

Considerable space saving and circuit simplification are made possible in the radio receivers, especially in short-wave and all-wave sets, by using crystal diodes as 2nd detector and avc rectifiers.

In Figure 1-6, one 1N34 is employed as a series-diode 2nd detector, and a second 1N34 as a shunt-diode avc rectifier. The capacitance and resistance values given in this circuit are for the popular 455 kc intermediate frequency.

The crystal diodes may be mounted under the chassis of the receiver with the capacitors and resistors associated with the circuit.

1.8 FM DETECTORS.

Germanium diodes simplify the circuits and construction of the frequency modulation 2nd detectors. The 1N35 duo-

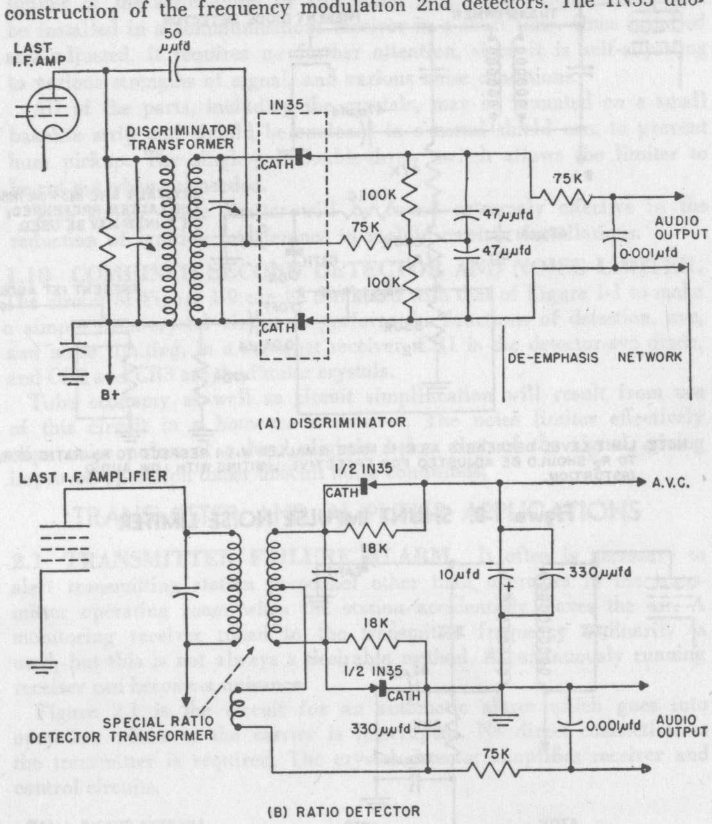


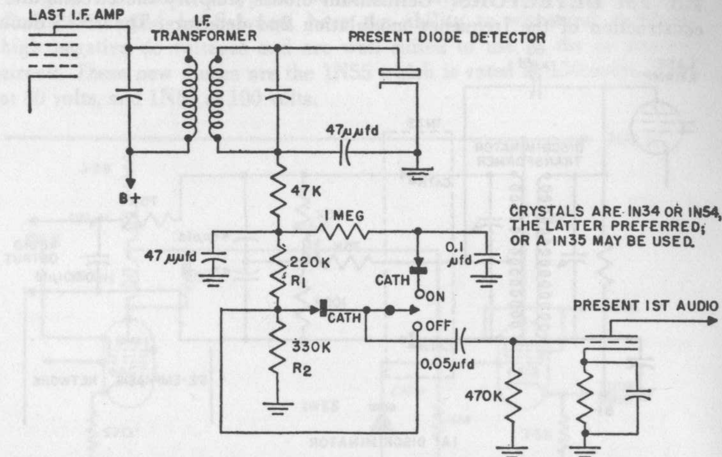
Figure 1-7. FM DETECTORS

diode, consisting of two factory-matched crystals, is especially suitable for this application.

Figure 1-7 shows the connection of the crystals in discriminator (A) and modified ratio detector (B) circuits for second detectors in both FM broadcast receivers and in the sound channels of television sets. Circuit B is a special adaptation of the conventional ratio detector for use with 1N34 or 1N35 crystals. Both of these circuits are suited for if frequencies of the order of 10 to 30 megacycles.

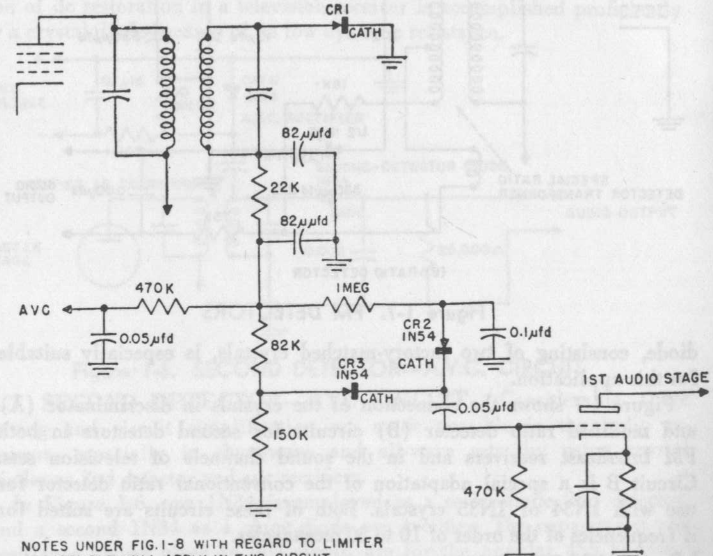
1.9 COMPACT SERIES—SHUNT IMPULSE NOISE LIMITER.

Figure 1-8 shows the use of two 1N34 and 1N54 crystals, or a single 1N35 duo-diode unit, in a compact yet extremely effective impulse noise



NOTE: LIMIT LEVEL DECREASES AS R_1 IS MADE SMALLER WITH RESPECT TO R_2. RATIO OF R_1 TO R_2 SHOULD BE ADJUSTED FOR EFFECTIVE LIMITING WITH LOW AUDIO DISTORTION.

Figure 1-8. SHUNT IMPULSE NOISE LIMITER



NOTES UNDER FIG. 1-8 WITH REGARD TO LIMITER ADJUSTMENT WILL APPLY IN THIS CIRCUIT.

Figure 1-9. COMBINED SECOND DETECTOR, A.V.C. AND NOISE LIMITER

limiter of the series-shunt or compound type. This simple limiter can be installed in a communications receiver in a short time. Once installed and adjusted, it requires no further attention, since it is self-adjusting to various strengths of signal, and various noise conditions.

All of the parts, including the crystals, may be mounted on a small bakelite strip and should be enclosed in a metal shield can, to prevent hum pickup. The single-pole-double-throw switch allows the limiter to be cut out when not needed.

This simple noise limiter will be found extremely effective in the reduction of ignition interference in mobile receiver installations.

1.10 COMBINED SECOND DETECTOR AND NOISE LIMITER. The circuit of Figure 1-9 can be combined with that of Figure 1-1 to make a simple three-crystal circuit to perform the functions of detection, avc, and noise limiting, in a superhet receiver. CR1 is the detector-avc diode, and CR2 and CR3 are the limiter crystals.

Tube economy as well as circuit simplification will result from use of this circuit in a home-made receiver. The noise limiter effectively clips noise pulses at a level slightly below that of the signal, giving improved operation under difficult noise conditions.

TRANSMITTER AND AMPLIFIER APPLICATIONS

2.1 TRANSMITTER FAILURE ALARM. It often is necessary to alert transmitting station personnel other than operators in the transmitter operating room when the station accidentally leaves the air. A monitoring receiver tuned to the transmitter frequency ordinarily is used, but this is not always a desirable method. A continuously running receiver can become a nuisance.

Figure 2-1 is the circuit for an automatic alarm which goes into operation whenever the carrier is interrupted. No direct connection to the transmitter is required. The crystal detector simplifies receiver and control circuits.

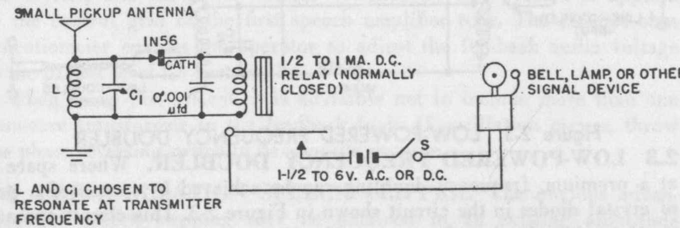


Figure 2-1. TRANSMITTER FAILURE ALARM

The values of coil L and variable capacitor C_1 are selected to tune to the station frequency. C_1 can be a screwdriver-adjusted trimmer. A 1N56 high-conduction diode is employed to insure maximum possible relay current. The pickup antenna may be a short inside or outside antenna, as receiving conditions dictate, or it may be a short vertical rod.

When the station is on the air, the relay will be energized by the crystal diode and the relay contacts will open. Switch S then is closed manually. If the station goes off the air, current will cease to flow through the relay coil, the contacts will close, and the alarm device (bell, horn, or lamp) will be operated.

2.2 TRANSMITTER ADJUSTING GIMMICK. The untuned, rf-operated crystal device illustrated in Figure 2-2 will find a host of uses in transmitter tuning-up and adjustment. When the small pickup coil is held near the plate or grid coil in any transmitter stage, it will pick up a small rf voltage which will be rectified by the 1N34 and caused to deflect the milliammeter. Adjustment of the 1000-ohm rheostat will prevent "pinning" of the meter by strong signals.

This gadget may be used as an rf indicator in neutralizing adjustments, stage tuning, exploring for parasitics and stray rf, and testing the effectiveness of shielding. Many other applications will occur to the reader. Headphones may be plugged into the jack for aural monitoring of amplitude modulated signals and for hum and noise tracing in transmitter stages.

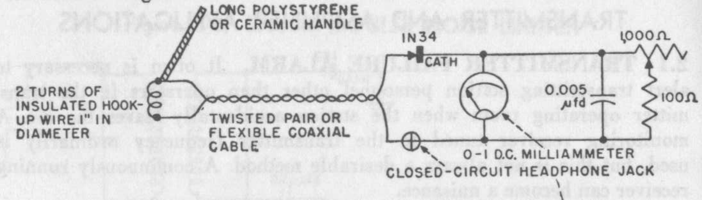


Figure 2-2. TRANSMITTER ADJUSTING GIMMICK

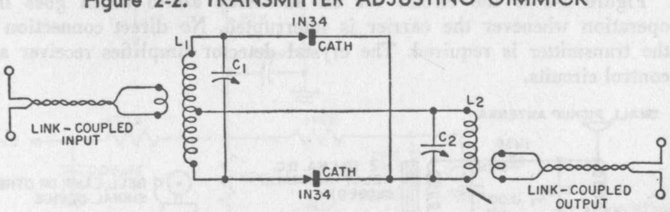


Figure 2-3. LOW-POWERED FREQUENCY DOUBLER

2.3 LOW-POWERED FREQUENCY DOUBLER. Where space is at a premium, frequency doubling can be achieved by means of a pair of crystal diodes in the circuit shown in Figure 2-3. This circuit operates on the principle that the output of a full-wave rectifier has twice the frequency of the ac input voltage. The doubling action is enhanced by the tank circuit L_2-C_2 which is tuned to twice the input frequency. The input tank circuit (L_1-C_1) is tuned to the input frequency. Two of these simple doubler stages in cascade will quadruple the input frequency.

Because of the low power-handling ability of the crystal diodes,

operation of this circuit is limited to input power levels of less than 1 watt. The crystal doubler accordingly can be used only ahead of pentode or beam power rf amplifiers having very high power sensitivity (that is, amplifiers requiring low grid driving power). Slightly higher power ratings are obtained with a pair of 1N56 diodes.

The crystal doubler is suitable for operation at frequencies up to 200 megacycles.

2.4 CARRIER-OPERATED INVERSE FEEDBACK CIRCUIT. Inverse feedback is invaluable in a modulated transmitter for improving quality and reducing hum and noise. It is not so easily applied, however, to efficiency-modulated circuits, such as grid-modulated, screen-modulated, cathode-modulated, and class-B linear amplifiers.

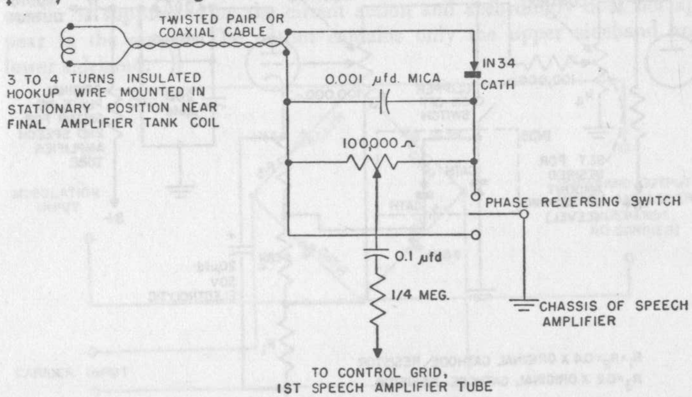


Figure 2-4. CARRIER OPERATED INVERSE FEEDBACK CIRCUIT

The crystal circuit shown in Figure 2-4 overcomes this difficulty by "sampling" the modulated carrier. The picked-up rf is demodulated by the crystal, and the audio voltage obtained by this process is applied to the control grid of the first speech amplifier tube. The 100,000-ohm potentiometer enables the operator to adjust the fed-back audio voltage to the proper level for best results.

When using this system, it is advisable not to include more than one iron-core transformer in the feedback loop. If oscillation occurs, throw the phase reversing switch to its opposite position.

2.5 PREMODULATION SPEECH CLIPPER. The obvious advantages of speech clipping may be obtained in an existing amplitude modulated transmitter by including a satisfactory clipper unit between the first and second stages of the speech amplifier.

Figure 2-5 shows a 2-crystal clipper circuit which may be connected conveniently in any speech amplifier. The original gain control (R_A) of the amplifier becomes the clipper control. This control is set by experiment to the desired level at which clipping is to take place and is not disturbed afterward. A second potentiometer (R_B) is installed as the amplifier gain control. The 1N35 duo-diode unit supplies two factory-matched crystals for this circuit.

The filter, consisting of a choke and three capacitors in the plate circuit of the 2nd speech amplifier stage, rounds off the speech waves after the clipping operation has squared them. This filter thus removes objectionable harmonics.

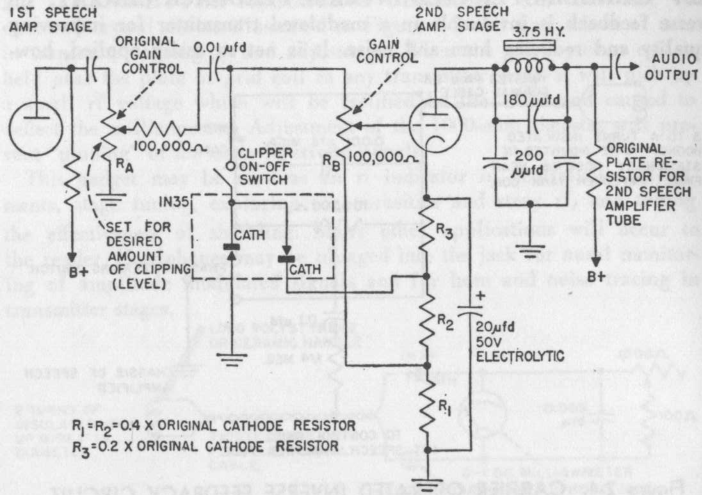


Figure 2-5. PREMODULATION SPEECH CLIPPER

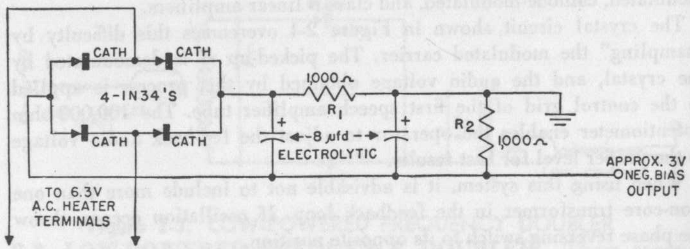


Figure 2-6. LOW-VOLTAGE BIAS SUPPLY

2.6 LOW-VOLTAGE BIAS SUPPLY. Fixed grid bias voltages between 1 and 3 volts for audio amplifiers may be obtained from the 6.3-volt tube heater terminals in the amplifier through a crystal rectifier and filter.

Figure 2-6 shows a 4-crystal, full-wave bridge circuit which makes an excellent bias supply which is compact and requires no attention.

The dc output voltage may be varied by changing the resistance value of R_2. As R_2 is decreased, the output voltage decreases, and vice versa.

INSTRUMENTS AND GADGETS

3.1 SIMPLE SIDEBAND GENERATOR. Figure 3-1 shows four matched crystal diodes connected in a "ring modulator" circuit. In lieu of four separate crystals, a Sylvania Type IN40 or IN41 Varistor may be used. The Varistor is a small, compact unit containing four matched diodes.

In this circuit, the rf carrier is fed into one pair of terminals, and the modulation (usually an audio frequency) into the other pair. The carrier is suppressed by the circuit action and accordingly does not appear in the output. The output contains only the upper sideband and lower sideband.

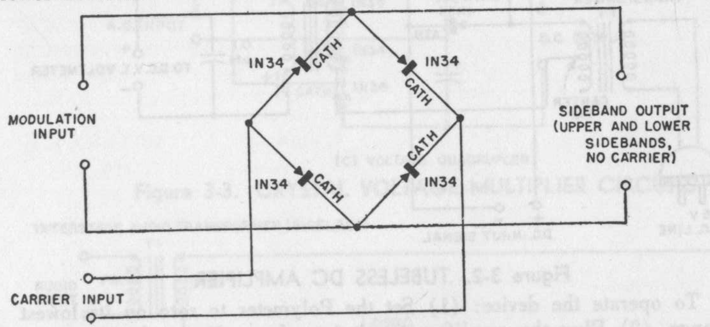


Figure 3-1. SIMPLE SIDEBAND GENERATOR

The upper sideband consists of the carrier frequency plus the modulating frequency. The lower sideband consists of the carrier frequency minus the modulating frequency. Thus; if the carrier is 1000 kc and the modulating frequency 1000 cycles, the upper sideband is 1001 kc and the lower sideband 999 kc. If desired, a suitable filter may be connected in the output to eliminate (suppress) one of the sidebands and pass the other. In this way, single sideband output may be obtained.

3.2 TUBELESS DC AMPLIFIER. This circuit (See Figure 3-2) is another application of the 4-crystal ring modulator. In this case, however, a dc voltage is substituted for the carrier. An ac voltage of 1¼ volt, derived from half of a 2½-volt filament transformer secondary, is delivered to the 4-crystal circuit as the modulating voltage.

The ac voltage switches the dc voltage on and off at a rate equal to the ac frequency in much the same manner that a mechanical vibrator might interrupt the dc circuit. This interrupted dc voltage then is stepped up through transformer T_2 and induces an ac voltage across the secondary of this transformer. The fifth IN34 rectifies this voltage and delivers it to a vacuum tube voltmeter such as the Sylvania Polymeter Type 221. The Polymeter should be switched to the dc indicating position. Thus, a small dc voltage may be stepped up to a value high enough to be read on the scale of the meter. The amount of amplification obtained depends upon the turn ratio of transformer T_2.

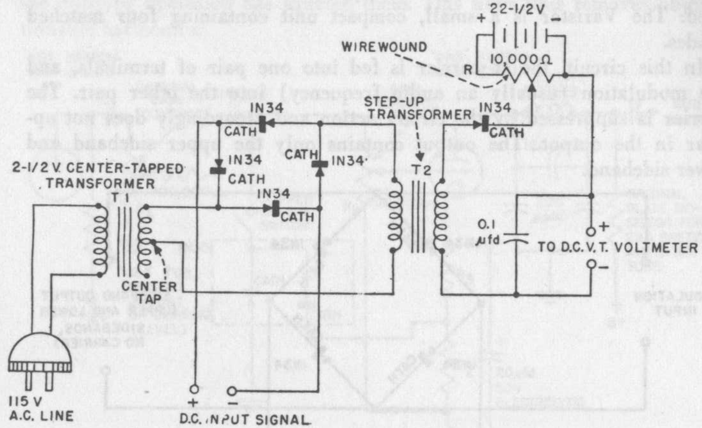


Figure 3-2. TUBELESS DC AMPLIFIER

To operate the device: (1) Set the Polymeter to zero on its lowest range. (2) Plug the amplifier circuit into the ac line and connect the voltmeter to the amplifier output terminals. (3) The meter will be deflected upward. Adjust potentiometer R to bring the meter pointer back to zero. (4) Apply the unknown dc voltage to the dc input terminals of the amplifier. (5) Read the voltage on the meter and divide this value by the turn ratio of the transformer to obtain the true value of the unknown voltage.

Best accuracy will be obtained if accurately-known small voltage values are fed into the amplifier and their corresponding meter deflections noted on a chart or graph.

3.3 VOLTAGE MULTIPLIER CIRCUITS. Figure 3-3 shows voltage doubler, tripler, and quadrupler circuits employing crystal diodes. These circuits are especially useful, since they can be operated at radio frequencies as well as at power-line and audio frequencies. At frequencies between 60 and 10,000 cycles, use 8-μfd electrolytic capacitors throughout. At all higher frequencies, use 0.01-μfd mica capacitors.

At low output current drains, the doubler circuit will deliver a dc voltage equal approximately to 2.8 times the r.m.s. value of the ac input voltage. The tripler dc output voltage will equal 4.2 times the ac input voltage. The quadrupler dc output voltage will equal 5.6 times the ac input voltage.

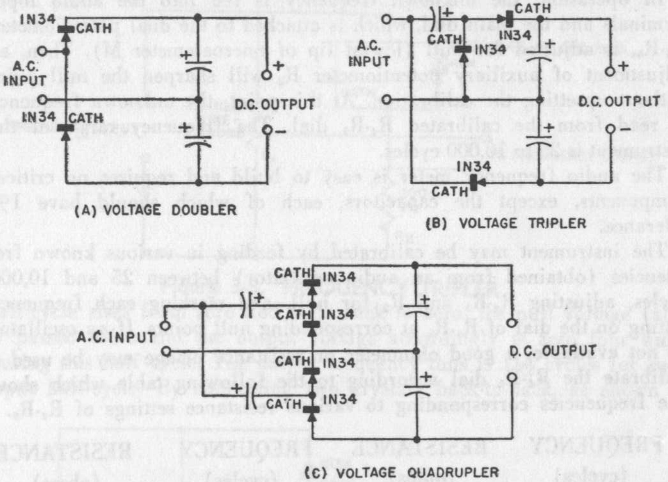


Figure 3-3. CRYSTAL VOLTAGE MULTIPLIER CIRCUITS

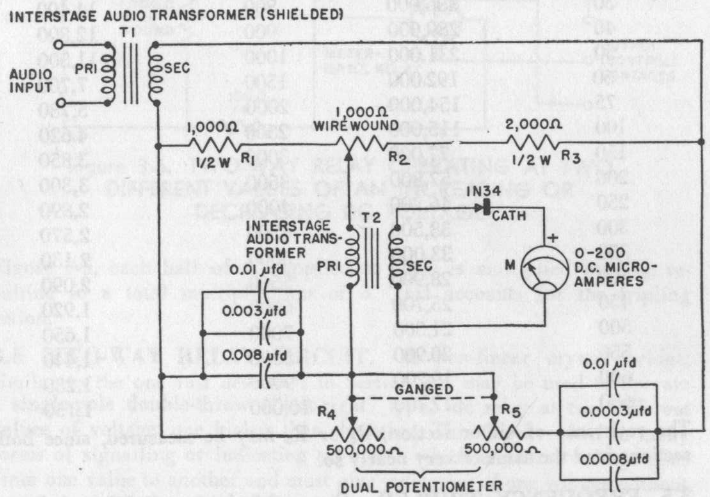


Figure 3-4. INDICATING AUDIO FREQUENCY METER

3.4 AUDIO FREQUENCY METER. This instrument (See Figure 3-4) will identify an unknown audio frequency directly in cycles per second. The circuit is "balanced" in a manner similar to the balancing of a bridge. The Wien bridge circuit is employed.

In operation, the unknown frequency is fed into the audio input terminals and the main dial, which is attached to the dual potentiometer, R_4-R_5, is adjusted for null (lowest lip of microammeter M). Then, an adjustment of auxiliary potentiometer R_2 will sharpen the null point without upsetting the calibration. At this point, the unknown frequency is read from the calibrated R_4-R_5 dial. The frequency range of the instrument is 25 to 10,000 cycles.

The audio frequency meter is easy to build and requires no critical components, except the capacitors, each of which should have 1% tolerance.

The instrument may be calibrated by feeding in various known frequencies (obtained from an audio oscillator) between 25 and 10,000 cycles, adjusting R_4-R_5 and R_2 for null, and marking each frequency setting on the dial of R_4-R_5 at corresponding null points. If an oscillator is not available, a good ohmmeter or resistance bridge may be used to calibrate the R_4-R_5 dial according to the following table which shows the frequencies corresponding to various resistance settings of R_4-R_5.

FREQUENCY (cycles)	RESISTANCE (ohms)	FREQUENCY (cycles)	RESISTANCE (ohms)
25	461,000	700	16,500
30	386,000	800	14,400
40	289,000	900	12,800
50	231,000	1000	11,500
60	192.000	1500	7,700
75	154,000	2000	5,780
100	115,000	2500	4.620
150	77,000	3000	3,850
200	57,800	3500	3,300
250	46,200	4000	2,890
300	38,500	4500	2,570
350	33,000	5000	2,130
400	28,900	5500	2,090
450	25,700	6000	1,920
500	21,300	7000	1,650
550	20.900	8000	1,440
600	19,200	9000	1,280
650	17,700	10,000	1,150

The resistance of either section, R_4 or R_5 may be measured, since both sections read the same or very nearly so.

3.5 FREQUENCY TRIPLER. Figure 3-5 shows a simple non-linear bridge circuit for tripling any frequency fed into its input terminals. This circuit is recommended for use at low ac levels, up to 1½ volts r.m.s. The output is not true sine wave.

The circuit is based on the fact that the bridge, having a crystal rectifier as one arm, may be balanced at only one voltage. This is because the crystal resistance changes with voltage. Consequently, as an applied ac

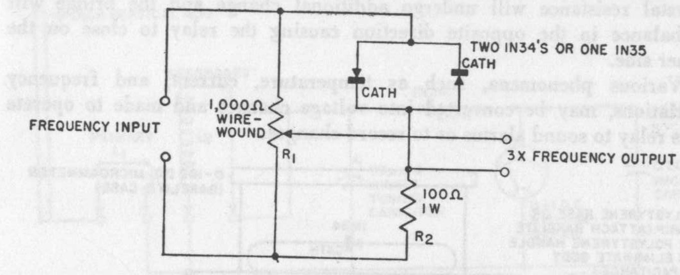


Figure 3-5. FREQUENCY TRIPLER

half-cycle rises from zero and falls back to zero, the null voltage value is passed twice and the output voltage accordingly is zero four times during this half cycle. The output frequency thus is 1½ cycles for each input half-cycle. By connecting two crystals back-to-back, as shown in

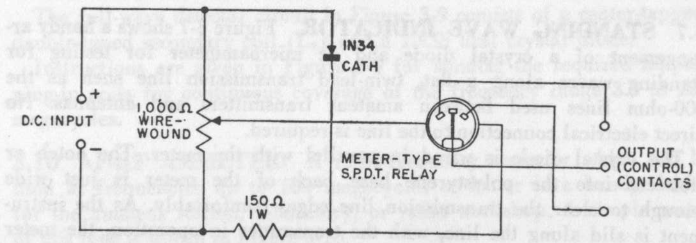


Figure 3-6. TWO-WAY RELAY OPERATING AT TWO DIFFERENT VALUES OF AN INCREASING OR DECREASING DC VOLTAGE

Figure 3-5, each half of the applied ac cycle is multiplied by 1½, resulting in a total multiplication of 3. This accounts for the tripling action.

3.6 TWO-WAY RELAY CIRCUIT. A non-linear crystal bridge, similar to the one just described in Section 3.5, may be used to operate a single-pole double-throw ("left-right" type) dc relay at two different values of voltage, one higher than the other. This is convenient in many forms of signalling or indicating set-ups in which a control voltage rises from one value to another and must give indication of one voltage without interfering with the other.

In operation, set the bridge initially (by adjusting the 1000-ohm potentiometer) at the lowest value of input voltage at which the relay is to close. When the circuit is adjusted properly, the relay armature will swing over to one contact. As the input voltage then is increased, the bridge will pass through null, due to changing crystal resistance, whereupon the relay will open. As the voltage is increased further, the crystal resistance will undergo additional change and the bridge will unbalance in the opposite direction causing the relay to close on the other side.

Various phenomena, such as temperature, current, and frequency variations, may be converted into voltage changes and made to operate this relay to sound alarms or to record changes.

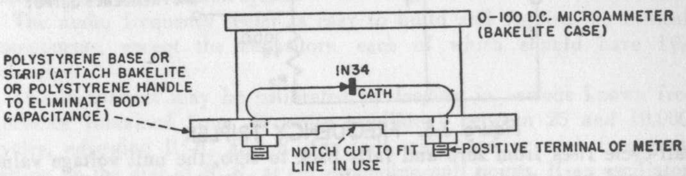


FIGURE 3-7. STANDING WAVE INDICATOR FOR TWIN-LEAD RF TRANSMISSION LINE

3.7 STANDING WAVE INDICATOR. Figure 3-7 shows a handy arrangement of a crystal diode and dc microammeter for testing for standing waves along a flat, twin-lead transmission line such as the 300-ohm lines used between amateur transmitters and antennas. No direct electrical connection to the line is required.

The crystal diode is wired in parallel with the meter. The notch or slot cut into the polystyrene base back of the meter is just wide enough to clear the transmission line edges comfortably. As the instrument is slid along the line, with the transmitter in operation, the meter will deflect up-scale to indicate peaks and down-scale to indicate nulls.

3.8 SIMPLE FIELD STRENGTH METER. This instrument (Figure 3-8) is indispensable for checking the gain and field pattern of transmitting antennas and for checking for presence of harmonics and interference. The entire unit may be built into a small metal radio utility box.

A Type 1N56 crystal diode is recommended since this crystal gives more dc output current than the 1N34 and accordingly will produce a higher meter deflection with a given rf signal.

Commercial short-wave plug-in coils may be used. Special coils for the ultra-high-frequency amateur bands may be wound according to specifications found in the amateur radio handbooks.

If the tuning dial of the field strength meter (attached to tuning capacitor C) is calibrated directly in megacycles by means of an rf test oscillator or signal generator, the instrument will be suitable as an absorption wavemeter for frequency measurements.

3.9 SENSITIVE FIELD STRENGTH METER. Sensitivity of the field strength meter may be increased by employing (1) full-wave detection with two matched crystals and (2) a sensitive dc microammeter in place of the milliammeter.

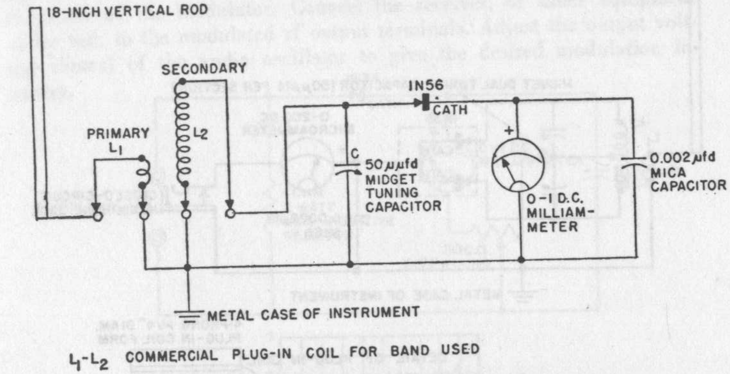


Figure 3-8. SIMPLE FIELD STRENGTH METER

The full-wave detector circuit in Figure 3-9 consists of a center-tapped, double-tuned secondary coil (L_2) and a 1N35 dual crystal diode.

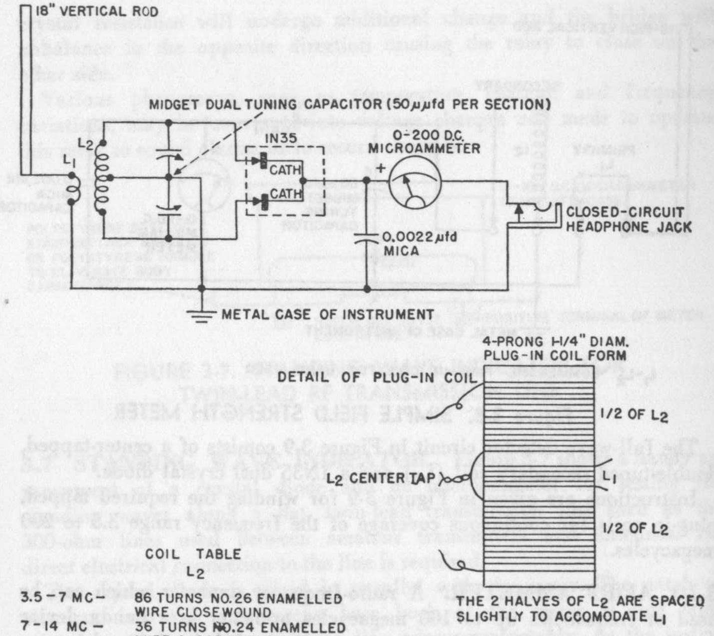
Instructions are given in Figure 3-9 for winding the required tapped, plug-in coils for continuous coverage of the frequency range 3.5 to 200 megacycles.

3.10 AF-RF AMMETER. A radio-frequency ammeter which can be used at frequencies up to 100 megacycles or better is a handy device for the amateur station, laboratory, or radio workshop. A simple meter of this type is shown in Figure 3-10.

This instrument consists basically of a crystal voltmeter (crystal diode plus a dc milliammeter) connected so as to measure the voltage drop across a non-inductive 1-ohm resistor. The unknown current flowing through this resistor sets up the voltage drop. By Ohm's Law, the voltage measured across the 1-ohm resistor will be equal to the current flowing through the resistor. Consequently, if the meter is calibrated 0-1 volt, it will indicate also 0-1 ampere.

Calibration of the instrument is simple. Apply an accurately-known ac voltage of 1 volt (60 cycles will do, but 1000 cycles will be better) to the input terminals. Then adjust the 300-ohm rheostat for full-scale deflection of the milliammeter. The meter indicates at full-scale as current flow of 1 ampere through the 1-ohm resistor. Reduce the input voltage to 0.9 volt and record the milliammeter reading. Repeat at various lower-voltage points in 1/10-volt steps, to obtain a calibration curve similar to the one shown in Figure 3-10. This chart then may be referred to when making measurements, to convert milliampere indications to amperes. Or a special ampere scale may be prepared from it for the milliammeter.

Because of the wide frequency range of the crystal, the ammeter can be operated at radio as well as audio frequencies.



COIL TABLE

L_2

3.5 - 7 MC -	86 TURNS NO.26 ENAMELLED WIRE CLOSEWOUND
7 - 14 MC -	36 TURNS NO.24 ENAMELLED WIRE CLOSEWOUND
14 - 28 MC -	20 TURNS NO.22 ENAMELLED WIRE SPACED TO WINDING LENGTH OF 1 INCH
28-54 MC -	12 " " " " " " " "
50-100 MC -	5 " " " " " " " "
100-200 MC -	2-1/2 " " " " " " " "

L_1 IN EACH CASE IS 1 TURN OF NO.24 ENAMELLED WIRE WOUND IN THE SPACE BETWEEN THE HALVES OF L_2

Figure 3-9. SENSITIVE FIELD STRENGTH METER

3.11 EXTERNAL MODULATOR FOR SIGNAL GENERATORS.

Most rf signal generators and test oscillators are modulated internally at an audio frequency of 400 cycles. It often is desirable to modulate the rf signal at some frequency other than 400 cycles, but this entails tampering with the internal wiring of the oscillator.

The simple 4-crystal device shown in Figure 3-11 can be connected to the rf output terminals of the signal generator and to the output terminals of any audio oscillator. It will combine the two signals and deliver a radio-frequency signal modulated at the frequency of the audio oscillator. In this way, the signal generator circuit need not be altered in any manner. The circuit is a type of diode modulator similar to those described in Sections 3.1 and 3.2.

When using the device, connect the output terminals of the signal generator to the rf input terminals of the modulator circuit. Switch-off the internal modulation of the signal generator so as to obtain a c.w.

signal. Connect the audio oscillator output terminals to the audio input terminals of the modulator. Connect the receiver, or other equipment under test, to the modulated rf output terminals. Adjust the output voltage control of the audio oscillator to give the desired modulation intensity.

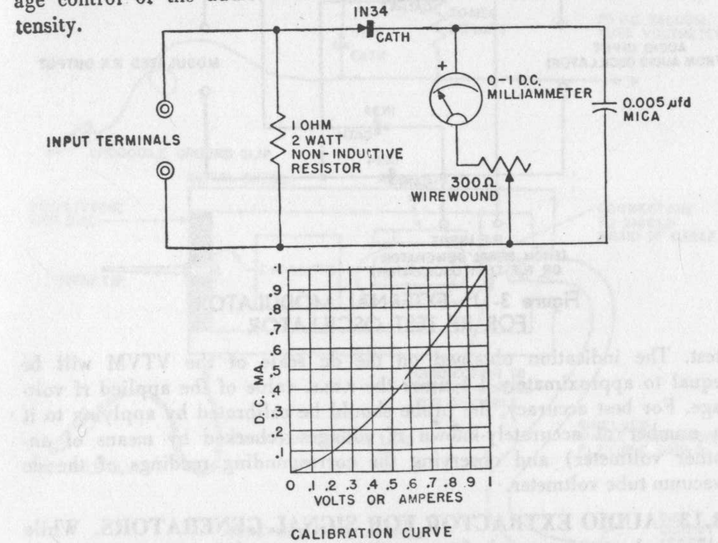


Figure 3-10. AF-RF AMMETER (0-100 MC)

Actually, this modulator suppresses the carrier frequency and delivers the two sidebands which result from the amplitude modulation process. But for audio frequencies up to about 2500 cycles, the modulated signal will be tuned-in on a receiver dial at the same point as the regular signal generator signal. Only at modulation frequencies above 5000 cycles will the receiver dial show the two sidebands as separate signals, one above and one below the carrier frequency point.

3.12 RF PROBE.

DC vacuum tube voltmeters now are standard equipment in laboratories, stations, and shops. A number of these instruments have no provision for checking rf voltages. It is advantageous to be able to measure rf voltages in receiver signal tracing and in various forms of experimental work.

Figure 3-12 shows details of a crystal-type rf probe which may be used in conjunction with any dc vacuum tube voltmeter. This is one of many types of such probes which have been developed since introduction of the germanium crystal diode.

This probe will handle frequencies up to 200 megacycles. The maximum voltage which may be checked with it will be 20 volts r.m.s. The 0.01-μfd input capacitor isolates the crystal and protects it and the circuit from harmful dc voltages which may be present in the circuit under

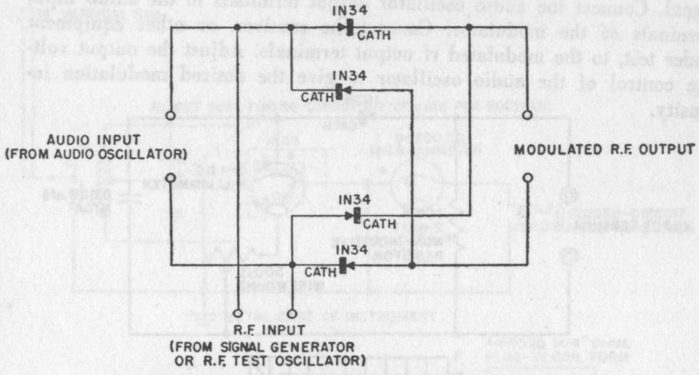


Figure 3-11. EXTERNAL MODULATOR FOR RF TEST OSCILLATOR

test. The indication obtained on the dc scale of the VTVM will be equal to approximately 1.4 times the r.m.s. value of the applied rf voltage. For best accuracy, the probe should be calibrated by applying to it a number of accurately-known rf voltages (checked by means of another voltmeter) and observing the corresponding readings of the dc vacuum tube voltmeter.

3.13 AUDIO EXTRACTOR FOR SIGNAL GENERATORS. While all signal generators and rf test oscillators are modulated internally, only a few of these instruments deliver an audio output signal in addition to rf. The audio voltage is useful for testing audio amplifiers and the audio channels of radio receivers, and for various other experimental purposes requiring a single test tone.

The circuit in Figure 3-13 extracts the audio signal from the modulated rf output of a signal generator. This device, which may be built easily into a small can or box, is connected to the output terminals of the signal generator and requires no tampering with the internal circuit of the instrument.

3.14 TUBELESS TONE GENERATOR. When an ac signal is applied to two crystals connected in a *full-wave* rectifier circuit, the output current delivered by the crystals is a pulsating dc having twice the frequency of the applied voltage. The full-wave circuit thus becomes a frequency doubler. A second full-wave circuit, added in cascade to the first one, will double the frequency again, thereby delivering 4 times the frequency of the input signal. Any additional full-wave circuit will double the frequency it receives, and the multiplication process may be carried on to a point at which the output voltage finally becomes too low to be useful. In this way, a number of stages may be cascaded, each stage output giving a tone which is an even multiple of the input frequency.

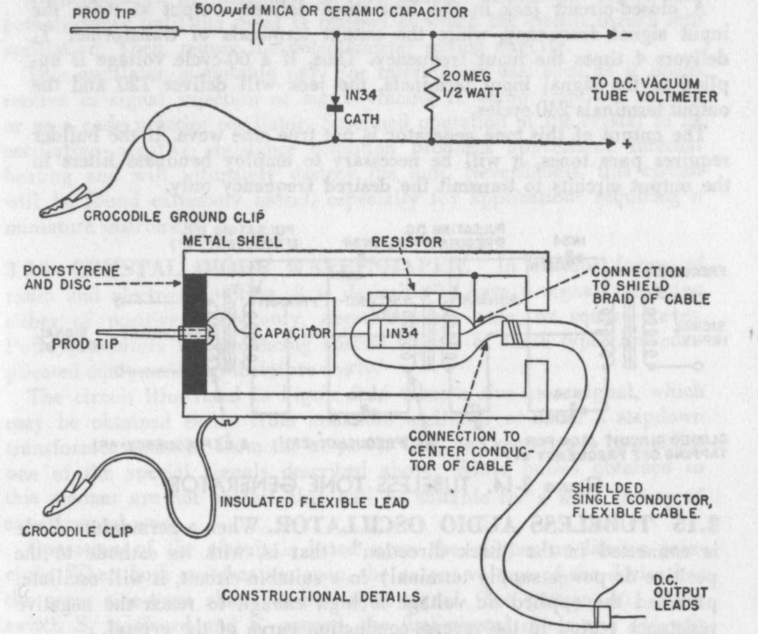


Figure 3-12. RF PROBE FOR DC VACUUM TUBE VOLTMETER

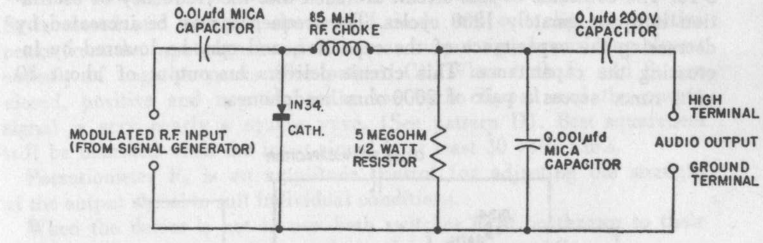


Figure 3-13. AUDIO EXTRACTOR FOR RF SIGNAL GENERATORS

Figure 3-14 shows a circuit of this kind for doubling and quadrupling any audio frequency within the range of the coupling transformers. The input signal may be taken from the ac power line or from an audio oscillator. Three audio transformers and four crystal diodes are employed. If the builder desires, two Sylvania 1N35 duo-diode units may be used in place of the four separate 1N34's. T_1 and T_2 are ordinary interstage audio transformers with single-ended primaries and push-pull secondaries. T_3 has a single-ended primary and secondary.

A closed-circuit jack in the first stage delivers output at twice the input signal frequency, while the output terminals of transformer T_3 delivers 4 times the input frequency. Thus, if a 60-cycle voltage is applied to the signal input terminals, the jack will deliver 120 and the output terminals 240 cycles.

The output of this tone generator is not true sine wave. If the builder requires pure tones, it will be necessary to employ bandpass filters in the output circuits to transmit the desired frequency only.

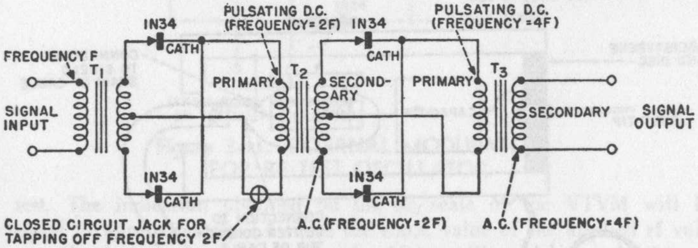


Figure 3-14. TUBELESS TONE GENERATOR

3.15 TUBELESS AUDIO OSCILLATOR.

When a germanium diode is connected in the "back direction" (that is, with its cathode to the positive dc power supply terminal) in a suitable circuit, it will oscillate, provided the applied dc voltage is high enough to reach the negative resistance region in the reverse-conduction curve of the crystal.

An audio oscillator circuit applying this principle is shown in Figure 3-15. The constants of this circuit are such that the frequency of oscillation is approximately 1200 cycles. The frequency may be increased by decreasing the capacitance of the capacitor, and may be lowered by increasing the capacitance. This circuit delivers an output of about 30 volts r.m.s. across a pair of 2000-ohm headphones.

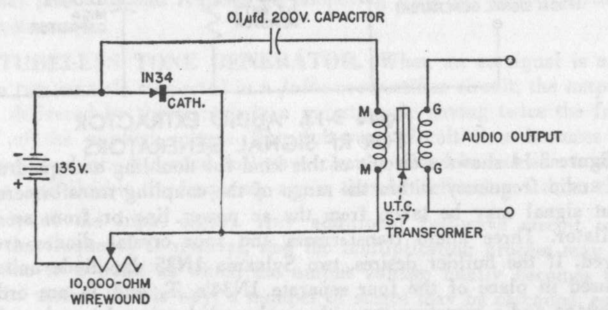


Figure 3-15. TUBELESS AUDIO OSCILLATOR

Adjustment of the oscillator is very simple: Rotate the 10,000-ohm potentiometer until the point is reached at which the circuit breaks into oscillation. Then, reduce the potentiometer setting slightly.

This oscillator is suitable only for intermittent use, such as it might receive in signal injection or signal tracing in audio amplifier testing, or as a code practice oscillator. Sustained operation of the crystal in its oscillating negative resistance condition produces appreciable internal heating and will ultimately destroy the unit. Nevertheless, this circuit will be found extremely useful, especially for applications requiring a miniature instrument.

3.16 CRYSTAL DIODE WAVE SHAPER.

In various forms of radio and electronic testing, it is desirable to have a signal consisting either of positive peaks only, negative peaks only, or square waves. Pulse generators for producing special signals of these types are complicated equipment and therefore costly.

The circuit illustrated in Figure 3-16 takes a sine-wave signal, which may be obtained easily from an audio oscillator or from a stepdown transformer operated from the ac power line, and converts it into either one of the special signals described above. While pulses obtained in this manner are not perfect, they will be suitable for a wide variety of experimental work.

Operation of the circuit is based upon the *clipper* or *limiter* principle. When both switches are open, the output voltage of the device has the same sine-wave shape as the input signal (See pattern A). When switch S_2 is closed and S_1 opened, the first crystal diode and 1½-volt cell clip the negative peaks from the input signal and deliver an output signal consisting almost entirely of positive peaks (See pattern B). When S_1 is closed and S_2 open, the second diode and cell clip the positive peaks from the input signal and deliver an output signal consisting almost entirely of negative peaks (See pattern C). When both S_1 and S_2 are closed, positive and negative peaks are both clipped and the output signal is very nearly a square wave. (See pattern D). Best squareness will be obtained when the input signal is at least 30 volts r.m.s.

Potentiometer R_2 is an amplitude control for adjusting the strength of the output signal to suit individual conditions.

When the device is not in use, both switches must be thrown to their *open* position to prevent battery drain through the crystals.

3.17 AF-RF WATTMETER

The instrument shown in Figure 3-17 will indicate audio-frequency or radio-frequency power up to 100 watts, either directly on a specially-drawn meter scale or by reference to a calibration curve such as the one shown below the circuit diagram. This wattmeter may be built into a small metal meter box.

After the circuit has been wired, the instrument must be calibrated in the following manner. Disconnect temporarily one end of resistor R_2, and short-circuit terminals 3 and 4. Apply an accurately-known 10-volt r.m.s. signal (60 cycles will do) to input terminals 1 and 2, and adjust

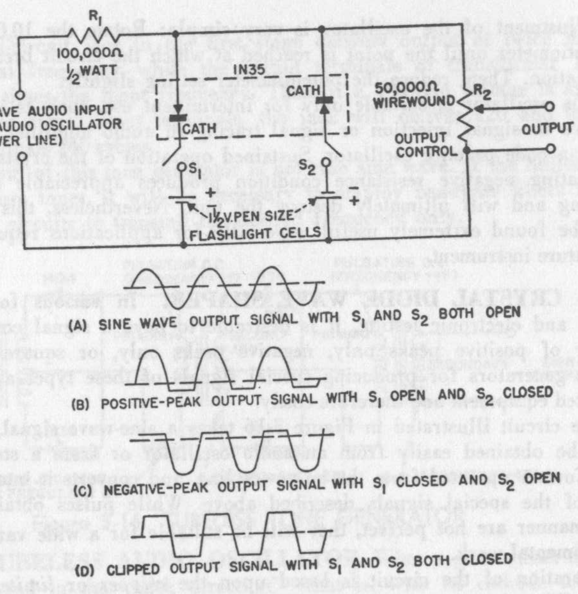


Figure 3-16. CRYSTAL DIODE WAVE SHAPER

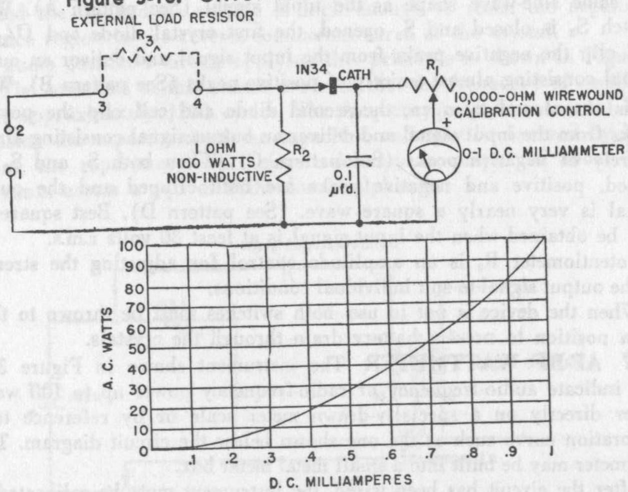


Figure 3-17. AF-RF WATTMETER

rheostat R_1 for exact full-scale deflection of the milliammeter. Because of the linearity of the crystal-meter combination in this voltage range,

only the single-point check need be made. Do not disturb the setting of R_1 unless a recalibration is required later on. Remove the signal voltage from terminals 1 and 2, remove the short-circuiting jumper from terminals 3 and 4, and reconnect resistor R_2.

This wattmeter is very simple to use. The following procedure is recommended. (1) Determine the output impedance of the amplifier, oscillator, or other device to be tested. (2) Connect to terminals 3 and 4 a 100-watt resistor (preferably non-inductive) which has a resistance value equal to 1 ohm less than the impedance of the power-delivering device. It may not always be possible to obtain a resistor having the exact resistance value required. In this case, it will be necessary to use a wirewound unit with a slider set to the desired ohmic value. If the output impedance of the power-delivering device is 1 ohm, do not use an external resistor at all. Instead, short-circuit terminals 3 and 4. (3) Connect terminals 1 and 2 to the output terminals of the power-delivering device. (4) Read output watts on the meter scale, or by reference to the curve given in Figure 3-17. (5) Multiply this meter reading by the output impedance of the device under test when this impedance is higher than 1 ohm.

When checking the power output of an audio amplifier, disconnect the loudspeaker voice coil from the amplifier, connect terminals 1 and 2 of the wattmeter in place of the voice coil, and connect a resistor to terminals 3 and 4 equal in ohmage to the voice coil impedance minus 1 ohm. The external resistor must be rated to handle at least 2 times the power output of the amplifier.

3.18 SENSITIVE AF-RF SIGNAL TRACER. Numerous crystal diode signal tracers have been designed by radio writers. The instrument shown in Figure 3-18 has the advantages that it will give meter readings, as well as headphone signals, at very low values of signal input voltage. This tracer may be used for trouble shooting in all of the rf, detector, oscillator, if, and audio stages of a radio receiver, and in audio amplifier systems.

A Type 1N54 high-efficiency diode is used for improved performance. The 0.01-μfd input capacitor protects the diode, headphones, and meter from any dc voltage which may be present in the circuit under test. The 200,000-ohm rheostat acts as a gain control to adjust the meter current to a readable value. The meter circuit is plugged into the jack in the end of the handle of the exploring probe for visual indications; the headphones for aural indications. A modulated signal is necessary to operate the headphones, but the meter will be actuated by either a modulated or unmodulated signal.

3.19 DISTORTION METER. This instrument (See Figure 3-19) can be used to measure the distortion percentage of audio amplifiers and oscil-

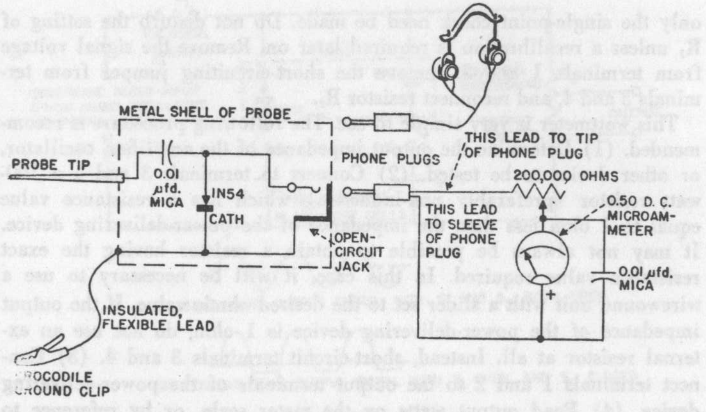


Figure 3-18. SENSITIVE AF-RF SIGNAL TRACER

lators. It consists of a bridged-T null network and a 3-range crystal voltmeter. With Switch S_2 in its top position, the instrument range is 0-100% distortion; with S_2 in its center position, the range is 0-10%; and with S_2 in its lower position, the range is 0-5%. The instrument operates at 400 cycles. The null network (consisting of the choke, two

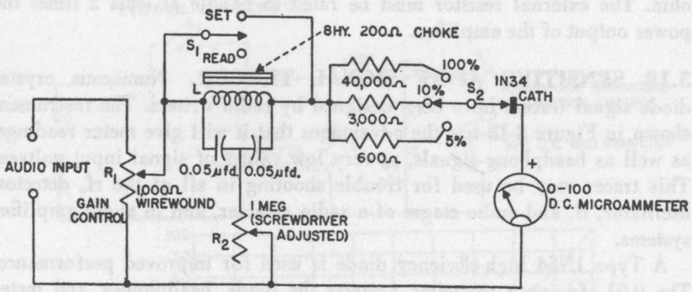


Figure 3-19. DISTORTION METER

0.05-μfd. capacitors, and 1-megohm rheostat) removes the 400-cycle fundamental frequency. Any voltage remaining is due to harmonics and is measured by the crystal voltmeter.

After the instrument has been completed, it must be calibrated in the following manner: The microammeter needs no special calibration on the 0-100% scale, it being read directly in percentage. The 0-10 and 0-5 scales must be calibrated separately, however, because of non-linearity of the crystal at the lower voltages. Apply a variable-voltage source to the audio input terminals of the distortion meter (60 cycles will do),

set gain control R_1 to the top of its range, throw switch S_1 to its SET position, and set switch S_2 to its 10% position. Adjust the voltage in 1/10-volt steps from 0.1 to 1 volt, marking the meter scale or making a calibration chart. The voltage scale then will show distortion percentages in the following manner:

RMS INPUT VOLTS	% DISTORTION
0.1	1
0.2	2
0.3	3
0.4	4
0.5	5
0.6	6
0.7	7
0.8	8
0.9	9
1.0	10

Next switch S_2 to its 5% position and apply a variable input in 1/10-volt steps from 0.1 to 0.5 volt and prepare another meter scale or reference chart as follows:

RMS INPUT VOLTS	% DISTORTION
0.1	1
0.2	2
0.3	3
0.4	4
0.5	5

For the initial adjustment: (1) Connect the input terminals of the distortion meter to a variable-frequency audio oscillator. (2) Set output control of oscillator to maximum. (3) Throw switch S_1 to SET. (4) Set oscillator dial to 400 cycles. (5) Adjust gain control R_1 (with S_2 on 5% range) for full-scale deflection of microammeter. (6) Throw S_1 to READ, noting drop in meter deflection. (7) Tune oscillator above and below 400 cycles, noting that meter deflection passes through null. Retune dial carefully for lowest dip in microammeter reading. This setting of oscillator dial should be 400 cycles. If it is not, due to inaccuracies in the capacitors and choke in the distortion meter, mark exact point on oscillator dial for quick re-tuning. (8) Adjust rheostat R_2 carefully for an improvement in the null. (9) When the best null point is obtained, the meter very likely will not read exactly zero. The reading at this point indicates the distortion percentage of the oscillator. This figure must be recorded, since it should be subtracted from any distortion readings obtained later on when this oscillator is employed.

To use the distortion meter, follow the instructions: (1) Connect the audio oscillator (set to the 400-cycle test frequency) to the input terminals of the amplifier under test. (2) Connect the input terminals of the distortion meter to the output terminals of the amplifier (that is, across the loudspeaker voice coil or across a substitute load resistor having the ohmic value of the voice coil impedance). (3) Set S_1 to SET. (4) Set S_2 to 100%. (5) With the oscillator and amplifier in operation, adjust R_1 for a meter reading. (6) Set S_1 to READ. (7) Read distortion percentage on the meter scale or by reference to the calibration chart. If a readable deflection is not obtained, throw S_2 to a lower range.

3.20 SIMPLE SELECTIVE TELEPHONE CIRCUIT. Figure 3-20 shows a simple wire telephone circuit by means of which either one of two remote listeners (both on a single, 2-wire line) may be addressed without the other one hearing. This scheme will appeal to Scouts, summer campers, and house-to-house telephone enthusiasts.

The circuit operates in this way: Listener A has a crystal diode "forward connected" in series with his headphones. In the forward direction, this crystal introduces very little resistance into the circuit and station. A accordingly hears clearly whatever is said into the microphone. Listener B, however, has a crystal "back connected" in series with his headphones. In the back direction, this crystal introduces a very high resistance into that portion of the circuit which includes headphones B. The currents flowing through these headphones therefore are too small to reproduce sound. Station B hears nothing.

In order to reverse the procedure and talk to station B, to the exclusion of A, simply reverse the polarity of the battery at the sending station.

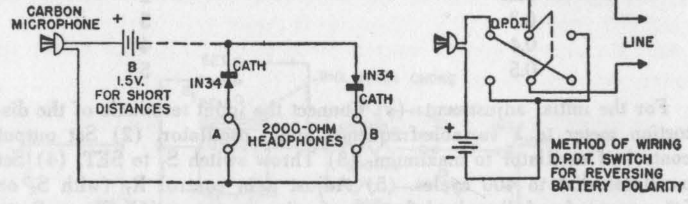


Figure 3-20. SIMPLE SELECTIVE TELEPHONE CIRCUIT

whereupon the crystal A becomes a high resistance and cuts out that station, while B receives.

For short distances, the battery can be a 1½-volt dry cell. For longer distances, the voltage must be increased to overcome the resistance losses in the wires. The best voltage for a given distance must be determined experimentally. For simplicity, only a one-way circuit is shown in Figure 3-20.

3.21 SELECTIVE TELEGRAPH CIRCUIT. By employing the same principle described in Section 3.20, a 2-wire line may be used for sending telegraph signals separately to either one of two receiving stations connected across the line. Instead of telegraphing, a bell or other alarm may be operated at will at either one of the stations without disturbing the other. Figure 3-21 shows the circuit used.

Each receiving station has a sensitive relay and crystal diode connected in series across the 2-wire line. At Station A, the crystal is forward-connected and allows between 2 and 3 milliamperes to flow through its associated relay coil when the key or switch is closed at the transmitting station. This current is sufficient to operate the relay. At Station B, the crystal is back-connected and passes only about 100 microamperes through its relay coil. This small current is insufficient to pick up the relay. When the polarity of the transmitting battery is reversed, the relay at Station B is actuated because its crystal anode then is connected to the positive battery terminal (forward connection), and the one at Station A is dead.

The relays may be used to operate telegraph sounders, bells, horns, lamps, locks, valves, or other electromechanical or electrical devices.

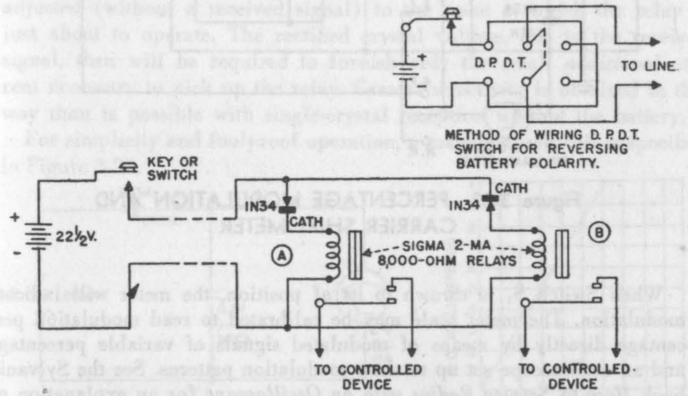


Figure 3-21. SELECTIVE TELEGRAPH CIRCUIT

The 22½-volt battery is adequate for operation up to several hundred feet when the wire used in the line is at least No. 18 in size. For longer-distance communication, the battery voltage must be increased, the most suitable voltage being determined by experiment.

3.22 MODULATION AND CARRIER SHIFT METER. The instrument shown is circuit schematic in Figure 3-22 will give direct indications of modulation percentage on either positive or negative peaks, and will indicate carrier shift when used to monitor an amplitude-modulated radio transmitter. This is the circuit of the popular Sylvania Modmeter.

The input terminals of this instrument are link coupled (by means of a small pickup coil and twisted-pair or coaxial line) to the final amplifier plate tank coil of the modulated transmitter. With the ganged switch, S_1, thrown to its rf position, the coupling between the pickup coil and the plate tank is varied while the 100-μfd. tuning capacitor is adjusted to deflect the milliammeter to a reference point near full-scale. This reading will not change unless carrier shift is present in the transmitted signal.

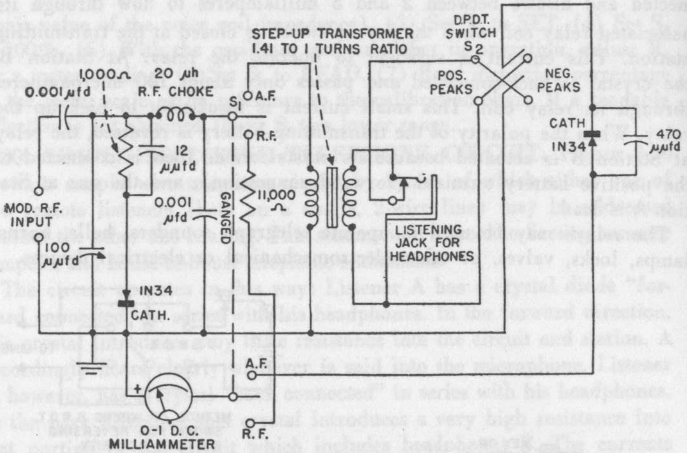


Figure 3-22. PERCENTAGE MODULATION AND CARRIER SHIFT METER

When Switch S_1 is thrown to its af position, the meter will indicate modulation. The meter scale may be calibrated to read modulation percentage directly by means of modulated signals of variable percentage and an oscilloscope set up to show modulation patterns. See the Sylvania book *How to Service Radios with an Oscilloscope* for an explanation of these patterns, how to obtain them, and how to interpret them. When switch S_2 is thrown to its left-hand position, positive-peak modulation will be indicated by the meter. With this switch in its right-hand position, negative-peak modulation will be indicated.

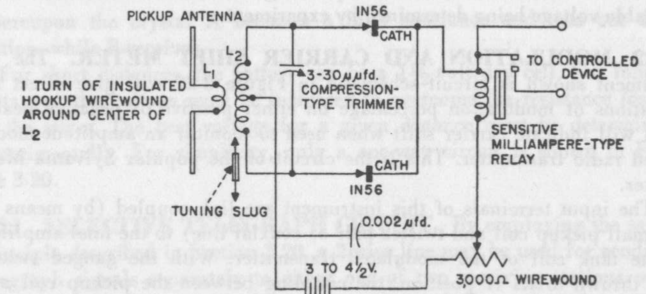


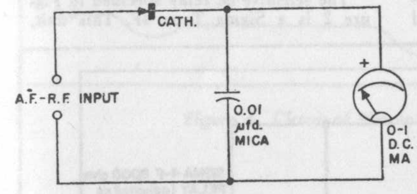
Figure 3-23. 144-MC RECEIVER FOR MODEL CONTROL

Headphones may be plugged into the closed-circuit listening jack for the purpose of monitoring the modulated signal for voice quality and for the presence of noise or hum. When making modulation percentage checks, however, the headphones must be removed.

3.23 RECEIVER FOR MODEL CONTROL. Figure 3-23 gives the circuit diagram of a 144-Mc-band crystal receiver for model control. This set has the particular advantage of small size and light weight, features which suit it well for airplane and small boat control.

Increased sensitivity is obtained in this circuit by the use of two Type 1N56 high-conduction crystal diodes in a full-wave detector circuit, and by use of a bias battery. The battery current through the relay coil is adjusted (without a received signal) to the point at which the relay is just about to operate. The rectified crystal voltage, due to the received signal, then will be required to furnish only the small *additional* current necessary to pick up the relay. Greater sensitivity is obtained in this way than is possible with single-crystal reception without the battery.

For simplicity and foolproof operation, a manufactured coil is specified in Figure 3-23.



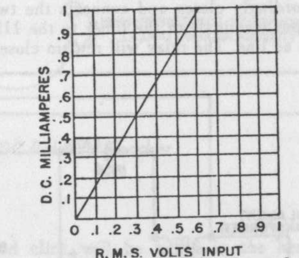


Figure 3-24. CRYSTAL VOLTMETER

3.24 CRYSTAL VOLTMETER. The crystal voltmeter has the advantages that it is capable of instant operation; requires no zero setting; has a wide frequency response extending from power-line frequencies to 200 megacycles or more; is compact enough to be built easily as an output indicator into other instruments such as wavemeters, oscillators, bridges, and monitors; and requires no batteries nor other power supply for its operation. Its input impedance, however, is low compared to a vacuum tube voltmeter. But this does not detract from its usefulness in many applications.

Figure 3-24 shows the simplest crystal circuit, employing a 1N34 diode, 0-1 dc milliammeter, and bypass capacitor. This meter will find a host of uses in the radio room.

The basic range of the meter is less than 1 volt r.m.s. signal input for full-scale deflection. Figure 3-24 shows a sample calibration curve for this instrument. The builder must calibrate his own meter, however, since individual crystals vary in conduction characteristics. The basic range of the meter may be extended, as in other ac meters, by use of multiplier resistors.

INTERVAL TIMER

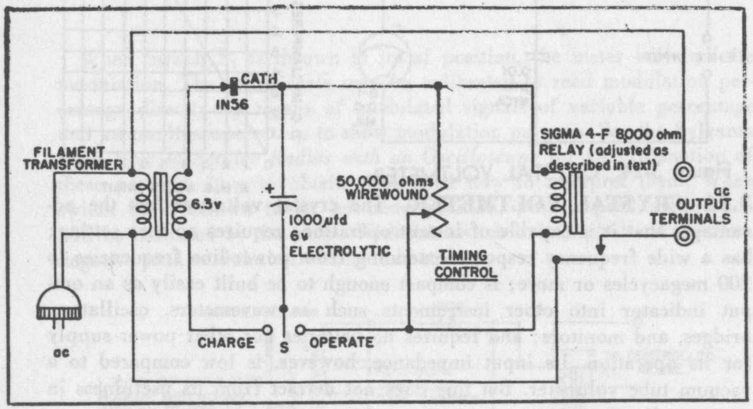
FIGURES 1, 2, and 3 show an interval timer which may be used to control directly electrical devices of various kinds. An important application of this device is controlling the lamp in a photographic printing box or enlarger.

In this circuit (See Figure 2), direct current supplied by a 1N56 Germanium Diode energized by the 6.3-volt winding of a small filament transformer is used to charge a 1000-microfarad electrolytic capacitor. The capacitor is charged by throwing the single-pole double-throw spring-return switch, S, momentarily to its left-hand position. When the switch then is released, it returns to its normal right-hand position and the capacitor charge causes a current to flow through the coil of the sensitive relay. The relay accordingly closes and connects the two output terminals of the timer to the 115-volt ac line. The relay will remain closed until the capacitor has discharged to a value below that required to energize the relay coil fully.

The time interval during which the relay remains closed is governed by the setting of the 50,000-ohm wirewound volume-control-type rheostat. The 50,000-ohm rheostat with the 1000μfd. capacitor will give time intervals between 1 and 15 seconds. Longer time intervals may be obtained by using a larger capacitor, for example 2000 to 4000 microfarads.

The output terminals are connected directly to a 115-volt device, such as a lamp, which is to be controlled. If the full line voltage is not desired for the timed power, the relay contacts should be connected directly to the two output terminals with no connection back to the power line.

The sensitive dc relay specified in Figure 2 is a Sigma Type 4F. This unit,



Timer Circuit

which may be obtained from electronic parts distributors and in some cases in the surplus market, has a coil resistance of 8000 ohms and is rated at 2 milliamperes. The reader must perform a simple operation to increase the sensitivity of the relay. This is done by rotating the single pivot-screw of the relay slightly in a clockwise direction. This loosens the armature spring and makes possible operation of the relay at currents as low as ½ milliampere. The spring tension must not be reduced too much or the relay will be sluggish in dropping out when current is removed.

Switch S should be a spring-return type. The normal resting position of the switch connects the capacitor to the relay circuit, as shown in Figure 2. Some readers will find it more desirable to use, instead of a switch, a single-pole double-throw pushbutton.

Use of the timer is simple: Throw switch S to its CHARGE position (the switch need not be held in this position longer than 1 or 2 seconds), then allow the switch to return to its OPERATE position The relay immediately will be picked up and will remain closed for a time interval determined by the setting of the rheostat. The controlled device, connected to the two output terminals of the timer, accordingly will operate during this interval. A scale, reading directly in seconds, may be drawn and installed under the pointer knob of the rheostat. This scale may be calibrated by means of a stop watch or the second hand of an ordinary watch or clock.

SIMPLE DC POLARITY CHECKER

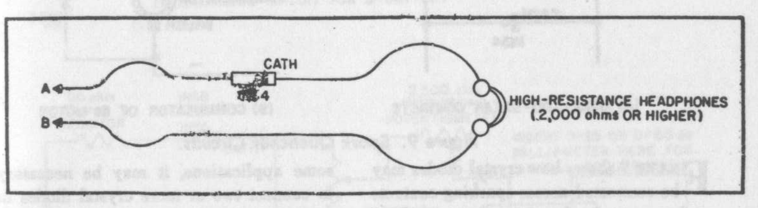
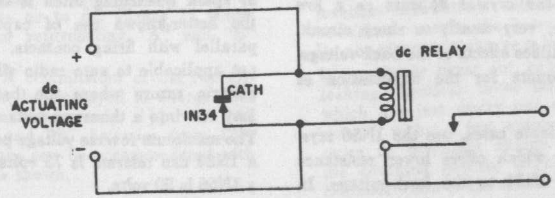


Figure 4. Circuit of Simple DC Polarity Checker.

A CRYSTAL diode and headphones may be used to check dc polarity when no other means is available. The simple arrangement for making this test is shown in Figure 4. Headphones must be the wirewound, not crystal type. The crystal diode must be connected with the polarity shown in the diagram; that is, with the crystal anode terminal "leading." When point A is touched to the positive terminal of the voltage source and point B to the negative terminal, a loud click will be heard in the headphones. When A is negative and B positive, little or no click at all is heard. This action is due to the fact that the crystal offers high resistance (no click) to one polarity, and low resistance (loud click) to the opposite polarity.

If 2000-ohm (or higher resistance) headphones are used, dc voltages as high as 80 may be checked with a 1N34 without damaging the crystal. The 1N58 will handle 100 volts.

INDUCTIVE-KICK QUENCHER FOR DC RELAYS



THE field coil of a small dc relay generates considerable inductive kick, by counter emf action, when the operating voltage is switched on and off. This kick produces sparking and pitting of the contacts of the actuating switch (or auxiliary relay) and can set up radio and television interference.

The inductive kick can be quenched effectively by means of a Germanium Diode connected in parallel with the relay coil, as shown in Figure 8. Note that the crystal cathode is connected to the positive terminal of the coil. Connected in this manner, the crystal appears as a high resistance to the operating voltage and draws only a tiny current. However, the objectionable back-voltage produced by the coil is of the opposite polarity, and to this voltage the crystal is a virtual short circuit. The crystal draws a heavy current while the back-voltage is present and absorbs the effect of this voltage.

A Type 1N34 Germanium Diode will be satisfactory in most applications of this type. In obstinate cases, the 1N56 will prove superior because of its higher conductivity. Two or more diodes connected in parallel also will increase the quenching action.

SPARK QUENCHERS

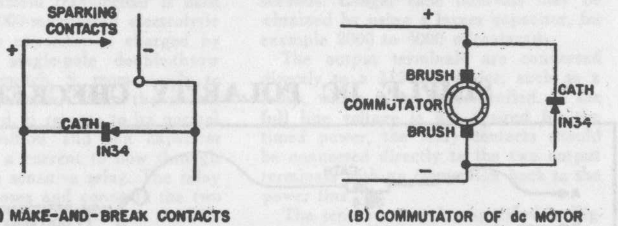


Figure 9. Spark Quencher Circuits.

FIGURE 9 shows how crystal diodes may be connected across sparking contacts and across the brushes of a small dc motor to suppress sparking. Such sparking leads to damage of the contacts or commutator and sets up radio and television interference.

Note that the crystal cathode is connected to the *positive* contact or brush. When connected in this manner, the crystal appears as a high resistance to the dc supply voltage and therefore draws only a few microamperes of current from the source. The sparking, however, is produced by a back-voltage which has a polarity opposite to that of the supply voltage. The positive of the back-voltage is applied to the crystal anode. To this polarity, the crystal appears as a low resistance, very nearly a short circuit, which nullifies effects of the back-voltage. This accounts for the suppression of sparking.

In obstinate cases, use the 1N56 crystal diode which offers lower resistance than the 1N34 to the back-voltage. In some applications, it may be necessary to connect two or more crystal diodes in parallel to handle the current. A good test is to check the heating of the diode after 5 minutes of operation. If a single diode is hot to the touch, use several in parallel.

For the most effective action in eliminating radio and television interference, mount the crystals as close as possible to the contacts or brushes.

The scheme shown in Figure 9(A) is especially effective for thermostats, dc switches, and low-voltage contactors. The circuit of Figure 9(B) is intended for small battery-operated motors, such as those employed in models, gaming machines, and similar devices. This method of spark quenching often is superior to the better-known use of capacitors in parallel with firing contacts. But it is not applicable to auto radio vibrators or electric razors where the back-voltage may run into a thousand volts or higher. The maximum reverse voltage peak which a 1N34 can tolerate is 75 volts; and for a 1N56 is 50 volts.

CHARGER FOR SMALL DRY BATTERIES

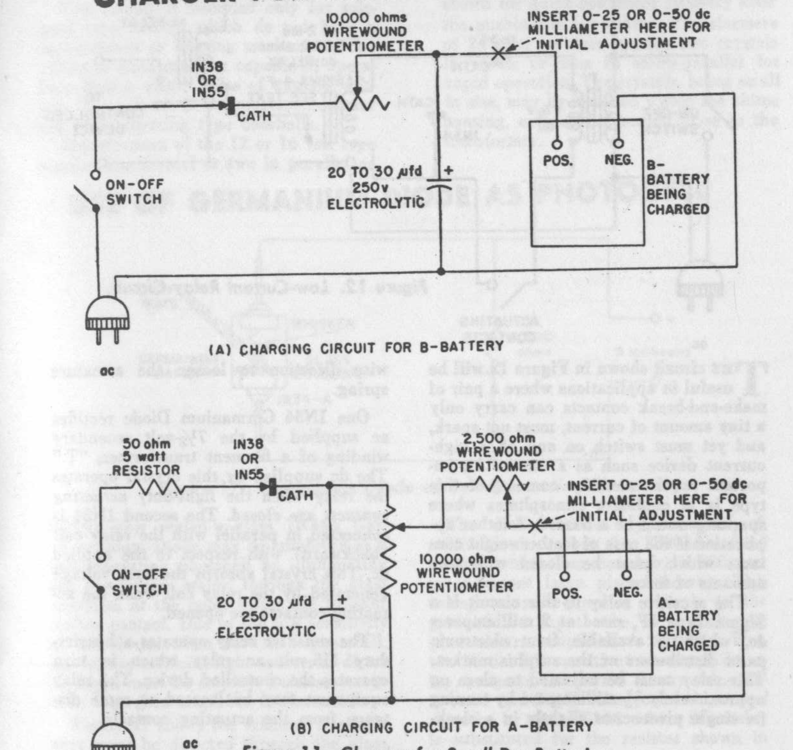


Figure 11. Charger for Small Dry Batteries.

SMALL dry "A" and "B" batteries, such as those used in hearing aids and portable radios, which have lost their pep can be rejuvenated sufficiently for at least one more service period by passing a small direct current through them.

A very compact charger can be made to operate from the ac power line by using a 1N38 or 1N55 crystal diode to convert the ac to dc. Figure 11 shows circuits for rejuvenating "A" and "B" batteries. A combination of the two circuits might be employed to charge both batteries simultaneously. 1½ volt "A" batteries, and "B" batteries from 22½ to 67½ volts can be accommodated with the circuits shown.

To adjust the circuit initially, insert temporarily a 0-25 or 0-50 dc milliammeter at the point marked "X" in the circuit diagram, and adjust the potentiometer for a current of 5 to 10 milliamperes through the battery. In the "A" battery charging circuit, both potentiometers must be adjusted.

The amount of time required to rejuvenate the battery will depend upon how much energy the battery has lost. Do not attempt to charge a battery which is completely burnt out, or one which is leaking chemical. Some small batteries which are just under par can be rejuvenated within a few minutes. Others require an overnight charge. Discontinue the charging process when the battery becomes warm to the touch.

LOW-CURRENT RELAY CIRCUIT

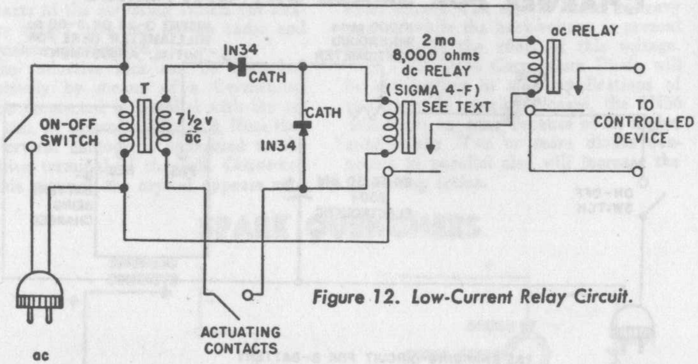


Figure 12. Low-Current Relay Circuit.

THE circuit shown in Figure 12 will be useful in applications where a pair of make-and-break contacts can carry only a tiny amount of current, must not spark, and yet must switch on and off a high-current device such as a motor. An important requirement for contacts of this type is in explosive atmospheres where sparking would be a hazard. Another application is the case of featherweight contacts which must be closed with tiny amounts of force.

The sensitive relay in this circuit is a Sigma Type 4F, rated at 2 milliamperes dc, which is available from electronic parts distributors or the surplus market. This relay must be adjusted to close on approximately ½ milliampere by turning its single pivot-screw slightly in a clockwise direction to loosen the armature spring.

One 1N34 Germanium Diode rectifies ac supplied by the 7½-volt secondary winding of a filament transformer, "T." The dc supplied by this crystal operates the relay when the light-duty *actuating contacts* are closed. The second 1N34 is connected in parallel with the relay coil "backward" with respect to the applied dc. This crystal absorbs the back voltage generated by the relay coil when the actuating contacts are opened.

The sensitive relay operates a heavier-duty 115-volt ac relay which in turn operates the controlled device. The relay equipment may be located at some distance from the actuating contacts.

DOOR-CHIME "PEPPER"

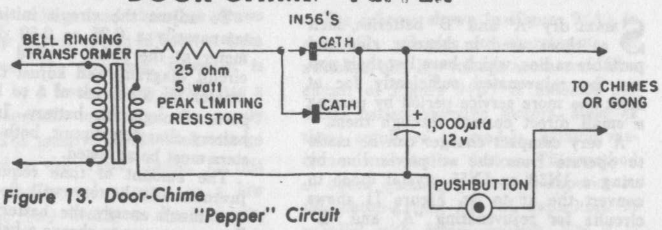


Figure 13. Door-Chime "Pepper" Circuit

THE circuit of Figure 13 is used to "pep up" door chimes or single-stroke signal gongs which have grown weak in service. The two crystal diodes in parallel supply dc to the 1000-microfarad capacitor which charges up to the peak value of the unloaded transformer secondary voltage. This full voltage is applied momentarily to the chime when the pushbutton is depressed. The capacitor charges quickly when the button is released or when the chime mechanism releases.

This circuit is intended only for solenoid type alarms which do not have a motor-driven or buzzing mechanism. The chime or gong must be capable of operating from a single pulse of applied voltage. The scheme is not recommended for use with vibrating type doorbells.

Transformers of the 12 or 16 volt type require one crystal or two in parallel as shown for quick condenser recovery after the pushbutton is released. Transformers of 24 volts or more require two crystals in series or four in series-parallel for rapid operation. The crystals, being small in size, may be installed within the chime housing, or may be located close to the transformer.

USE OF GERMANIUM DIODE AS PHOTOCELL

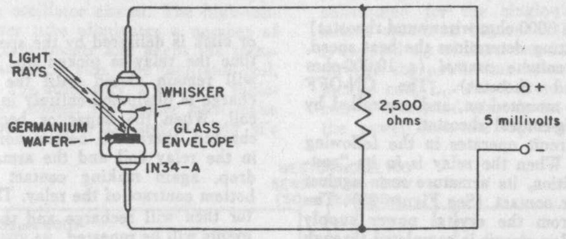


Figure 17 Germanium Diode as Self-Generating Photocell.

THE new sealed-in-glass 1N34A Germanium Diode may be employed as a self-generating photocell by illuminating the germanium wafer, through the glass envelope, at the point where the whisker makes contact. Due to the low sensitivity of this device when used as a photocell, an intense artificial light source, or direct sunlight, must be employed unless a suitable high-gain amplifier is also used.

Figure 17 shows the scheme. The light rays must be directed through the glass envelope in such a manner as to illuminate the *face* of the germanium wafer. A 2500-ohm ½ watt carbon resistor is employed as the load resistance. The output voltage is positive at the whisker terminal and negative at the germanium terminal. Any external device connected to the output terminals, to utilize the light-generated voltage, must have high resistance (preferably several times the value of the 2500-ohm load resistance).

The diode delivers approximately 5 millivolts dc across the 2500-ohm load resistor when illuminated by a 200-watt incandescent lamp placed nearby. This voltage may be applied directly to the grid of the input tube in a high-gain photoelectric amplifier. A 2000-ohm Weston Model 705 sensitive meter-type dc relay (selected to operate at any value between 1 and 5 millivolts) can be operated directly by the 1N34A when this relay is substituted for the resistor shown in Figure 17.

Although the sealed-in-glass type Germanium Diode is relatively insensitive when compared with conventional self-generating photocells, it will be of interest where high light intensities are available (as through concentration of a light beam through lens systems) and where its very small size offers appeal. Voltage output will vary with individual diodes.

ELECTRONIC METRONOME

The circuit schematic of the metronome is shown in Figure 23. The low current required for operation of the unit is supplied by a 1N34 Germanium Diode powered by the 6.3-volt secondary winding of a small filament transformer. The "beating" mechanism is a sensitive dc relay. This is an inexpensive Sigma 4-F 8000-ohm unit which must be adjusted by the reader, as described in Article 9, to operate on ½ milliampere. Beats are delivered by a 3½ inch-diameter PM dynamic speaker. There are only two adjustable components—the *timing*

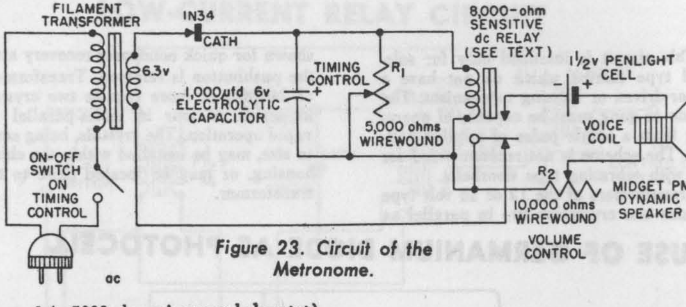


Figure 23. Circuit of the Metronome.

control (a 5000-ohm wirewound rheostat) whose setting determines the beat speed, and the *volume control* (a 10,000-ohm wirewound rheostat). The ON-OFF switch is mounted on, and controlled by the timing-control rheostat.

The circuit operates in the following manner: When the relay is in its "resting" position, its armature rests against the lower contact (See Figure 23). The circuit from the crystal power supply to the relay circuit is completed through this lower contact. The 1000-microfarad electrolytic capacitor is charged by rectified current flowing from the 1N34 crystal diode. When the capacitor becomes charged, its voltage is applied to the relay coil and the relay accordingly picks up its armature. The armature then makes contact with the upper contact of the relay, closing the circuit from the 1½-volt cell through the volume control and the voice coil of the speaker. A pop or click is delivered by the speaker each time the relay is picked up. The relay will remain closed until the capacitor charge is dissipated entirely in the relay coil. When the capacitor becomes discharged, there will be no more current in the relay coil and the armature will drop, again making contact with the bottom contract of the relay. The capacitor then will recharge and the cycle of events will be repeated.

The length of time taken for the capacitor to charge and discharge (and therefore the number of beats obtained in a given time interval) depends upon the setting of the time-control rheostat connected in parallel with the relay coil.

The 10,000-ohm rheostat gives good control of the volume. At maximum volume, the small speaker will deliver a loud "plop" which competes effectively with piano music.

WIRED-RADIO-CONTROL RELAY SYSTEM

OFTEN, it is desirable to switch-on an electrical device located in the same building but at some distance from the control point, without running special wires for the purpose. Use of an "on-the-air" radio system is ruled out because in most cases the transmitter power must be so high that a radio station license and operator license will be required.

Wired radio is entirely satisfactory for this purpose. In this system, the controlling system is generated by a miniature, low-powered, low-frequency transmitter and is piped over the regular power line. At the remote point, a simple, low-frequency receiver picks up the signal by direct connection to the power line and uses it to operate a relay. By using a crystal detector in the receiver, tubes are eliminated and no power is taken by the receiver. This results in maximum economy of operation both during operation and during standby periods.

The components of a simple, effective wired-radio-control system are shown in the accompanying illustrations. Figures 29 and 30 show the tiny transmitter, Figure 31 the receiver relay unit, and Figure 32 the circuit schematics of the two units. No antennas nor interconnecting wires are needed. The receiver is plugged into the power line at one location, and the transmitter at another. When the control switch in the transmitter is closed, the receiver relays also close. When operation is desired at different locations, it is necessary merely to plug in transmitter and receiver at the desired points. Both transmitter and receiver operate on a frequency of approximately 100 kc. The radio signal is confined very well to the power line with the result that only a negligible amount of radio interference can be created.

The transmitter (See Figure 32-B) employs a 117-volt tube in a series-type Hartley oscillator circuit. The high-voltage-heater tube eliminates a number of circuit components and keeps the transmitter small in size. The oscillator coil, L_2, is a 2½ millihenry, a 4-pi-type radio-frequency choke. The reader must make a tap between the 1st and the 2nd pi's from the lower end of the choke by carefully scraping the insulation from the wire connecting these two pi's and soldering a thin wire lead to the scraped portion. The pickup coil, L_1, is made by winding 6 turns of No. 18 insulated solid hookup wire tightly around the outside of the rf choke. This pickup coil is seen plainly in Figure 30. If desired, a single-pole, single-throw pushbutton may be substituted for the single-pole control switch shown in Figure 32(B). Energy is coupled out of the transmitter and sent through the power line by means of the pickup coil, L_1. The bottom end of this coil is connected directly to one side of the power line, the top end is capaci-

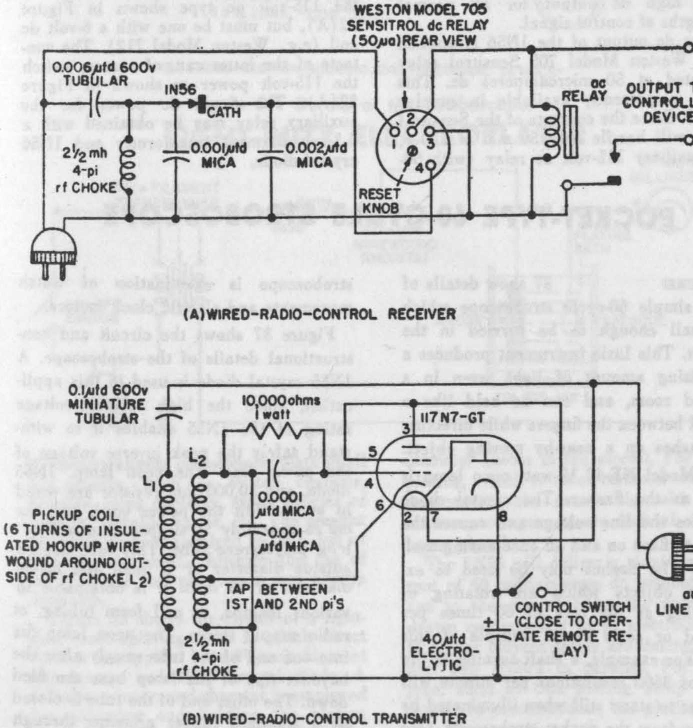


Figure 32. Circuits of the Wired-Radio-Control Equipment.

tance-coupled to the other side of the line through the 0.1-microfarad capacitor which prevents the pickup coil from short-circuiting the line. The transmitter is built in a small, metal radio utility box 4" long, 1½" wide, and 1½" high. Figures 29 and 30 show constructional details.

The control signal from the transmitter is picked up from the power line by the receiver. One side of the receiver circuit is connected directly to the power line; the other side is capacitance-coupled to the other side of the line through a 0.006-microfarad capacitor (See Figure 32-A) which prevents the receiver from short-circuiting the line. The receiver tuning coil, like the transmitter coil, is a 2½ millihenry, 4-pi-type rf choke. The 1N56 high-conduction crystal diode supplies high dc output for all normal strengths of control signal.

The dc output of the 1N56 is applied to a Weston Model 705 Sensitrol relay operated at 50 microamperes dc. This relay is presently available in surplus stocks. Since the contacts of the Sensitrol relay will handle only 50 ma. at 120 v, an auxiliary 115-volt ac relay (with 50-ma. coil) having heavy-duty contacts is provided to switch power to the controlled device.

The Sensitrol relay contacts are magnetic and remain closed, once the relay has operated, until they are reopened by turning a re-set knob at the rear of the case. The Sensitrol relay may be obtained also with the re-set shaft extending through the front glass of the instrument). This feature may be objectionable, especially in applications requiring that the relay release automatically when the control signal is switched-off. For automatic release, a non-magnetic meter-type relay, such as the Weston Model 813, is recommended. However, the contacts of the Model 813 can handle only 30 milliamperes at 6 volts dc. For this reason, the *auxiliary relay* cannot be the 115-volt ac type shown in Figure 32(A), but must be one with a 6-volt dc coil (e.g., Weston Model 712). The contacts of the latter can, of course, switch the 115-volt power as shown in Figure 32(A). The 6-volt dc power for the auxiliary relay may be obtained with a 6.3-volt filament transformer and 1N56 crystal diode.

POCKET-TYPE 60-CYCLE STROBOSCOPE

FIGURES 37 show details of a simple 60-cycle stroboscope which is small enough to be carried in the pocket. This little instrument produces a surprising amount of light, even in a lighted room, and can be held like a pencil between the fingers while directing its flashes on a near-by moving object.

A Model NE-48 ¼-watt neon lamp is used as the flasher. The crystal diode rectifies the line voltage and causes the lamp to flash on and off once during each cycle. The flashes may be used to examine objects which are rotating or vibrating at the rate of 60 times per second or some exact multiple of this rate. For example, a shaft turning at the rate of 3600 revolutions per minute will appear to stand still when illuminated by flashes from the pocket stroboscope. One important application of this simple stroboscope is examination of watch movements and electric clock motors.

Figure 37 shows the circuit and constructional details of the stroboscope. A 1N55 crystal diode is used in this application, since the high reverse voltage rating of the 1N55 enables it to withstand safely the peak inverse voltage of the power line. The neon lamp, 1N55 diode, and 30,000 ohm resistor are wired in series with the power cord, and the entire assembly is slipped into a 3½"-long polystyrene tube. This tube has an outside diameter of ¾ inch and inside diameter of ⅝ inch. It is obtainable in various lengths, as coil form tubing, at radio supply stores. The neon lamp fits into one end of the tube snugly after the bayonet tips of the lamp base are filed down. The other end of the tube is closed by a standard rubber grommet through which the power cord passes.

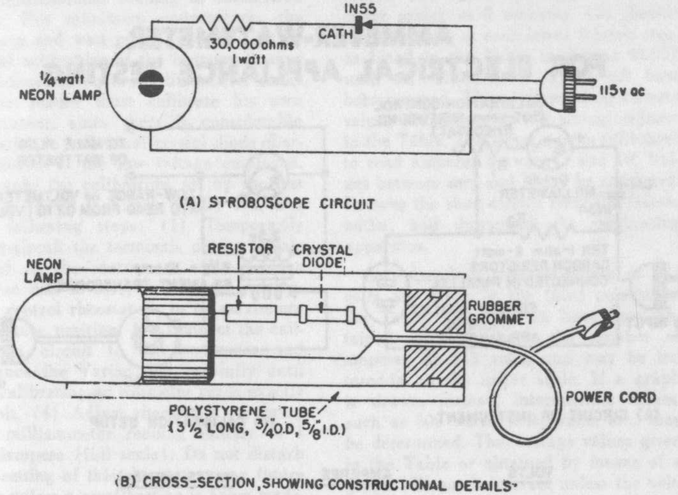
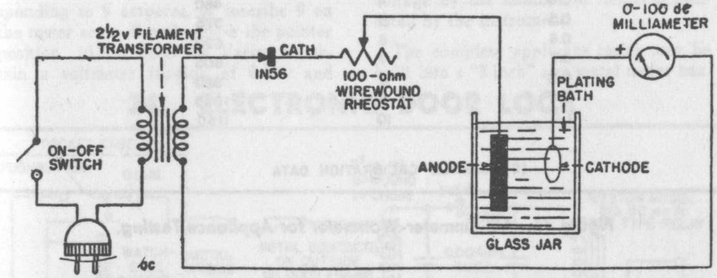


Figure 37. Details of the Stroboscope.

LIGHT-DUTY ELECTROPLATER

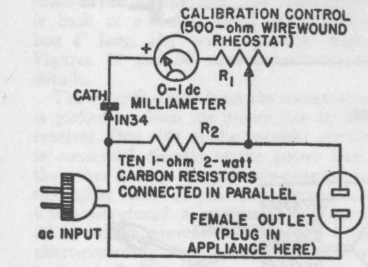


EXPERIMENTERS occasionally plate small objects, such as switch contacts, brushes, relay contacts, small articles of jewelry, metallic curios, etc. The amount of direct current required to do a job of this kind is small. However the use of batteries for the purpose is not always desirable.

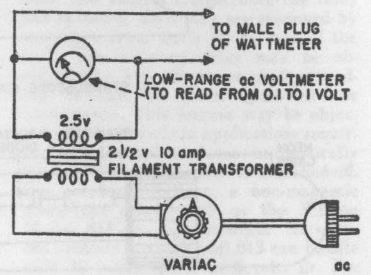
Figure 38 shows the circuit of a light-duty electroplating setup in which direct current is supplied by a 2½-volt filament transformer and 1N56 crystal diode. A 100-ohm wire-wound rheostat is employed for adjusting and holding the plating current to a predetermined value. The current level is read with the dc milliammeter shown in the circuit. For silver plating, which is most common with experimenters, the current is held to 50 milliamperes per square inch of surface being plated.

The 1N56 will deliver a maximum current of 60 milliamperes dc without damage to the crystal when the current is drawn continuously as in electroplating. If higher current levels are desired, connect two 1N56's in parallel. For small jobs, such as this plating setup is intended to accommodate, the plating fluid may be contained in a water glass, mayonnaise jar, or even a test tube.

AMMETER-WATTMETER FOR ELECTRICAL APPLIANCE TESTING



(A) CIRCUIT OF INSTRUMENT



(B) CALIBRATION SETUP

VOLTS	AMPERES	WATTS (AT 115v)
0.1	1	115
0.2	2	230
0.3	3	345
0.4	4	460
0.5	5	575
0.6	6	690
0.7	7	805
0.8	8	920
0.9	9	1035
1.0	10	1150

(C) SAMPLE CALIBRATION DATA

Figure 41. AC Ammeter-Wattmeter for Appliance Testing.

ELECTRICAL repairmen will find the crystal meter circuit shown in Figure 41 (A) useful for checking the amperes and watts drawn by electrical appliances such as motors, heaters, lamps, irons, etc. This instrument is as easy to use as a voltmeter.

The circuit consists of a simple ac voltmeter (Germanium Diode in series with a 0-1 dc milliammeter) connected in parallel with a 0.1-ohm resistor. The latter is made up of ten 2-watt carbon 1-ohm resistors connected in parallel with each other. All current drawn by the appliance under test must pass through the 0.1-ohm resistor. This current sets up a voltage drop across the resistor and this voltage deflects the meter. The meter reading is interpreted in terms of amperes or watts. By using a low value of series resistance, such as 0.1 ohm, the voltage drop is not high enough to reduce detrimentally the appliance voltage.

Use of the instrument is simple: The male plug is inserted into a power-line receptacle, the appliance is plugged into the female outlet of the instrument, and the amperes or watts read by referring

the milliammeter reading to calibration data. For maximum convenience, the ampere and watt points, obtained in the initial calibration of the instrument, may be lettered-in on the milliammeter scale.

The reader must calibrate his own instrument, since there is considerable variation in individual crystal diode characteristics at the low voltage employed. To make the calibration, set up the test circuit shown in Figure 41 (B) and take the following steps: (1) Temporarily short-circuit the terminals of the female outlet in the instrument. (2) Set the Variac dial to zero, and set the calibration control rheostat R_1 to its maximum-resistance position. (3) Connect the calibration circuit to the wattmeter and advance the Variac dial carefully until the calibrating ac voltmeter reads exactly 1 volt. (4) Adjust rheostat R_1 to bring the milliammeter reading exactly to 1 milliampere (full scale). Do not disturb the setting of this rheostat at any future time unless a recalibration is being made. (5) Reduce the Variac until the ac voltmeter reads 0.9 volt. Record the milliammeter reading at this point as corresponding to 9 amperes, or inscribe 9 on the meter scale directly above the pointer position. (6) Reduce the Variac to obtain a voltmeter reading of 0.8 v and record this value (or mark it on the meter scale) as 8 amperes. (7) Repeat the procedure at each lower 0.1-volt step, as listed in the Table in Figure 41 (C) until all values down to 0.1 volt have been covered. The corresponding ampere values are shown in the second column in the Table. The meter now is calibrated to read amperes between 1 and 10. Values between zero and 1 may be estimated. Remove the short-circuit from the female outlet, and disconnect the calibrating apparatus.

Corresponding wattage values *at 115 volts* are given in the third column of the Table. These values have been obtained by multiplying the number of amperes by 115 volts, and may be lettered-in on the meter scale. If a graph is drawn, instead, intermediate values, such as 500 watts, 1000 watts, etc., may be determined. The wattage values given in the Table or obtained by means of a graph will not be correct unless the voltage *measured at the appliance* is 115 v. For any other voltage value, determine wattage by multiplying the appliance voltage by the number of amperes indicated by the instrument.

The complete appliance tester may be built into a "3-inch" size metal meter box.

24. ELECTRONIC DOOR LOCK

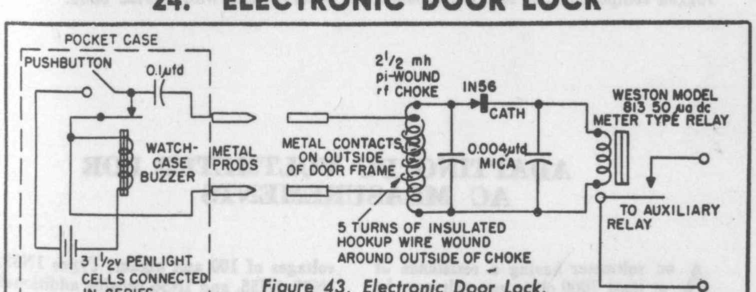


Figure 43. Electronic Door Lock.

FIGURE 43 shows the circuits of transmitter and receiver employed in a simple radio-controlled door lock. The transmitter employs the damped wave set up by the sparking contacts of a small watch-case type buzzer and can be made small enough (about the size of a hearing aid) to be carried in an ordinary suit coat pocket.

The receiver is a 50-kc crystal diode circuit which consumes no power during idle periods and needs no attendance. Two metal plugs or nails connected to the input coil of the receiver pass through the door frame and are accessible from the exterior.

In use, the two metal prods extending from the pocket transmitter are touched to the two door plugs and the transmitter pushbutton depressed. This operates the buzzer which transmits a damped wave through to the receiver and operates its relays and the electric door lock. Clever prowlers who see the system in operation will assume that the pocket device is a battery, but will learn that dc from a battery will not operate the system.

The contacts of the 50-microampere dc relay will not handle the current required to operate the door lock. A second relay accordingly must be employed. The sensitive relay operates the second relay, and the latter operates the door lock.

Both transmitter and receiver are very broad in response and therefore do not require critical tuning. For the same reason, there will be no difficulties due to frequency drift. Neither transmitter nor receiver uses tubes, hence maintenance problems, aside from occasional replacement of the penlight cells in the transmitter, are eliminated.

The electronic lock may be used on house and garage doors, as well as the doors of secret compartments, cabinets, storerooms, and other private chambers.

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-nose 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.

ADAPTING DC VOLTMETER FOR AC MEASUREMENTS

A DC voltmeter having a resistance of at least 1000 ohms per volt may be converted for emergency measurements of ac voltage by connecting a crystal diode temporarily in series with one of the indicating meter terminals *at the meter*. Connect the cathode terminal of the crystal to the positive terminal of the meter. A 1N34 will be satisfactory for short tests at all voltages. However, when long, continuous tests are to be made at voltages of 100 and higher, Types 1N38, 1N39, 1N55, and 1N58 provide additional crystal safety.

The meter will not be highly accurate, especially on ranges up to 10 volts, unless a special calibration is made. For emergency use, however, when comparative values will suffice, the ac voltage may be read on the regular dc scales of the meter.

BERNARDS AND BABANI PRESS RADIO BOOKS