ELECTRONIC SHORTCUTS FOR HOBBYISTS

24 CRYSTAL DIODE SIMPLIFIED APPLICATIONS FOR THE HOME HOBBYIST, EXPERIMENTER AND MODEL MAKER

Price 25¢

SYLVANIA ELECTRIC PRODUCTS INC.

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SYLVANIA ELECTRIC PRODUCTS INC.

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FOREWORD

Quite a few thousand words have been written in the last few years on applications of the versatile germanium diode. Most of this literature has been prepared for the benefit of readers who work with radio communications. We feel, therefore, that the radio amateur, experimenter, engineer, and service technician have been well supplied with information.

This booklet has been prepared expressly for another type of reader — the electrician, electrical experimenter, electronic hobbyist, and model maker. It has not been an easy task to develop circuits and gadgets of particular interest to the experimenter in these categories. However, we have selected from a growing mass of practical developments those devices which we believe will be of real service to a long neglected group of electrical men. Radio technicians will, of course, also find interest in the circuits and data contained in this booklet.

The great value of the Germanium Diode lies in the fact that it requires no power supply for its operation. It therefore can be used in systems in which standby power and frequent replacements of components are undesirable. Furthermore, the crystal diode is small in size and is simple in nature.

SYLVANIA ELECTRIC PRODUCTS INC.

ELECTRONICS DIVISION

1740 BROADWAY NEW YORK 19, N. Y.

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1. INTERVAL TIMER

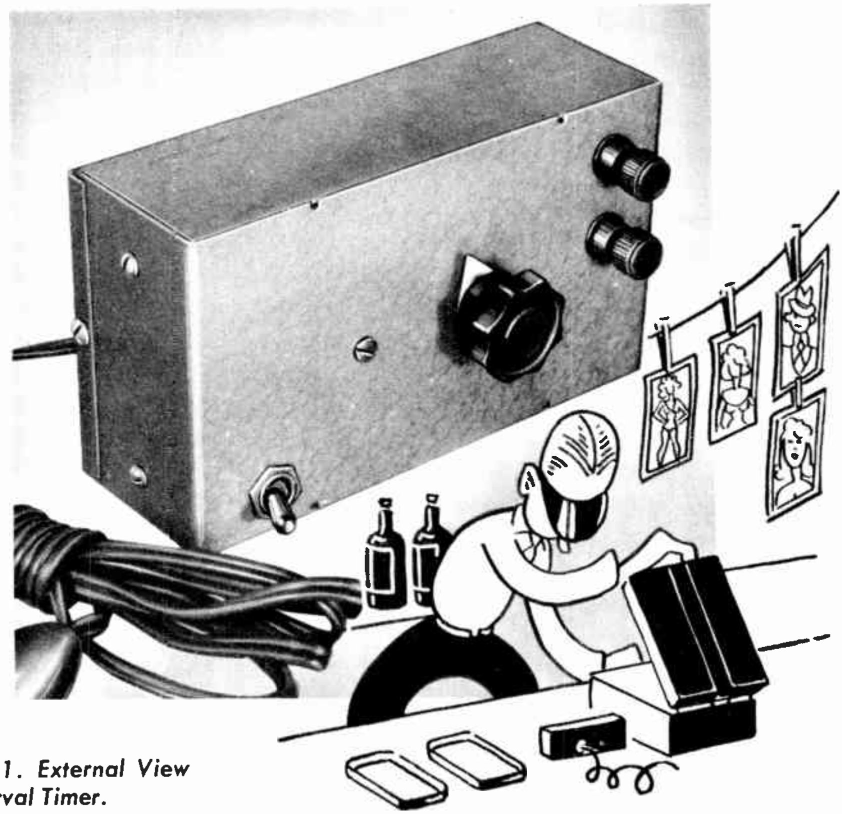


Figure 1. External View of Interval Timer.

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,

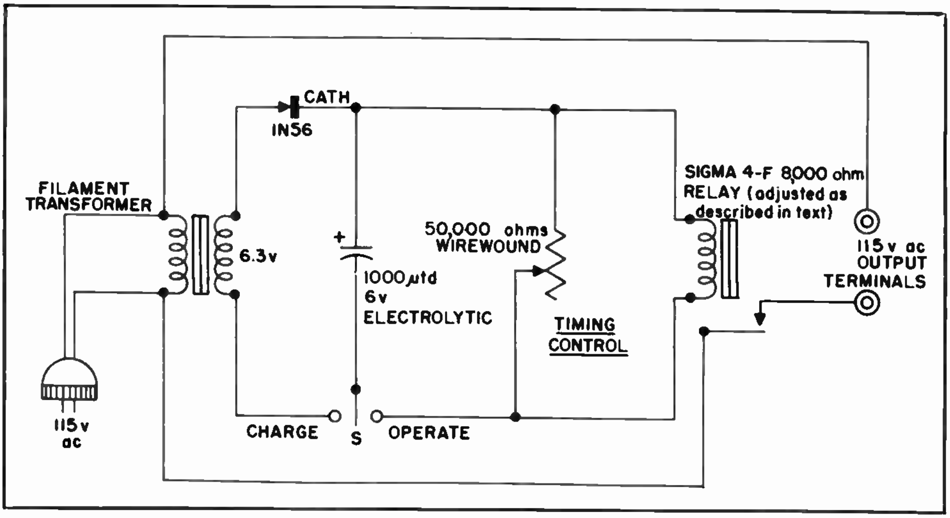


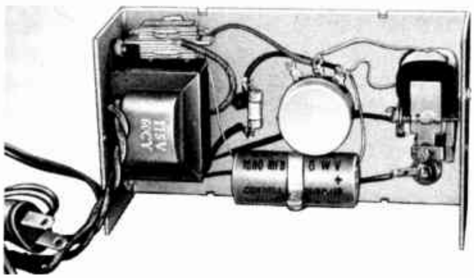
Figure 2. Timer Circuit

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.

Figure 3. Internal View of Timer.



2. SIMPLE DC POLARITY CHECKER

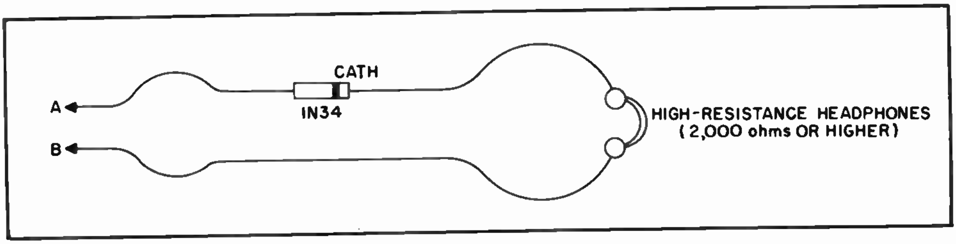


Figure 4. Circuit of Simple DC Polarity Checker.

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 60 may be checked with a 1N34 without damaging the crystal. The 1N58 will handle 100 volts.

3. POLARITY REVERSAL ALARM

IN many dc applications, such as battery charging circuits, electroplaters, etc. where an output voltmeter either is not used or cannot easily be seen by a distant operator, the correct polarity of the line must be maintained. Trouble is caused by any accidental reversal of polarity, however it may occur. Hence, any reversal must be signalled immediately to the operator.

Figure 6 shows the circuit of a simple polarity reversal alarm. A small, Sylvania S48 2-volt pilot lamp is connected in series with a crystal diode and resistor across the line to be monitored. The cathode terminal of the crystal normally is connected to the positive side of the line. The crystal connected in this manner offers high resistance and the lamp cannot light. If the polarity of the line is reversed, the crystal cathode then is connected to the *negative* side of the line, and the crystal presents a low resistance to the line voltage. The larger current then flowing through the crystal circuit lights the lamp. A visual alarm which may be seen at some distance is provided.

Figure 5. External View of Polarity Reversal Alarm.

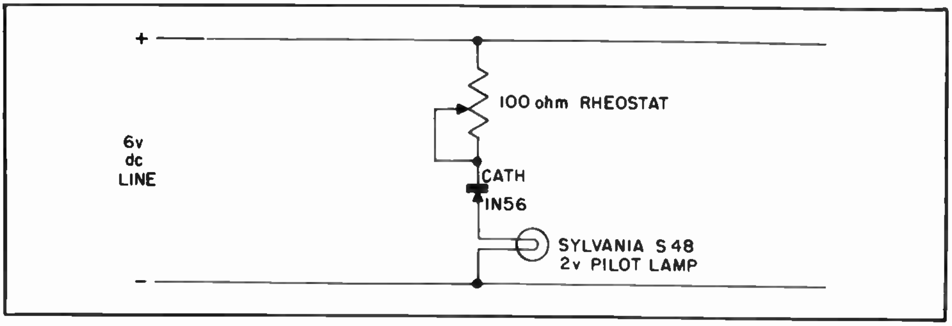


Figure 6. Circuit of Polarity Reversal Alarm.

The circuit as shown in Figure 6 is entirely satisfactory for short-time indications, since the resistor limits the crystal current to 60 milliamperes. If there is likelihood that the lamp might burn for some time before attracting the operator's attention, two crystal diodes should be connected in parallel to handle the current. If line voltages higher than 6 volts are employed, the resistance of the rheostat must be increased to a value which will limit current through the crystal and lamp to 60 milliamperes. The exact value of this resistance will have to be determined experimentally for the particular line voltage used.

To set the circuit of Figure 6 initially, make the upper side of the line negative and adjust the rheostat until the lamp burns. A dc milliammeter may be connected temporarily in series with the crystal and lamp to check the current. In normal operation, keep the upper side of the line positive.

External and internal views of the polarity reversal alarm are shown by Figures 5 and 7, respectively. As shown in these photographs, the instrument is built in a 4" x 2" x 1½" radio utility box which may be hung or mounted near the line to be monitored.

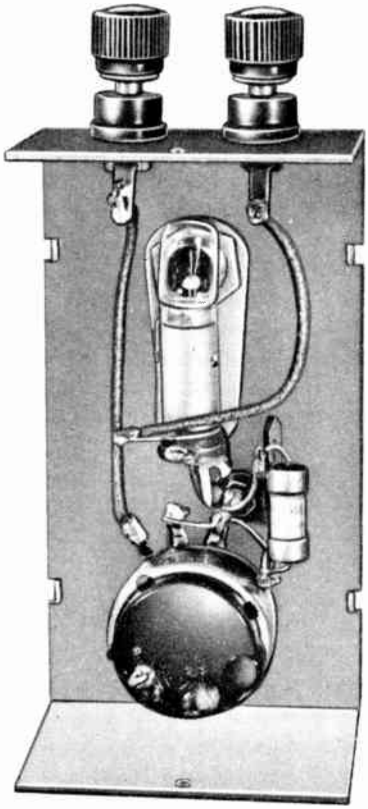


Figure 7. Inside View of Polarity Reversal Alarm.

4. 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.

5. INDUCTIVE-KICK QUENCHER FOR DC RELAYS

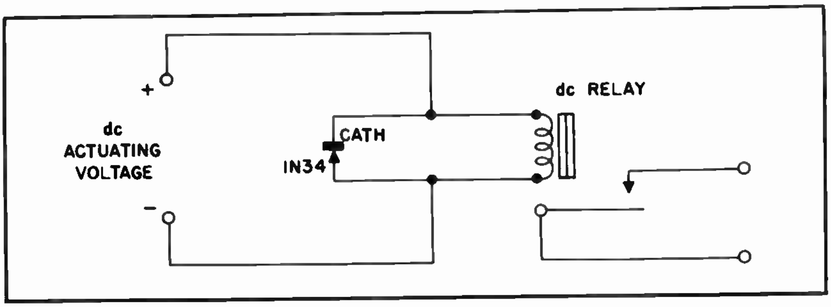


Figure 8. Circuit of Relay Inductive-Kick Quencher.

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.

6. SPARK QUENCHERS

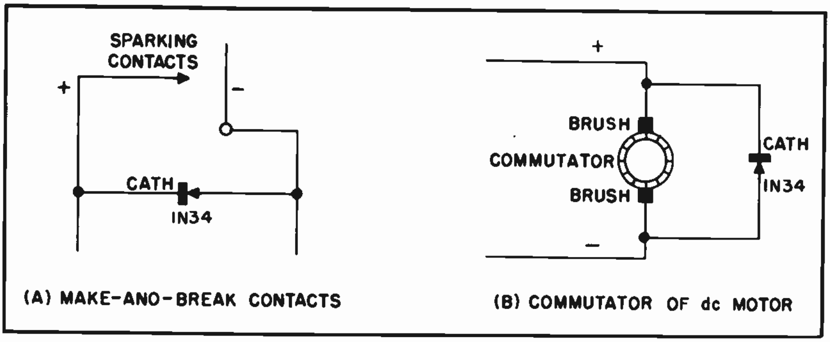


Figure 9. Spark Quencher Circuits.

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 60 volts; and for a 1N56 is 40 volts.

7. REPLACING TUBES WITH GERMANIUM DIODES

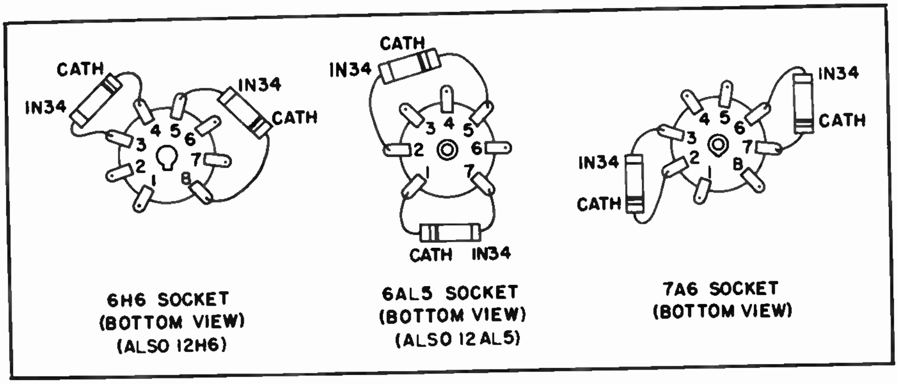


Figure 10. Replacing Tubes with Crystals (Socket Diagrams).

GERMAMIUM Diodes may be used as diode and duo-diode detectors in original installations or as replacement of diode and duo-diode type vacuum tubes in home-made radio receivers, AM and FM tuners, and TV sets. This change is often desirable since the Germanium Diode has no filament and, therefore, requires no heating current. The Germanium Diode will also eliminate any hum produced by the tube it replaces, will generate no heat, and, in many instances, will afford better reception. Tubes which may be replaced successfully are types 6AL5, 6H6, 6H6G, 7A6, 12AL5, and 12H6.

The substitution of Germanium Diodes for a tube involves only a simple soldering operation in many cases. There are instances, however, where a circuit change may be necessary to obtain the best performance from the diode. In the event that the substituted Germanium Diode results in a markedly lower signal level, the value of load resistor or resistors should be checked. Germanium Diodes work most efficiently into loads of 50,000 to 100,000 ohms rather than the 250,000 ohms or so commonly used with vacuum tube diodes.

Two Germanium Diodes will be needed for each tube replacement. Simply turn the receiver chassis upside down, remove the diode-type tube from its socket, and solder the pigtail leads of the 1N34's to the proper socket contact lugs, as shown in Figure 10. Do not disturb any of the wiring to the socket. It will not be necessary to disconnect the filament wires from the socket, since no current is drawn through these leads when the tube is removed from the socket.

In ac-dc sets and others in which the tube filaments are connected in series, a special wirewound resistor must be connected between the filament lugs of the socket when the tube is replaced with crystals. The following table shows the correct value of resistor to use, and the socket terminals between which it must be connected.

TUBE REPLACED	WIREWOUND SUBSTITUTION RESISTOR	SOCKET TERMINALS FOR RESISTOR CONNECTION
6AL5	21 ohms, 5 watts	3 and 4
6H6, 6H6G	21 ohms, 5 watts	2 and 7
7A6	42 ohms, 2 watts	1 and 8
12AL5	84 ohms, 2 watts	3 and 4
12H6	84 ohms, 2 watts	2 and 7

8. CHARGER FOR SMALL DRY BATTERIES

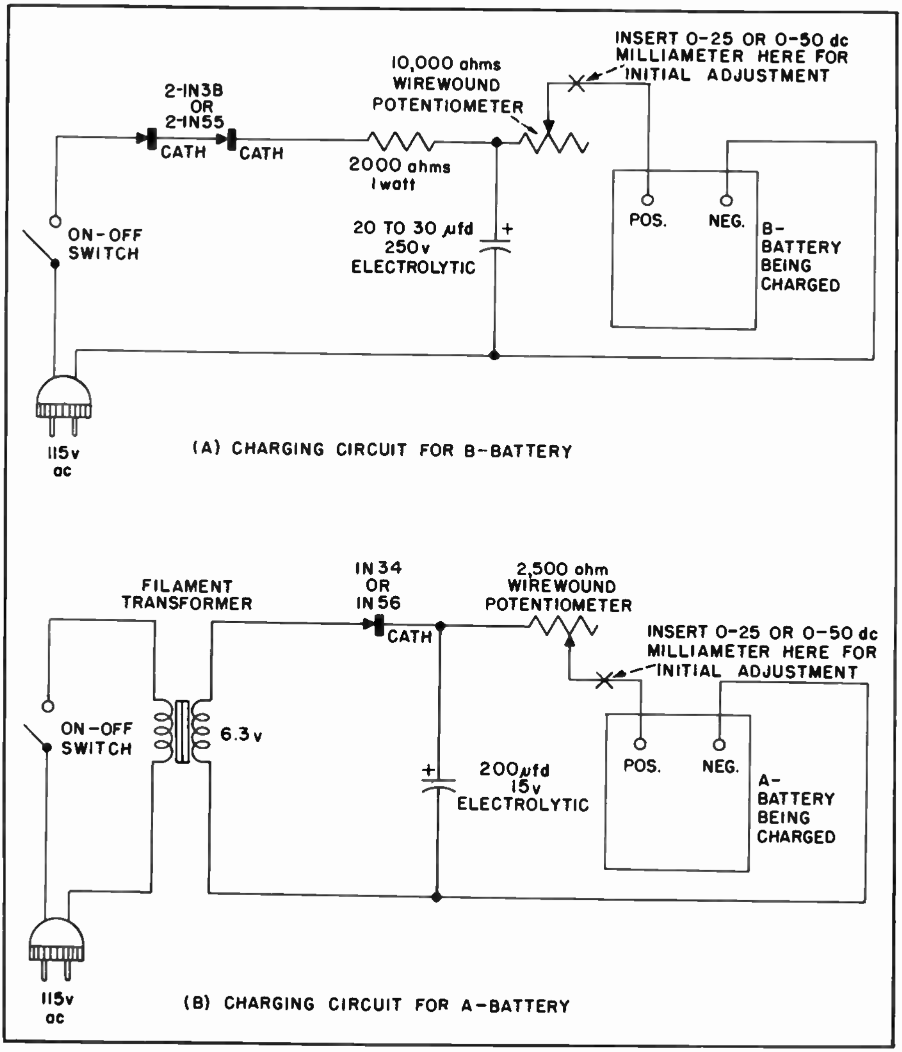


Figure 11. Charger for Small Dry Batteries.

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 two 1N38 or two 1N58 crystal diodes to convert the ac to dc. Figure 11 shows circuits for rejuvenating "A" and "B" batteries. 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 a 0-25 or 0-50 dc milliammeter at the point marked "X" in the circuit diagram. Adjust the potentiometer for a current of 5 to 10 ma through batteries composed of flashlight-size cells; for batteries with smaller cells, the current should be between 2 and 5 ma.

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 or at the end of 24 hours, whichever happens first.

9. LOW-CURRENT RELAY CIRCUIT

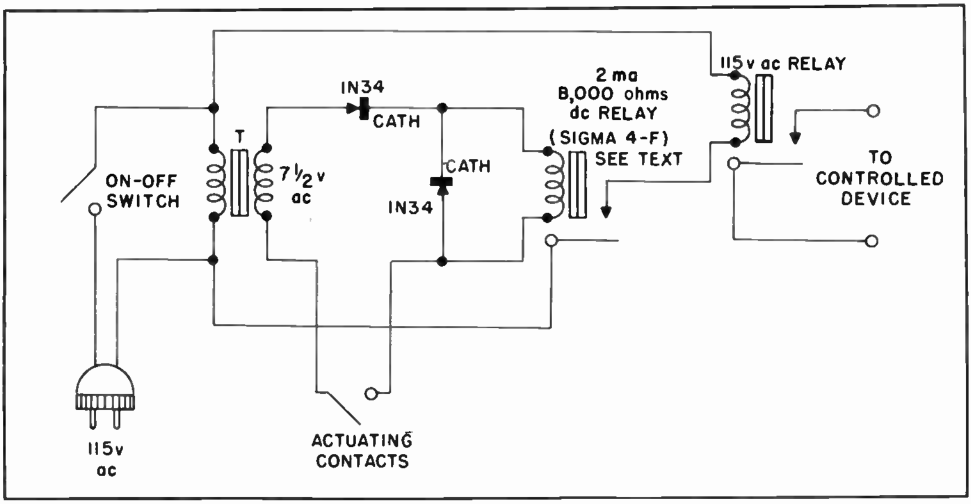


Figure 12. Low-Current Relay Circuit.

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.

10. DOOR-CHIME "PEPPER"

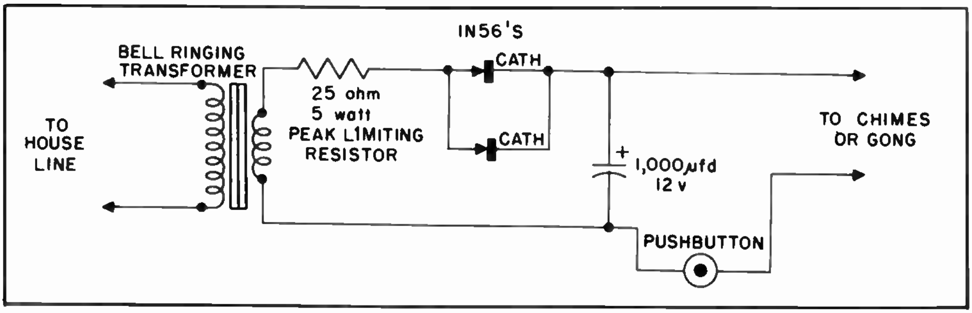
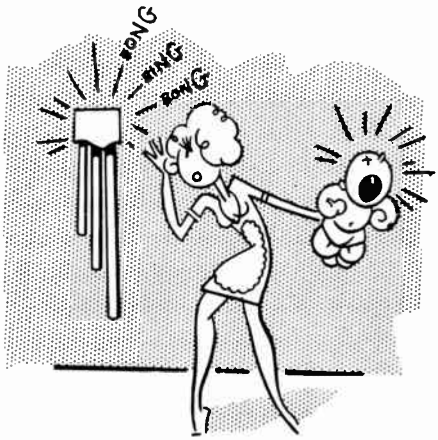


Figure 13. Door-Chime "Pepper" Circuit



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.

11. CRYSTAL-POWERED PHOTOELECTRIC RELAY

THE self-generating selenium photocell is especially attractive to electrical experimenters and builders of electronic equipment, since it is rugged, has long life, and requires no tubes for its operation. However, the low dc output of this type of electric eye formerly has made necessary the use of expensive high-sensitivity microampere-type relays in order to secure photoelectric control of devices.

If a small dc bias is applied to this type of cell, the photoconductive property of the selenium may be used, and the cell will operate a more rugged, less expensive relay. Since the current drain is low, the dc bias may be supplied by a Germanium Diode rectifier operated from the 6.3-volt winding of a small filament transformer.

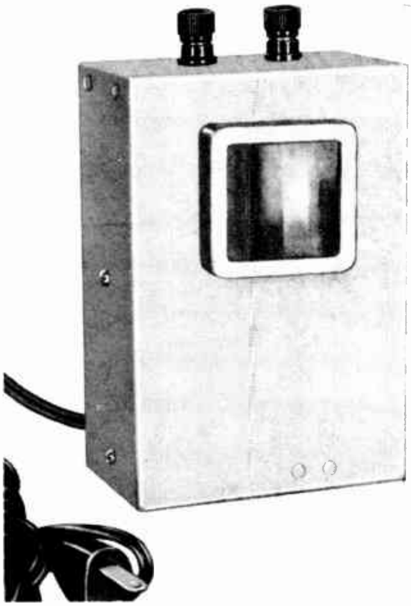


Figure 14. External Viaw of the Photoelectric Relay.

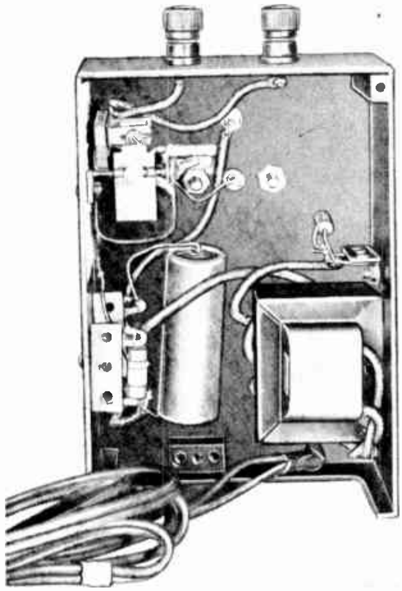


Figure 15. Inside the Photoelectric Relay.

Figure 16 shows the circut of a crystal-powered photocell relay utilizing this operating principle. The dc relay is a 2-milliampere Sigma Type 4F. The reader must adjust the relay (in the manner described in Article 9) so that it will operate on approximately ½ milliampere.

The photographs, Figures 14 and 15, show how the electric eye unit is built. A small aluminum box is used to house the unit shown here, but the reader may use any other type of enclosure desired.

This photoelectric relay is adaptable to a variety of applications: such as intrusion alarms, object counters, light-operated switches, headlight-operated garage-door opener, interrupted light-beam door opener, machine safety control, etc. Its action is reliable and positive. Not having high-gain amplifier tubes in the circuit, the device is free from false operation due to extraneous signals.

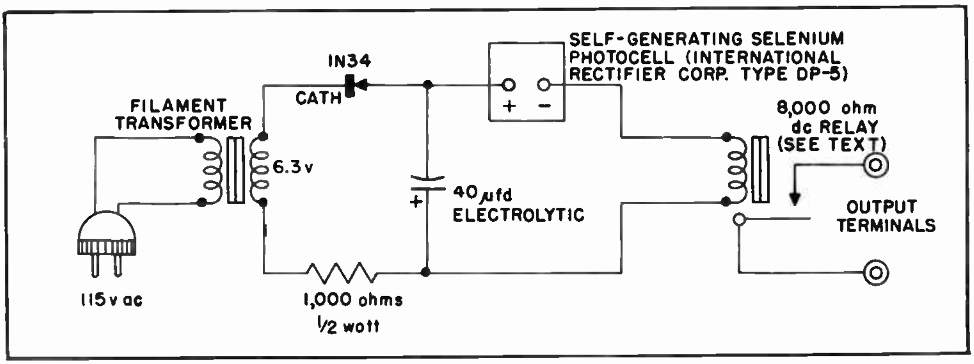


Figure 16. Circuit of the Crystal-Powered Photoelectric Relay.

12. USE OF GERMANIUM DIODE AS PHOTOCELL

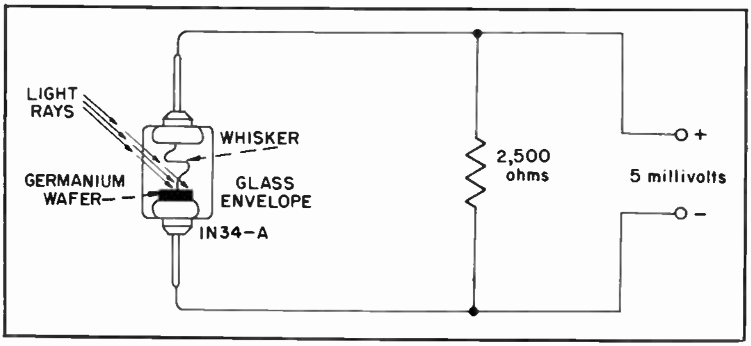


Figure 17. Germanium Diode as Self-Generating Photocell.

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.

13. SIMPLE CRYSTAL RADIO

A CRYSTAL set is the simplest radio receiver which can be built. Having no tubes, it requires no batteries or other form of local power supply, and it delivers speech and music reproduction with amazing clarity. When operated with an outside antenna and a good ground connection, the crystal radio will give reliable headphone operation on all local broadcast stations and occasionally will pick up a distant station, as well.

Figures 18, 19, and 20 show constructional details of a simple, small-sized crystal radio in which all of the parts are mounted on the frame of a 365-microfarad tuning capacitor. This simple, space-saving assembly can be mounted inside a small box (approximately 4" x

4" x 4" in size) and a tuning dial attached to the protruding shaft of the tuning capacitor. The simple circuit schematic is given in Figure 20.

The 1N34 crystal diode is mounted in small fuse clips which in turn are attached to a 1-inch-square Lucite plate bolted to the tuning capacitor frame (See Figure 18). The pigtail leads are cut from the 1N34, since they are not needed in the fuse-clip type mounting. The coil is a manufactured "antenna coil"—Miller Type 20-A—which comes equipped with a slip-over primary winding. The two upper wire leads seen in the photographs are connected to antenna and ground; the two lower ones to the headphones. The mica bypass capacitor is mounted, by means of its pigtail leads, between the tuning capacitor frame and the cathode lug of the crystal holder. This method of mounting may be seen in Figure 19.

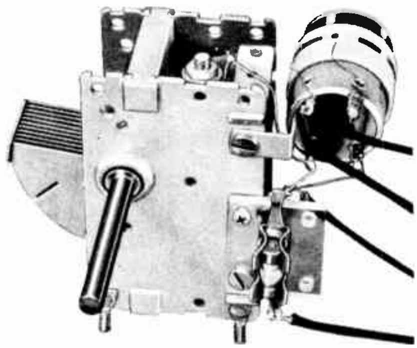


Figure 18. Overall View, Crystal Radio.

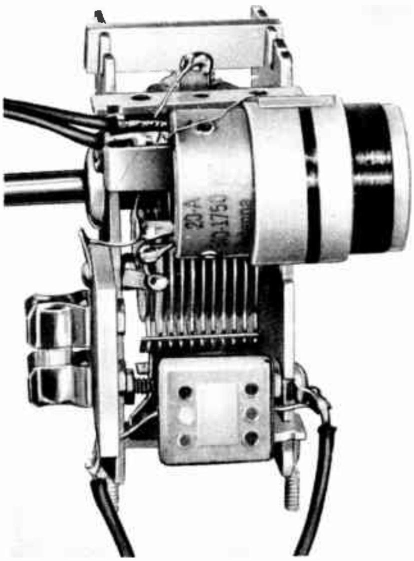


Figure 19. Side View of the Crystal Radio.

This miniature crystal set covers the entire standard broadcast band. Headphones connected to it should have a resistance rating of at least 2000 ohms. Do not use crystal type headphones. When loudspeaker operation is desired, the output leads may be connected directly to an audio amplifier with a 500,000-ohm ½-watt carbon resistor connected between the latter's input terminals.

The miniature crystal radio described in this article is the basis of the radio-operated alarm described in Article 15.

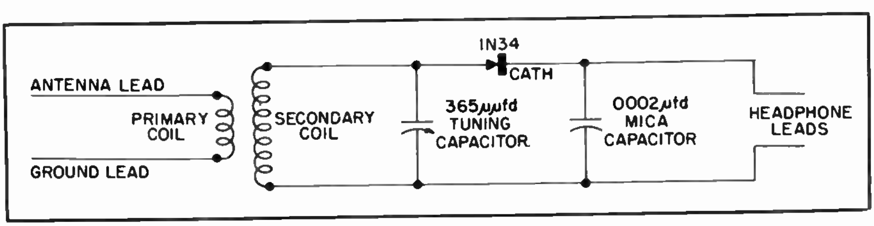


Figure 20. Circuit of the Crystal Radio.

14. ELECTRONIC METRONOME

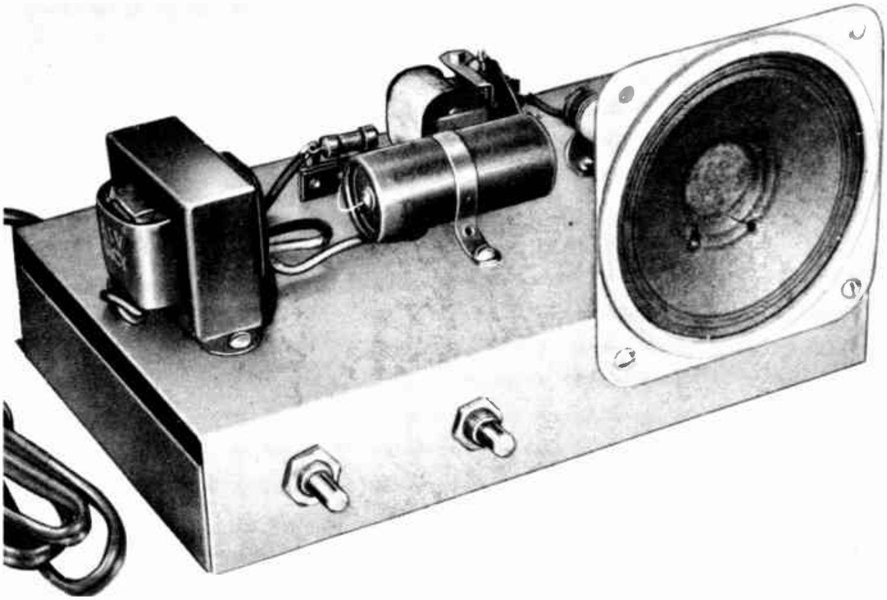


Figure 21. Overall View of the Electronic Metronome.

FIGURES 22, 23, and 24 show an electronic metronome which can be set to give beats or clicks at any rate between several beats per second to 1 in several minutes. This device can be used to replace the old clockwork-type metronome and is handy for setting rhythm in music and dancing practice and in timing operations of many sorts. In the photographs, the metronome chassis is shown removed from the small table-radio-type wooden cabinet in which it is housed.

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 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.

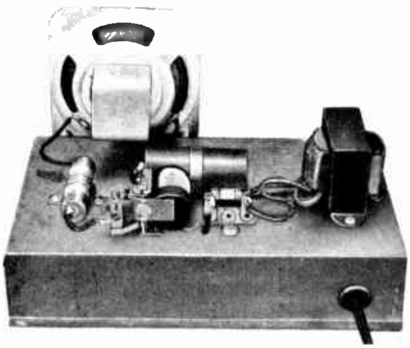


Figure 22. Top View of the Metronome.

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

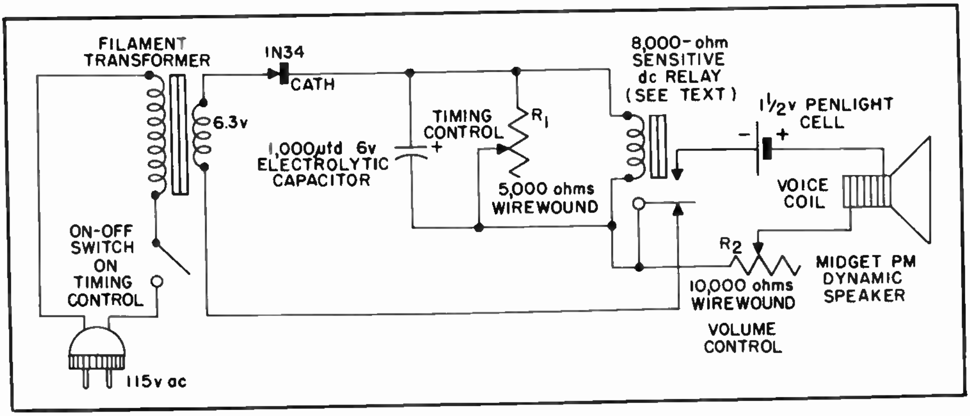


Figure 23. Circuit of the Metronome.

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 contact of the relay. The capacitor then will recharge and the cycle of events will be repeated.

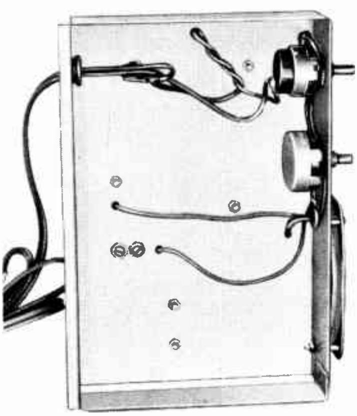


Figure 24. Under-Chassis View of the Metronome.

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.

15. RADIO-CONTROLLED RELAY

Figure 25. Front View of the Radio-Controlled Relay.

FIGURE 27 gives the circuit schematic of a simple radio-controlled relay designed to operate from the carrier wave of any local broadcast station between 500 and 1600 kc. The receiver used in this device is the simple crystal set described in Article 13. However, operation is not restricted to the broadcast band. The reader may wind a coil for any other station frequency according to directions given in the amateur radio handbooks.

This relay device, when connected to an outside antenna and a good ground, and tuned to the desired station frequency, closes a local circuit when the station transmitter is switched-on. There is a number of uses to which such a gadget can be put. For example, an *electronic alarm clock* can be devised by having the relay operate a buzzer or bell when a dependable early-morning station goes on the air. Also, the device may be used to turn-on a radio receiver at the time that a desired station starts broadcasting. A particular feature of the crystal-type radio-controlled relay is its ability to operate and standby without any power consumption from local sources. There are no tubes to deteriorate from constant operation during idle periods.

The sensitive dc relay operated by the crystal detector in this device is a Weston Sensitrol meter-type unit for 50 microampere operation. The contacts of this

relay can be moved closer together to obtain operation, when desired, on currents as low as 15 microamperes. This relay is presently obtainable in the surplus market. After the Sensitrol relay once has operated, it will remain closed until its magnetic contacts are separated by turning the re-set knob at the rear of the instrument case. (One type of Sensitrol relay may be obtained with the re-set shaft extending more conveniently through the front glass). If the reader prefers that the relay contacts release automatically when the controlling radio carrier is interrupted, a Weston Model 813 non-magnetic relay may be used.

Figures 25 and 26 show constructional details of the radio-controlled relay unit. In Figure 25, the antenna and ground binding post terminals are on the left-hand side of the front panel, and the output binding posts on the right. A 3-inch dial allows station settings to be logged. In Figure 26, the crystal tuning unit (also described in Article 13) is seen bolted directly to the bottom of the metal case by means of the mounting screws of the tuning capacitor.

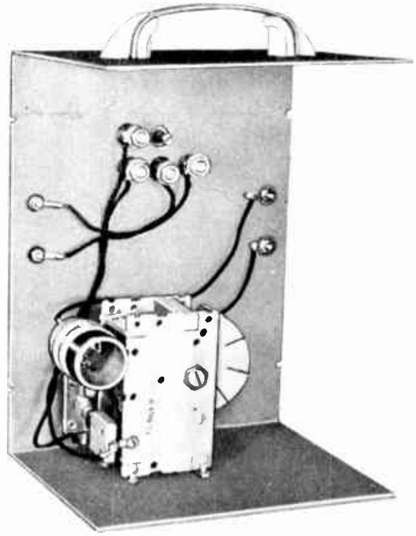


Figure 26. Inside View of the Radio-Controlled Relay.

The Sensitrol relay will operate directly any device which does not require more than 5 watts at 120 volts. For control of heavier-duty devices, the radio-controlled relay must operate a second relay with heavier contacts which, in turn, controls the heavy-duty device. Figure 28 shows how a 115-volt ac relay may be operated as the auxiliary unit. The coil of the latter relay must not require more than 50 milliamperes. This second relay may be mounted inside the cabinet of the radio-controlled unit. If the Model 813 non-magnetic relay is employed in

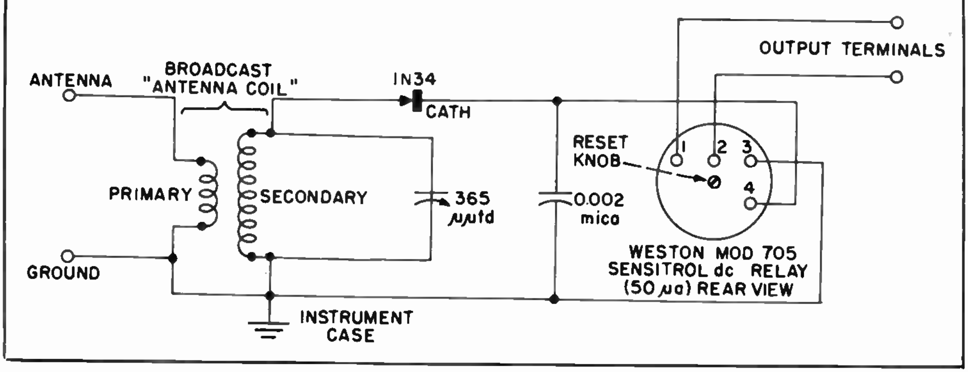


Figure 27. Circuit of the Radio-Controlled Relay.

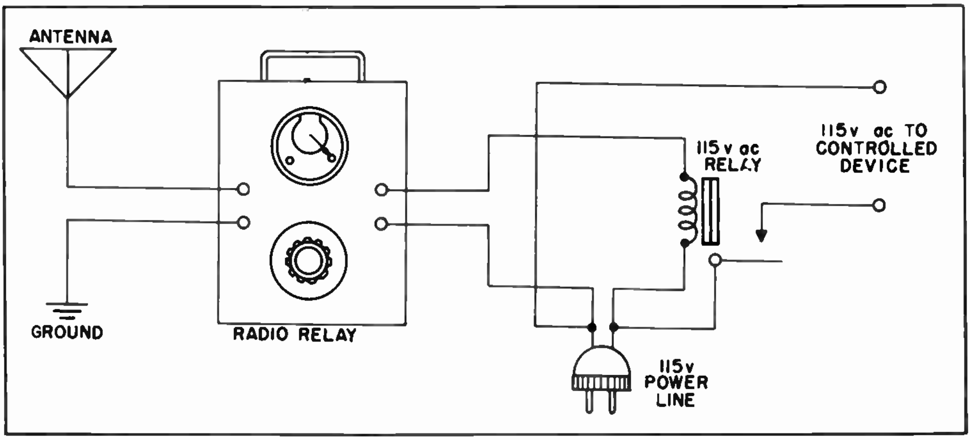


Figure 28. Circuit for Control of Heavy-Duty Devices with the Radio Relay.

the radio-controlled circuit, the auxiliary relay must not draw more than 30 milliamperes at 6 volts, and should be a dc type (not connected to the power line as shown in Figure 28), since this is the maximum current which can be handled by the contacts of the Model 813. The auxiliary relay then may be a Weston Model 712 (6 vdc) or any similar type with a 30-ma. coil and heavy-duty contacts.

16. WIRED-RADIO-CONTROL RELAY SYSTEM

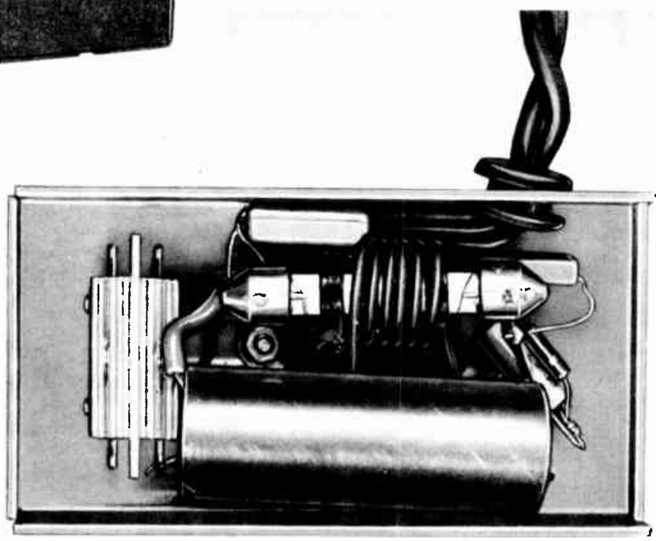
Often, it is desirable to switch-on an electrical device located in the same building but at some distance from the control point, without running special wires for the purpose. Use of an "on-the-air" radio system is ruled out because in most cases the transmitter power must be so high that a radio station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

Figure 29.
External View of the Wired-Radio-Control Transmitter.

Figure 30.
Under-Chassis View of Wired Radio Transmitter.



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-

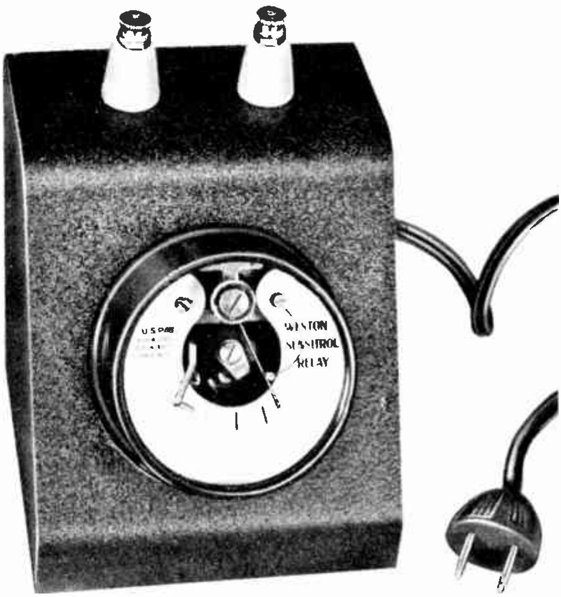


Figure 31. Wired-Radio-Control Receiver.

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.

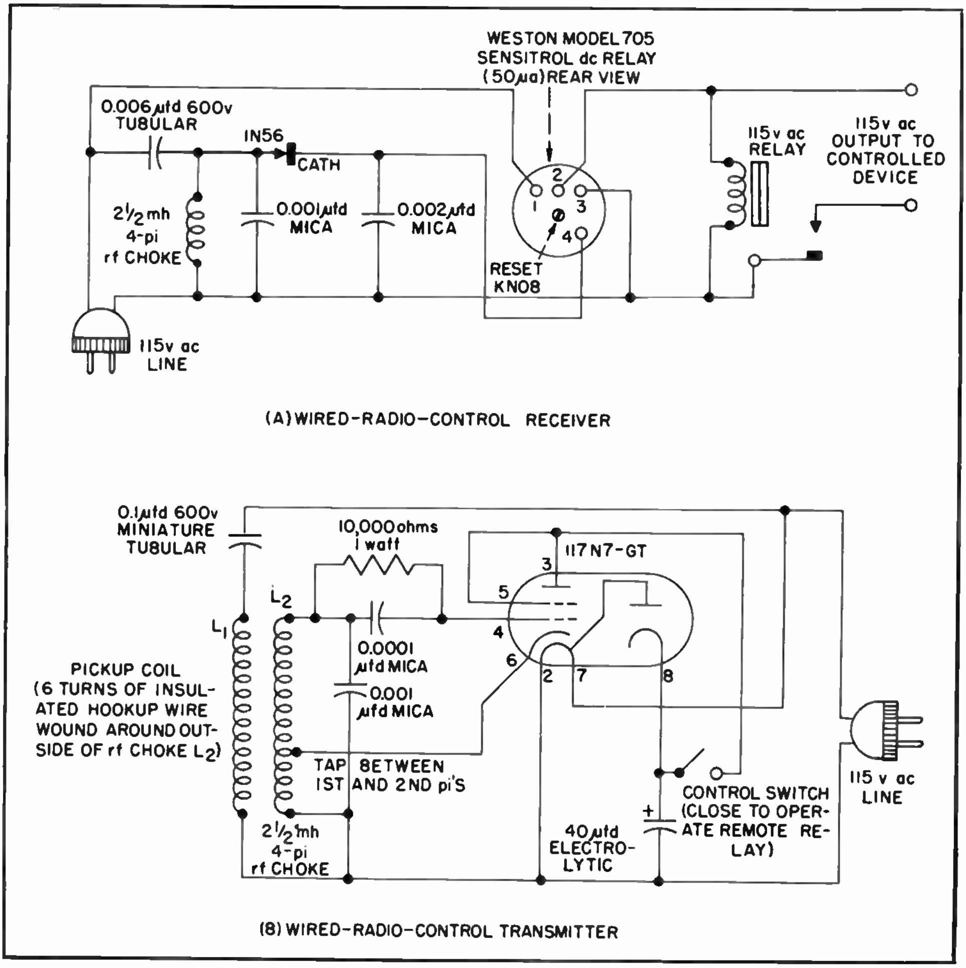


Figure 32. Circuits of the Wired-Radio-Control Equipment.

The entire receiver is built into a sloping-front metal meter case of the so-called "3-inch" size. Figure 31 shows the completed receiver.

Some of the possible applications of the wired-radio-control relay are (1) switching-on of remotely-located motors, fans, circuit breakers, door locks, and similar equipment, (2) operation of door- or window-operated burglar alarms in installations such as separated buildings where the running of interconnecting wires is undesirable; (3) switching-on of remote radio receivers or transmitters; (4) operating remote lights; (5) operating remote garage door openers; etc.

17. RADIO CONTROL SYSTEM FOR MODEL TRAINS

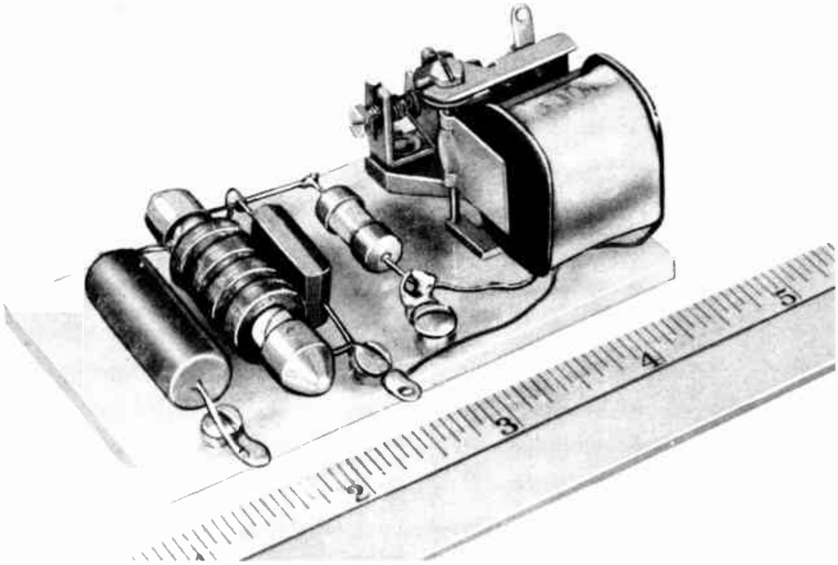


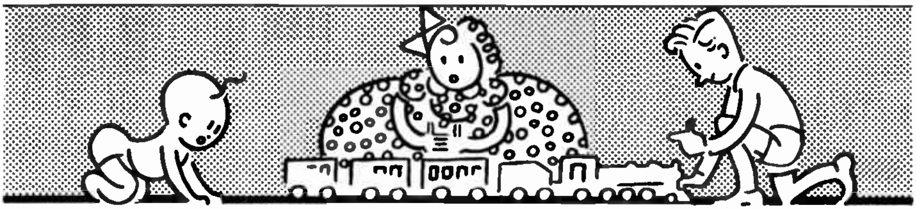
Figure 33. Radio-Control Receiver for Model Trains.

MODEL railroad hobbyists can use radio impulses transmitted over the tracks to control various devices such as whistles, headlights, car couplers, etc. on board the locomotive or one of the cars. A satisfactory system for radio control consists of a "wired-radio" transmitter operated at the control point, and a miniature receiver-relay installed in the car.

The transmitter is similar to the wired-radio-control transmitter described in Article 16 and is built from the same parts. The only point of difference is that a pickup coil is not used in the railroad transmitter (See Figure 34B) but the oscillator coil itself is connected through capacitors to the tracks. The tracks used must be the same ones which carry power for operation of the locomotive motor. In some model train setups, the two regular tracks are used. In others, one outside track and a central third rail are employed.

The transmitter uses a 117-volt tube which includes both a power supply rectifier and a pentode oscillator. The circuit is a simple series-type Hartley oscillator. The oscillator coil in the transmitter is a 2½ millihenry 4-pi-type radio-frequency choke. The reader must make a tap between the 1st and 2nd pi's of this choke, as explained in Article 16.

The receiver picks up the control signal from the tracks. If it is installed in the locomotive, the pickup leads may be connected to the brushes or wheels which pick up the motor driving power from the tracks. If the receiver is installed in one of the cars, provision must be made for contacts to roll or slide along the "hot" tracks. The receiver tuning coil is a 2½ millihenry 4-pi-type rf choke with a 0.001-microfarad mica capacitor connected in parallel with it. The 1N34 crystal diode converts the received control signal into dc which is applied to the dc relay. This relay is a surplus Sigma 4F which has an 8000-ohm coil and is rated at 2 milliamperes. The reader must adjust the armature-spring tension, as explained in Article 13, to obtain relay operation at ½ milliampere. The receiver



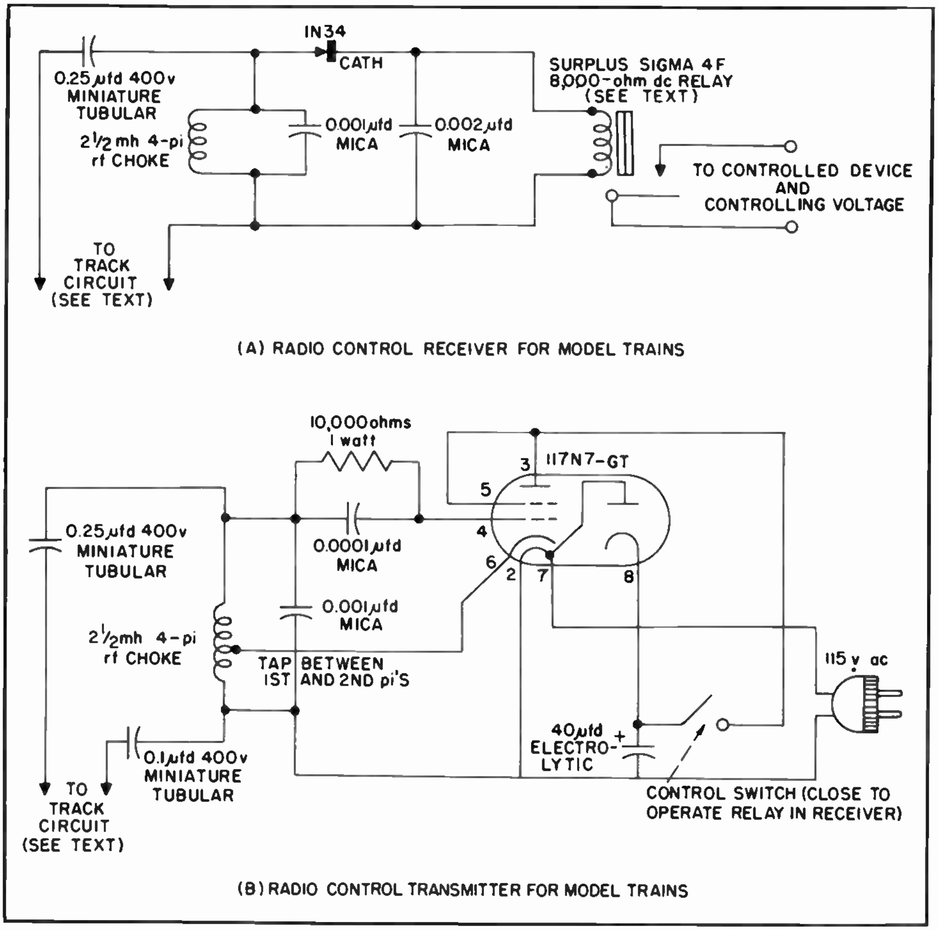
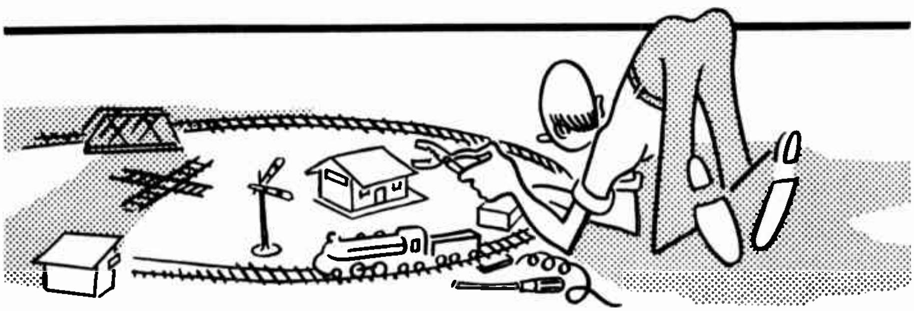


Figure 34. Details of Radio-Control Unit for Model Trains.



parts are mounted on a 3½" x 2" plate of 3/16"-thick polystyrene or other insulating material, as shown in Figure 33. If more compact construction is desired, the parts can be grouped more closely around the relay.

This radio relay system operates at approximately 100 kc and creates only negligible interference with a radio in the same room. The signal strength is adequate for positive control even when the tracks are shunted by the locomotive motor and headlight lamp. The receiver relay operates whenever the transmitter control switch is closed, and releases when the switch is opened.

Several separate receivers may be employed to perform various operations, provided each is tuned to a separate frequency and the transmitter likewise is made tunable to each of these frequencies. Tuning in the transmitter may be accomplished by switching-in a separate mica capacitor for each new frequency in place of the 0.001-microfarad unit shown in parallel with the rf choke. Each separate receiver then must have the same value of capacitance connected across its choke coil. The receivers will operate separately, provided the control frequencies are spaced as far apart as practicable.

18. POCKET-TYPE 60-CYCLE STROBOSCOPE

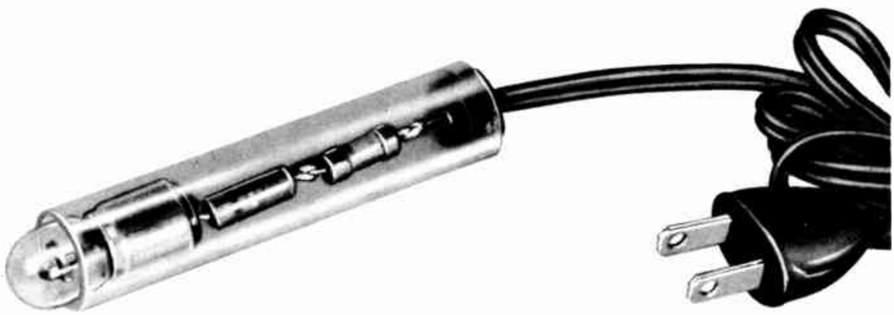


Figure 35. Pocket-Type 60-cycle Stroboscope.

FIGURES 35, 36, and 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 with-

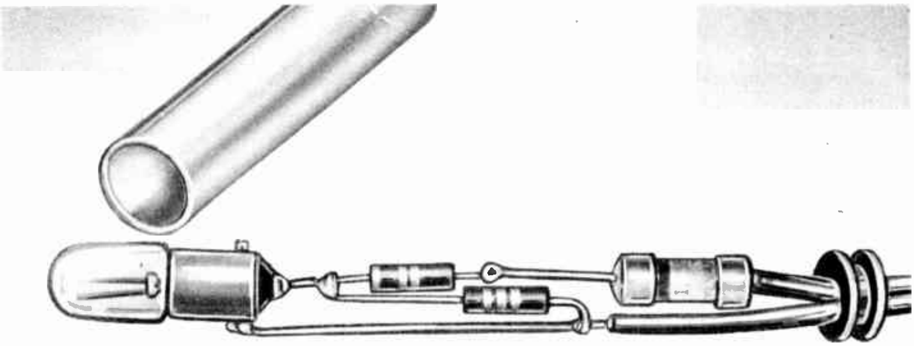


Figure 36. Exploded View of the Stroboscope.

stand safely the peak inverse voltage of the power line. The neon lamp, 1N55 diode, 30,000 ohm resistor, and 130,000 ohm resistor are wired as shown in Figures 36 and 37, 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.

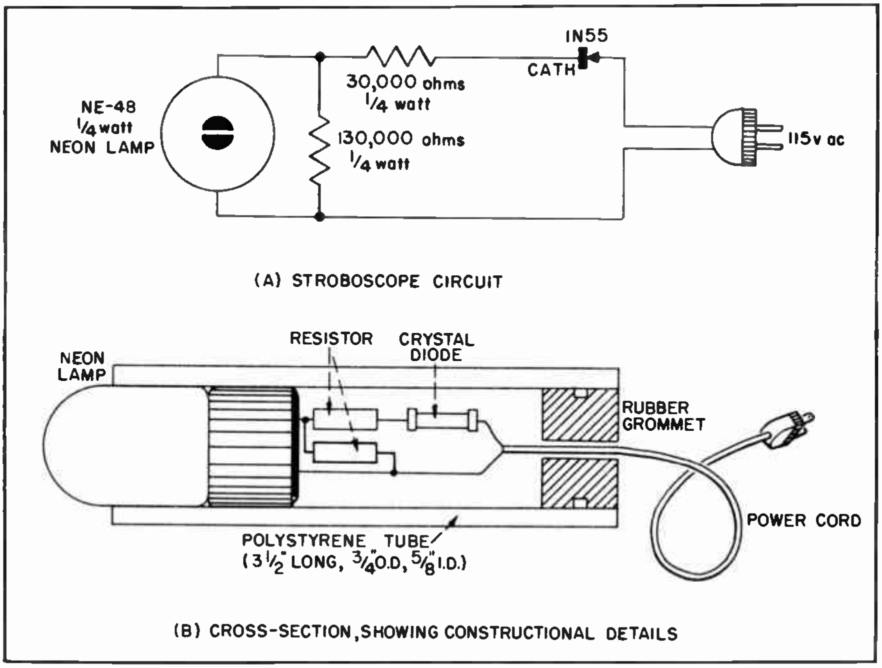


Figure 37. Details of the Stroboscope.

19. LIGHT-DUTY ELECTROPLATER

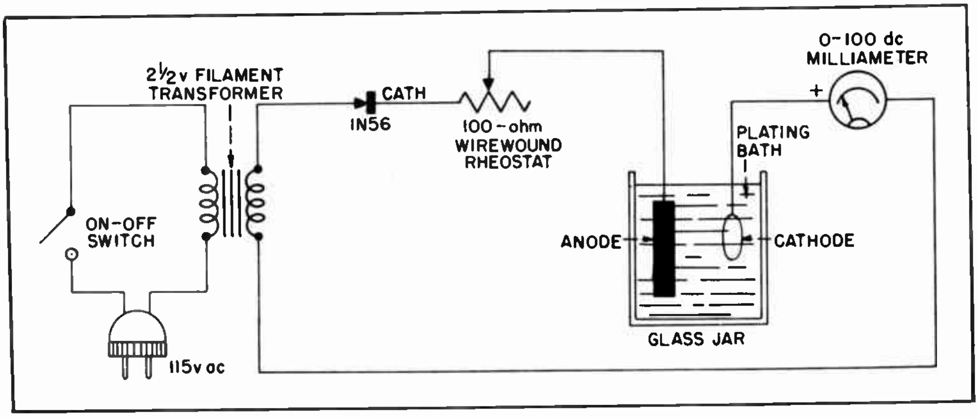


Figure 38. Light-Duty Electroplating Circuit.

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.

20. LOW-CURRENT CRYSTAL POWER SUPPLIES

WHEN power supplies are called upon to deliver only small current values (not in excess of 50 milliamperes dc), real savings in space can be obtained by using crystal diodes as rectifiers. Figure 39 shows several circuits for low-current power supplies. These units may be employed for operating dc relays from ac, supplying fixed bias voltage for amplifiers, microphone voltage for simple "house-line" telephones, and similar uses.

Figure 39(A) shows a half-wave power supply. The 1N34 may be used in this circuit to supply output currents not exceeding 50 milliamperes; the 1N56 up to 60 ma. The secondary of the step-down transformer should deliver not more than 20 volts rms and the resistance of the output circuit (resistance of the dc device to be operated plus any additional series resistance required) must be adjusted for an output current not in excess of the average anode current (maximum) rating of the crystal diode type used.

Figure 39(B) shows a full-wave circuit. Here, each half of the center-tapped secondary winding of the step-down transformer must deliver not more than 20 volts rms. The resistance of the output circuit (resistance of the dc device to be operated plus any additional series resistance required) must be adjusted for

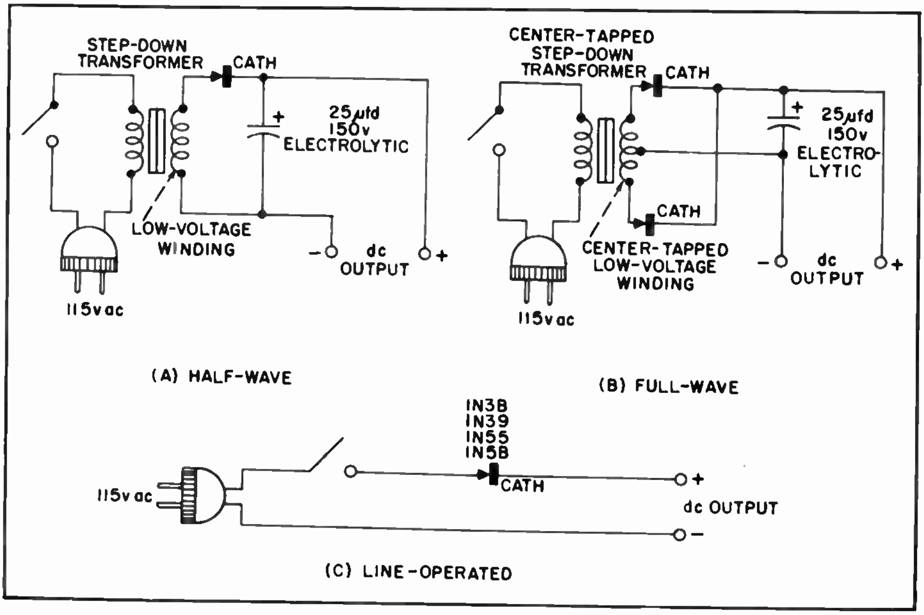


Figure 39. Low-Current Power Supplies.

an output current not in excess of twice the average anode current (maximum) rating of the crystal diode type used.

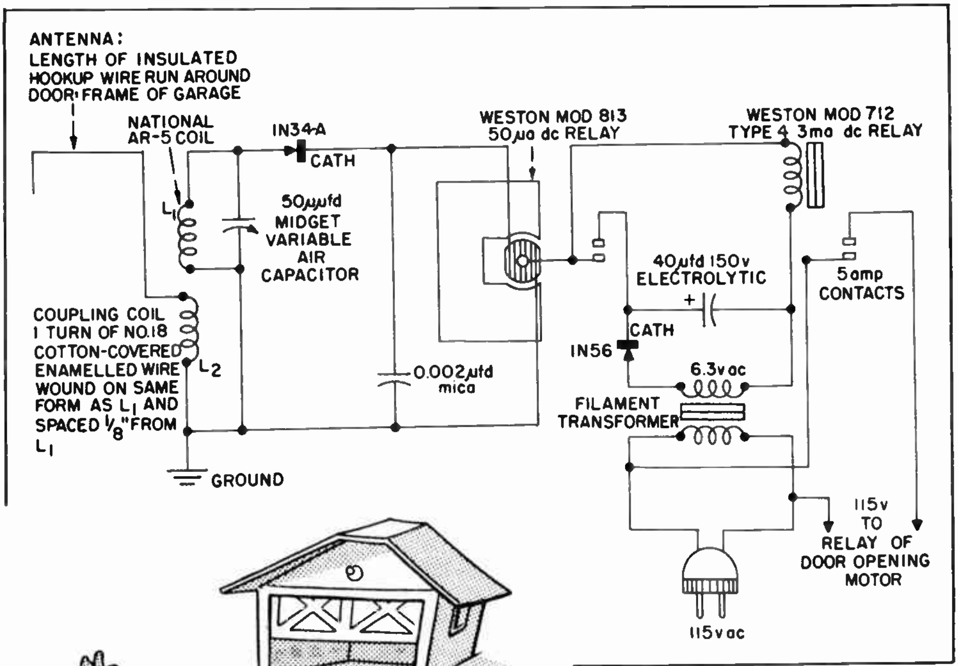
Figure 39(C) shows a half-wave circuit which may be operated directly from the power line for 100-volt, low-current output. This circuit is recommended only for applications in which a filter capacitor is not required. Here, the resistance of the output circuit (resistance of the device to be operated plus any additional series resistance required) must be adjusted carefully for an output current not in excess of the average anode current (maximum) rating of the crystal diode type employed. Only types 1N39 and 1N55 are recommended for this application, since these types are able to withstand the peak inverse voltage of the power line. However, two each of types 1N38 or 1N58 may be substituted.

21. RADIO-OPERATED GARAGE DOOR OPENER

The radio ham who has a transmitter in his car can use his sending set to open his garage door by radio control. We do not recommend this scheme for use by unlicensed experimenters, since at least 10 to 20 watts transmitter power is required, and this amount of power fed into the automobile antenna meets the requirements of a radio station.

Figure 40 gives the circuit schematic of the receiving apparatus installed in the garage. The front-end of the receiver employs a crystal detector, therefore no power is drawn by the equipment when it is idle. This is an essential feature, since there are no tubes to be kept burning when the equipment is not in use.

Coil L_1 has been selected for 6-meter operation. However, if the car transmitter operates on some other frequency, L_1 may be changed to tune to the used frequency. The receiver circuit gives positive opera-



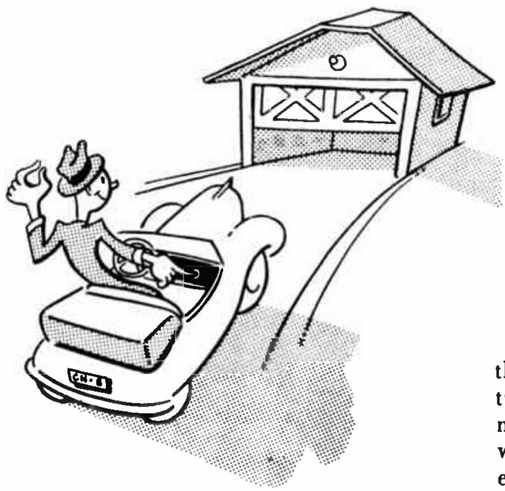


Figure 40. Radio Garage Door Opening Receiver.

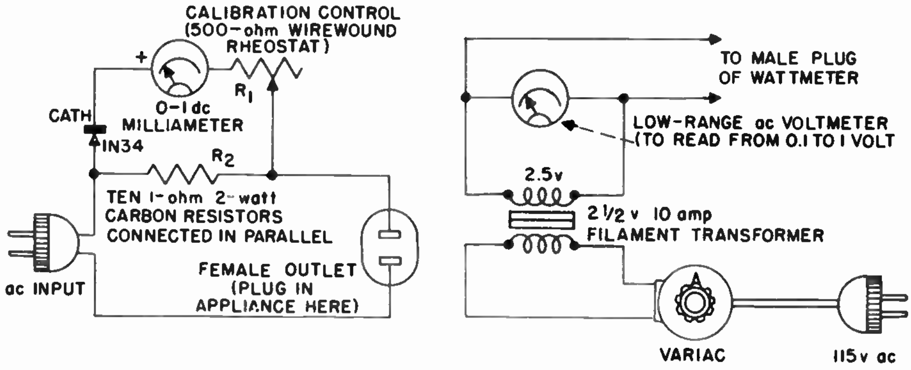
tion at distances up to 15 feet between the car and the garage-door antenna, which is ample for all practical purposes. At the same time, the receiver is not sensitive enough to be operated erroneously by signals from local stations.

To adjust the receiver initially, turn on the transmitter and rotate the 50 μμfd. tuning capacitor in the receiver to the point where the relays operate. Tune-in the signal "on the nose." The receiver tunes rather broadly, so that the transmitter frequency can deviate appreciably without control action being lost. To operate the system, it is necessary only to drive up near the garage door, switch-on the transmitter, and hold the control signal until the relay-controlled motor system has completed the job of opening the door.

Two crystal diodes are employed in the receiver-relay unit. One of these is the 1N34-A radio detector. The other, a 1N56 high-conduction diode, supplies 6 volts dc for operation of the Model 712 relay.

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

22. 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.

23. DC-AC CONVERTER

FIGURE 42 shows the circuit of a single-crystal converter which may be used to change small dc voltages into small ac voltages and to step the resultant ac voltages up to higher values for easy measurement or for use in operating sensitive ac relays.

Two small 2½-volt filament transformers are used in conjunction with a 1N34 crystal diode. The 2½-volt winding of transformer T_1 is connected to the crystal diode which rectifies the ac voltage and passes positive pulses through the 2½-volt winding of transformer T_2. The small dc voltage is applied to the dc input terminals in the polarity shown in the diagram. This dc voltage accordingly is added to the rectified positive pulses.

The positive pulses are stepped up through transformer T_2 across whose secondary an ac voltage appears which is proportional to the primary pulses plus or minus the applied dc. A high-resistance ac voltmeter or high-resistance ac relay may be connected to the ac output terminals.

To set the circuit, connect the dc source to the dc input terminals but do not yet switch-on the dc voltage. Connect the ac voltmeter to the ac output terminals and plug the converter into the power line. There will be a steady deflection of the meter which must be balanced out by means of a 1½-volt dry cell and 10,000-ohm rheostat connected to the *meter movement.* The positive terminal

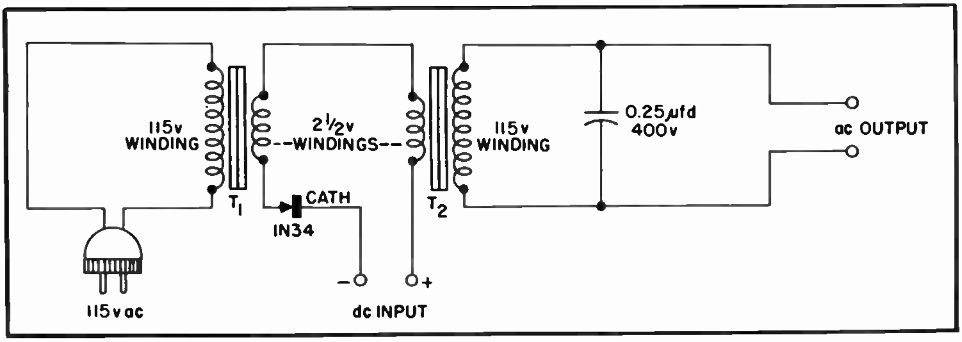


Figure 42. DC-to-AC Converter.

of this balancing circuit must be connected to the negative terminal of the meter. To balance, adjust the rheostat to bring the meter pointer down to zero. Now, switch-on the dc voltage and note the meter reading. The step-up ratio of transformer T_2 is better than 40 to 1. A dc input voltage of 10 millivolts thus will appear as approximately 0.4 volt at the ac output terminals.

Response of the circuit is not linear, so an individual calibration is necessary when high accuracy is desired. This calibration may best be carried out by applying a series of known small voltage values to the dc input terminals and logging the readings of the ac voltmeter.

24. ELECTRONIC DOOR LOCK

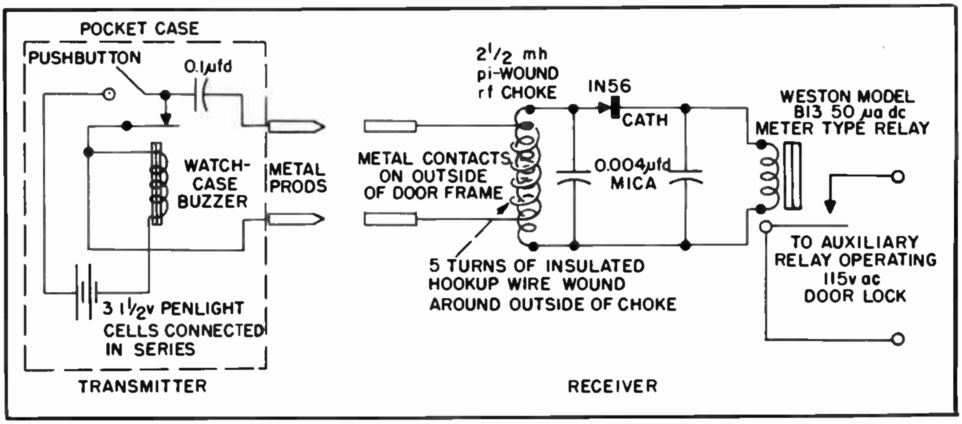


Figure 43. Electronic Door Lock.

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.
8. The corresponding "A"-type diodes, which are hermetically sealed in glass, may be substituted in each instance.

RATINGS AND CHARACTERISTICS OF SYLVANIA GERMANIUM CRYSTAL DIODES

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

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

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

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

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

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

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

SYLVANIA Germanium Diodes

RATINGS

TYPE	DESCRIPTION	CONSTRUCTION	CONTINUOUS REVERSE WORKING VOLTAGE (volts Max.)	REVERSE VOLTAGE For Zero Dynamic Resistance (volts Min.)
1N34	General Purpose Diode	Ceramic	60	75
1N34A	General Purpose Diode	Glass	60	75
1N35*	Matched Duo-Diode	Ceramic Duo-Diode	50	75
1N38	100-Volt Diode	Ceramic	100	120
1N38A	100-Volt Diode	Glass	100	120
1N39	200-Volt Diode	Ceramic	200	225
1N40**	Varistor	Plug-In	25	75
1N41**	Varistor	Lug-Type	25	75
1N42**	100-Volt Varistor	Plug-In	50	120
1N54	High Back Resistance Diode	Ceramic	35	75
1N54A	High Back Resistance Diode	Glass	50	75
1N55	150-Volt Diode	Ceramic	150	170
1N55A	150-Volt Diode	Glass	150	170
1N56	High Conduction Diode	Ceramic	40	50
1N56A	High Conduction Diode	Glass	40	50
1N58	100-Volt Diode	Ceramic	100	120
1N58A	100-Volt Diode	Glass	100	120
1N60	Video-Detector Diode	Ceramic	25	30
1N71***	Low Impedance Varistor	Plug-In	40	50

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

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

AND CHARACTERISTICS

FORWARD CURRENT at +1 volt (ma. Min.)	AVERAGE ANODE CURRENT (ma. Max.)	RECURRENT PEAK ANODE CURRENT (ma. Max.)	INSTANTANEOUS SURGE CURRENT (ma. Max., 1 sec.)	REVERSE CURRENT (µa Max.)
5.0	50	150	500	50@−10v, 800@−50v
5.0	50	150	500	30@−10v, 500@−50v
7.5	22.5	60	100	10@−10v
3.0	50	150	500	6@−3v, 625@−100v
4.0	50	150	500	5@−3v, 500@−100v
1.5	50	150	500	200@−100v, 800@−200v
12.75 (@ 1.5 volts)	22.5	60	100	40@−10v
12.75 (@ 1.5 volts)	22.5	60	100	40@−10v
12.75 (@ 1.5 volts)	22.5	60	100	6@−3v, 625@−100v
5.0	50	150	500	10@−10v
5.0	50	150	500	7@−10v, 100@−50v
3.0	50	150	500	300@−100v, 800@−150v
4.0	50	150	500	500@−150v
15.0	60	200	1000	300@−30v
15.0	60	200	1000	300@−30v
4.0	50	150	500	800@−100v
4.0	50	150	500	600@−100v
†	50	150	500	†
15.0	60	200	1000	300@−30v

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

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

SYLVANIA ELECTRIC PRODUCTS INC.

ELECTRONICS DIVISION

1740 BROADWAY NEW YORK 19, N. Y.

25¢

Industrial Uses

FOR GERMANIUM CRYSTALS

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.

Industrial Uses for Germanium Crystals

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

FIRST EDITION
FIRST PRINTING

INTRODUCTION

Our previous booklets on germanium crystal applications have stressed the use of the crystal in communications and experimental work for the radio hobbyist. From time to time, many of the schemes described in these booklets have been adapted to industrial use with good results.

Realizing that there are many applications of germanium crystals which are of particular use to industry and of only secondary interest to the communications workers who were the first to benefit by introduction of semiconductor devices, we have devoted this booklet entirely to industrial applications.

It has been rather difficult to make a selection from the numerous applications which were either devised by us or suggested by others. In order to arrive at a conclusion, we talked with plant engineers, industrial engineers, and consultants; we tested and screened applications, and then screened again. The final result is in the material presented herein. We feel that each application offered will introduce the useful germanium crystal to some of our most exacting users — the men who keep the wheels of industry turning.

No license is to be implied with respect to any inventions described herein, and no responsibility is assumed for the application or interpretation of the information contained herein, or for any infringement of patent or other rights of third parties which may result from the use of that information.

We hope that this booklet will be widely and well read and that it, like its predecessors, will be valued for its usefulness.

Sylvania Electric Products Inc.

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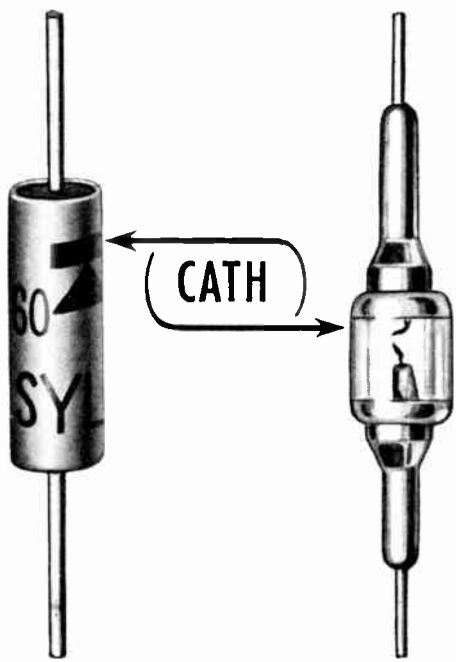
LIST OF ILLUSTRATIONS

FIGURE

In all Sylvania circuits diagrams showing germanium diodes, the bar of the diode symbol represents the cathode. On each Sylvania Germanium Diode, the cathode side is indicated by a color band and the label "CATH".



CHAPTER 1

Relays and Relays Applications

1.1 Polarity-Sensitive DC Relay.

The high back-to-front resistance ratio of a germanium crystal may be used to give a low-current DC relay a sense of polarity. Figure 1-1 shows the simple circuit.

The relay and diode are connected in series with the DC input terminals. When terminal 1 is positive, high current flows through the crystal which is forward-connected for this polarity, and the relay is actuated. When terminal 1 is negative, the high back resistance of the crystal (which is reverse-connected for this polarity)

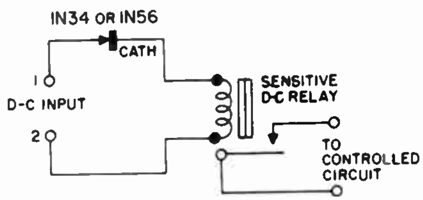


Fig. 1-1

allows only a minute current to flow and the relay cannot operate. Reversing the crystal permits the relay to operate when terminal 1 is negative.

Crystal types 1N34 and 1N34A are recommended for relay coil currents up to 50 ma., and 1N56 for 60 ma. Higher currents can be handled by parallel-connecting additional crystals as required. For high-voltage operation, a sufficient number of crystals may be connected in series, in place of the single crystal shown.

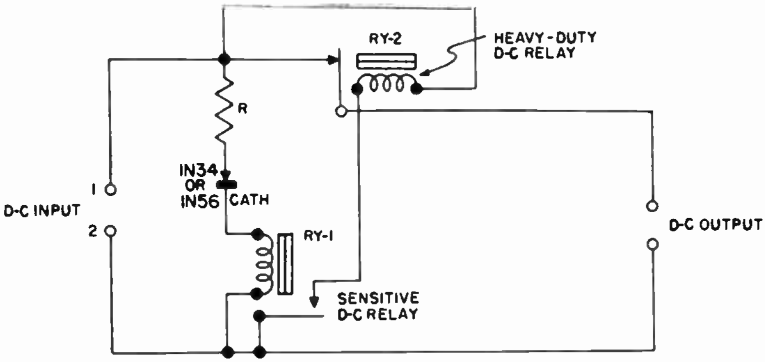


Fig. 1-2

1.2 Protection Relay for DC Lines.

Some DC devices operate in reverse, fail to operate, or are damaged by accidental reversal of the DC line polarity. Examples are DC motors, polarized relays, electron tubes, electroplaters, and batteries on charge. A crystal-controlled polarity-sensitive relay system can be used to protect such devices by removing the voltage automatically in case of line polarity reversal.

Figure 1-2 shows the circuit of a protective system. The crystal is connected in series with the coil of a sensitive, normally-open DC relay (RY-1) and enough series resistance R (if needed) to limit the crystal and relay current to a safe value. Relay RY-1 operates on a few milliamperes. The DC is connected from the INPUT to OUTPUT terminals through the normally-closed contacts of a heavy-duty DC relay, RY-2. The coil of this latter relay is designed to operate directly from the DC supply voltage.

Input terminal 1 normally is negative. At this polarity, the germanium crystal is reverse-connected and appears as a high resistance in series with relay RY-1. This high resistance prevents relay RY-1 from picking up. Relay RY-2 accordingly is not actuated, and DC voltage appears at the OUTPUT terminals of the circuit.

If the line polarity is reversed, input terminal 1 is positive, the crystal conducts, and relay RY-1 closes. This, in turn, actuates the heavy-duty relay, RY-2, which opens the line and removes voltages from the OUTPUT terminals.

The coil of relay RY-1 must operate on not more than 50 ma. DC if a 1N34 crystal is used, or not more than 60 ma. for a 1N56. Crystals may be paralleled for higher current values. Relay RY-2 may be any convenient unit which will operate on the DC supply voltage and whose coil current can be handled safely by the contacts of RY-1.

1.3 Novel Lock-In Relay.

At high reverse voltages, germanium crystals have a "breakdown" characteristic. That is, the reverse current increases suddenly when the breakdown voltage is reached. This action is somewhat analogous

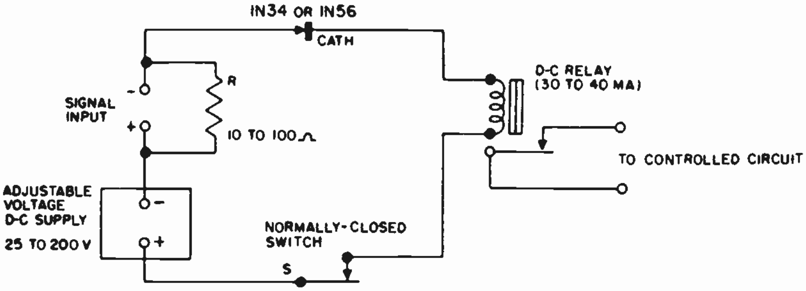


Fig. 1-3

to the breakdown of a neon bulb or other gaseous tube. Momentary interruption of the voltage or reduction to a lower value in some cases will restore normal current flow. The voltage at which breakdown occurs is somewhat more negative than the value listed in crystal tables under the heading "Reverse Voltage for Zero Dynamic Resistance," but is approximately –75 for the 1N34 and –50 for the 1N56.

A unique application of this breakdown phenomenon is a simple lock-in DC relay which will pick up on the application of a small pulse of AC or DC and will remain closed, after the pulse has passed, until the circuit is interrupted momentarily.

Figure 1-3 shows the circuit for accomplishing this action. The DC supply voltage is adjusted to a value slightly under that required for crystal breakdown. This may be done with the aid of a 0-100 DC milliameter inserted temporarily between the relay coil and the cathode of the crystal. At breakdown, the meter deflection will jump abruptly to a high value. The crystal must be operated as close as possible to the breakdown point without a spontaneous occurrence of breakdown. A small voltage (either AC or DC with the polarity shown in Figure 1-3) then applied momentarily at the SIGNAL INPUT terminals, across resistor R, will trigger the crystal and pick up the relay. High current then will continue to flow, keeping the relay closed, until switch S momentarily is opened.

The magnitude of signal voltage which will trigger the circuit into operation depends upon individual crystal characteristics and upon the resistance of the relay coil. It will be between 10 and 15 volts (DC or peak AC) for the 1N34 or 1N56, becoming lower as the crystal temperature increases from prolonged or closely-repeated operation.

This circuit is intended for intermittent operation only, since operation of the crystal beyond the breakdown voltage level produces internal heating. The crystal characteristic has a reverse bend at break down; consequently the circuit should contain a minimum amount of protective resistance.

1.4 Wide-Band AC Relay.

The addition of a germanium crystal rectifier to a milliampere-type DC relay converts the latter into a dependable AC relay capable of operating over a wide frequency range including power-line, supersonic, ultrasonic, and radio frequencies.

The efficiency of the circuit is increased by connecting a second crystal, D_2, (See Figure 1-4) in the reverse direction across the relay coil. On positive half-cycles of applied signal voltage (input terminal 1 positive), the upper crystal, D_1, conducts and energizes the relay coil. Crystal D_2, being reverse-connected, offers high resistance and does not detract appreciably from the relay current. When input terminal 2 goes positive, crystal D_2 then is forward-connected and, since it offers a low-resistance path, conducts around the relay and D_1.

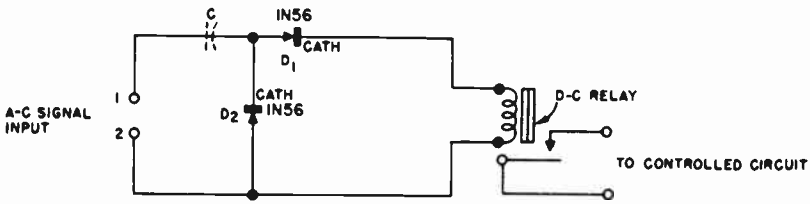


Fig. 1-4

If desired, a capacitor, C, may be added to block any DC component in the circuit, thereby preventing damage to the crystals and relay. Suggested values of capacitance are 0.25 to 1 ufd. for frequencies from 50 to 5000 cycles, 0.02 to 0.05 ufd. for 5000 to 20,000 cycles, 0.01 ufd. for 20 to 500 kc., 0.001 ufd. for 500 kc. to 2 Mc., and 100 ufd. for frequencies higher than 2 megacycles.

With type 1N56 crystals, a maximum delay current of 60 ma. DC can be handled. For higher currents, two or more 1N56's may be connected in parallel in place of each of the single crystal, D_1 and D_2. AC voltages as high as 1000 volts r.m.s. can be handled if an appropriate series resistor is connected between input terminal 1 (or capacitor C) and crystal D_1.

1.5 Coil Protector for Sensitive DC Relay.

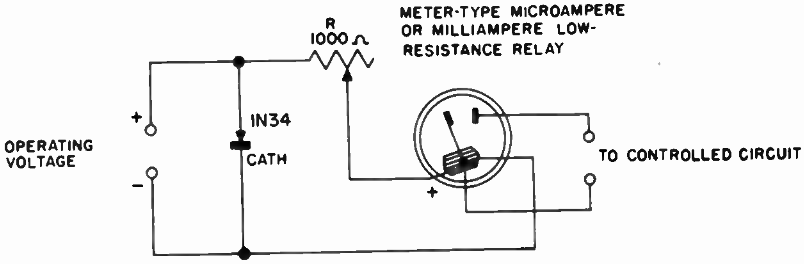


Fig. 1-5

Coil burnout is a serious problem when using microampere-type DC relays in industrial equipment where the relay coil resistance must be low and in which the applied voltage may rise unexpectedly to excessive levels. Germanium crystals in compressor circuits have been used to protect sensitive DC milliammeters and microammeters under similar conditions and can be used also for relay protection.

Figure 1-5 shows a crystal compressor circuit for relay coil protection. Current through the crystal increases non-linearly at a rapid rate as the DC operating voltage increases, and is several times the relay current. At higher voltages, more current thus flows through the crystal than through the relay. The result is a tapering-off of the relay current after the applied voltage reaches and exceeds a value determined by the experimental setting of rheostat R.

Because of the added resistance of the rheostat, a higher voltage than ordinary will be required to close the relay. Also, because of the crystal current, a higher current level is required by the circuit than by the relay if used alone. However, in many cases this will cause little or no inconvenience. It is not advisable to allow more than 50 ma. to flow through the crystal if it is a 1N34, 34A, 38, 38A, 39, 54, 54A, 55, 55A, 58, 58A, or 60; or more than 60 ma. if it is a 1N56 or 56A. Two or more crystals may be connected in parallel for higher currents or in series for higher applied voltages.

1.6 Selective DC Relay System.

Occasionally, it is desired to operate a series of relays, each connected at a different station across a common DC line, and to have each relay operate only when the bus voltage reaches a predetermined value. This scheme is unsuccessful with conventional relays, since the lower-voltage will receive excessive voltage when the higher-voltage units are operated.

Germanium crystal limiting circuits may be employed to hold each relay voltage constant at a predetermined value. The scheme is illustrated by Figure 1-6 which shows two stations only but which may be applied to as many more as desired. This scheme is satisfactory only for use with high-resistance relays, since heavy current loading will destroy the regulating action of the circuits.

Assume that terminals A and B supply a low-voltage relay, and terminals C and D a high-voltage relay. As the control voltage is increased, A and B will deliver voltage up to a level corresponding to the local voltage e_1. This will be the pickup voltage of the low-voltage relay. As the control voltage increases beyond this point, the voltage at A and B will remain constant, thus protecting the relay or other equipment connected to the terminals. Terminals C and D also will deliver a voltage which will level off to a constant value as the control voltage exceeds the local voltage e_2. The pickup voltage of the high-voltage relay corresponds to e_2.

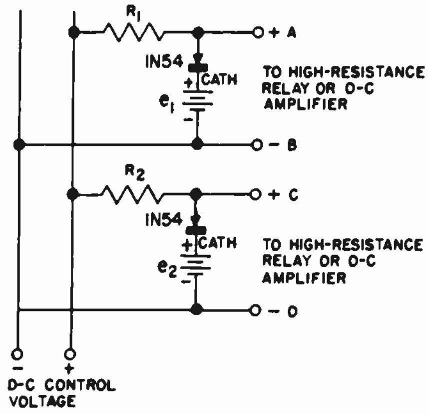


Fig. 1-6

By proper choice of voltage e_1 and e_2 and of series resistors R_1 and R_2, each relay will pick up at a given level of the control voltage and will continue to hold without an increase in current until the control voltage falls below that value. Voltages e_1 and e_2 can be supplied by a small rectifier system, although batteries are shown for simplicity in the circuit diagram.

The high resistance of the crystals in the reverse direction prevents discharge of the local voltage sources back into the DC line.

1.7 Proportional Hold-In, Drop-Out Relay.

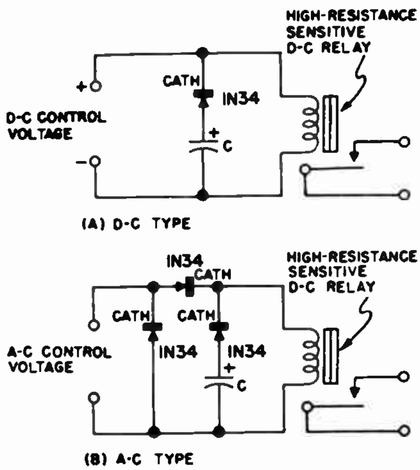


Fig. 1-7

Figure 1-7 shows two interesting circuits for relays with delayed dropout, the delay time being proportional to the length of time the relay was held in. When the control voltage is applied only momentarily, the relay will pick up and drop out quickly; but when the relay has been held in for a considerable time, it will drop out only after a proportionate interval.

In Figure 1-7 (A), when the control voltage is applied the relay will be picked up immediately but capacitor C cannot charge instantaneously because the reverse-connected crystal acts as a high resistance limiting the charging current. The voltage must be sustained over an appreciable interval in order to charge the capacitor to the full value of the control potential. When the control voltage is interrupted, current then will flow from the capacitor through the low forward resistance of the crystal and will continue to hold in the relay until the charge has been dissipated or sufficiently reduced to drop out the relay. If the voltage was not applied for a long enough interval to charge the capacitor, the relay will drop out immediately upon interruption of the voltage, or shortly thereafter.

The circuit of Figure 1-7 (B) is similar, except that two additional crystals have been provided as rectifiers for an AC control voltage.

The capacitances may be chosen experimentally, with a capacitor decade or substitution box, to give desired timing intervals in conjunction with the relay coil resistance and operating voltage available. Best results will be obtained with sensitive (milliampere-type) DC relays having high coil resistances, since these units have low current requirements and can be held in successfully by capacitor discharge currents.

1.8 "Wave-Front" Relay.

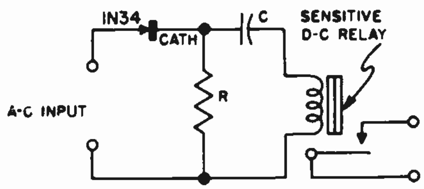


Fig. 1-8

When an AC voltage is applied to the INPUT terminals of the circuit shown in Figure 1-8, the crystal conducts and a DC voltage is developed across resistor R. This DC voltage charges capacitor C through the coil of the sensitive DC relay. Capacitor charging current flowing through the coil actuates the relay. But the capacitor becomes fully charged and then current ceases to flow. The relay accordingly drops out and remains open although the AC voltage may still be present at the INPUT terminals. Further closures of the relay may be accomplished only by interrupting and re-applying the AC or by raising the AC voltage appreciably.

The result of this action is that the relay closes momentarily when a constant AC voltage first is applied. It then opens and remains open (although the AC signal is maintained) unless the signal is thrown off and on. Because the start of an AC signal, or wave train, actuates the relay, the name *wave-front* relay seems appropriate.

Resistance R must have a value such that capacitor C can discharge through it quickly when the AC has been removed. The speed at which the relay closes depends upon the time constant determined by capacitance C and the relay coil resistance. Suggested values are R = 100 ohms and C = 1 microfarad for a 9000-ohm coil (1-milliampere DC relay). The applied signal would be of the order of 12 volts r.m.s at frequencies of 60 cycles to 10 Mc. For 60 cycle input, a 2 microfarad condenser will probably improve operation.

1.9 Transient-Operated Lock-In Relay.

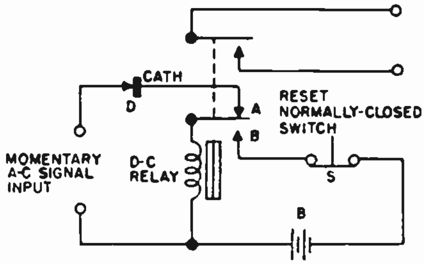


Fig. 1-9

Figure 1-9 shows a circuit in which a relay will lock-in in response to a signal applied momentarily to the input terminals of the circuit, and will remain locked in, although the original signal has ceased, until the local circuit momentarily is interrupted. In this manner of operation, the circuit is analogous to that of a thyratron tube.

Operation of the circuit is simple: An AC signal is rectified by crystal D and the resulting direct current actuates the relay. The relay armature moves from contact A, opening the signal circuit, and reaches contact B. This closes the local circuit from the battery or DC power supply (B) through the relay coil. This local source then will continue to hold the relay closed (and disconnected from the signal circuit) until it is interrupted by the RESET switch, S. In order to prevent buzzer action, contact B must be set close enough to the armature that positive contact will be made quickly after the armature leaves contact A.

A number of these relay circuits may be cascaded for counting purposes. The basic circuit is useful also for removing power to protect critical equipment at the first appearance of dangerous surges. Another use is to short circuit the input terminals of sensitive industrial recording equipment to protect the latter from damaging signal levels.

1.10 Simple Spark Suppressor for Relay Contacts.

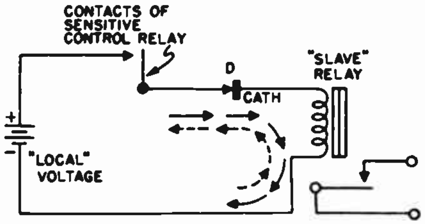


Fig. 1-10

Numerous schemes have been worked out for using the unilateral conductivity of sensitive relays. Figure 1-10 shows an extremely simple version involving merely the connection of a crystal D, in series (with proper polarity) with the contacts of a sensitive relay and the coil of a slave-relay.

When the contacts close, direct current flows through the crystal and slave-relay coil in the direction of the solid arrows. The crystal resistance is low in this direction. When the contacts of the control relay open, the collapsing magnetic field of the slave-relay coil generates a high-voltage counter e.m.f. which causes a current to flow in the direction of the dotted arrows. This high voltage ordinarily would cause severe sparking at the contacts of the control relay. But with the crystal in the circuit, the reverse current encounters the high back resistance of the crystal and therefore is limited.

The relay circuit should be checked first without the crystal to determine the peak value of the counter e.m.f. generated with the relay contacts open. This may be done with a voltage-calibrated oscilloscope. The proper crystal type then to use is one which has a reverse operating voltage rating equal to, or higher than the measured peak voltage. If the peak voltage exceeds the rating of any type, several crystals may be connected in series to obtain the required voltage rating.

In some cases the series circuit has proven more effective and given longer crystal life than the more common method of connecting a crystal in parallel with the slave-relay coil.

The presence of one or more crystals in the circuit may require that the "local" DC voltage be raised slightly above normal for the slave relay, in order to overcome the small crystal forward resistance.

THE MAN BEHIND THIS SIGN ⇨

1.11 Spark Suppressor for Inductive-Load Relay.

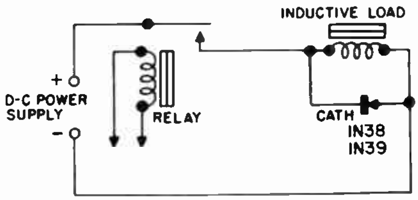


Fig. 1-11

Relay contacts are subject to severe sparking and wear when switching inductive loads. Such loads include motors, solenoids, contactors, heavier-duty relays, locks, valves, etc.

The sparking can be reduced by reverse-connecting a high-back-voltage crystal such as 1N38 or 1N39 across the inductive load, as shown in Figure 1-11. When the inductive device is operating, current flow through the crystal is small because of the high-back resistance. When the relay opens, however, the counter e.m.f. generated by the collapsing magnetic field in the inductance is of opposite polarity, and the resulting energy is dissipated in the low forward resistance of the crystal, instead of sparking across the opening relay contacts.

In the past, crystals often have been connected in this way across industrial relay coils, but it is not generally known that the same connection can be used successfully with motors and other heavier-duty magnetic equipment.

The peak value of the counter e.m.f. should be checked with a voltage-calibrated oscilloscope before installing the crystal. If this voltage exceeds the rated continuous reverse working voltage of a single crystal of any type, the proper number of crystals should be connected in series to handle this peak counter e.m.f. without breakdown.

1.12 Remote Carrier-Current-Controlled Relay.

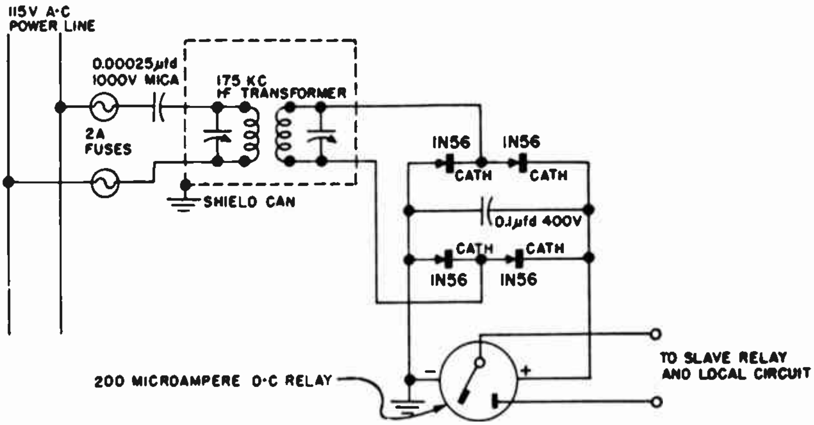


Fig. 1-12

A simple relay-receiver for remote control operations performed over the AC power line is shown in Figure 1-12. This unit operates on an r.f. carrier frequency of 175 kc. and can be actuated over several hundred feet of power line by means of a small 5- or 10-watt-output 175-kc. oscillator coupled into the power line.

The tuning unit is a 175-kc. i.f. transformer peaked to the operating frequency. The primary is coupled to the power line through a 0.00025-ufd. 1000-volt mica capacitor which offers high impedance to the power frequency and thus allows the receiver to be connected continuously to the line.

The detector consists of four 1N56 high-conduction crystals connected in a full-wave bridge circuit. DC output from the bridge actuates a 200-microampere DC relay which, in turn, operates a heavy-duty slave relay for the control of any desired machine or device.

Possible applications are the control of remotely-located motors, switches, signals, lights, locks, doors, and similar devices. Use of the available power line makes it unnecessary to run special wires.

CHAPTER 2

Timing Circuits

2.1 Delayed-Make Circuit.

In the circuit shown in Figure 2-1, a DC voltage appears across the load at some instant after switch S is closed. The delay interval is governed by the time constant of resistor R_1 and capacitor C.

When switch S is closed, point B receives a constant positive potential equal to one-half of the DC supply voltage. Point A, however, initially is at zero potential, since capacitor C cannot charge immediately. As the capacitor charges through resistor R_1, the potential at point B and the 1N34 anode grows more positive. But

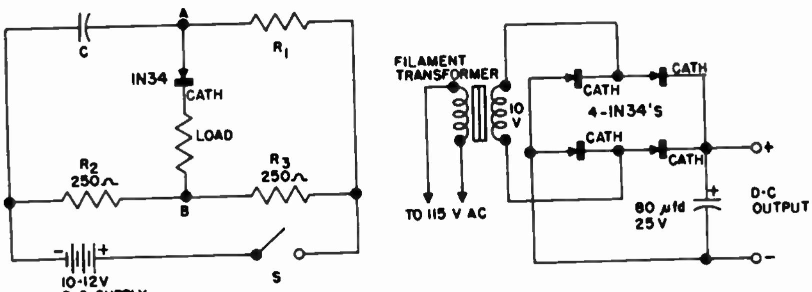
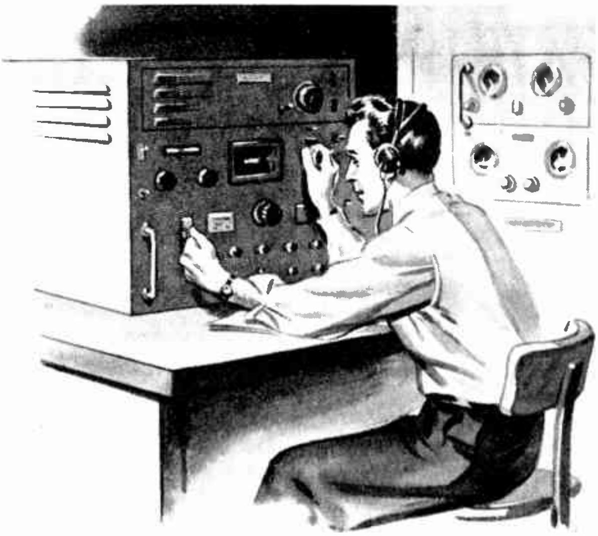


Fig. 2-1

since the 1N34 cathode is more positive than the anode, no current can flow through the crystal into the load. When the capacitor becomes fully charged, point A will be more positive than point B, and the crystal will conduct. The load then will be activated. At the instant that the positive potential at A exceeds that at B, the crystal quickly switches current into the load. The rapidity of operation is one advantage of this circuit.



The values of C and R_1 are chosen for the desired delay time. A rheostat may be used at R_1 when adjustment of the timing rate is desired. In order to allow ample current flow through the load, it is preferable to choose R_1 low and C high in value for a given time constant.

The load device may be a low-current DC relay, or a load resistor across which a potential is developed for presentation to an industrial DC amplifier system.

If operation from the AC power line is desired. a miniature power supply may be constructed with a filament transformer, germanium crystal bridge rectifier, and electrolytic capacitor (as shown also in Figure 2-1) and substituted for the battery.

2.2 Crystal as Timing Resistor.

In most R-C-type electronic timers, the adjustable resistor setting the timing rate is a high-resistance potentiometer. The high value of resistance required in this application makes necessary the use of a composition-type of rheostat or potentiometer, and this type usually is not stable nor does it hold its calibration over long periods.

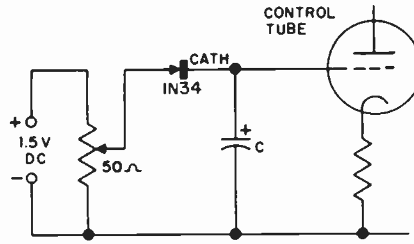


Fig. 2-2

In the timer circuit shown in Figure 2-2, the resistance component of the timing circuit is a 1N34 crystal. The forward resistance of the crystal varies over wide limits with applied voltage. If the voltage is varied between 0.1 and 1.5 v., a small 50-ohm wirewound potentiometer may be used for the calibrated timing control. A wirewound control enhances accuracy and stability.

When the potentiometer is set for 0.1 volt, the resistance of the crystal is approximately 4000 ohms. At 1.5 volts applied, the crystal resistance is about 100 ohms. This is a resistance range of 40 to 1. The timing interval is governed by the time constant of the crystal resistance and the capacitance C. This is a delayed-make type of time delay circuit.

The DC voltage across the fully-charged capacitor, C, varies with the setting of the potentiometer. The relay or other load device in the plate circuit of the tube, and the circuit constants, accordingly must be chosen for operation at the lowest voltage which will appear across the capacitor at full charge. This will insure that operation will be obtained at all settings of the timing potentiometer.

2.3 Timing Marker Generator.

It is of value to use timing waves for reference in the recording of industrial data. The timing-wave pattern is recorded parallel to the data trace. When no timing system is provided internally by the recording equipment, it is convenient to record an AC signal of accurately-known frequency for this purpose. In this way, a reference time base is established. This technique is employed with industrial oscilloscopes and oscillographs and other direct-writing recorders. Occasionally, a reasonable sharp pulse with a known repetition rate is preferred to a sine wave for timing purposes, but suitable pulse generating equipment can be both complicated and costly. Figure 2-3 show a simple arrangement for deriving timing pulses from a sine wave signal.

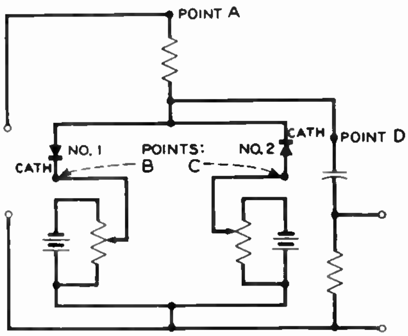


Fig. 2-3(A)

In this circuit, a 1N54 duo-diode is used as a biased rectifier. The bias is supplied by batteries providing voltages as determined by the desired operating point which can be any convenient voltage within the peak back voltage rating of the crystal (Figure 2-3 (B)).

The AC signal may be obtained from an audio oscillator or from the power line, depending on frequency requirements. The output is a sharp pulse, either positive or negative in direction, whenever the input voltage passes a point determined by the battery voltages.

The voltage waveforms at Point D, with different components disconnected are as follows; assuming sine wave input, and battery polarities as shown in Figure 2-3 (A):

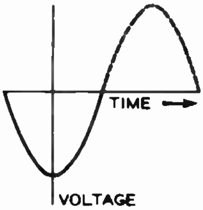


Fig. 2-3(B)

1. Crystal #2 Disconnected (A)
2. Crystal #1 Disconnected (B)
3. Both Crystals Connected (C)

A

B

C

D

The output, with both diodes connected is shown at D

Using these circuit components, it is possible to make the quantity $V_A = V_B$ less than 0.1V.

Crystal 1) 1N35
Crystal 2)

R = 56K

R_D = 5.6K

C_D = 300 f

The circuit operation is as follows, assuming that an indication is desired at some point where the input signal is negative.

Crystal #1, biased in the conducting direction, will conduct during the period when point A is more positive than point B.

Crystal #2, biased in the back direction, will conduct during the period when point A is more negative than point C.

Thus, during a finite period of time, based upon V_A - V_B, neither crystal will be in conduction, and a sudden voltage change is evident across C_D and R_D. After differentiation, the output is available as a pulse of considerable magnitude whenever the input voltage goes through the level determined by V_A and V_B. It is also possible to get a recognizable output when V_A is made equal to V_B. This is due to the fact that when the voltage applied to the crystals is going through zero, the crystals exhibit an extremely high resistance in both forward and back directions. This, in effect, causes a period of non-conduction across both crystals, and a voltage change at point D. The output magnitude will be somewhat smaller in this case, for the output is dependent upon the voltage change at point D, and in turn upon V_A - V_B.

2.4 Discharge Stretcher for R-C Timing Circuits.

Resistance-capacitance combinations are widely used in electronic timing circuits. In these arrangements, a capacitor is charged from a DC voltage and then allowed to discharge through a resistor. The circuit remains in operation until the capacitor has discharged completely or until the capacitor voltage has fallen to some critical value. The capacitor voltage is applied to a high-impedance load, such as the grid-cathode circuit of a vacuum tube.

In some applications, particularly those involving multiple timing operations, it is desirable that the capacitor should not discharge completely between operations, but should retain some of its voltage below the deactivation point of the circuit. The residual voltage reduces the time interval necessary to re-start the circuit by again energizing the capacitor.

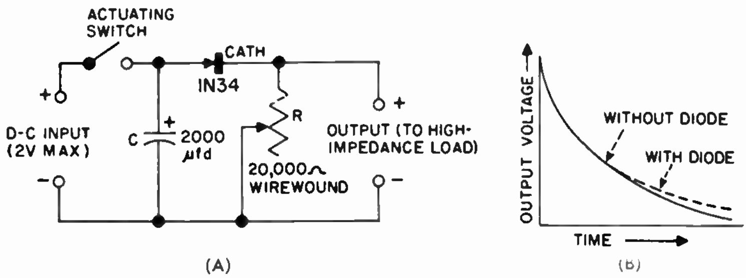


Fig. 2-4

The discharge interval may be stretched by the simple expedient of connecting a 1N34 crystal in series with the C and R elements of the timing combination, as shown in Figure 2-4(A).

Operation of the circuit is based upon the non-linear rate at which the crystal forward resistance varies with applied voltage, this resistance being highest at low voltages. When capacitor C is fully charged (1 to 2 volts), the crystal resistance is negligible compared to the resistance of the timing control, R. As the capacitor discharge voltage falls, the crystal resistance increases, becoming appreciable with respect to the control resistance, thereby increasing the time required for the capacitor voltage to fall to a given low value. The curve in Figure 2-4(B) shows approximately how the decay of output voltage is prolonged by the crystal.

2.5 AC-Operated Slow-Release Timing Circuit.

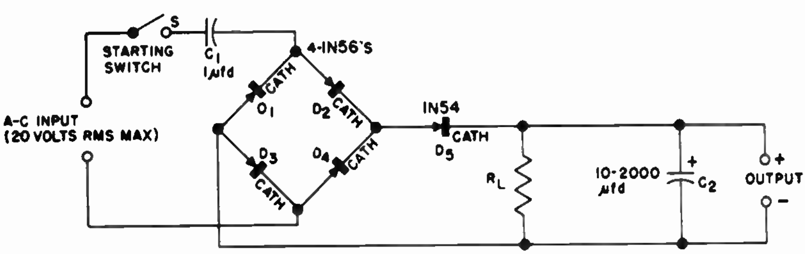


Fig. 2-5

Crystals are used both for rectifying and blocking in the AC-operated timing circuit shown in Figure 2-5. This circuit will be attractive in applications where only AC is available for operation.

When the starting switch, S, is closed, the four bridged-connected 1N56 crystals (D_1 to D_4) deliver a DC voltage to the R-C timing circuit (R_LC_2) through the forward-connected 1N54 series crystal, D_5. Capacitor C_2 is charged by this voltage which appears also across the OUTPUT terminals.

When switch S is opened, capacitor C_2 then discharges through resistor R_L at a rate determined by the time constant of the R-C combination. Since crystal D_5 is reverse-connected with respect to the capacitor voltage, any leakage path back toward the input half of the circuit is of very high resistance. Furthermore, both halves of the bridge rectifier also are reverse-connected with respect to this polarity of voltage. The result is that most of the discharge current flows through resistor R_L.

The discharge resistor, R_L, may be chosen with respect to capacitance C_2 to give the desired timing interval. For direct operation R_L may be the high-resistance coil of a sensitive DC relay.

When R_L is a resistor (fixed or variable), the output terminals of the circuit may be connected to a high-impedance system such as an industrial DC amplifier input.

GERMANIUM DIODE INSTALLATION HINTS

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

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

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

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

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

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

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

CHAPTER 3

Power Supply Applications

3.1 General Use of Crystals as Power Supply Rectifiers.

Within the limitations of its relatively low continuous forward current ratings, the germanium crystal offers several advantages as a simple power supply rectifier which merit consideration in designing and modifying low-voltage industrial equipment.

For a given current rating, the germanium crystal has less bulk and weight than many other "metallic" rectifiers. It also has the following additional advantages: (1) higher frequency response, (2) lower voltage drop, (3) higher operating efficiency, (4) lower self-capacitance, (5) less hysteresis, (6) better low-voltage operation, (7) closer matching between units, (8) lower internal heating, and (9) higher average ratio of permissible peak to average forward current.

Germanium crystals may be connected in series to withstand higher applied voltages, in parallel to pass higher currents than rated, and in series-parallel for both higher voltage and higher current. Series limiting resistors may be connected in series with these crystals, in the same manner as with other "metallic" rectifiers, to limit peak currents to safe values.

From the tables of ratings and characteristics, the two crystal characteristics which are of greatest interest in the selection of units for sine-wave power rectification are (a) average anode current and (b) continuous reverse working voltage. When a crystal is selected for its ability to supply safely the desired maximum DC output current, its continuous reverse working voltage also must be higher than the peak inverse voltage normally present in the power supply circuit. Only by meeting *both* of these requirements will the crystal be a satisfactory choice. Thus, a 1N34 might be selected on the basis of ability to handle a desired output current level of 45 ma., but we note that its maximum continuous reverse working voltage rating is 60 v. and this would unsuit it for 45-ma. operation at *115 volts* (in a simple rectifier circuit without capacitors or inductors, the peak inverse voltage would be 163 volts). Neither would two 1N34's in series be satisfactory. A single 1N39, however, would suffice, since its maximum reverse voltage rating is 200 v.

In power supplies, germanium crystals may be employed in the conventional manner in half-wave, full-wave center-tapped, bridge, voltage multiplier, single-phase, and polyphase circuits.

3.2 100-MA. 115-Volt Rectifier Arrangement.

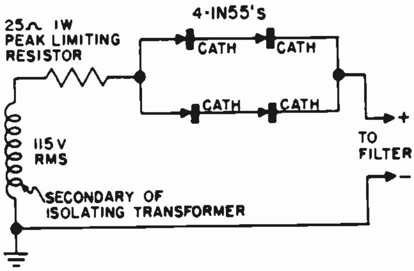


Fig. 3-1

Figure 3-1 shows how four 1N55 or 1N55A 150-volt crystals can be connected to provide all the advantages of the germanium rectifier in a half-wave power supply circuit delivering 100 milliamperes DC Max. for an applied AC voltage or 115 r.m.s.

Because of the excellent frequency characteristics of the germanium crystal, this rectifier may be used at full efficiency and without derating in power supplies operated by high frequency generators, as well as at the common power-line frequencies.

Even with four crystals and a limiting resistor, the rectifier element will be small and may be mounted unobtrusively in existing equipment.

3.3 Low-Voltage AC Varistor.

Two closely-matched crystals can be connected as shown in Figure 3-2, to provide conduction on both halves of the AC cycle.

At low values of applied voltage (especially between 0.05 and 0.2 v.) the crystal conduction characteristic is quite non-linear. At

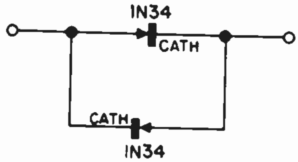


Fig. 3-2

these voltages the connection shown provides AC action similar to that obtained with thyrite resistors but at the low potentials and high frequency at which thyrite normally is not effective. In the pronounced non-linear region of the germanium crystal, a large change in crystal current is required to produce a small change in voltage drop across the crystal.

Various low-voltage devices (for operation between zero and 250 millivolts AC), in which thyrite may not be effective because of the low potentials involved, may be set up with the germanium varistor of Figure 3-2. These applications include millivolt AC voltage regulators, frequency multipliers, compressors, expanders, voltage-change multipliers, and constant current potentiometers found in literature on thyrite uses.

The non-linear conduction characteristic of the 2-crystal varistor, like the thyrite resistor used in many industrial applications, introduces appreciable odd-harmonic distortion. This fact must be considered when applying the device to power supply and other circuits.

3.4 Low-Voltage Limit of Crystal Rectifiers.

One of the chief advantages of the germanium crystal as a power supply rectifier is its performance at low AC voltages. Recent exhaustive tests by Sylvania physicists, however, set 1 millivolt peak as the minimum practical voltage which will be rectified satisfactorily.

At signal levels below 1 mv., the front-to-back current ratio deteriorates to the point that rectification ceases and the full AC cycle is passed with some loss.

The simple germanium crystal rectifier, in the absence of preceding AC amplification, therefore, is not recommended for use at applied voltages under 1 mv. peak. Sylvania silicon crystals are recommended at lower voltages.

3.5 General-Purpose Midget Variable Power Supply.

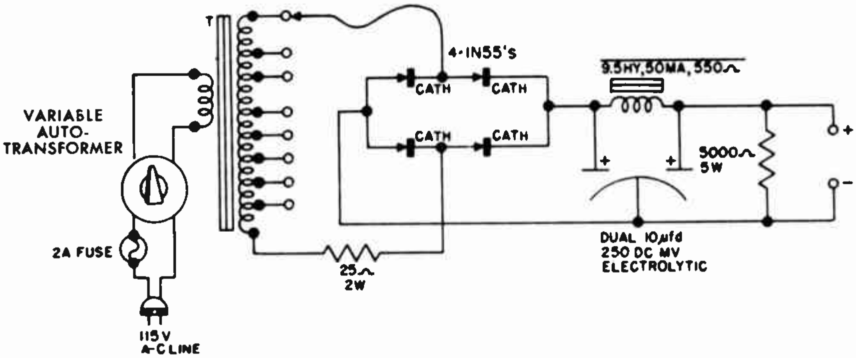


Fig. 3-3

A portable, AC-operated, variable output DC power supply is invaluable to the industrial technician as a substitution source and as a handy unit for supplying DC relays, timing equipment, light-sensitive apparatus, and similar gear during test or developmental work, as well as in trouble-shooting.

Figure 3-3 shows the circuit of a practical 50-ma. unit of this type which will supply full-load voltages as high as 117. This unit employs a 20-tap transformer which gives voltage steps of 1.1, 1.4, 1.5, 2.0, 2.5, 3.0, 5.0, 6.3, 7.0, 7.5, 12, 25, 30, 35, 50, 70, 85, 110, and 117. The DC output voltage is continuously variable in any step range by means of a primary Powerstat.

The rectifier is a full-wave bridge employing four 1N55 crystals. A 25-ohm, 2-watt resistor protects the crystals from excessive peak current.

This power supply offers the advantages of small size, light weight, easy portability, smooth output adjustment, and a wide selection of voltage ranges to suit a variety of industrial test demands. It will be useful in the industrial laboratory, as well as in the shop and on the assembly line.

CHAPTER 4

Applications to Industrial Instrumentation

4.1 DC-to-AC Converter Circuits.

Numerous industrial tests involve the measurement or amplification of small DC potentials of the order of millivolts. Thermocouple and strain gage output voltages are examples. The difficulties attendant to DC amplification have caused considerable attention to be given to the technique of converting the small DC voltages into proportionate AC voltage, amplifying the latter with a conventional AC amplifier, and then rectifying the amplified product back to DC. Several methods are in use for accomplishing the conversion. One employs a vibrator-type interrupter to chop the DC at a rapid rate.

Several schemes for DC-AC conversion are available in which germanium crystals accomplish the desired result through their modulating ability. All moving parts thus are dispensed with. Each of the circuits (Figure 4-1) is powered by a constant AC voltage, and delivers an AC output voltage which is proportional to the applied unknown DC voltage. The output voltage must be applied only to a high impedance (100,000 ohms or higher) which is the case when it is presented to the input of an AC amplifier.

In Figure 4-1(A), constancy of amplitude of the AC supply voltage is secured by using a square wave signal at a frequency of 400 to 500 cycles. The square wave is self-limited by its generator.

The conversion from DC to AC is accomplished by two 1N54 crystals. If no DC is applied to the DC INPUT terminals, crystal D_1 short circuits the negative half-cycle of the square wave, and crystal D_2 the positive half-cycle, with the result that no signal reaches the DC OUTPUT terminals. When a DC voltage is applied

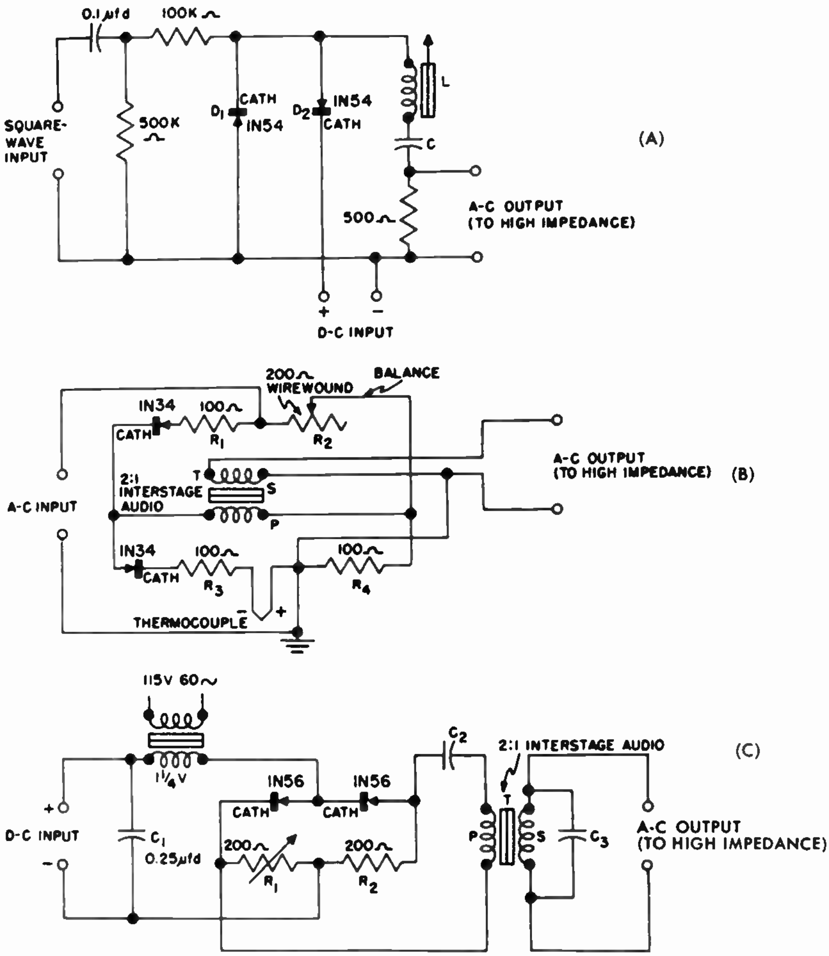


Fig. 4-1

to the DC INPUT terminals, it biases crystal D_2 and a proportionate part of the positive half-cycle of the square wave is transmitted. Thus, whenever DC is applied to the circuit, a square-wave positive half-cycle signal is transmitted through the filter, LC, to the AC OUTPUT terminals. The peak amplitude of the square-wave AC voltage applied to the AC INPUT terminals should be of the order of the maximum DC voltage to be handled.

The filter, LC, is adjusted to pass the frequency of the square-wave voltage, and the L and C values may be chosen accordingly.

This is a simple process, since the arrangement is a rudimentary series resonant circuit. By employing a tuneable choke at L, the filter may be adjusted closely to the pass frequency selected.

The circuit shown in Figure 4-1(B) was designed primarily to convert the weak DC output of a thermocouple into proportionate AC to be amplified by a conventional amplifier, but other DC signal sources may be used as well. The arrangement is a 4-arm bridge in which 1N34 crystals act as voltage-sensitive resistors in two arms.

A constant-amplitude sine-wave voltage is applied to the AC INPUT terminals. The BALANCE potentiometer, R_2, then is adjusted for zero AC output at room temperature. When subsequently the thermocouple temperature changes, the change in its generated DC voltage alters the resistance of the adjacent crystal, upsetting the bridge balance. A proportionate unbalance AC voltage consequently appears at the AC OUTPUT terminals. The maximum r.m.s. value of the AC input voltage will be of the order of 1 volt for most applications.

The circuit shown at Figure 4-1(C) is another 4-arm bridge with two 1N56 crystals acting as voltage-sensitive resistors in two arms, somewhat differently arranged from the preceding example. The AC and DC voltages are applied to the bridge in series with each other.

With the DC signal source connected to the DC INPUT terminals but delivering no voltage at the moment, the bridge is balanced for zero signal voltage at the AC OUTPUT terminals by adjusting the variable arm, R_1. When a DC signal subsequently is applied, the corresponding current flowing through the crystals will change the resistance of the latter and unbalance the bridge. An unbalance AC voltage, proportional to the applied DC, then appears at the AC OUTPUT terminals.

For improved output amplitude, both primary and secondary windings of the output transformer, T, are tuned to the frequency of the AC supply voltage. The primary of this transformer is tuned by capacitor C_2 with which it forms a series resonant circuit, and the secondary C_3 with which the latter winding forms a parallel resonant circuit.

4.2 Industrial R.F. Voltmeter.

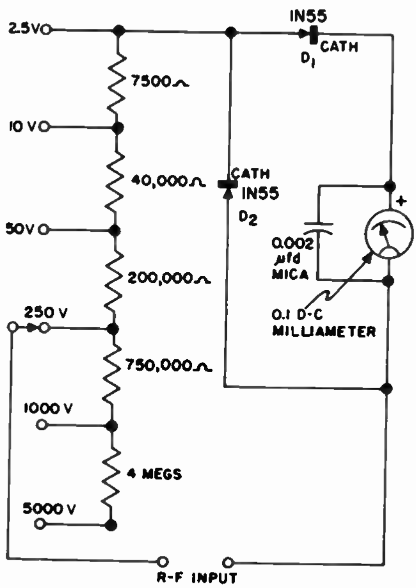


Fig. 4-2

High-powered radio-frequency generating apparatus is used in industry for dielectric heating, induction heating, soldering, hardening, etc.

An instrumentation problem usually arises when it becomes necessary to check performance of this equipment by measuring actual radio-frequency voltages. Ordinary AC voltmeters have serious errors at the frequencies involved and accordingly are unsatisfactory. AC vacuum-tube voltmeters have the necessary frequency response but are so sensitive that they are deflected erroneously and often are damaged by strong radio-frequency fields. A satisfactory solution is a non-electronic-type of AC voltmeter employing germanium crystals as meter rectifiers.

Figure 4-2 shows the simple circuit of such a meter. Using an inexpensive 0-1 DC millameter, and providing 100 ohms per volt sensitivity (which is adequate and foolproof for this application), six full-scale voltage ranges are provided: 0-2.5, 10, 50, 250, 1000 and 5000 volts r.f. The instrument can be used without frequency error from 50 cycles to approximately 40 Mc., and with varying amounts of negative error from 40 to 100 Mc. This adequately covers the radio frequencies employed in industry.

The meter rectifiers are two 1N55 crystals. On positive half-cycles of signal voltage, crystal D_1 conducts and deflects the milliammeter. On negative half-cycles, crystal D_2 conducts around the meter and D_1. If a DC component is present in the circuit under test, a 0.1-ufd. high-voltage capacitor may be connected in series with one of the R.F. INPUT terminals to protect the crystals and milliammeter. Due correction must be made at the test frequency for the presence of the capacitor in the circuit.

Since the crystal conduction curve is non-linear at low-current densities, an individual AC calibration must be made for this voltmeter. The scale of the milliammeter cannot be used directly if highest accuracy is desired. The calibration can be made at the power line frequency if no higher-frequency source is available. The procedure consists of applying a series of accurately-known AC voltages to the R.F. INPUT terminals and noting the corresponding deflections of the milliammeter. A card or graph then may be drawn, or a special scale prepared for the meter. If precision resistors are used in the range switching circuit, accuracy in switching will be obtained. A special calibration will be necessary for the 2.5-volt range.

4.3 Replacing Germanium Crystals in Demodulators.

The same sensitive, reliable operation may be expected when germanium crystals are used in ring demodulators, phase comparators, and discriminators in industrial measuring equipment as in other applications of germanium crystals. Such circuits are employed in carrier-type equipment used with strain gages, accelerometers, displacement pickups, and similar transducers. Improved performance results from the long-term stability and lower dynamic impedance of the germanium crystal.

It is important to employ closely-matched crystals in these applications. Where two crystals are indicated, type 1N35 duo-crystal usually will suffice. Matched 1N56's, obtainable on special order, are desirable where higher conductance is desired. Where four conventional crystals are indicated, Varistor Types 1N40 (plug-in) and 1N41 (lug-type) are satisfactory. Varistor Type 1N42 consists of four 100-volt crystals. Varistor 1N71 contains four high-conduction (low-impedance) crystals.

4.4 Improvised Low-Voltage D.C. Standard.

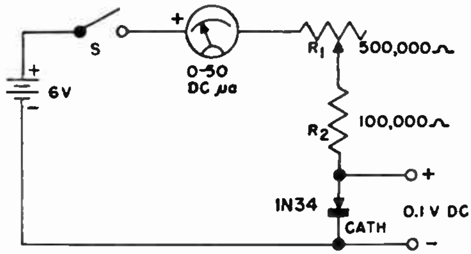


Fig. 4-3

The simple circuit in Figure 4-3 will supply a 0.1-volt DC potential to a high-impedance load or zero-current circuit for calibrations and other tests of the potentiometric type. In use, this circuit is similar to a standard cell.

Operation is based upon the non-linear forward conduction characteristic in the 1N34 at low current densities. With a series resistor, the crystal forms a voltage regulating (constant voltage) circuit. In this arrangement shown in Figure 4-3, for example, a voltage drop of 0.1 v. appears across the crystal when control R_1 is adjusted for a crystal current of approximately 20 microamperes, as indicated by the meter. If the 6-volt supply increased to 30 volts (5 times), the crystal voltage drop would rise only to a 0.2 v. With any normal small shift in the 6-volt supply, the change in crystal voltage drop would be so small as to be hardly detected. Resistor R_2 is a limiting resistor to prevent damage to the microammeter and crystal should control R_1 accidentally be advanced to zero resistance.

4.5 Signal Rectifier for Direct-Writing Graphic Recorder.

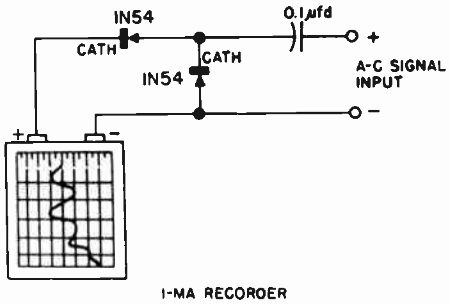


Fig. 4-4

Such instruments are widely used for the automatic recording of industrial data. Since this is a direct current instrument, however, only those impulses which can be transduced into DC may be used. Frequently, however, industrial signals are alternating and cannot be recorded directly with this instrument.

Figure 4-4 shows how two 1N54 crystals and a 0.1-ufd. capacitor can be connected ahead of the 1 ma. recorder to adapt it, when needed, to AC signals up to radio frequencies. Deflection of the recorder will be equal approximately to the average value of the AC component.

The simple adaptor can be removed easily when the recorder is to be used on DC. The shunt-connected second crystal in the circuit prevents flutter of the recording pen at low frequencies.

If the data to be recorded is a current component, a 100-ohm shunt resistor should be connected between the two AC SIGNAL INPUT terminals. For voltage recording, the shunt must be removed. In either case, a special calibration must be performed with recorder deflections plotted against known AC inputs, because of the non-linearity of the germanium crystal at current levels of 1 milliampere and less.

On the next two pages are complete

RATINGS AND CHARACTERISTICS

Sylvania's line of crystal diode components includes 31 diode types, a duo-diode and four varistor networks. All are lightweight, compact, rugged circuit elements having low shunt capacity, no contact potential and require no heater supply or mounting hardware. They have exceptional electrical stability and are strongly resistant to thermal shock.

Among the 31 crystal diodes are types designed to withstand working voltages up to 50, 60, 100, 150 or 250 volts in the reverse direction, to exhibit exceptionally high back resistance or to possess a high forward conduction characteristic.

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

The duo-diode Type 1N35 is a mounted pair of 1N34

OF SYLVANIA CRYSTAL DIODES

diodes carefully matched for use in balanced circuits, for full-wave rectification, modulation or demodulation.

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

All Sylvania Crystal Diodes have a nominal shunt capacitance of $\mu\mu f.$, tolerate an ambient temperature range of —50° to +75° C and have an average life of more than 10,000 hours.

The principal electrical ratings for each diode and the duo-diode and varistor types are shown on the next two pages.

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Germanium Crystals

RATINGS

MAXIMUM RATING AT 25° C

TYPE	DESCRIPTION	AMBIENT TEMPERATURE RANGE (0°C.)	CONTINUOUS RECURRENT REVERSE WORKING VOLTAGE (VOLTS)	CONTINUOUS RECURRENT PEAK ANODE CURRENT (MA.)	AVERAGE ANODE CURRENT (MA.)	SURGE CURRENT (MA. 1 SEC.)
1N34	General Purpose Diode	−50 to +75	60	150	50	500
1N34A	General Purpose Diode	−55 to +75	60	150	50	500
1N35	Matched Duo-Diode (Note 1)	−50 to +75	50	60	22.5	100
1N38	100 Volt Diode	−50 to +75	100	150	50	500
1N38A	100 Volt Diode	−55 to +75	100	150	50	500
1N39	200 Volt Diode	−50 to +75	200	150	50	500
1N40	General Purpose Varistor (Note 2)	−50 to +75	25	60	22.5	100
1N41	General Purpose Varistor (Note 2)	−50 to +75	25	40	22.5	50
1N42	100 Volt Varistor (Note 2)	−50 to +75	100	50	22.5	75
1N54	High Back Resistance Diode	−50 to +75	35	150	50	500
1N54A	High Back Resistance Diode	−50 to +75	50	150	50	500
1N55	150 Volt Diode	−50 to +75	150	150	50	500
1N55A	150 Volt Diode	−50 to +75	150	150	50	500
1N56	High Conduction Diode	−50 to +75	40	200	60	1000
1N56A	High Conduction Diode	−50 to +75	40	200	60	1000
1N58	100 Volt Diode	−50 to +75	100	150	50	500
1N58A	100 Volt Diode	−50 to +75	100	150	50	500
1N59	250 Volt Diode	−50 to +75	260	150	50	500
1N60	Video Detector Diode	−50 to +75	25	150	50	500
1N67	High Back Resistance Diode	−50 to +75	80	100	35	500
1N69	General Purpose Diode	−55 to +75	60	125	40	400
1N71	Low Impedance Varistor (Note 5)	−50 to +75	40	200	60	1000
1N81	High Back Resistance Diode	−55 to +75	40	90	30	350
1N82	UHF Mixer Diode	−50 to +75				
1N82A	UHF Mixer Diode	−50 to +75				
1N105	Video Detector Diode	−50 to +75	25	150	50	500
1N109	Harmonic Generator Diode	−50 to +75	15	150	50	500
1N111	Computer Diode	−50 to +75	60	150	25	500
1N112	Computer Diode	−50 to +75	60	150	25	500
1N113	Computer Diode	−50 to +75	60	150	25	500
1N114	Computer Diode	−50 to +75	60	150	25	500
1N115	Computer Diode	−50 to +75	60	150	25	500
1N119	Computer Diode	−50 to +75	60	150	25	500
1N120	Computer Diode	−50 to +75	60	150	25	500
1N132	Video Detector Diode	−50 to +75	25	150	50	500
1N172	UHF Mixer Diode	−50 to +75				

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

Note 2—Consists of four specially selected and matched diodes whose resistances are balanced with ±2.50% in the forward direction of 1.5 volts. For additional balance, the forward resistance of each varistor pair is matched to within three ohms. Ratings shown are fo reach diode.

Note 3—Units are tested in a circuit employing an input of 1.6 volts rms at 40 MC, 75% modulated at 400 cycles. Demodulated output across a 4700 ohm resistor shunted by a 5 μμf capacitor is a minumum of 1.55 volts peak to peak.

Note 4—Minimum specified reverse resistance applies to all points between 0 and −10 volts with 0 cps sweep.

Note 5—Consists of four specially selected diodes whose forward currents are matched within a range of 1 ma. with 1 volt applied. Ratings shown are for each diode.

Note 6—The 1N82, 1N82A, and 1N172 are low noise and low conversion loss UHF television miser crystals. The noise factor of the 1N82 is 16 db max., that of the 1N82A is 14 db ma. The noise factor is measured at 700 mc with a local oscillator drive (bias current) of 0.5 ma.

Note 7—Units are tested in a circuit employing a fundamental frequency of 126 MC. The rectified 3rd harmonic output is 0.5 ma minmum.

Note 8—Minumum specified reverse resistance applies at

AND CHARACTERISTICS

CHARACTERISTICS AT 25° C

PEAK REVERSE VOLTAGE FOR ZERO DYNAMIC RESISTANCE (VOLTS MIN.)	FORWARD CURRENT AT +1 VOLT (MA. MIN)	REVERSE CURRENT (MA. MAX.)	FORWARD RESISTANCE AT +1 VOLT (OHMS MAX.)	REVERSE RESISTANCE (OHM MIN.)
75	5	50 @ –10V, 800 @ –50V	200	200K @ –10V, 625K @ –50V
75	5	30 @ –10V, 500 @ 50V	200	330K @ –10V, 100K @ –50V
75	7.5	10 @ –10V	133	1.0 meg @ –10V
120	3	6 @ –3V, 625 @ –100V	333	500K @ –3V, 160K @ –100V
120	4	6 @ –3V, 500 @ –100V	250	500K @ –3V, 200K @ –100V
225	3.0	200 @ –100V, 800 @ –200V	250	500K @ –100V, 250K @ –200V
75	12.75 @ 1.5V	35 @ –10V	118 @ 1.5V	250K @ –10V
75	12.75 @ 1.5V	40 @ –10V	118 @ 1.5V	250K @ –10V
120	12.75 @ 1.5V	800 @ –100V	118 @ 1.5V	125K @ –10V
75	5	10 @ –10V	200	1.0 meg @ –10V
75	5	7 @ –10V, 100 @ –50V	200	1.4 meg @ –10V, 500K @ –50V
170	3	300 @ –100V, 800 @ –150V	333	330K @ –100V, 187K @ –150K
170	4	500 @ –150V	250	300K @ –150V
50	15	300 @ –30V	67	100K @ –30V
50	15	300 @ –30V	67	100K @ –30V
120	4	700 @ –100V	250	140K @ –100V
120	4	600 @ –100V	250	167K @ –100V
275	3.0	800 @ –250V	333	300K @ –250V
30	Note 3	Note 4	......	150K (Note 4)
100	4.0	5 @ –5V, 50 @ –50V	250	1 meg @ –5V, 1 meg @ –50V
75	5	50 @ –10V, 850 @ –50V	20	200K @ –10V, 588K @ 50V
50	15	300 @ –30V	67	100K @ –30V
50	3	10 @ –10V	333	1.0 meg @ –10V
Note 6				
Note 6				
75	Note 3	Note 4	......	150K (Note 4)
75	Note 7	....	......	......
75	5	Note 8	200	400K @ 55°C (Note 8)
75	5	Note 8	200	200K @ 55°C (Note 8)
75	2.5	Note 8	400	400K @ 55°C (Note 8)
75	2.5	Note 8	400	200K @ 55°C (Note 8)
75	2.5	Note 8	400	100K @ 55°C (Note 8)
75	5	Note 8	200	400K @ 55°C (Notes 8 & 9)
75	5	Note 8	200	200K @ 55°C (Notes 8 & 9)
30	Note 10	Note 4	......	150K (Note 4)
Note 6				

55°C for all points between –10V and –50V with 60 cps sweep.

Note 9—Reverse recovery time for these units is specified and defined as the time required for the diode to recover to a given reverse current when the operating voltage necessary to give 30 ma forward conduction is rapidly switched to –35 volts.

Type	Reverse Current ua	Reverse Resistance ohms	Recovery Time usec.
1N119	700	50 K	0.5
	82.5	400 K	3.5
1N120	700	50 K	0.5
	175	200 K	3.5

Note 10—Units are tested in a circuit employing an input of 0.1 volts rms at 44 MC. Rectified output is a minimum of 140 μa with a 3600 ohm load and 65 μh shunted by 5 $\mu\mu f$ capacitor.

Note 11—Normally supplied with ½" minimum leads but will be supplied without leads for clip-in applications upon request.

The polarity of all Sylvania crystals is indicated by a graphic symbol (—➔|—) on the body, the arrow of which indicates the direction of easier (conventional) current flow.

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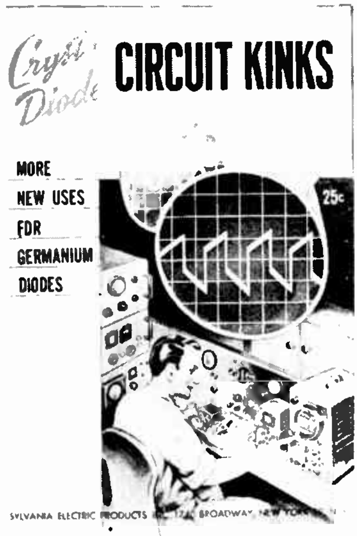

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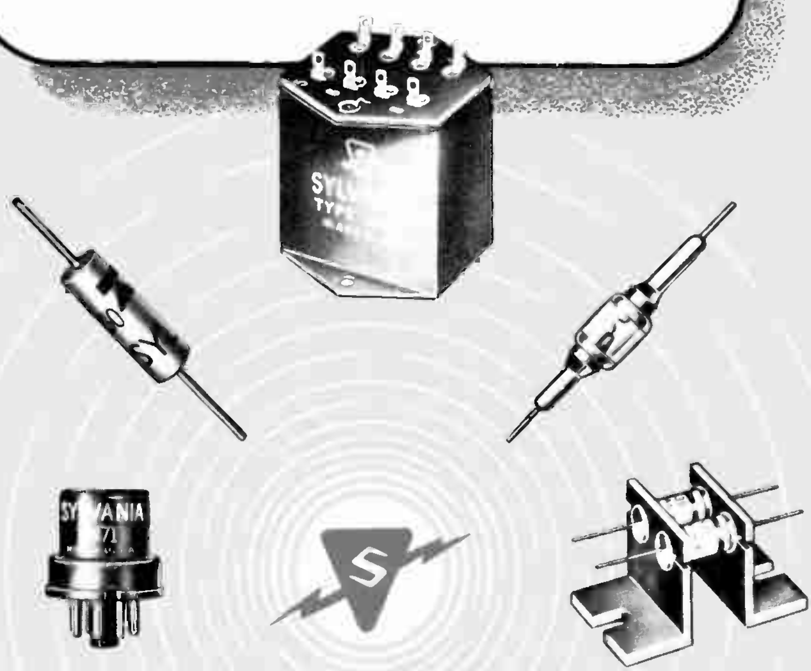

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