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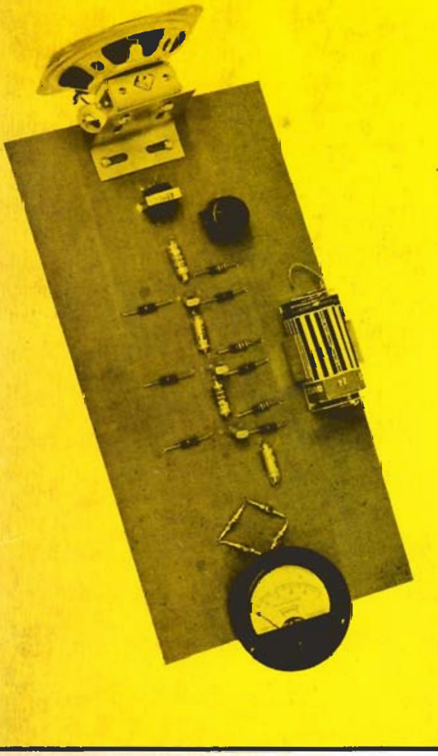
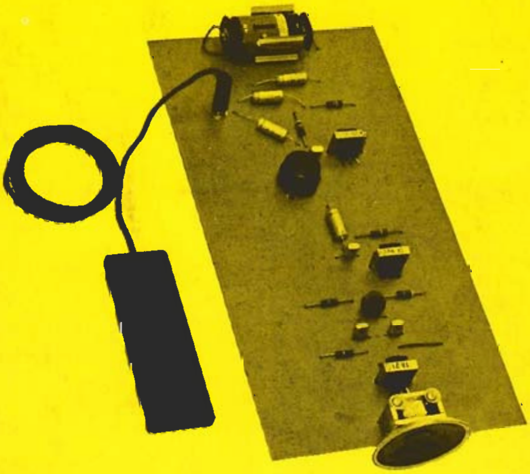
TRANSISTOR CIRCUIT handbook

FOR THE HOBBYIST



APPLAUSE METER



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30 USEFUL

Battery-Powered Transistor Circuits

EASY AND INEXPENSIVE TO MAKE, WITH LOW-COST
SYLVANIA TRANSISTORS.

TRANSISTOR CIRCUIT HANDBOOK

for the Hobbyist

SYLVANIA

Subsidiary of *GENERAL TELEPHONE & ELECTRONICS*

SYLVANIA ELECTRIC PRODUCTS INC.
SEMICONDUCTOR DIVISION
100 SYLVAN ROAD • WOBURN, MASS.

FIRST EDITION

PREFACE

This manual of practical transistor circuits has been prepared from data obtained from the actual construction and testing of the many circuits.

Basic theory has been held to a minimum since considerable theoretical discussion is readily available.

In presenting this booklet, which will join the Sylvania family of publications on the practical applications of transistors, we hope to satisfy the need voiced by innumerable hobbyists for practical circuits with which they may get acquainted with transistors.

All 30 circuits contained in this booklet specify transistors available at costs low enough to enable the hobbyist to build any circuit at an average cost of under $5. The circuits have been performance-tested to do their designed functions. If you desire increased transistor output, other Sylvania transistor types produced for commercial and industrial applications are available at extra cost.

See listings of transistors and their characteristics on pages 60 — 65. If higher rated transistors are used, compensations should be made in the value of other components in the circuits. All components for the circuits contained in this booklet are available from your local Sylvania Distributor.

Acknowledgment is given to the Sylvania Semiconductor Applications Engineering Group at Woburn, Massachusetts, and to United Engineers, Inc., of Boston, Massachusetts, for building and testing the circuits and preparing text material for this booklet.

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.

Sylvania Electric Products Inc.

SYLVANIA HOBBYIST CIRCUITS

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ELEMENTARY TRANSISTOR THEORY

The transistor performs many of the functions formerly possible only with vacuum tubes. As an amplifying device, the transistor is smaller than the tube, has no filament, and can be operated in any position. It also is non-microphonic, mechanically rugged, and makes more efficient use of its d-c power supply than the tube does. Transistors can oscillate with only a few microwatts of d-c input power.

(A) NPN TRANSISTOR

SYMBOL

(B) PNP TRANSISTOR

SYMBOL

FIGURE 1-1—Junction Transistor Forms and Symbols.

Experimental transistors have been made from several semiconductor materials, but most commercial units presently are made from germanium. Sylvania was one of the pioneers in the use of the germanium in the crystal diode, predecessor of the transistor.

The heart of the junction-type transistor is a thin wafer of highly-refined germanium into which three distinct conduction regions have been created by introducing controlled amounts of certain chemical impurities. A wire lead is attached to each of these regions.

These regions are designated as N-type germanium when the added impurity is a material rich in electrons, and P-type when the material is deficient in electrons—or, to another way of saying, rich in holes. Electric conduction through an N-type semiconductor is by means of electrons, and through a P-type semiconductor by means of holes. Holes travel through the material somewhat more slowly than electrons.

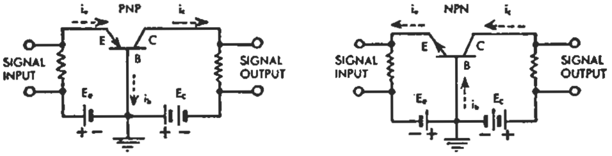
The arrangement of the conduction layers in the germanium wafer is shown in Figure 1-1. In this illustration, the P and N regions have been magnified for the sake of clarity, but in reality they are quite thin. Figure 1-1 (A) shows the cross section and circuit symbol of the NPN type of junction transistor, while Figure 1-1 (B) shows the PNP type. In each type, one outer layer is termed the emitter electrode, the center layer the base, and the other outer layer the collector. Emitter, base, and collector correspond roughly to cathode, grid, and plate of a triode tube.

To complete the transistor, the processed 3-region germanium wafer is hermetically-sealed in a suitable casing and its three pigtail leads brought out through an insulating header for circuit connections.

The N-P and P-N junctions processed into the germanium (see Figure 1-1) form equivalent crystal diodes. When a d-c voltage is applied to either junction in such a way that the N region is made negative and the P region positive, a high forward current flows. Conversely, when the N region is positive and the P region negative, a low reverse current flows. Thus, the junction exhibits the properties of high forward current, low reverse current, and rectification which characterize the crystal diode.

In a transistor, the emitter electrode is so called because this electrode, when d-c biased for forward current flow, effectively injects or emits current carriers (electrons or holes) into the center base region of the germanium wafer. The collector receives its name from the fact that this electrode, when d-c biased for reverse current flow, apparently collects these carriers which then increase the reverse current. In the NPN transistor, the injected carriers are electrons from the N-type emitter layer; in the PNP type, they are holes from the P-type emitter layer.

DC Biasing. Figure 1-2 shows how the transistor is connected to sources of emitter and collector d-c bias voltage, and the points at which signals might be fed in and taken out. Figure 1-2 (A) shows connections for the PNP transistor; Figure 1-2 (B) for the NPN type.



(A) PNP TYPE (B) NPN TYPE

FIGURE 1-2—Transistor Bias and Signal Connections.

In each case, the emitter supply (Ee) biases the emitter junction in the forward (low resistance, high-current) direction, and the collector supply (Ec) biases the collector junction in the reverse (high-resistance, low-current) direction. Because of the difference in emitter and collector resistance, Ec can b much higher than Ee. A steady value of emitter current (Ie) flows through the emitter junction. The corresponding steady value of collector current (Ic) is proportional to the emitter current. When the emitter voltage is reduced to zero, while maintaining the collector voltage, a small static value of collector current (cutoff or leakage current, Ico) flows through the high resistance of the collector junction.

Operation, Current Gain (Alpha). In the PNP transistor, the emitter injects positive holes. These carriers travel through the base region where a few are neutralized by the electrons in the N-type germanium found there. But the base is very thin, so most of the holes survive to reach the collector junction where they are attracted by the strong negative field due to the high collector voltage. They succeed in increasing the collector current from the low Ico value to a higher level. If all of the holes injected by the emitter managed to reach the collector, the final collector current would equal the emitter current and the transistor would be considered to have an emitter-collector current gain (α, alpha) of 1. However, some holes do recombine with electrons in the base region and thus can contribute nothing to the increase in collector current. In practice, therefore, alpha for a junction transistor approaches unity but usually does not reach this value. Practical values range from 0.80 to 0.999 in commercial junction transistors. Alpha is comparable to the amplification, mu, of a vacuum tube.

The NPN junction transistor operates in the same manner, except that the injected carriers are electrons which pass through a P-type (hole-rich) base region toward a positively-charged collector.

The forward resisance of the emitter junction is designated Re, the reverse resistance of the collector Rc, the emitter voltage drop Ve, and the collector voltage drop Vc. Base current Ib, is very small compared to either Ic or Ie because of the few carriers available for this current flow. From the current and voltage relationships, the emitter and base resistances are seen to be low in value and the collector resistance high.

Voltage and Power Amplification. Although the foregoing explanation shows the transistor essentially to be a current-operated device, the transistor can display voltage and power amplification as well. In Figure 1-2, input signal is applied in series with the d-c emitter bias, Ee. Signal-voltage fluctuations cause corresponding fluctuations in emitter current, Ie, and in turn in collector current, I . Although the current gain is slightly less than 1 in this case, the collector resistance level, as previously explained, is higher than the emitter circuit resistance level, and the output-signal voltage therefore is larger than the input-signal voltage. Power amplification also results because of this resistance ratio. The magnitude of voltage and power amplification depends upon various other parameters which must be taken into consideration in accurate calculations. These parameters include load resistance and generator resistance.

Base-Collector Current Amplification (Beta). In Figure 1-2, the base is the transistor electrode common to both input and output circuits. In this arrangement, the current amplification factor, alpha, is the ratio of a collector current change to the emitter current change and must be less than unity. A different situation results when the emitter is made the common electrode, as in Figure 1-3.

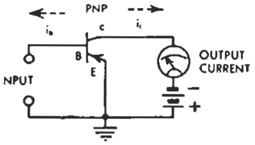


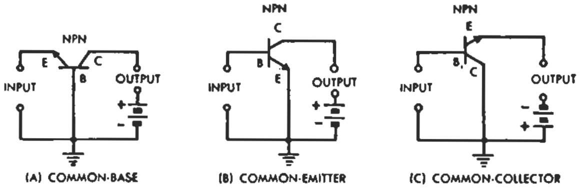
FIGURE 1-3—Circuit to Demonstrate High Base-Collector Current Amplification.

In this arrangement, a small current (Ie) flows out of the base and produces a large change in collector current (Ic). In practice, Ib is in microamperes and Ic in milliamperes. This base-collector current amplification, which is many times the alpha value for the same transistor, is designated β (beta) and is related to alpha in the following respect: $\beta = \alpha / (1- \alpha)$.

A PNP transistor is shown in Figure 1-3, but an NPN type may be used with the same results if the battery polarities are reversed.

Transistor Circuit Configurations

Depending upon which of its terminals are used for input and output, a transistor may be connected into its circuit in any one of three ways. These configurations, illustrated in Figure 1-4, are termed common-base, common-emitter, and common-collector.



(A) COMMON-BASE (B) COMMON-EMITTER (C) COMMON-COLLECTOR

FIGURE 1-4—Transistor Configurations.

The common-base roughly is equivalent to the grounded-grid vacuum-tube amplifier, the common emitter to the grounded-cathode, and the common-collector to the cathode follower. The common-base will be recognized as the type of circuit shown earlier in Figure 1-2, and the common-emitter in Figure 1-3. While NPN transistors are shown in Figure 1-4. PNP units can be used by reversing the battery connections. The common-emitter is the only transistor configuration producing a phase reversal between output and input signals. In the common-base and common-collector circuits, output is in phase with input.

The frequency response and current gain of the common emitter and common collector circuits are essentially the same. This frequency response is lower than that of the common base circuit, whereas the current gain is greater than that of the common base circuit.

The common-base circuit has the lowest input impedance and the highest output impedance. The common-collector circuit has high input and low output impedances. Moderate input and output impedances are provided by common emitter circuits.

The configuration employed depends upon the requirements. The common-emitter, for example, while having an input impedance of the order of 1000 ohms, provides the highest voltage gain and power gain. The common-collector, on the other hand, provides much higher input impedance but, like the cathode follower tube amplifier, will not afford a voltage gain in excess of 1.

Transistor Parameters

Input and output impedances of the three configurations vary with junction transistor types and to a slight extent between individual units of the same type. However, representative values of input and load resistances are: 60 and 100,000 ohms respectively for the common-base; 600 and 20,000 ohms, common-emitter; and 0.5 megohm and 20,000 ohms, common-collector.

Unlike the vacuum tube, the transistor does not possess isolated input and output circuits. The output impedance, for example, depends upon the value of input impedance, and vice versa, and is affected also by the impedance of the generator (signal source). This interdependence of transistor parameters necessitates a different approach to circuit design than that employed with tubes.

The principal parameters of the junction transistor are: emitter-collector amplification factor (α), base-collector amplification factor (β), base resistance (rb), collector resistance (rc), emitter resistance (re), base voltage (Vb), collector voltage (Vc), emitter voltage (Ve), base current (ib), collector current (ic), emitter current (ie), collector power (pc), and emitter power (pe). The external circuit into which the transistor operates can contain base resistance (Rb), collector resistance (Rc), and emitter resistance (Re). It also includes one or more bias supply voltages; base voltage (Vbb or Ebb), collector voltage (Vcc or Ecc), and emitter voltage (Vee or Eee).

* * *

1. ALIGNMENT MULTIVIBRATOR

This free-running multivibrator circuit produces alternating plus and minus pulses at its output. The frequency at which the pulses are generated is roughly 700 cycles per second. An emitter-follower stage is used to reduce loading on the multivibrator section, and also to provide a low impedance for the pulse output.

The circuit provides a convenient means of signal generation for troubleshooting of both radios and amplifiers. When applied to the input of any stage in the radio frequency or intermediate frequency section of a receiver, it modulates radio frequency signals normally present at these points. The amplitude modulation sidebands are subsequently detected and heard in the loudspeaker of the set. Once the faulty circuit section of the receiver has been found and repaired, the multivibrator may then be used to align the intermediate frequency stages. Adjustments are made until the audible output tone is a maximum. If applied to the input of audio stages in either receivers or high-fidelity amplifiers, the signal is amplified directly, producing the same audible output tone. If a speaker is not connected to the output of the audio amplifier, or if there is no audio amplifier section present, the Signal Tracing Probe may be used in conjunction with a meter or oscilloscope.

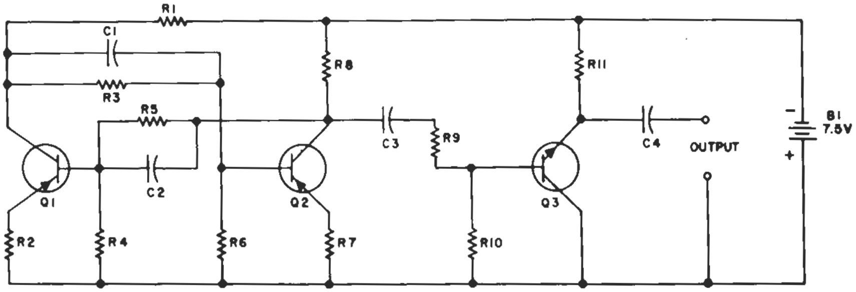


FIGURE 1 — ALIGNMENT MULTIVIBRATOR

Transistors Q1 and Q2 constitute the active part of the multivibrator circuit. When one is conducting, the other is non-conducting. When transistor Q1 fires, its collector voltage rises sharply. This sudden rise is coupled by capacitor C1 and resistors R3 and R6 to the base of the transistor Q2, shutting it off. The base voltage then drops exponentially until conduction again starts in transistor Q2. A this time, capacitor C2 and resistors R4 and R5 couple the sharply rising voltage at the collector of Q2 to the base of Q1. Resistors R1 and R8 are collector loads for the two transistors. Capacitor C3 is used to complete the pulse shaping and couple the signal from the collector of Q2 to the base of the Q3 emitter-follower stage. R10 is the bias resistor for this stage, and R9 is a parasitic suppressor. Ouput from the circuit is coupled by capacitor C4 to block the dc voltage present at the emitter of Q3.

PARTS LIST

B1 — 7.5-volt battery
C1, C2, C3 — 100 mmfd mica capacitor, 100 v
C4 — 0.022 mfd mica or paper capacitor, 100 v
Q1, Q2 — Sylvania 2N1266 transistor
Q3 — Sylvania 2N229 transistor
R1, R8 — 6.8 k, ½ w
R2, R7, R11 — 560 Ω, ½ w
R3, R5 — 150 k, ½ w
R4, R6 — 47 k, ½ w
R9 — 100 Ω, ½ w
R10 — 15 k, ½ w

2. AUDIO VOLTMETER

Frequently the home experimenter finds it necessary to measure low-level audio signals. Conventional vacuum-tube voltmeters do not fill this need since the lowest scale commonly provided is 1 or 1.5 v rms full scale. This circuit has a full-scale sensitivity of 10 mv rms, enabling the measurement of audio voltages as low as 1 mv rms with a reasonable degree of accuracy, and thus providing a simple and inexpensive solution to these measurement problems.

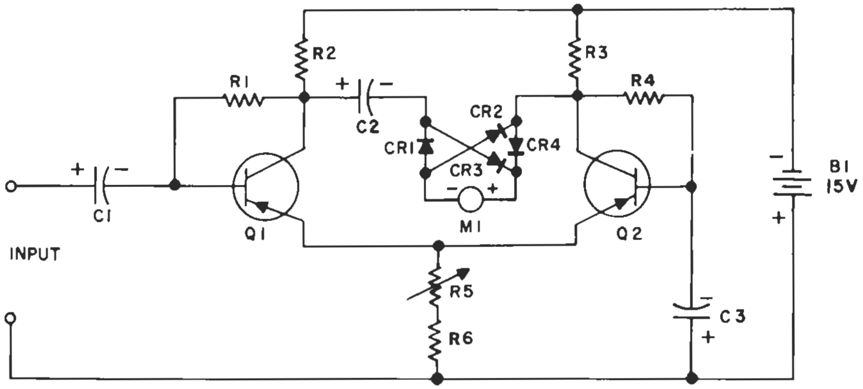


FIGURE 2 — AUDIO VOLTMETER

Typical applications would include: checking of the record compensation characteristics in preamplifiers; frequency response characteristics of audio power amplifiers; continuity in intercom networks; microphone triggered circuits; and specialty circuits such as the relay memory circuit illustrated in this book. Once the experimenter has advanced to the stage of designing his own circuits, the audio voltmeter will prove an invaluable asset for checking out the performance of these new circuits and comparing the measured values with those derived from calculations. Knowing that a circuit is operating exactly as intended is indeed a gratifying experience to the designer.

A-c amplification is used throughout the circuit. A full-wave bridge rectifier circuit composed of diodes CR1, CR2, CR3, and CR4 is used to convert the amplified alternating voltage to a direct current for driving the meter movement. The two transistor amplifiers, connected in a differential configuration, supply the amplified alternating voltage to the meter rectifier circuit. Bias for the two stages is provided by resistors R1 and R4. Resistors R5 and R6 provide an emitter coupling which effects the phase inversion required for the differential action. Thus, when the input signal goes positive, the collector current in the first stage is decreased, lowering the collector voltage and raising the emitter voltage. Since the emitter of transistor Q2 is connected to the emitter of Q1, it is also raised in voltage. This increases the current in the second stage, raising the voltage across the collector load resistor R3. Capacitor C3 effectively grounds the base of the second stage for audio frequencies, keeping the gain of this stage at a high level.

Once the circuit has been constructed, it should be calibrated if it is to provide maximum utility. This is done by obtaining another meter which is already calibrated, and connecting both meters to a common signal source at a frequency of about 1000 cycles per second. Resistor R5 is then adjusted so that the constructed meter reads the same as the calibrated meter. The setting of R5 should now be left alone. If, at some time in the future, one of the components in the circuit requires changing, the circuit will have to be re-calibrated. Calibration should be such that 10 mv rms at the input results in a full-scale deflection. The response of the meter is constant within 1 db from 17 cycles per second to 250 kilocycles per second, and has an input impedance of 1.2 k ohms. This impedance can easily be increased by placing an emitter follower stage ahead of C1 and Q1. Full utility will be obtained by adding an attenuator section at the front, with each setting marked with a specific value of full-scale deflection.

PARTS LIST

B1 — 15-volt battery
C1 — 10 mfd electrolytic capacitor, 25 volt
C2, C3 — 50 mfd electrolytic capacitor, 25 volt
CR1, CR2, CR3, CR4 — Sylvania 1N34A diode
M1 — dc meter movement, 100 microamperes full-scale
Q1, Q2 — Sylvania 2N1266 transistor
R1, R4 — 120 k, ½ w
R2, R3 — 6.8 k, ½ w
R5 — 1 k carbon potentiometer, ⅓ w or larger
R6 — 1.8 k, ½ w

3. BRIDGE NULL DETECTOR

In design projects, and occasionally in trouble-shooting, reactance bridges are used in order to ascertain the values of inductors, capacitors, and resistances. Bridge circuits offer the designer what is probably the most precise method of obtaining the value of a component. However, the accuracy which can be obtained with a bridge is limited to the known accuracy of the fixed components in the legs of the bridge. It is also a function of how good a balance has been obtained in the bridge. To balance a bridge, one or more elements are varied until the voltage at the output terminals is minimized. This operation is called "nulling" the bridge. Obviously, the degree of nulling which can be obtained is dependent upon how small a null signal can be detected. The minimum null level which can be detected is determined by the sensitivity of the device being used to measure the null. The circuit shown here is intended for this application of null-detecting. It is particularly well suited for this purpose, since it has both a sensitive output indication and a high gain amplifier section. Combined, these permit measurement of an unbalance as low as I microvolt (one millionth of a volt) rms.

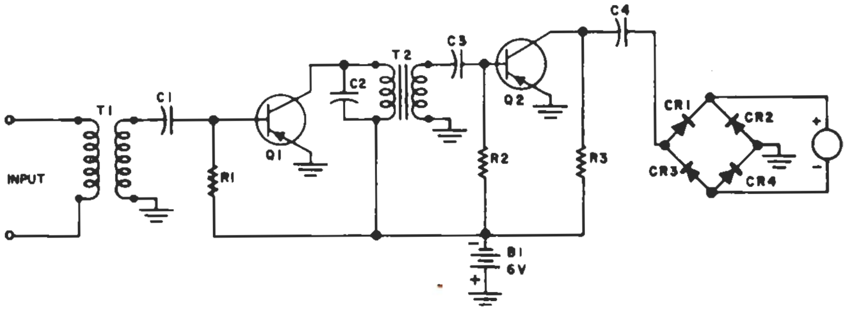


FIGURE 3 — BRIDGE NULL DETECTOR

Two grounded-emitter amplifier stages constitute the active part of the circuit. The null signal from the bridge is coupled into the first stage by transformer T1 and coupling capacitor C1. The capacitor is used to permit biasing of the transistor Q1. The first stage is then coupled to transistor Q2 by means of interstage transformer T2. The primary of this transformer is tuned by capacitor C2 to provide a higher impedance than offered by the primary of T2 alone. This increases the gain obtained in the first stage. The output voltage from the amplifier is developed across collector load resistor R3. Capacitor C4 then couples it to the full-wave bridge rectifier circuit formed by diodes CR1, CR2, CR3, and CR4. The d-c output from the rectifiers drives the microammeter. Resistors R1 and R2 in the amplifier section provide bias for the transistors. The center frequency of the amplifier section is 700 cycles per second; the 3 db points occur at 400 cycles per second and 2 kilocycles per second. In order to realize maximum sensitivity from the circuit, it should be used with bridges which operate within this frequency range. One kilocycle per second is perhaps the most commonly used frequency in bridge circuits, and is ideal for this circuit.

When using the circuit, an attenuator section should be used at the input prior to balancing the bridge to a null error of less than 40 microvolts rms. Perhaps an easier technique is to shunt the microammeter with a resistor to lower its sensitivity. The meter impedance can be found by placing different-valued resistors across the meter until one is found which drops the meter reading to one half its initial value. The meter resistance is simply equal to the value of this resistor. A typical value for a sensitive meter is 1 k ohms. For example, use of a 10-ohm resistor across the meter will then drop the circuit sensitivity by the ratio of 1 k/ 10 = 40 db. This results in on-scale deflections for input levels as high as 4 mv rms. Failure to observe this precaution will probably damage the meter.

PARTS LIST

B1 — 6-volt battery
C1, C3 — 0.5 mfd paper, 100 volt
C2 — 0.002-0.005 mfd mica or ceramic disc, 100-volt
C4 — 0.25 mfd paper, 100-volt
CR1, CR2, CR3, CR4 — Sylvania 1N64 diodes
M1 — Meter, 200 microamperes full-scale
Q1, Q2 — Sylvania 2N1265 transistor
R1, R2 — 1 meg, ½ w
R3 — 6.8 k, ½ w
T1 — Stancor TA-24
T2 — Stancor TA-27

4. FREQUENCY METER

Frequently the need arises for a wide band frequency measuring device covering at least the audio spectrum. A device of this type is invaluable in work with audio amplifiers, intercom systems, and the audio sections of ham gear. It also has wide application in the analysis of mechanical resonances. The matching of enclosures to loudspeakers is a good example of this. By drivng the loudspeaker with an amplifier the acoustical resonance points can be found. Measurement of the exact frequency at which they occur is made with the frequency meter. Once the resonance frequencies are known, appropriate design changes can be made to eliminate them. Resonances in complex machinery are often difficult to analyze with strobe-light techniques if the members under analysis are partially hidden by other members of the machine, or if they are completely concealed in some sort of sealed enclosure. In instances such as this, it will be found many times that excellent sound conduction is afforded by other parts of the machinery attached to the member suspected of resonance. A contact microphone attached to these other parts or to the enclosure can therefore be used to drive an amplifier and loudspeaker. Unwanted resonances can readily be detected in this manner. Frequency of the resonance is then determined by connecting the frequency meter to the amplifier.

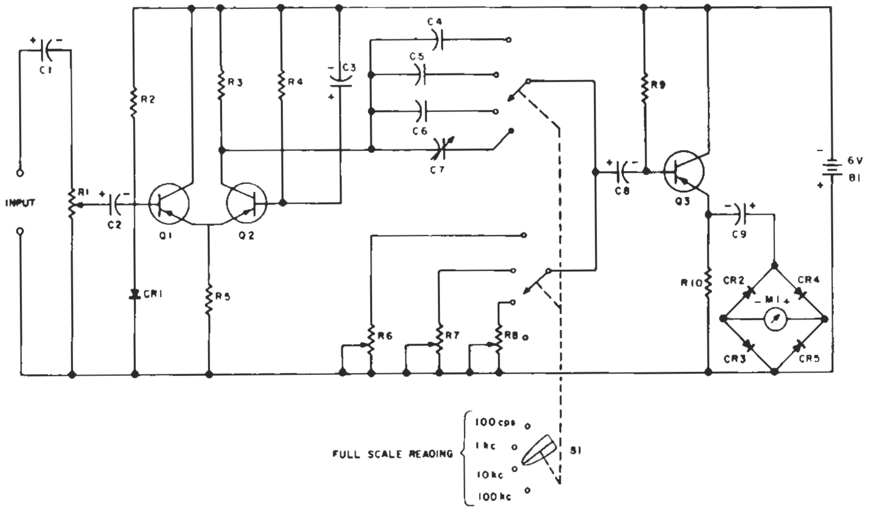


FIGURE 4 — FREQUENCY METER

Circuits generally given for frequency meters are inconvenient in two respects – a large signal ranging from 10 to 15 volts rms is required, and the signal level as it is fed to the circuit must be precisely adjusted to a fixed value. The accuracy of the frequency reading is no better than that with which this setting is made. The circuit indicated here removes both of these restrictions. Readings on signals as low as 1 volt rms can readily be made, and a precision adjustment of the signal level is not necessary. Furthermore, this circuit can be used for determination of frequencies ranging all the way from 10 cps up to 100 kcps. In any frequency indicating instrument, the accuracy of the indication is no better than that of the source used for colibration. Thus good calibration is a common requirement. Another requirement common to many frequency indicating devices is that one particular frequency predominates in the input signal. This is usually the case in mechanical or electrical resonance situations. If signals at more than one frequency are present, and their amplitudes are similar, the meter indication can become meaningless.

The circuit used is basically a simple one, most of the complication being added by the range switching and calibration provisions. Transistors Q1 and Q2 are used in an emitter-coupled clipper circuit which symmetrically limits the input signal in addition to providing voltage gain for it. Potentiometer R1 provides a rough adjustment on the amplitude of the signal fed to the clipper circuit. The symmetrically clipped output of this stage consists of the fundamental and odd harmonics of the input signal. This fundamental and its harmonics are then attenuated by the skirt of a high-pass filter. By making the skirt rise linearly with frequency, signals at high frequencies are attenuated less than are those at low frequencies. The level of the signal as it emerges from the skirt of the high-pass filter is thus proportional to frequency. The high-pass filter is formed by capacitors C4, C5, C6, and C7 in conjunction with resistors R6, R7, R8, and the input resistance of transistor Q3. This third transistor is connected as an emitter follower to provide maximum isolation of the low impedance metering circuit from the high-pass filter. Diodes CR2, CR3, CR4, and CR5 form a full-wave bridge circuit for driving meter M1. Diode CR1 in the input section prevents shifting of the crossover point in the clipper section by shorting input voltage which would otherwise reverse bias transistor Q1.

When using the circuit, always start with potentiometer R1 adjusted for minimum signal input to transistor Q1. Both connection and disconnection of the battery to the circuit will result in a rapid needle deflection as capacitor C9 charges and discharges through the meter. This is normal and will not damage the meter. With the battery connected, the setting of potentiometer R1 is advanced. As this is done, the meter indication will rise rapidly to some value, then stop as limiting occurs in the clipper stage. Once the needle has stopped, the potentiometer should be advanced no further. If the needle is off-scale, a lower frequency scale should be selected with the wafer switch, S1. The meter must be calibrated separately on each scale. For this procedure, try to obtain a well-calibrated signal generator, since the meter accuracy will be no better than that of the generator used for calibration. Calibration should be made at the mid-point of each scale — that is, at 50 cps, 500 cps, 5 kcps, and 50 kcps. For the low scale, a 60 cps power line signal is ideal. To calibrate, first follow the above instructions regarding potentiometer R1. Then make adjustment for each scale so that the meter reading corresponds to the calibration frequency. Resistors R6, R7, R8, and capacitor C7 provide adjustment for their respective scales. Once calibrated, all but the highest range will yield linearities within 3 percent from one-third full-scale to full-scale. On the 100 kcps scale, linearity is within 3 percent to 60 kcps, within 5 percent to 70 kcps, and within 15 percent to 100 kcps.

PARTS LIST

B1 — 6-volt battery
C1, C2, C8 — 6 mfd electrolytic, 25-volt
C3 — 2 mfd electrolytic, 25-volt
C4 — 0.056 mfd paper or three 0.02 mfd disc ceramic in parallel
C5 — 5600 mfd disc ceramic
C6 — 5600 mfd disc ceramic
C7 — 10-100 mfd trimmer
C9 — 50 mfd electrolytic, 25-volt
CR1 — Sylvania 1N34 diode
CR2, CR3, CR4, CR5 — Sylvania 1N60 diode
M1 — 100 microampere full scale movement
Q1, Q2, Q3 — Sylvania 2N1266 transistor
R1 — 50 k potentiometer
R2, R4 — 180 k, ½ w
R3, R5 — 3.3 k, ½ w
R6, R7, R8 — 500 k potentiometer
R9 — 47 k, ½ w
R10 — 2.2 k, ½ w
S1 — 2 pole 4-position rotary wafer switch

5. GRID DIP METER

In the design and checking of tank circuits for intermediate and radio frequencies, a grid dip meter is almost indispensible. In many high frequency circuits, the self-capacitance of the inductor windings constitute an appreciable part of all of the total capacitance. It is thus extremely difficult or impossible to evaluate just how much capacitance is present. The inductance of the coil is likewise a difficult parameter to evaluate, since spacing of the turns, length-to-diameter ratio, and core material have very large effects on mutual coupling of the individual turns, and hence on the total inductance of the unit. The grid dip meter provides an easy means for evaluating the frequency at which the circuit is actually resonant. The device is actually an oscillator circuit, the frequency of oscillation being determined by a variable capacitor and inductor. For a given inductor, any given capacitor setting corresponds to a particular oscillation frequency. When the tank circuit of the grid-dipper is coupled magnetically by the inductor to another tank circuit, power will be transferred to and dissipated in the second tank if tuned to the same frequency. This transfer of power lowers the output voltage in the first tank circuit. This is indicated by the meter.

The circuit presented here is limited in its high frequency response to about 10 megacycles per second by the beta cutoff of the drift transistor. Despite the fact that it is limited, however, the circuit has a decided advantage over conventional grid dip meters in that its battery supply makes it much more portable and hence more versatile than conventional units.

Capacitor C3 and inductor L1 form the tank circuit of the oscillator. Positive feedback is applied to the emitter of transistor Q1 by capacitor C2. Resistors R1 and R2 provide bias for the transistor, while capacitor C1 effectively grounds the base for the frequencies of oscillation. Resistors R3 and R4 control the gain of the amplifier. By making R4 sufficiently small, the circuit will oscillate. Should power be drawn by another tank circuit tuned to the same frequency, the collector current will change. Since the meter M1 monitors collector current, it will reflect this change. Potentiometer R5 controls the amount of current sampled, and hence the position of the meter needle.

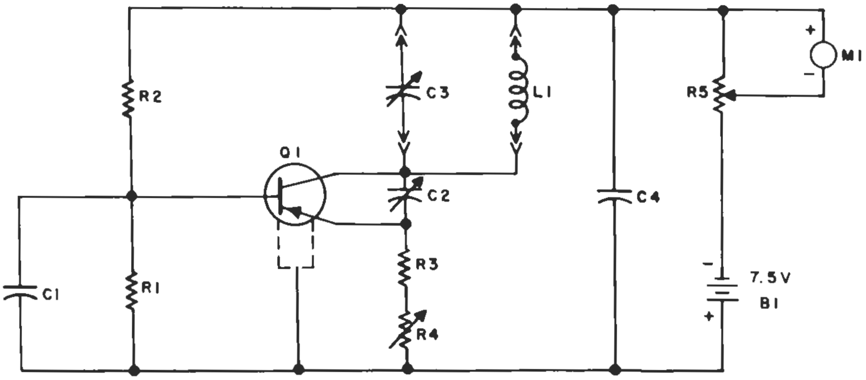


FIGURE 5 — GRID DIP METER

A 4-50 mmfd variable capacitor can be used for capacitor C2. For most applications, it will be set at about 20 mmfd. Higher values might be required for frequencies below 100 kilocycles per second. Values for capacitor C3 and inductor L1 are dependent upon the frequencies at which the circuit is to oscillate. For most applications, a 0-365 mmfd variable capacitor will suffice for C3. A 250 microhenry choke used as L2 will then tune the circuit across the broadcast band.

PARTS LIST

B1 — 7.5-volt battery
C1, C4 — 0.01 mfd ceramic disc or paper
C2 — see text
C3 — " "
L1 — " "

M1 — 100 microampere movement (d-c)
Q1 — Sylvania 2N1264
R1 — 15 k, ½ w
R2 — 47 k, ½ w
R3 — 560 Ω, ½ w
R4, R5 — 5 k potentiometer, ½ w

6. RELATIVE IMPEDANCE METER

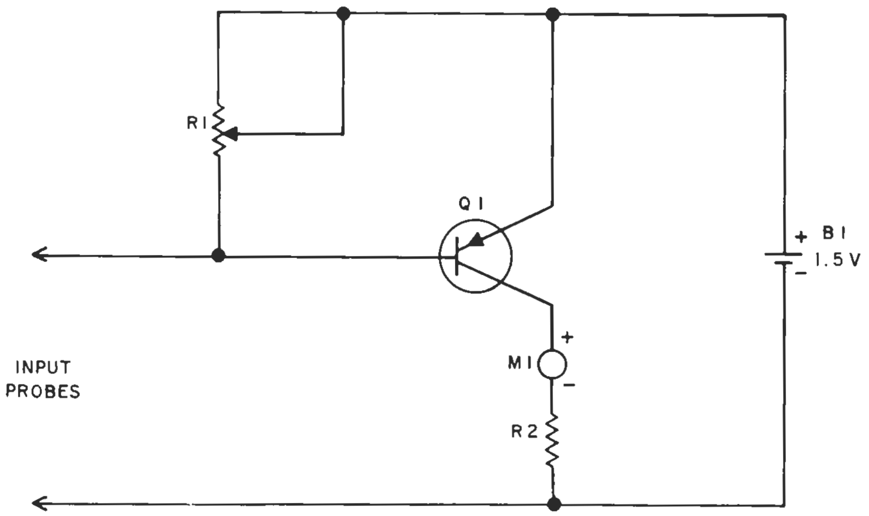


FIGURE 6 — RELATIVE IMPEDANCE METER

In many projects of the home experimenter, it is not necessary to know the absolute value of an impedance. In these situations, relative indications only are required. By relative is meant simply whether one impedance is larger or smaller than another, and by roughly what ratio. This circuit provides a means of indicating this sort of relative impedance level. It can be used to determine whether or not insulation on wires is good, and whether or not there is continuity in the filaments of incandescent light bulbs and vacuum tubes used in radios and amplifiers.

A unique application for the circuit is in determining the strength of electrolyte solutions. Ordinary saline solutions, electro-plating solutions and the like fall into this category. For these measurements, all other power to the electrolyte tank is momentarily turned off to prevent damage to the circuit. Probe wires suitable for immersion into the electrolyte tank are then attached to the input of the circuit, and the relative impedance measurement is made. Deterioration of the electrolyte solution with usage will be indicated as a change in the meter reading. The circuit can also be used in trouble-shooting electronic circuits. It will, for instance, readily indicate burned-out resistances, shorted semiconductors, and so on.

Very little difficulty will be encountered in construction of the circuit, since there are only a few parts and their placement is non-critical. The expense of the parts is very small, making it possible for the experimenter to build several of the circuits for different applications.

Basically the circuit is a grounded-emitter amplifier, the output of which is used to drive the milliameter M1. Bias current is supplied to the transistor Q1 through the impedance being measured at the input terminals. Since variations in this source impedance cause similar changes in the bias current, the collector current driving the milliameter will also reflect the change, since the collector current is the bias current multiplied by the current gain of the transistor. The sensitivity adjustment, potentiometer R1, shunts bias current from the control junction of the transistor. The sensitivity of the circuit is decreased in this manner to permit measurement of low impedances. Typical salt solutions, for instance, have impedance levels of only several thousand ohms. A value for R1 of 500 ohms will adapt the circuit most readily to this application. With the probes in the weakest solution to be used, set the sensitivity control R1 so that the meter reads full scale. The setting of the control should not be changed now, until all of the relative impedance readings have been made. Increasing the value of R1 will adapt the circuit to higher levels of source impedance. Making R1 infinite (accomplished by leaving R1 out of the circuit) will adapt the circuit for impedances as high as a megohm. When sampling a new type of source impedance, always set the sensitivity adjustment at minimum (center tap shorting out the resistor). Then slowly increase the setting. If this procedure is not followed, damage to the meter movement will probably result. Despite its simplicity, this is a rather sensitive circuit.

PARTS LIST

B1 — 1.5-volt battery
M1 — 1 milliampere full-scale meter movement
Q1 — Sylvania 2N1266 transistor
R1 — 500 Ω potentiometer, ½ w
R2 — 820 Ω, ½ w

7. SIGNAL TRACING PROBE

Signal-tracing at low levels is easily accomplished by use of this versatile circuit. Amplifying both audio and intermediate frequency signals, this device can be used for trouble-shooting anything from a table radio to high-fidelity amplifiers and pre-amplifiers. Using two transistors, one diode, and headphones, it will provide an audible tone for input levels below

100 microvolts at audio frequencies. Modulated intermediate frequencies can be detected at roughly the same level. With only a 1.5-volt battery, the packaged unit can be made very small, increasing its versatility even more.

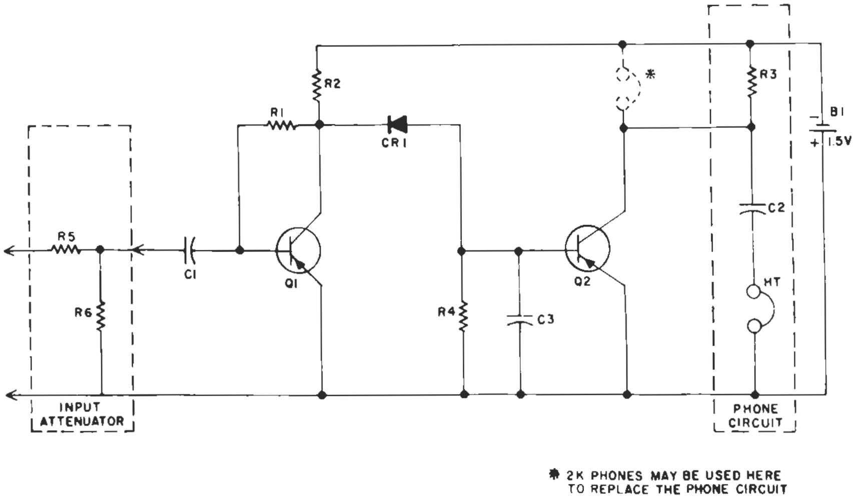


FIGURE 7 — SIGNAL TRACING PROBE

Two grounded-emitter stages are used for amplification of the input signal. The first stage, Q1, provides wide-band amplification for audio and intermediate frequencies. Diode CR1 passes audio signals on to the following stage, or detects the modulation present on intermediate frequencies. Resistor R4 and capacitor C3 constitute a rejection filter for the inaudible and hence unwanted intermediate carrier. Transistor stage Q2 amplifies the audio signal present at the output of diode CR1. The headphones may be connected in either of two places. The connection shown as "phone circuit" will provide a more uniform tone when several frequencies are present at the input. The alternate connection across resistor R3 provides a higher sensitivity, permitting detection of very low input levels.

If input levels in excess of 0.25 v rms are to be detected, an attenuator section should be used. This is easily constructed with resistors R5 and R6. If R6 is 10 k ohm, the maximum input level becomes 2.5v. rms; for R6 equal to 1 k ohm, an input level of 25 v rms is permissible. Capacitors C1 and C2 attenuate frequencies below roughly 500 cycles per second. For tracing signals with frequencies as low as 50 cycles per second, increase capacitor C1 to 0.1 mfd and connect the headphones directly across resistor R3. Headphones with a 2000-ohm impedance are preferable since they provide better sensitivity than headphones having a higher impedance. The reason for this is that amplifier stage Q2 provides more power gain with the lower impedance load.

PARTS LIST

B1 — 1.5-volt battery
C1, C2 — .01 mfd ceramic disc. mica, or paper capacitor, 100 v
C3 — .001 mfd ceramic disc, mica, or paper capacitor, 100 v
CR1 — Sylvania 1N60 diode
HT — 2000-ohm headphones
Q1, Q2 — Sylvania 2N1265 transistor
R1 — 82 k, ½ w
R2 — 6.8 k, ½ w
R3 — 1 k, ½ w
R4 — 47 k, ½ w
R5 — 100 k, ½ w
R6 — 10 k, ½ w (for 10:1 reduction)
1k, ½ w (for 100:1 reduction)

8. TRANSISTOR BETA CHECKER

The hobbyist will have many occasions to use this simple yet extremely functional beta checker. Not infrequently, circuits do not operate properly when first turned on. Sometimes portions of the circuit are improperly wired. At other times, one or more components are faulty. The transistors in a circuit are generally the components most likely to become damaged. This is true for several reasons. The percentage overload which can be tolerated by transistors is much smaller than that which can be tolerated by other typical components like resistors, capacitors, and transformers. Accidental application of an incorrect voltage to the circuit can easily damage a transistor while it seldom damages the other components. Should the small seals on the case become cracked for instance, impurities can enter the case and the transistor action will degrade and eventually cease entirely. Another danger in handling is the use of a soldering iron which is too hot or too large. Excess heat, either radiated directly to the transistor case from an iron held too close, or conducted up the leads from the joint being soldered, will cause damage to the transistor.

The circuit shown has a minimum of parts, and will readily indicate whether or not a transistor is functioning. A degenerative bias scheme is used to compress a wide range of d-c current gain values into a fairly small indicator scale. An ordinary 1000 ohm-per-volt meter movement is used on the 5-volt scale to provide the gain indication. It is essential that this type of meter be used, and be used on this scale since the 5 kohm load which it presents to the circuit is calibrated into the voltage versus gain readings.

If a more sensitive movement is used, resistance should be shunted across its terminals to lower its impedance to 5 kohms. In the event that a vacuum tube voltmeter is used, the value for the shunt resistance is exactly 5 kohms, since the impedance of the meter itself is several megohms.

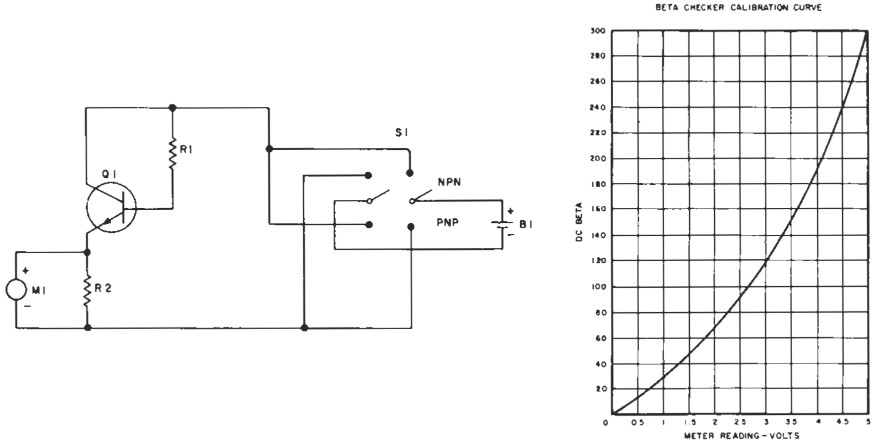


FIGURE 8 — TRANSISTOR BETA CHECKER

A battery reversing switch is provided which enables measurement of both NPN and PNP transistors. The polarity of meter leads as shown on the schematic is correct for NPN transistors. For PNP, simply reverse these meter leads when changing the switch to the PNP position. The circuit will work with all but the larger heat-sink type transistors. This includes units with power ratings of up to 200 mw. Because the meter reading is directly proportional to the battery voltage in addition to varying with d-c beta, a fresh battery should be used. A battery with slightly higher or lower voltage can be used provided that the meter indication is corrected. If a 10½ volt battery is used, for instance, it is 16.7% higher than the 9-volt value. The meter indication will thus be 16.7% higher than the value which would be obtained with a 9-volt battery. The d-c beta may be determined from the graph above.

PARTS LIST

B1 — 9-volt battery
M1 — 1 kohm/volt meter on 5-volt scale
Q1 — transistor being tested — either PNP or NPN
R1 — 200 k, ½ w, 1% tolerance
R2 — 1 k, ½ w, 1% tolerance
S1 — Double-pole, double-throw switch, center off (the type used for switching TV antennas will do)

9. CRYSTAL RECEIVER

(formerly "Direct-Coupled Receiver")

This receiver circuit utilizes the gain of transistor stages to obtain the highest sensitivity possible from a simple crystal detector arrangement. The power gain of the transistors also permits the driving of a loudspeaker at the output. While the receiver provides more sensitivity than the conventional arrangement which uses only a tank circuit, crystal detector, and headphones, its sensitivity still does not approach that of a superheterodyne receiver. Nevertheless, it is a simple and inexpensive circuit to build and will give good reception for local stations.

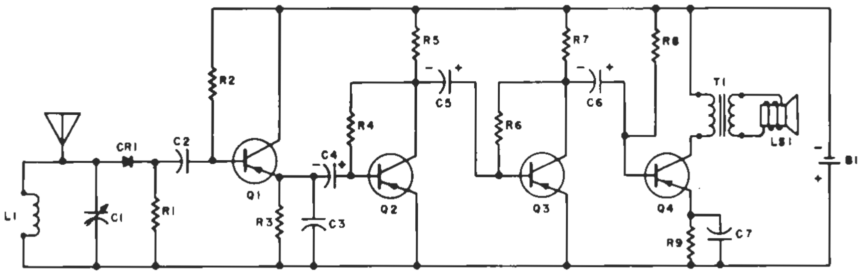


FIGURE 9 — CRYSTAL RECEIVER

The basic limitation in crystal receiver sensitivity is the noise level of the crystal itself. The conventional crystal detector circuit using headphones does not have enough gain to amplify the signal to the point where the noise is heard at a high level. Broadcast signals likewise have to be at relatively high levels, with respect to crystal noise to be heard with this type of circuit. Use of transistors provides enough gain between the crystal and the audio output device to enable one to hear broadcast signals down at the level of the crystal noise. The price one pays for this sensitivity is that the crystal noise must now be tolerated in addition to the signal.

The parallel resonant circuit, or so-called tank circuit, formed by L1 and C1 is used to provide station selectivity at the brodcast frequencies. With the capacitor entirely closed, the coil slug should be adjusted to bring in stations at the low end of the AM band (550 kc). With the coil slug left in this position, opening the capacitor plates will now tune the circuit up to the high end of the band (1600 kc). Diode CR1 is a nonlinear device which provides demodulation of the broadcast carrier and its sidebands. The output of the diode which is passed through capacitor C2 now consists of the broadcast carrier frequency as well as the original modulating frequency.

The high input impedance of the Q1 emitter-follower stage provides good sensitivity by retaining a high Q in the tank circuit. Transistors Q2, Q3 and Q4 are all connected in the ground-emitter amplifier configuration. Resistors R2, R4, R6 and R8 provide bias; resistors R5 and R7 are collector loads; and capacitors C4, C5, and C6 provide interstage coupling. Capacitor C3 is used to suppress high frequencies in the amplifier. Since the amplifier has no gain at the broadcast frequencies, only the audio signal at the output of capacitor C2 is amplified. Transformation of the loudspeaker impedance to a reasonable value of collector load impedance is accomplished by output transformer T1.

PARTS LIST

B1 — 6-volt battery
C1 — 0-365 mmfd tuning capacitor
C2, C3 — 0.02 mfd ceramic disc or paper
C4, C5, C6 — 1.0 mfd electrolytic, 15 v
C7 — 25.0 mfd electrolytic, 15 v
CR1 — Sylvania 1N64 or 1N34 diode
L1 — Ferri-loopstick antenna coil
LS1 — 3-6 ohm loudspeaker
Q1, Q2, Q3, Q4 — Sylvania 2N1265 transistor
R1, R8 — 470 k, ½ w
R2, R4, R6 — 220 k, ½ w
R3, R5, R7 — 2.2 k, ½ w
R9 — 100 Ω, 1 w
T1 — Argonne AR-133 or equivalent

10. IF AMPLIFIER (10.7 MC)

Not until you have tried building an amplifier operating in the megacycle region will you appreciate the intricacies involved. Many purely mechanical considerations such as parts placement, lead length, and shielding will make the difference between a functioning circuit and an inoperative one. While some individuals might actually put this circuit to use, it is intended mainly to familiarize the hobbyist with the construction of a high frequency amplifier, and to dispel some of the fear and misunderstanding which is commonly associated with this type of circuit. The persevering hobbyist will prove that length of leads, layout of parts, and adjustment of the tuned circuits is not beyond the capacity of those willing to give it a try. Some test equipment will be required for checking the amplifier, but the type needed is relatively inexpensive and generally available. Specifically, a signal generator covering from 10-11 megacycles per second and a vacuum-tube voltmeter with diode probe will be needed. Because the frequency of 10.7 mc is a bit higher than the range for which the 2N1264 transistor was intended, the amplification of the circuit will be only moderately high. In addition, the tuned circuits do not employ ferrite slugs, and will therefore have a lower impedance which results in less gain.

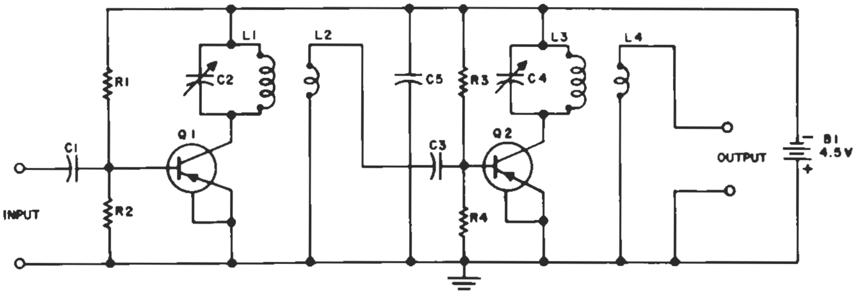


FIGURE 10 — IF AMPLIFIER (10.7 MC)

Once the builder succeeds in getting the circuit to operate properly, there is still the challenge of using it for a specific application. The most obvious application is that of an intermediate frequency amplifier in a standard FM broadcast band receiver. In buliding this amplifier, it would be well to use a heavy copper bus wire (#14 or larger) for the ground line. To avoid unintentional feedback and oscillation problems, intermediate frequency amplifiers are usually laid out so that the stages are placed one after the other in a line. A fairly neat arrangement will result if the 4.5 volt supply line is placed parallel to and approximately 1½″ from the ground bus. The transistors, tuned circuits, resistors, and capacitors are then assembled between the supply line and the ground bus in the same order as they appear on the schematic. All leads should be kept as short as possible.

The two stages are identical, being grounded-emitter amplifiers with tuned circuit collector loads which are adjusted to be resonant at 10.7 mc. Inductors L1 and L3 are made by winding approximately 30 turns of #30 single-cotton-covered wire on a ceramic form ¼″ in diameter and 1″ long. The turns should be wound close together. A small amount of Duco cement will hold them firmly in place. The link coils L2 and L4 are made by winding

5 to 10 turns of similar #30 wire tightly over the coils L1 and L3. For tuning, connect a signal generator at the input and a meter with diode probe at the output. Adjust capacitor C2 and C4 to maximize the output. Approximately 25 db of gain should be obtained. The bandwidth of the amplifier is about 400 kc.

PARTS LIST

B1 — 4.5-volt battery
C1, C3 — 150 mmfd, ceramic disc or mica
C2, C4 — 3 to 50 mmfd or 5 to 80 mmfd adjustable padder or trimmer
C5 — 1500 mmfd, ceramic disc or mica
L1, L3 — 2.5 microhenry coil (see text)
L2, L4 — link coil (see text)
Q1, Q2 — Sylvania 2N1264 transistor
R1, R3 — 120 k, ½ w
R2, R4 — 6.8 k, ½ w

11. THEREMIN

The theremin is an electronic musical instrument which is capable of producing clear, variable musical tones. To operate it, tune a standard AM broadcast receiver to somewhere in the middle of the dial. Now adjust inductor L1 (ferrite loop coil) until a whistling sound is heard. Repeat this procedure with the second inductor, L2, until a squealing sound is heard. Now adjust the tuning of the broadcast receiver to obtain the lowest tone possible. The instrument is now ready for playing. By bringing a hand close to either of the inductors, the tone will change, increasing and decreasing as the hand is moved towards and away from the inductor. A richer tone can be produced by introducing vibrato. This is done by oscillating the hand about the region corresponding to the desired center tone. The oscillations are rapid, and have a relatively small excursion.

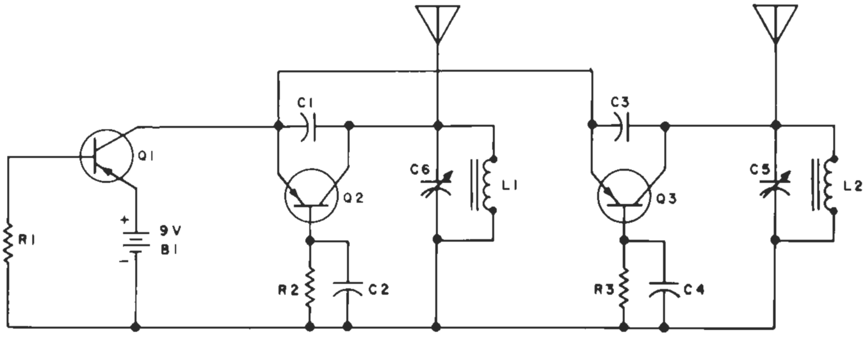


FIGURE 11 — THEREMIN

Transistors Q2 and Q3 operate independently as radio frequency oscillators. Transistor Q1 provides d-c current for the oscillators at an impedance level which is adequate to mix together the oscillator outputs. Inductor L1 is adjusted so that it resonates with capacitor C6 at the radio frequency desired, thus constituting the tank circuit for transistor Q2. Inductor L2 and capacitor C5 perform a similar function for transistor Q3. Capacitors C1 and C2, and resistor R2 provide feedback and bias for transistor Q2, while capacitors C3 and C4, and resistor R4 do the same for transistor Q3. The oscillators are adjusted to frequencies which are nearly the same, differing only by a low audio frequency. In the broadcast receiver, both of these frequencies are detected. In the detection process, the difference frequency is developed and amplified as an audible tone. Placing a hand near either of the inductors in the theremin changes the capacitance in the tank circuit and shifts the frequency at which the circuit oscillates. If the frequency of the other oscillator section has not been similarly shifted, the difference frequency as it is generated in the broadcast receiver, changes. The effect, then, is an increase or decrease in the pitch of the audible tone.

For best radiation, it is recommended that the loose turns of wire on each of the ferrite coils be unwound and extended away from the rest of the circuitry. For improvement in reception, place the theremin near the broadcast receiver. If the coils of the theremin have been adjusted prior to unwinding the loose turns, they will probably require a little touch-up, since extending the wire changes the inductance value slightly, shifting the frequency of oscillation. Capacitors C5 and C6 can be set for around 100 mmfd, then left alone. Should difficulty be encountered in getting the stages to oscillate, they can be set to different values.

PARTS LIST

B1 — 9-volt battery
C1, C3 — 200 mmfd disc ceramic or mica
C2, C4 — 0.01 mfd, disc ceramic or paper
C5, C6 — 0-200 mmfd trimmer capacitors
L1, L2 — ferrite loop antenna
Q1 — Sylvania 2N1265 transistor
Q2, Q3 — Sylvania 2N1264 transistor
R1 — 180 k, ½ w
R2, R3 — 47 k, ½ w

12. TRANSMITTER MODULATOR

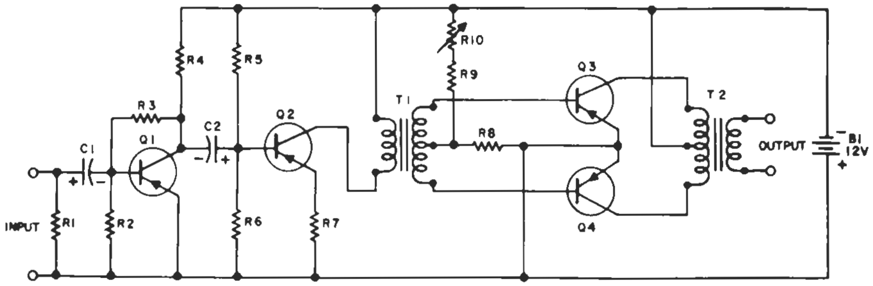


FIGURE 12 — TRANSMITTER MODULATOR

A very attractive approach to the modulation requirement of a mobile transmitter is provided by this modulation amplifier. Operating directly from a 12-volt car battery, there is no need for a power supply, and there are no filaments to drain battery power. The chassis need be only large enough to provide adequate heat sink area for the output power transistors and mounting room for the two transformers. The output level of this circuit is large enough to drive transmitters having power inputs of up to 20 watts. This circuit will thus fill the needs of many mobile hams with a package that is very compact, requires no special high voltage supply, and requires a minimum of battery power.

The amplifier is basically comprised of three grounded-emitter stages. The first of these is a preamplifier for handling the output of low-level microphones. The second stage uses a 2N255 power transistor to drive the phase-splitting transformer T1. The secondary of this transformer connects to the bases of the 2N307 push-pull power output transistors. These drive the primary of the modulation transformer T2, the secondary of which is connected to the RF final amplifier stage in the transmitter. Resistor R10 is a 4-watt wirewound unit and can be either a potentiometer or slide-type adjustable resistor. It is adjusted for a given pair of output 2N307's so that the current for these transistors is 50 ma under a no-signal condition. This current can be readily measured at the battery connection since it constitutes nearly all of the total current. When driving with full power output, the circuit will draw approximately 1 ampere.

PARTS LIST

B1 — 12-volt battery
C1, C2 — 10 mfd, 25-volt electrolytic
Q1 — Sylvania 2N1265 transistor
Q2 — Sylvania 2N255 power transistor
Q3, Q4 — Sylvania 2N307 power transistor
R1 — 470 k, ½ w
R2 — 6.8 k, ½ w
R3 — 100 k, ½ w
R4 — 3.3 k, ½ w
R5 — 120 k, ½ w
R6 — 10 k, ½ w
R7 — 47 Ω, ½ w
R8 — 12 Ω, ½ w
R9 — 100 Ω, 1 w
R10 — 500 Ω, 4 w variable, wirewound
T1 — Stancor TA-7 transformer
T2 — Triad TY 66A transformer

13. WIRELESS MICROPHONE

This wireless microphone has many versatile uses, and is particularly well suited for those with an inclination toward detective work. It is essentially an oscillator operating in the AM broadcast band, such that its output can be detected by standard broadcast receivers. A microphone at the input is used to pick up voice signals. These are then amplified and used to modulate the transmitter. Since all of the parts are small, the unit can be packaged in a small volume. This enables the user to hide the device easily for concealed-microphone applications. Use of a short antenna increases the range of the transmitter. Since a very fine wire can be usd for this function, it can readily be concealed under table cloths, along base boards, and the like. When used with conventional ac-dc superheterodyne receivers, a range of 20 feet is typical. Since the range is not appreciably affected by wooden and even concrete walls, applications for the circuit are almost unlimited. In addition to its undercover uses, the unit can also be used wherever a one-way intercom is required. In a typical situation it could be used as a remote baby monitor. Another use to which the circuit can be put is that of a "phone-oscillator." For this application, a phonograph cartridge is connected to the circuit in place of the microphone. By connecting both the microphone and phone cartridge to the circuit through a switch, and using the two inputs alternately, a complete radio program can be simulated.

Transistor Q3 is the active element of the oscillator stage. Other important components of this stage are capacitors C3 and C4, and inductor L1. The short 2 or 3 foot antenna wire is connected to the collector of Q3 as shown. The frequency of the oscillator is determined principally by capacitor C4 and inductor L1. Transistors Q1 and Q2 are both used in grounded-emitter configurations for audio amplification. Their function is simply to amplify the low-level audio at the input to a level which is adequate for amplitude-modulating the oscillator stage. When using ceramic phonograph cartridges with relatively high output levels, the first stage of gain is not needed and connection is made directly to capacitor C2, coupling into the second stage. It should be noted that the circuit does not, however, provide for record equalization.

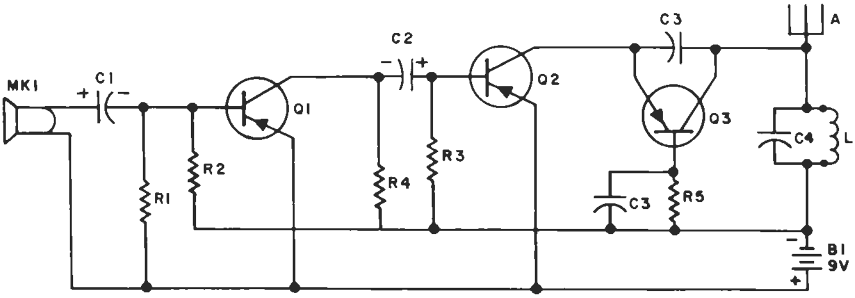


FIGURE 13 — WIRELESS MICROPHONE

To use the circuit, tune the broadcast receiver to a place in the band where there is no radio signal present. Now adjust L1 in the transmitter circuit by moving the slug in or out of the coil. When the transmitter frequency nearly matches that of the receiver, a whistle will be heard. Tune to the middle of this whistle, and the circuit is ready to operate. Since length and placement of the antenna will have a slight effect on the oscillator frequency, these should not be changed once the circuit has been adjusted.

PARTS LIST

B1 — 9-volt battery
C1, C2 — 5 mfd electrolytic, 15-volt
C3 — 100 mmfd mica or tubular ceramic
C4 — 360 mmfd mica or tubular ceramic, or 0-365 mmfd adjustable
C5 — 0.02 mfd paper or disc ceramic
L1 — Ferri-loopstick antenna coil
MK1 — Virtually any microphone — magnetic or capacitive type
Q1, Q2 — Sylvania 2N1265 transistor
Q3 — Sylvania 2N1264 transistor
R1 — 9.1 k, ½ w
R2 — 470 k, ½ w
R3 — 150 k, ½ w
R4 — 560 k, ½ w
R5 — 47 k, ½ w

14. APPLAUSE METER

An applause meter can be used for all sorts of events in which an impartial judge is required for deciding which participant the audience most favors. Requiring only a small battery, the meter can be used for all sorts of outdoor events in addition to the usual indoor applications. At practically any type of a sports meet – swimming, football, hockey, or scout meets, the meter will prove an invaluable asset in making decisions on winners in both serious and comic matters. Many people will choose to dispute a judge's opinion of which group shouted and applauded the loudest, but few will dare challenge an electronic applause meter.

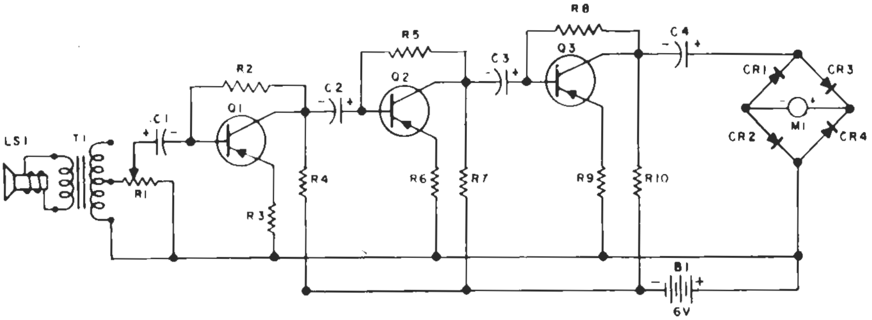


FIGURE 14 — APPLAUSE METER

In construction of the meter, it would be well to place the loudspeaker pickup on one side, and the meter on either the top or the opposite side. In this manner, a meter reading can be made with ease while the loudspeaker pickup is pointd directly at the cheering crowd. To give all concerned an even break, it is essential that the loudspeaker be generally aimed at the center of each spector group being monitored.

The hobbyist is undoubtedly familiar with the most common use of a loudspeaker – that of converting electrical energy into sound waves. However, it can also be used in the opposite manner to effectively act as a microphone. Its application in this circuit utilizes this capability to drive the coupling transformer T1. The secondary of T1 is capacitively coupled by C1 to the base of transistor Q1. Transistors Q1, Q2, and Q3 comprise a three-stage audio amplifier. All stages are connected in the grounded emitter configuration. The output of the third stage is capacitively coupled by C4 to a full wave rectifier circuit which then provides d-c current for the indicating meter. A gain potentiometer is provided at the input for use as a sensitivity control. For a given set of spectator readings, the sensitivity control should not be changed. Since the circuit is still useful without the loudspeaker as a high-gain amplifier and indicator, it can be used for relative indications of low-level input signals. When used in this manner simply disconnect one of the secondary leads of the input transformer T1.

PARTS LIST

B1 — 6-volt battery
C1, C2, C3, C4 — 10 mfd electrolytic, 25-volt
CR1, CR2, CR3, CR4 — Sylvania 1N64 diode
LS1 — 3-6 ohm loudspeaker
M1 — 1 milliampere full-scale meter
Q1, Q2, Q3 — Sylvania 2N1265 transistor
R1 — 5 k, ½ w potentiometer
R2, R5, R8 — 150 k, ½ w
R3, R6, R9 — 100 Ω, ½ w
R4, R7, R10 — 2.2 k, ½ w
T1 — Stancor TA-33 or equivalent

15. AUDIO AMPLIFIER

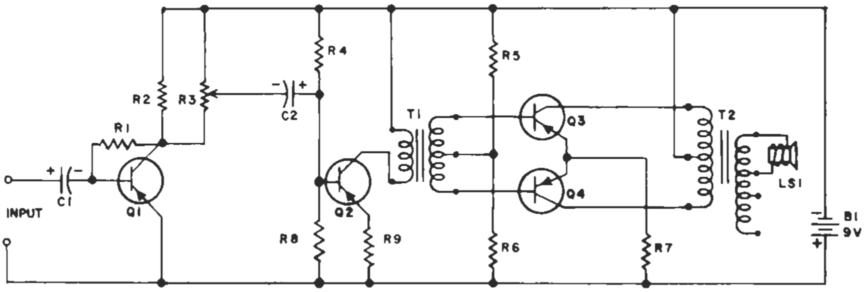


FIGURE 15 — AUDIO AMPLIFIER

This circuit provides a high degree of audio amplification, and is the answer to a problem encountered by many hobbyists—that of a single unit capable of amplifying the output of a microphone or other low-level input device to a level high enough for driving a loudspeaker. Use of this single unit thus avoids the annoying interconnection of sub-units such as preamplifiers, amplifiers, and output circuits, to accomplish this simple function. The various sub-units frequently require different supply voltages, therefore making interconnections inconvenient. Also, many more components are involved and more space is required than is really warranted. A gain control is also provided in this circuit to permit adjustment of the output level at the loudspeaker. Uses for the amplifier include connection to microphones, telephone pickups, and radio receiver front ends. It can also be used as a signal tracer in repair jobs.

The amplifier derives its gain from three grounded-emitter stages in cascade. The first stage is resistance-capacitance coupled to the second. Gain potentiometer R3 shunts the collector load resistor R2. Transformer coupling is used between the second and third stages, providing the phase-splitting action required for driving the push-pull configuration formed by transistors Q3 and Q4. Another transformer, T2, is used to sum the push-pull output produced by Q3 and Q4, and to provide the proper impedance match to the loudspeaker. Since three taps are available on the output transformer, loudspeakers having impedances of 4, 8, or 16 ohms can be used.

Since the amplifier does have a very high gain, precautions should be observed in the mechanical layout of the parts. In particular, care should be taken to assure that leads connecting the collectors of transistors Q3 and Q4 to the primary of transformer T2 are kept well away from the circuitry driving the inputs of transistors Q1 and Q2. As an example, mount the gain potentiometer R3 at the input end of the chassis, well away from transformer T2.

PARTS LIST

B1 — 9-volt battery
C1, C2 — 10 mfd electrolytic, 15-volt
LS1 — any 4, 8, or 16 ohm loudspeaker
Q1 — Sylvania 2N1265 transistor
Q2, Q3, Q4 — Sylvania 2N1266 transistor
R1 — 68 k, ½ w
R4 — 120 k, ½ w
R2, R6, R8 — 560, ½ w
R3 — 5 k, ½ w potentiometer
R5 — 6.8 k, ½ w
R7 — 100, ½ w
R9 — 10 k, ½ w
R10 — 100, ½ w
T1 — Stancor TA-5 or equivalent
T2 — Stancor TA-10 or equivalent

16. AUDIO PHOTOMETER

The output of this circuit is a steady tone, the frequency of which is roughly 1 kilocycle per second. The circuit is unique in that the tone can be varied by changing the light intensity illuminating the sun battery. Hence the name, "audio photometer"—an audio oscillator, the frequency of which is determined by light intensity. Most of the other light-sensitive circuits shown in this book have been useful for monitoring such things as: lights on or off in remote rooms, doors open or closed, and so on. However, they had in common the requirement that the observer watch an indicator light. Using this circuit, there is no need to watch the device for a visual indication—one can read books, build electronic circuits, and in general do many other things while monitoring the circuit's audible output all the while. It is interesting to note how sensitive the ear is to small changes in audio frequency.

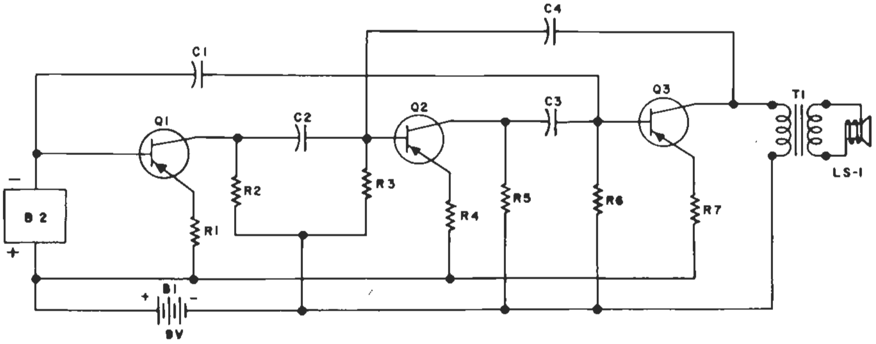


FIGURE 16 — AUDIO PHOTOMETER

Three grounded-emitter amplifiers having positive feedback connections are used to form an oscillator circuit. The output from the first stage is coupled by capacitor C2 to the second stage. Similarly, capacitor C3 couples from the second stage to the third. Emitter resistors R1, R4, and R7 stabilize the gain of the three stages. Since a single grounded-emitter stage produces a phase shift or 180 degrees, two stages will produce a phase shift of 360 degrees. Thus Coupling from the collector of Q3 back to the base of Q2 via capacitor C4 constitutes positive feedback. Likewise, capacitor C1 couples from the collector of Q2 (through C3) to the base of Q1. The frequency of oscillation is determined by small phase shifts which are developed through the amplifier stages by the various resistors and capacitors. When the intensity of illumination on the sun battery is changed, the bias current which it supplies to transistor Q1 is similarly changed. This varies both the input and output impedances of the first stage, changing the phase shifts involved in that part of the circuit. Oscillations in the circuit must now shift to a different frequency, where they meet the 360-degree loop phase shift requirement. The shield connection on the transistors can be connected to the emitter lead, or simply cut off close to the case since shielding is not required at the relatively low frequencies used.

PARTS LIST

B1 — 9-volt battery
B2 — Sun battery, International Rectifier Corp. Type B2M or equivalent
C1, C3 — 0.1 mfd ceramic disc or paper, 50-volt
C2 — 0.02 mfd ceramic disc or paper, 50-volt
C4 — 0.05 mfd ceramic disc or paper, 50-volt
LS1 — 3-6 ohm loudspeaker
Q1, Q2, Q3 — Sylvania 2N1264 transistor
R1 — 390 Ω, ½ w
R2, R5 — 10 k, ½ w
R3, R6 — 100 k, ½ w
R4, R7 — 47 Ω, ½ w
T1 — Thordarson TR-29 or equivalent

17. BOAT HORN

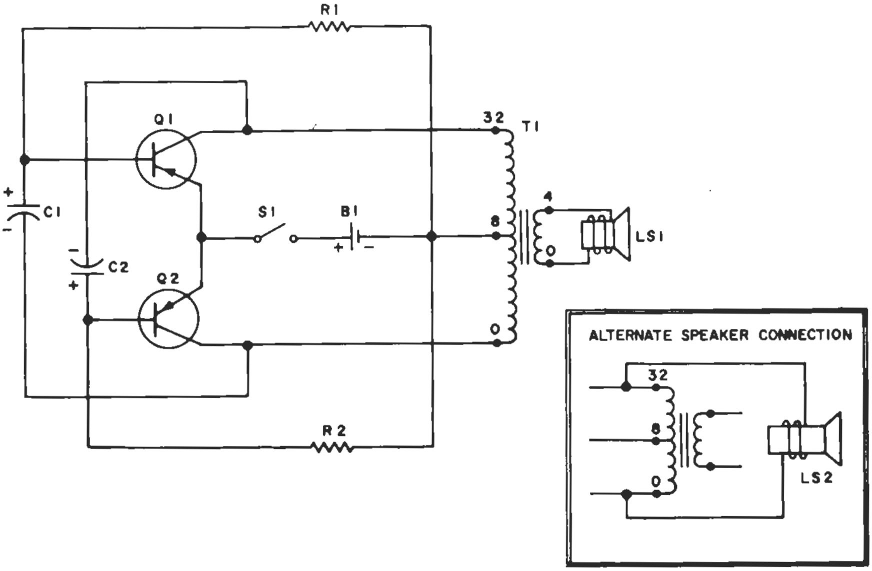


FIGURE 17 — BOAT HORN

While the circuit has been called a boat horn, it can be used wherever there is a requirement for a sounding device. Mounted on a boat, it makes a compact sounding device which can be heard over a considerable distance.

It can also be used in conjunction with burglar and fire alarm systems. Another application is in sending messages through woods and similar areas where optical communication is impossible. Morse code could be used, or secret codes could be devised for message privacy.

The circuit is basically a free-running multivibrator, using power transistors. The power output stage, which would be required in any event, is used to generate the audio frequency as well. Resistors R1 and R2 provide base bias current for the transistors which are connected in the ground-emitter configuration. Capacitors C1 and C2 couple the collector voltage from one half of the multivibrator to the base of the other half. Thus, if transistor Q1 suddenly fires, its collector voltage rises with respect to the negative battery terminal. This sudden rise, coupled to the base of transistor Q2, back biases this stage, cutting it off. At cutoff, its collector voltage drops to the negative battery potential. This negative voltage swing is coupled to the base of transistor Q1 by capacitor C2, causing transistor Q1 to conduct more heavily. Transistor Q1 continues to conduct until the base voltage of Q2, dropping exponentially with respect to time, is low enough for conduction to start. At this time, the triggering process repeats, with transistor Q2 cutting off transistor Q1.

If the horn is to be used out-of-doors, it would be well to invest in a loudspeaker which is designed to withstand the weather. Paging trumpets, commonly used in railroad stations and other terminals, and on mobile announcing rigs, are an example of this. For indoor use, an ordinary hi-fi tweeter is adequate for the job. Connect the speaker to terminals on the output transformer which have an impedance half that of the loudspeaker. An alternate connection is shown on the schematic for 48-ohm paging trumpets.

In construction, provide good heat sinks for the two transistors. Heat sinks 1½" by 2½" made from 1/16" aluminum are adequate. Since the collectors of these transistors are tied to the case and hence to the heat sinks, the heat sinks must be electrically insulated from each other and from the rest of the circuit.

PARTS LIST

B1 — 12-volt battery (1 ampere drain) conventional auto or boat battery, or 2 Burgess F4P1 batteries wired in series.
C1, C2 — 2.0 mfd, electrolytic, 25-volt
LS1 — 8-ohm tweeter, Lafayette HK-3 or equivalent*
Q1, Q2 — Sylvania 2N307 power transistor
R1, R2 — 220 Ω, 1 w
S1 — single-pole, single-throw pushbutton switch, normally open
T1 — Lafayette TR-94 or equivalent
*LS2 for alternate connection — 45 ohm paging trumpet; University CMIL-45, University MIL-45, or equivalent

18. INTERCOM

Frequently, it would be quite convenient if it were possible to speak with a person in another part of the house. The intercom is a system which has two "stations" between which two people may carry on a conversation. The system described here consists of a master station and one remote station.

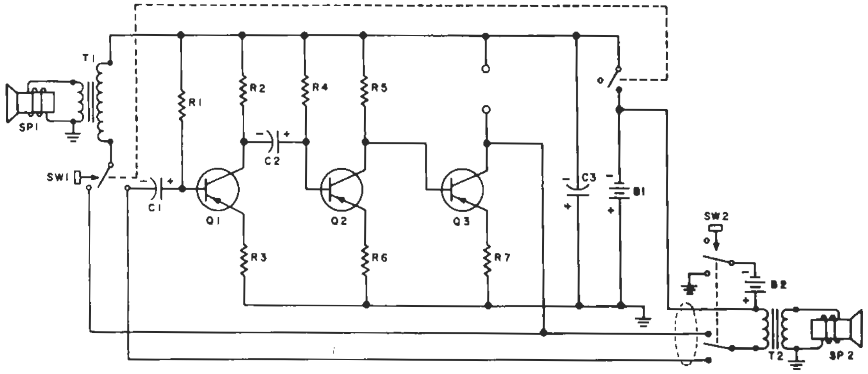


FIGURE 18 — INTERCOM

The master station contains a speaker, input-output transformer, amplifier, battery, and "push-to-talk" switch. The remote station contains a speaker, input-output transformer and a second battery. If the positive terminal of each battery is grounded to a water pipe or radiator, only three wires need be run between the master and remote station.

When neither switch is pushed, both B1 and B2 are disconnected and the primary windings of both transformers are connected to the amplifier output. To make a call from the master station, it is only necessary to push SW1. This switch connects B1 to power the amplifier and also connects the secondary winding of T1 to the input of the amplifier. SP1 now acts as a microphone. The signal from the speaker is coupled through T1 and C1 to the base of Q1. The amplified signal at the collector of Q1 is coupled through C2 to the base of the second common emitter amplifier stage Q2. The output of Q2 is direct-coupled to the base of Q3. The collector current of Q3 flows through the primary winding of T2 and produces a sound output from SP2.

Pushing SW2 connects B2 to the amplifier and connects the primary of T2 to the amplifier input, allowing the person at the remote station to speak.

PARTS LIST

B1, B2 — 9-volt battery
C1, C2, C3 — 25 mfd, 12-volt
Q1, Q2, Q3 — Sylvania 2N1265
R1, R4 — 560 k, ½ w
R2, R5 — 4.7 k, ½ w
R3, R6 — 100 Ω, ½ w
R7 — 1000 Ω, ½ w
SW1, SW2 — DPDT pushbutton switch
SP1, SP2 — 3.2 Ω, 4-inch PM speaker
T1, T2 — 2000 Ω to 3.2 Ω, output transformer, Lafayette Radio TR 93

19. MICROPHONE PREAMPLIFIER

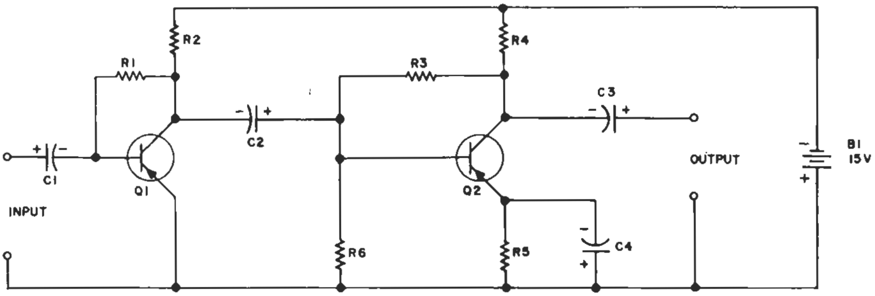


FIGURE 19 — MICROPHONE PREAMPLIFIER

Many a home experimenter has found to his annoyance that the low output level of most microphones is inadequate for driving most common power amplifiers. This simple-to-build microphone preamplifier provides an inexpensive solution to the problem. It can be used with practically any low-level, low-impedance microphone where the output is in the vicinity of –50 to –60 dbm. Even when the preamplifier output is loaded with relatively low impedances, an undistorted output of one-half volt rms can be obtained. This is sufficient to drive most power amplifiers to full rated output, even when the amplifier employs a low input-impedance transistor stage. The frequency response at the high end is far in excess of what is needed for audio applications, while the low frequency response is adequate for most microphones. The circuit can also be put to use as a preamplifier for low-level phonograph pickups. When used in this manner, the output should be fed into an equalizer circuit to provide the proper recording compensation.

Operation of the circuit relies upon the gain provided by two grounded emitter stages. Advantage is taken in both stages of the high audio frequency gain developed by the 2N1265 transistor. Capacitor C2 couples the signal from the first stage to the base of the second. In this second stage, the builder will note that the emitter bias resistor R5 is bypassed by capacitor C4 to provide the maximum gain possible at audio frequencies. When the output is used to drive a 600-ohm line, a frequency response from 100 cycles per second to 120 kilocycles per second is obtained with a maximum output level of 0.4 v rms. The voltage gain with this load is 65 db. When used to drive another amplifier with a grounded emitter input stage, the typical load on the preamplifier will be approximately 1.5k ohms. Under these conditions, the bandwidth is extended to 45 cycles per second at the low end, and the maximum output voltage is increased to 0.8 v rms. With a 1.5k ohm load, the circuit has a voltage gain of 70 db. If the input level to the preamplifier is higher than 250 microvolts rms, an attenuator should be used to reduce the signal to this level. If this is not done, distortion will occur in the output. As an aid in building the attenuator, an input impedance of 1.5k ohms can be assumed for the preamplifier. A construction hint—building the unit in a small metal can to provide shielding might avoid bothersome hum pickup in later use.

PARTS LIST

B1 — 15-volt battery
C1, C2, C3 — 10 mfd electrolytic capacitor, 25-volt
C4 — 50 mfd electrolytic capacitor, 25-volt
Q1, Q2 — Sylvania 2N1265 transistor
R1, R3 — 150 k, ½ w
R2, R4 — 6.8 k, ½ w
R5 — 100, ½ w
R6 — 15 k, ½ w

20. PHASE INVERTER

Amplification and phase inversion of audio signals are accomplished in this circuit. Having a single-ended input and balanced Class A push-pull output, it is ideal for driving Class A push-pull power amplifiers in high-fidelity applications. Perhaps the finest feature of the circuit is its elimination of the conventional phase-splitting transformer. This transformer normally limits the frequency response of the driver stage, and in addition limits the undistorted power available from the amplifier at the lower audible frequencies. Further, having a much wider passband than the transformer, negative feedback can be applied from the final output transformer to a point much closer to the input of the complete amplifier than would be possible with a typical transformer interstage coupling. This, then, is truly a boon to the high-fidelity addict.

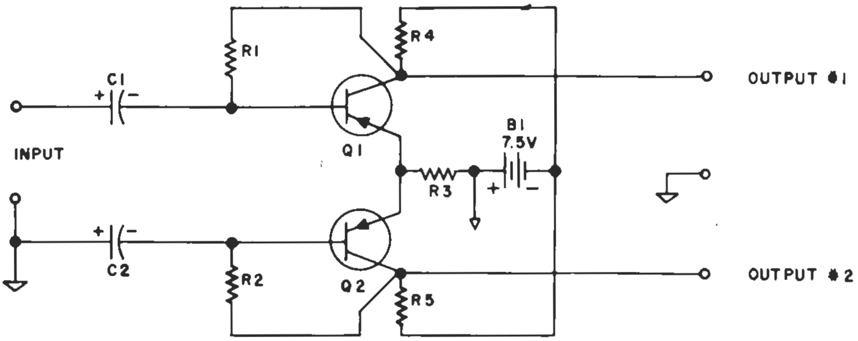


FIGURE 20 — PHASE INVERTER

Basically, the circuit consists of two transistor amplifiers, one being a common base, the other a common emitter. The input signal drives the base of the Q1 stage. The Q2 stage is driven by emitter coupling from the first stage. The common emitter resistance R3 provides a balancing action, maintaining approximately equal collector currents in the two transistors. In this manner, differences in current amplification between the two transistors have virtually no effect on the balance of the output voltages. The output voltage balance is essentially as good as the match of the collector loads, these being determined as resistors R4 and R5 in parallel with their respective loads. Bias is provided by resistors R1 and R2. Low frequency response is determined by the values of capacitors C1 and C2 relative to the transistor impedances. For the indicated values, the phase inverter passes frequencies from 9 cycles per second to 80 kilocycles per second. Driving

3000-ohm loads, an undistorted single-ended output voltage of 0.9 v rms can be obtained with an input of 50 mv rms. The push-pull output is then 1.8 rms. Input impedance to the circuit is roughly 1.8k ohm. This value is used as the load impedance for the stage preceding the phase inverter.

PARTS LIST

B1 — 7.5-volt battery
C1 — 10 mfd electrolytic capacitor, 15 v
C2 — 50 mfd electrolytic capacitor, 15 v
Q1, Q2 — Sylvania 2N1265 transistor
R1, R2 — 47 k ohm, ½ w
R3 — 560 Ω, ½ w
R4, R5 — 2.7 k, ½ w

21. RELAY ACTUATOR

This relay actuator circuit can be used to acknowledge and remember various events which occur during the absence of the owner. Virtually any event from which an alternating electrical output can be obtained can be used to activate the circuit. The circuit will remember only one event, and thus will not register multiple occurences of this event. However, it is extremely useful in registering such things as whether or not the phone rang while the owner was away, whether or not lights were turned on, if doors were opened or door bells rung, if photo-electric burglar alarm circuits were tripped, and so on. A push-button resets the memory function of the actuator.

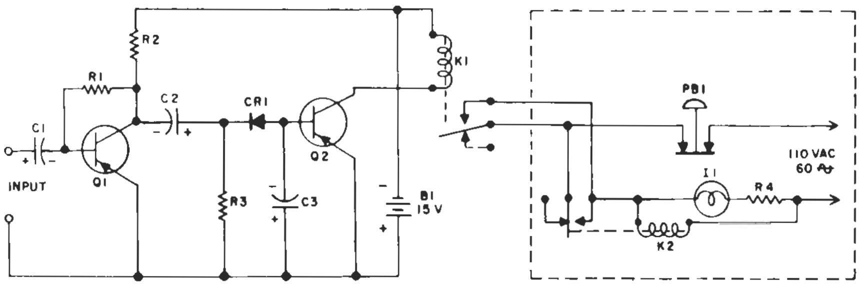


FIGURE 21 — RELAY ACTUATOR

The circuit is basically comprised of two transistors, two relays, and one diode. The first transistor stage, employing Q1, is a grounded-emitter ac amplifier. Resistor R2 is its collector load, while resistor R1 provides bias.

Ac output from the stage is coupled by capacitor C2 to a peak detector circuit implemented by diode CR1. Resistor R3 and capacitor C3 form a filter network for this detector. On application of an ac signal to the input, a negative voltage is thus developed at the base of transistor Q2. This voltage causes conduction in Q2. Collector current for transistor Q2 flows through relay K1, energizing the relay. Closure of the contacts of relay K1 applies 110 v ac to the coil of relay K2. Relay K2 therefore closes. In so doing, its own contacts are used to provide holding action. In this manner, when the input to the actuator circuit is removed, opening relay K1, relay K2 remains closed. Since the indicator light is directly across the coil of relay K2, it is illuminated whenever relay K2 is closed. Voltage for relay K2 can be removed only by use of the push-button PB1. The light may be turned off by resetting the push-button.

Input voltages as low as 3 mv rms will actuate the circuit. However, slightly higher voltages will produce more reliable operation. The circuit retains this sensitivity for input frequencies ranging from ½ cycle per second to almost 1 megacycle per second. A typical telephone pickup coil such as the Lafayette MS-16 or the Shield M-133 will produce an output ranging from 10 to 30 mv for a telephone ring, the exact value being a function of its position with respect to the telephone. If input voltages larger than ½ volt rms are to be encountered, one should use an input attenuator similar to those indicated in other circuits in this book.

PARTS LIST

B1 — 15-volt battery
C1, C2, C3 — 10 mfd electrolytic capacitor, 25 v
CR1 — Sylvania 1N34A diode
K1 — Advance SO 1C 4000D relay or equivalent
K2 — Potter & Brumfield Type CA3A or equivalent 110 vac relay, having at least one normally open contact
I1 — neon lamp; NE-2 or NE-51
PBI — SPST normally closed push-button switch
Q1, Q2 — Sylvania 2N1265
R1 — 330 k, ½ w
R2 — 6.8 k, ½ w
R3 — 15 k, ½ w
R4 — 1.5 meg, ½ w

22. TELEPHONE AMPLIFIER

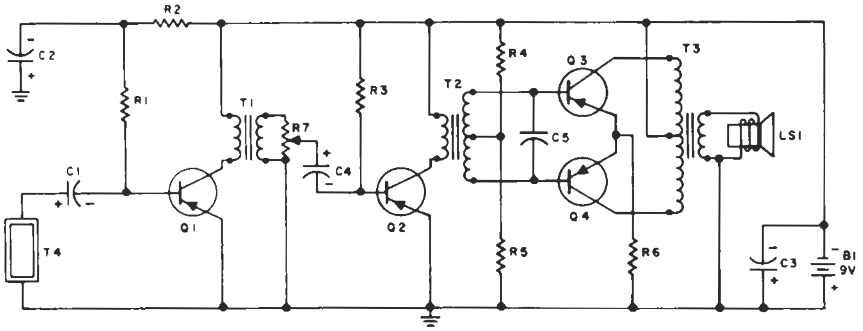


FIGURE 22 — TELEPHONE RECEIVER P. A.

How many times have you wished that more than one person could listen in on a long distance telephone call? Even on local calls there is frequently the need for a device which enables several people to hear both sides of the conversation. Without any electrical connections to the telephone lines whatsoever, this circuit will enable you to perform these functions. The loudspeaker can be placed either close to or at some distance from the telephone, pickup, and amplifier. In thie latter case it effectively provides a one-way (listen only) telephone extension. Certainly many hours of fun and of genuine usefulness can be obtained with the circuit.

Amplification in the circuit relies on three grounded-emitter stages, the last of which is push-pull. The telephone pickup drives the input stage through coupling capacitor C1. This capacitor blocks the dc which is present across the control junction of transistor Q1, thereby preventing its appearance across the pickup T4. The interstage transformer T1 is used to provide an impedance match from the first stage to the second. Potentiometer R7 is the gain adjustment for the amplifier and controls the output level at the loudspeaker. Interstage transformer T2 provides both impedance matching between the second and third stages and phase-splitting for the push-pull drive. The output transformer T3 matches the output signal from the push-pull stage to the loudspeaker.

Since the gain of the amplifier is fairly high, the usual rules apply to the mechanical layout. Keep all leads as short as possible, and keep transformers T2 and T3 away from the input section. Capacitors C2, C3, and C5 are used for bypass purposes to prevent oscillations at both high and low frequencies. The schematic shows one side of the secondary of transformer T3 grounded. While this connection does not have to be made, it reduces the possibility of unwanted oscillations in the circuit. Also, if the circuit oscillates reverse the connections on the secondary of T1. If headphones are to be used, they should be connected from the collector of Q2 to B-. To silence the loudspeaker, disconnect the primary of transformer T2 from the collector of Q2 and short it to B-.

PARTS LIST

B1 — 9-volt battery
C1, C4 — 2 mfd, electrolytic, 15-volt
C2, C3 — 8 mfd, electrolytic, 15-volt
C5 — 0.01 mfd, ceramic disc or mica, 100-volt
LS1 — 3-6 ohm loudspeaker
Q1, Q2, Q3, Q4 — Sylvania 2N1265 transistor
R1 — 470 k, ½ w
R2 — 150 k, ½ w
R3 — 270 k, ½ w
R4 — 4.7 k, ½ w
R5 — 68 Ω, ½ w
R6 — 12 Ω, ½ w
R7 — 100 k, ½ w potentiometer
T1 — Argonne AR-104, Stancor TA-27, or equiv.
T2 — Argonne AR-109, Stancor TA-35, or equiv.
T3 — Argonne AR-119, Stancor TA-21, or equiv.
T4 — Telephone pickup coil, Lafayette MS-16, Shield M-133, or equiv.

* * *

23. AUTOMATIC GARAGE LIGHT

Those who do not have two-way switches in their garages know well the unpleasantries of finding their way in the dark through a garage filled with bicycles, a wheelbarrow, ladders, and so on. Add to this the task of carrying a large bag of groceries, and you really have a challenge. An effective solution to the whole problem is provided by this circuit. It automatically turns on the garage lights when the detector is illuminated by the auto headlamps. Then, after the headlamps have been turned off, it holds the garage lights on for an additional 1½ to 20 minutes, allowing the driver to walk comfortably to the garage door with his cargo—all with the benefit of light. This one should prove to be a real bruise-saver for many hobbyists.

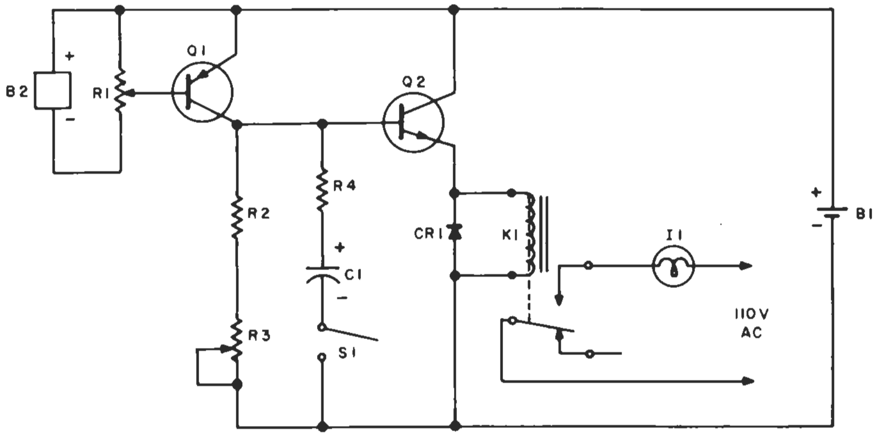


FIGURE 23 — AUTOMATIC GARAGE LIGHT

Basic components in the circuit are a sun battery, two transistors, an energy storage capacitor, and a relay. The heart of the circuit is actually the energy storage capacitor and its associated charge and discharge paths. Operation evolves around charging the capacitor rapidly through a small resistance, then discharging it slowly through a much larger resistance. The exponentially-discharging voltage across the capacitor is used to control the output relay.

Illumination of the sun battery generates a bias current for transistor Q1. If the illumination is turned on abruptly, the transistor is biased on in the same abrupt manner. This lowers the output impedance of the transistor, providing a charging path for capacitor C1. Resistor R4 is used to limit the charging current surge. Potentiometer R1 adjusts the circuit sensitivity so that the charging action takes place at the desired levels of illumination. When the illumination is returned to the former ambient level, conduction in Q1 decreases markedly and its output impedance rises. Capacitor C1 now commences to discharge through the parallel combination of the output impedance of Q1, the delay resistances R2 and R3, and the input impedance of transistor Q2. Since Q2 is connected as an emitter follower, its input impedance is high. The emitter follower action also serves to drive the relay with a voltage which is a replica of the exponentially-discharging capacitor voltage. Since the input impedance of Q2 is fixed, resistors R2 and R3 are used to provide a variable discharge path, changing the delay time, Diode CR1 is used across the relay to damp voltage spikes generated by the relay coil with sudden withdrawal of drive voltage.

By opening switch S1, the large time constant is removed from the circuit and the sensitivity adjustment R1 can be set rapidly. As the control is advanced, the relay will close upon illumination of the sun battery. As it is further advanced, a point will be reached at which the relay will no longer open upon returning to ambient light. The control should be set just below this point so that the relay definitely opens upon returning to the brightest ambient light which will be expected. The switch S1 is now closed for normal operation. If an increase in delay time is desired, simply vary R3 to increase the amount of resistance in this leg of the circuit. Since the best setting for R1 might vary somewhat with the setting of R3, the former setting should be checked again with S1 open.

Variation of R3 will change the delay time from roughly 1½ to 15 minutes, depending upon the level of ambient light. Completely removing R2 and R3 will increase the delay to approximately 20 minutes. In normal operation, the relay will close some 2 to 5 seconds after being exposed to the trip light. For uniform time delays, the illumination must be maintained for 15 to 20 seconds.

If more than one ampere is to be drawn (i.e., a light bulb larger than 100 watts), it would be well to use a second relay operating directly on the 115 vac line. The contacts of the sensitive relay in the delay circuit will then simply connect the coil of the second relay to the power line.

The hobbyist might find it necessary to shield the sun battery so that it is sensitive to only a car-headlamp light level. This will prevent difficulties with high ambient light levels, and will also prevent the circuit from locking-up on the garage light which it turns on.

PARTS LIST

B1 — 15-volt battery
B2 — Sun battery, International Rectifier Corp., Type B2M or equivalent
C1 — 1000 mfd electrolytic, 15-volt
CR1 — Sylvania 1N34 diode
I1 — 115-volt light bulb, wattage not greater than 100
K1 — 1 kohm sensitive relay, Sigma 11F-1000G or equivalent
Q1 — Sylvania 2N1265 transistor
Q2 — Sylvania 2N229 transistor
R1 — 10 k potentiometer
R2 — 22 k, ½ w
R3 — 1 meg potentiometer
R4 — 1 k, ½ w
S1 — Single-pole, single-throw switch; slide, toggle, or push button

* * *

24. INTERVAL TIMER

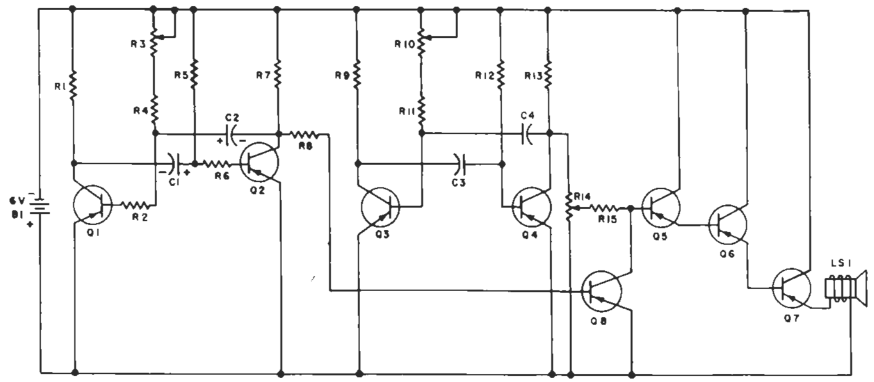


FIGURE 24 — INTERVAL TIMER

Many chess players find their game a great deal more challenging when a time limit is set on the moves. The extent of the time limit is rather arbitrary, being determined mostly by preference of the players. Under timed conditions, a move is forfeited unless completed within the time limit. Many alternate moves must therefore be considered in a very short time. Even the time allotted the opponent for his move becomes precious to a player and must be used for the formulation of strategy. When playing with timed moves, it is to a player's advantage to move just prior to expiration of his time limit, even though his decision might have been made some time before this. Should he make his move prior to the last possible moment, he gives his opponent a little additional time in which to analyze the effect of this last move. If, however, the player misjudges his time remaining, and it expires before he has made his move, he must accept a forfeit. Timed moves can thus spur on an exciting game.

Since the execution of critical moves might well depend on a fraction of a second, and since few people can be relied upon to perform a timing function with this accuracy, a mechanical or electronic timer seems imperative. The circuit shown here is tailor-made to this application. From the loudspeaker output, short audio beeps are heard. The time from one beep to the next is adjustable. Also adjustable are the pitch and loudness of the beep. This should be appreciated by the more sophisticated chess players.

Four basic sections are used to generate the beeps. They are the time-interval generator, the audio tone generator, a gate circuit, and the audio amplifier section which drives the loudspeaker. The time-interval generator controls the gate, which then passes the audio tone on to the amplifier and loudspeaker.

A multivibrator configuration using transistors Q1 and Q2 is employed for the time-interval generator. A similar configuration using transistors Q3 and Q4 generates the audio frequency tone. The pitch of the audio tone is controlled by the setting of potentiometer R10 and is adjustable from 400 cycles per second to 1.5 kilocycles per second. Both multivibrators run continuously, the time-interval generator running at a much lower rate. The setting of potentiometer R3 determines the time interval from the beginning of one beep to the beginning of the next. This time is adjustable from 7 to 25 seconds. Since the circuit is a symmetrical, the half formed by transistor Q1 conducts for a much longer interval than does the half formed by Q2.

Transistors Q5, Q6, and Q7 constitute a three-stage direct-coupled audio amplifier section. By connecting all stages as emitter followers, a high input impedance and low output impedance are obtained. The input to the audio amplifier is derived from the tap on loudness control R14. Gating of the audio signal is accomplished by transistor Q8 which is controlled by the time-interval generator. When transistor Q1 is conducting, transistor Q2 is non-conducting, and a large bias current for gate transistor Q8 flows through resistors R13, R14, and R15, effectively removing bias voltage from transistors Q5, Q6, and Q7. Therefore, no audio output is heard. Each time transistor Q1 conducts for its short interval, the bias for Q8 is decreased and Q8 is essentially cut off. This returns bias voltage to the audio amplifier section, and the audio tone is heard as a beep.

In addition to its use as a chess timer, the circuit can be used as a code practice oscillator. For this type of use, simply remove the end of resistor R8 which is connected to the collector of Q2, and connect it to the key. The other side of the key connects to the negative battery terminal. The key must be of the normally-closed type, opening when depressed.

PARTS LIST

B1 — 6-volt battery
C1 — 10 mfd, electrolytic, 15-volt
C2 — 80 mfd, electrolytic, 15-volt
C3, C4 — 0.0047 mfd disc ceramic or paper
LS1 — 4 to 8-ohm loudspeaker
Q1, Q2, Q3, Q4, Q5, Q6, Q8 — Sylvania 2N1265 transistor
Q7 — Sylvania 2N255 power transistor
R1, R7, R9, R13 — 20 k, ½ w
R2, R6 — 4.7 k, ½ w
R3, R10, R14 — 250 k potentiometer, ½ w
R4 — 68 k, ½ w
R5 — 620 k, ½ w
R8, R11, R12 — 100 k, ½ w
R15 — 47 k, ½ w

25. LIGHT AMPLIFIER

When the subject of amplifiers is mentioned, most people think immediately of a device which amplifies voltages. Here is an unusual circuit which effectively amplifies light. The input is a light intensity, and likewise the output is a light intensity. Increasing the intensity of the input light will cause a corresponding increase in the intensity of the output light. Actually, the device is not truly a light amplifier, in that it does not amplify light at its electromagnetic frequency. Rather, use is made of a sun battery to convert light energy to electrical energy. The electrical energy is then amplified by a dc amplifier and used to drive a light bulb. The light bulb, of course, converts the electrical energy back into light energy.

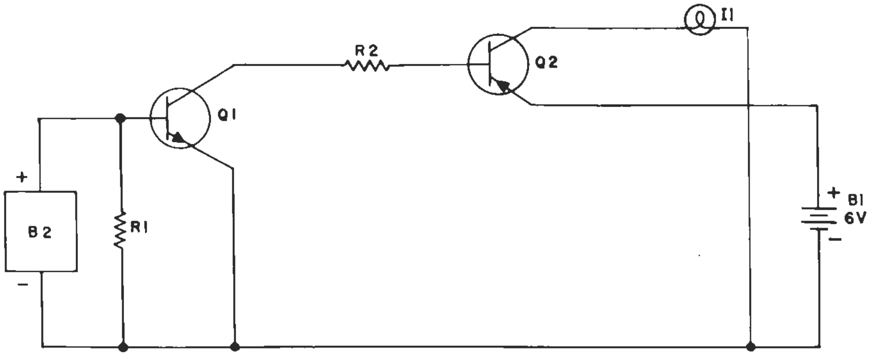


FIGURE 25 — LIGHT AMPLIFIER

With the transistors used in the circuit, only small pilot-type bulbs can be used in the output stage. The circuit is necessarily limited, therefore, to indicator applications. If high power driver stages were used, an entire room could be illuminated with the output of the circuit. As an indicator device, one application would involve placing the sun battery and amplifier in one room, with the indicator lamp in another room. The observer could tell by the brightness of the indicator lamp whether or not any lights were on in the other room and, if on, approximately how many. Secret communications systems could also be set up with this circuit. For this application, the sun battery would be concealed in a place known only to those aware of its presence. Without arousing suspicion one person could, in waving a flashlight around in a seemingly careless manner, actually illuminate the sun battery in a pattern which sent coded messages to a remote observer stationed by the indicator light.

The circuit utilizes two grounded-emitter amplifier stages to generate sufficient output level for driving a pilot bulb. The sun battery differs from an ordinary photoelectric cell in that it is itself a power source, generating a bias current for the first transistor when light strikes it. Photoelectric cells do not act as generators, but rather vary a bias current which is fed through them from another source. The collector load resistance R2 prevent burn-out of transistor Q1 by lowering its collector voltage when extremely high light intensities strike the sun battery. It also prevents burn-outs of the pilot bulb. When mounting transistor Q2, use a metal panel at least 2 inches on each side to provide heat sink action.

PARTS LIST

B1 — 6-volt battery
B2 — sun battery, International Rectifier Corp., B2M
I1 — pilot lamp, #51 or other 6-volt lamp
Q1 — Sylvania 2N229 transistor
Q2 — Sylvania 2N255 transistor
R1 — 4.7 k, ½ w
R2 — 100 Ω, ½ w

* * *

26. METAL LOCATOR

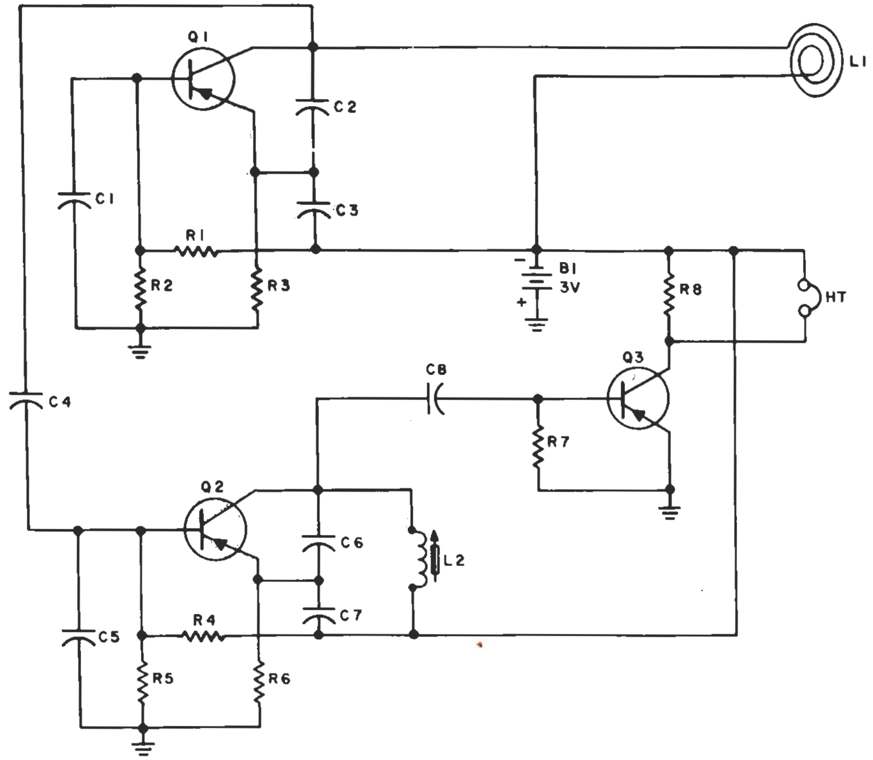


FIGURE 26 — METAL LOCATOR

Here is a device which will certainly come in very handy when enlisted for carpentry and home-modification jobs. By using this metal detector, a great deal of time can be saved in trying to get a fix on wall studs with nails, piping and even wiring located within the wall. With this information about the construction of the wall, the user can determine his best approach for the required modifications. Unlike most metal detectors which involve some sort of a magnetized compass needle, this device does not have to be held with any particular orientation. Changing its crientation relative to different objects will have some effect on the indication, but in general, the orientation of the device is not dictated by the instrument itself. In another application, the device could be used to locate small metal parts such as nuts, washers, bolts, and screws which had been accidentally dropped onto a thick carpet while working inside, or onto the ground while working outside. Games could also be devised in which the winner is the individual who can find the most concealed items in a given period of time.

Operation of the circuit is dependent upon the fact that metals of a ferromagnetic nature can be used to increase the inductance of a coil by placing them within the field of the coil. If the coil is used in the tank circuit of an oscillator, the frequency will shift as the inductance varies with different positions of the ferromagnetic material. Since it is easiest to build this type of oscillator at frequencies above the audio band, the output frequency cannot be heard directly. However, an audible signal can be generated by beating the oscillator with the output of another oscillator differing in frequency from the first by an amount which is within the audible spectrum. The circuit shown here utilizes this technique. One oscillator circuit is built around transistor Q1 and the probe coil, L1. The fixed frequency oscillator is built around transistor Q2. Capacitor C4 couples the output of the variable oscillator to the input of the fixed frequency oscillator. Modulation of the second signal by the first to produce the audio difference frequency then occurs in transistor Q2. This audio difference frequency is coupled by capacitor C8 to an audio amplifier stage where its level is increased so that it can be heard in the headphones. Transistor Q3 provides this amplification as a grounded-emitter stage.

While non-ferromagnetic materials do not change the inductance of the coil, they frequently will change the Q of the coil. In many oscillator circuits, this is adequate to shift the frequency some small amount. Therefore, in addition to ferromagnetic pieces, items made of copper, brass, and aluminum will also be detectable.

To operate the circuit, the slug of coil L2 is adjusted so that a low frequency growl is heard in the earphones. If metal is now placed near pickup coil L1, it will increase the inductance and lower the frequency of the variable oscillator. This causes the audio output frequency to increase. Best sensitivity is obtained when the object is well coupled to the pickup coil—that is, right next to the wire itself, instead of at the center of the loop.

PARTS LIST

B1 — 3-volt battery
C1, C5 — 0.001 mfd ceramic disc or paper
C2 — 0.02 mfd ceramic disc or paper
C3, C8 — 0.01 mfd ceramic disc or paper
C4 — 100 mmfd disc or mica
C6 — 0.002 mfd ceramic disc or mica
C7 — 0.001 mfd ceramic disc or mica
HT — Crystal or 2 kohm headphones
L1 — 14 turns of #18 enameled wire, 5½" dia., scramble wound
L2 — 20 mh, slug-tuned
Q1, Q2, Q3 — Sylvania 2N1266 transistor
R1, R2, R4, R5, R8 — 5.1 k, ½ w
R3, R6 — 330 Ω, ½ w
R7 — 3.3 meg, ½ w

27. MODEL TRAIN HORN

The action in a model train setup will be greatly enhanced with the addition of this electronic horn. The tone of the horn is such that it simulates very nicely the sound made by a diesel roaring down the tracks. The circuitry can either be built into a small package and enclosed in one of the cars, in which case it would be triggered on by a fourth-rail track section, or the speaker can be camouflaged in scenery somewhere in the middle of the track layout. When used in the latter manner, a single horn can be used for any number of trains. Uninformed observers will assume that the sound is coming from whatever train happens to be passing the area near the speaker. For increased versatility, certain of the components in the circuit may be connected with switches such that different tones are generated for different trains. The horn circuit can also be used to add a great deal of realism to the action of model boats. With appropriate component changes the circuit will create fog-horn or other sounds.

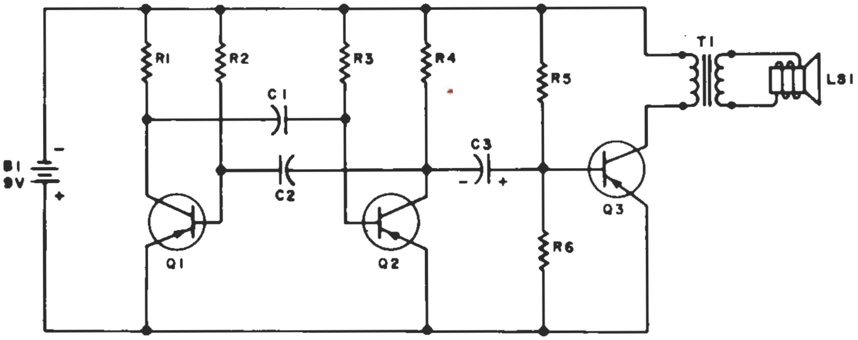


FIGURE 27 — MODEL TRAIN HORN

Operation of the circuit depends basically on the square-wave output generated by the multivibrator or flip-flop circuit. Transistors Q1 and Q2 are the active elements in the flip-flop circuit. Resistors R1 and R4 comprise the load resistors, while capacitors C1 and C2 couple signals from the collector of one transistor to the base of the other in order to provide the regenerative action of the flip-flop circuit. Once the resistance values have been determined, the values of capacitors C1 and C2 can be varied to change the frequency at which the circuit operates. Capacitor C3 couples the output from the collector of Q2 to an audio amplification stage. Transistor Q3, connected as a grounded-emitter, provides this amplification. The impedance level of the amplified audio signal is then transformed by output transformer T1 so that maximum power is delivered to loudspeaker LS1. Current drain of the circuit is low, and the level of audio output is neither too small nor too large to detract from the realism which this effect can create.

The parts list indicates a value of 0.02 mfd for capacitors C1 and C2. This value will result in a sound very much like that of a diesel. For higher pitched sounds, the capacitors can be decreased to 0.0047 mfd. For boat applications where a lower frequency is desired to simulate foghorns, use a value of 0.033 mfd. To facilitate changing tone rapidly, these different values can be wired to a switch which connects any desired value to the appropriate point in the circuit. To improve the air-loading of the loudspeaker and thus increase audio power output at the low frequencies of interest, prevent the back-wave from cancelling the front-wave by flush-mounting loudspeaker LS1 on a panel of some sort.

PARTS LIST

B1 — 9-volt battery
C1, C2 — 0.02 mfd disc ceramic or paper (see text)
C3 — 1.0 mfd electrolytic, 15-volt
LS1 — 3 to 4-ohm loudspeaker*
Q1, Q2, Q3 — Sylvania 2N1265 transistor
R1, R4 — 6.2 k, ½ w
R2, R3 — 270 k, ½ w
R5 — 180 k, ½ w
R6 — 12 k, ½ w
T1 — Argonne AR-135 (do not connect center tap)*
***A miniature 10-ohm speaker (Lafayette SK-61) can be used with a 2 k to 10-ohm transformer (Lafayette SK-62)**

28. PHOTO-ELECTRIC COMPARATOR

The photo-electric comparator circuit shown here is only slightly more complex than a conventional photo-electric circuit. However, its performance is far superior to the conventional circuit for many applications. The conventional circuit is sensitive to the absolute magnitude of light hitting the cell, and will trip its circuit when a variation in an unwanted background such as daylight is experienced. Hence it cannot be made responsive solely to some weaker source unless the daylight ambient can somehow be screened from it. Frequently this is difficult or impossible to accomplish. Obtaining response from a source which is only slightly weaker than the ambient would require a constant resetting of the sensitivity control as the daylight background changed.

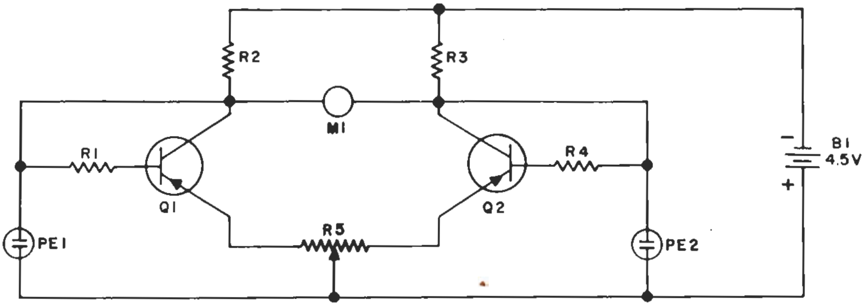


FIGURE 28 — PHOTO-ELECTRIC COMPARATOR

The differential circuit described here avoids these difficulties by using a second photo-cell to sense the ambient light only. The output from the first cell, which is sensitive to both ambent and the desired light source, is subtracted from the output of the second cell in the circuit. Thus the circuit is responsive to only the desired light source, and variations in ambient light over a very large range can be tolerated with no effect on the circuit output. It is clear, then, that the uses of this circuit are based on differences in light value rather than on absolute light value.

An application for which the circuit is particularly well suited is the determination of differences in color of two objects which have an otherwise similar surface. The color difference will produce a difference in reflected light from the two objects, provided that they are equally well illuminated and the cells are held the same distance away. In other applications, the circuit can be used without adjustment as a function of light ambient, to detect people passing doorways, the passage of electric trains in a model railroad setup, the opening and closing of doors, and so on. The output of the circuit as it is indicated here is simply a meter movement. By adding another stage of gain, the circuit will trip a relatively inexpensive relay. This in turn can be connected to a counter or other device such as a buzzer.

Operation of the circuit relies on the fact that the photo-cell impedance changes with light intensity. With no illumination, the resistance of the photo-cells is very high – in excess of a megohm. The difference between the collector currents of the two stages then determines the current that will flow through the meter. The individual collector currents are dictated by the bias resistors R1 and R4, and by the balance potentiometer R5. R5 is adjusted so that the collector currents are equal and the meter has no deflection. Illumination of one of the cells lowers its impedance drastically – ordinary room illumination lowers it to 4k ohm, while a flashlight beam will lower it to roughly 400 ohms. When the impedance of one cell is lowered in this manner, it drops the voltage of the collector to which it is connected. If the second photo-cell is not subjected to the same light intensity, the voltage drop at the collector of the first transistor appears across the meter, causing a current to flow through it. Note that with the photocells used, attention to polarity is not required.

PARTS LIST

Q1, Q2 — Sylvania 2N1266 transistor
R1, R4 — 120 k, ½ w
R2, R3 — 680 Ω, ½ w
R5 — 5 k potentiometer, ½ w
B1 — 4.5-volt battery
M1 — 1 ma d-c meter, zero-centered
PE1, PE2 — Sylvania CDS-9M photo-electric cell

* * *

29. RAIN ALARM CIRCUIT

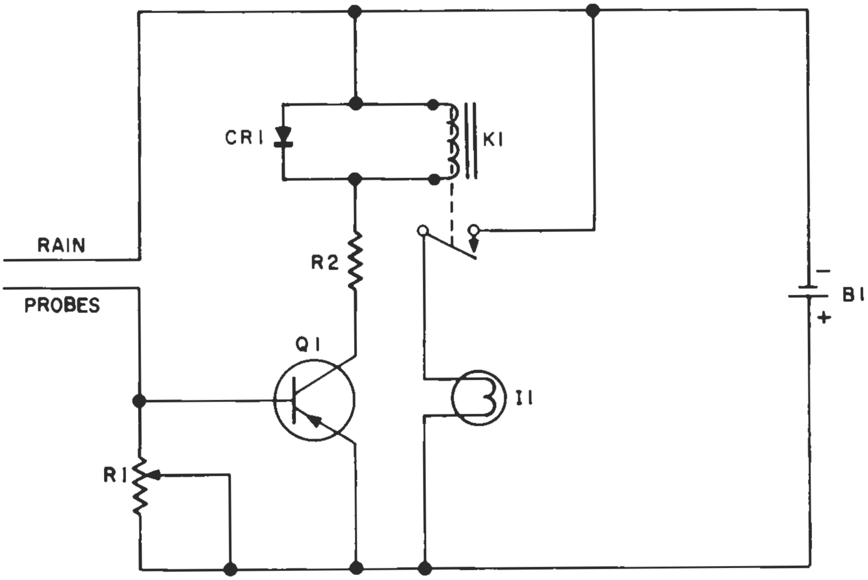


FIGURE 29 — RAIN ALARM CIRCUIT

How many times have we been caught off guard by unexpected rain? By using this circuit to provide an alarm or to activate mechanisms, much of this inconvenience can be done away with. When a drop of water falls across the probes of this sensitive circuit, a relay closes. The relay can be used to control any number of devices. Among these would be included a buzzer to provide an audible warning that it is time to get the clothes off the line. Another application would use the relay to energize a solenoid-controlled pin-lock on windows, closing them when the rain starts. If any high-current devices such as solenoids or motors are to be controlled, it would be well to use an intermediate relay in the circuit. The contacts of the sensitive relay would then be used to energize the coil of a relay having high current-capacity contacts.

Convertibles can be kept dry by connecting the circuit directly to a 12-volt auto battery, mounting the detector probes just forward of the windshield, and using the relay to control the motor which puts up the top. Again, an intermediate relay should be used for the heavy-current requirements. For this application, the output of the detector circuit should be interlocked wih the ignition so that it will operate only when the car is parked.

The configuration used for the detector circuit uses the impedance provided by the drop of rain water to control the bias current for the transistor, which is used as a grounded-emitter amplifier. When a drop of water falls on the probes, a small current flows through it to the transistor. The amplfied output current of the transistor flows through relay K1, pulling in its armature. The schematic shows only a pilot light connected to the output. However, the relay contacts can be used to control any of the many functions mentioned above. Potentiometer R1 is a shunt across the control junction of the transistor. If its value is low, a large part of the current flowing through the drop of rain will flow through R1 instead of through the transistor. In this manner, decreasing the value of R1 will decrease the sensitivity of the circuit. Decreased sensitivity might be desired to avoid nuisance trips in which the crcuit responds to a single drop of water instead of to several of them. Diode CR1 is used to short the high voltage spike generated by the inductance of relay K1 when the transistor cuts off. It allows the energy from the inductance to dissipate in the resistance of the relay coil.

The probe is easily constructed by supporting two bare conductors (copper, bare or tinned) so that they run parallel to each other with a separation of about 1/16th of an inch. A two-inch length is adequate. Several probes constructed in this manner can be connected in parallel, all of them feeding the same circuit. In this case, they would be mounted in different locations. It is well to keep the probe wires slightly elevated from underneath surfaces, since surface contamination might in itself produce a low enough impedance to trip the circuit.

PARTS LIST

B1 — 12-volt battery
CR1 — Sylvania 1N34A diode
I1 — 12-volt indicator lamp
K1 — 1 kohm sensitive relay
(Sigma 11F-1000G or equivalent)
Q1 — Sylvania 2N1265 transistor
R1 — 5 k, ½ w potentiometer
R2 — 220 Ω, 1 w

30. WIRELESS REMOTE PHOTO FLASH

Frequently in photography, a single photo-flash unit on the camera gives rise to unsatisfactory results. Failure to edge-light profiles and thus provide relief and definition, produces a picture which is flat and lacks interesting texture. A clever solution to the problem is afforded by this slave photo-flash unit, which is triggered by the light of the flash attached to the camera. By placing this slave unit off to one side, lighting will be cast on the subject in addition to that provided by the main flash unit.

It is essential, in placing the slave-flash unit off to the side, to point the sun battery to receive light from the flash on the camera. If light from the camera flash fails to illuminate the sun battery cell, the slave unit will not function properly. Another precaution which should be taken is to affix some sort of light shield on the camera side of the slave flash. Although the slave flash is not in direct view of the camera and hence does not appear in the picture, this precaution will prevent the possibility of light from the slave unit being received directly by the camera. Any of the standard flashbulbs can be used with circuit. The use of a white or blue bulb is determined, as it is for the main flash unit, by the type of film in the camera.

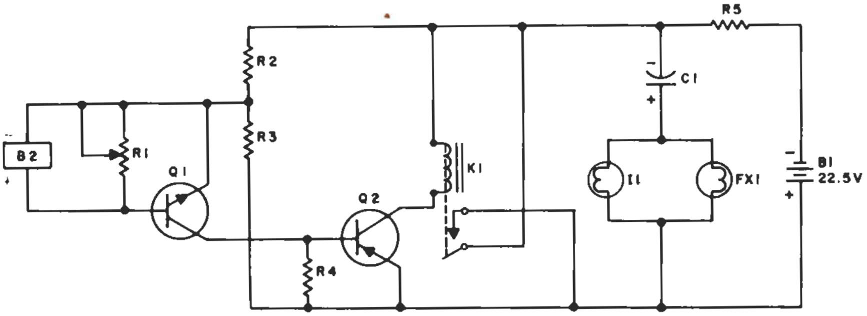


FIGURE 30 — WIRELESS REMOTE PHOTO FLASH

Operation of the slave unit depends on a sun battery, a direct-coupled wideband amplifier, and a conventional battery-capacitor firing circuit. By using a wide-band amplifier, a fast response time is obtained – assuring the slave flash will fire while the camera shutter is still open. Transistors Q1 and Q2 constitute the amplifier, both being grounded-emitter stages. When light impinges on the sun battery B2, a current is generated which forward biases transistor Q1. As the light intensity increases, the bias and hence the collector current of Q1 increases. Since a large part of this collector current is simply bias current for transistor Q2, the collector current in the second stage also increases. As it increases, it causes the armature of relay K1 to pull in. In closing, the contacts of K1 connect capacitor C1 directly across the parallel combination of the indicator light and flashbulb. With the relay open, capacitor C1 is charged to 22½ volts. When the relay closes, the capacitor discharges, firing the slave flashbulb. Resistor R1 provides a means of adjusting the firing sensitivity of the circuit. When the arm on R1 is adjusted to completely short out the resistor, the sun battery output is shorted and no bias current flows through transistor Q1. As the arm is backed off, the loading on the sun battery is reduced, and more of the generated current serves to bias the transistor. To adjust the circuit for the light level in a given room, remove the flashbulb and slowly turn the sensitivity control until the circuit just starts to make a buzzing sound. Indicator lamp I1 will glow. Now turn the control back, to a point just beyond that where the indicator light goes out. Be sure that you are not shielding any of the normal room light from the sun battery when making this adjustment or it will fire when you back away. The flashbulb can now be inserted, and the circuit is ready to fire upon receipt of the flash from the main camera flash unit.

PARTS LIST

B1 — 22½-volt battery
B2 — Sun battery, International Rectifier Corp. Type B2M or equivalent
C1 — 100 mfd electrolytic, 25-volt
FX1 — Flashbulb — any conventional type consistent with power supply and socket
I1 — 6-10-volt indicator lamp such as #51 or #47
Ki — 500 ohm relay, single-pole, single-throw, normally open Sigma Type 550 G-11F or equivalent
Q1 — Sylvania 2N229 transistor
Q2 — Sylvania 2N255 transistor
R1 — 10 k, ½ w potentiometer
R2, R3 — 15 k, ½ w
R4 — 470 Ω, ½ w
R5 — 100 Ω, ½ w

GENERAL DATA ON SYLVANIA GERMANIUM TRANSISTORS**

Revision of Nov. 15, 1959

				Maximum Ratings					Characteristics							
									DC Current Gain, hFE		Cutoff Current (ua maximum at rated voltage)		Cutoff Frequency (Minimum Values)			
Type	Application	Class	Outline	Max. Diss. at 25°C Ambient	Max. VCB	Max. VCE	Max. IC(ma)	Max. Junction Temp.(°C)	Min.	Max.	ICBO	ICER(1)	fab(mc)	fae(mc)	Circuit Power Gain db (typical)	Sylvania Socket No.
RF-IF AMPLIFIER									Limits shown are typical distribution limits.							
2N94	IF Amplifier	NPN	A	50 mw	....	20	50	75	10	80	....	50	2	....	26 (3)	7460-0013
2N94A	RF-IF Amplifier	NPN	A	50 mw	20	20	50	85	19(2) (270cps)	....	....	50	5	....	....	7460-0013
2N139	IF Amplifier	PNP	A,B(4)	80 mw	....	—20	15	85	22(2)	110(2)	5(—12.v)	50(—18.v)	....	....	26.5 (3)	7460-0013
*2N169A	IF Amplifier	NPN	C	65 mw	25	25	20	75	36(2)	220(2)	5(5)	....	2		25	7460-0013
*2N216	IF Amplifier	NPN	A	50 mw	....	18	10	75	5(2)(3)	15(2)(3)	....	50	2	....	26 (3)	7460-0013
2N218	IF Amplifier	PNP	A	80 mw	....	—20	....	85	22(2)1.kc	110(2)1.kc	5(7)	50(—18.v)	....	....	26.5 (3)	7460-0013
2N233	IF Amplifier	NPN	A	50 mw	10	10	50	75	10		....	50	....	....	21 (min)	7460-0013
2N233A	IF Amplifier	NPN	A	50 mw	....	18	50	75	10	50	....	50	2		24 (3)	7460-0013
2N247	1.5mc (Drift) Amplifier	PNP	D	35 mw	—40	VEB- —0.5	10	100	20(2)	175(2)	50	....		....	27 (1.5mc)	....
*2N292	IF Amplifier	NPN	C	65 mw	15	15	20	85	6(2)	44(2)	5	....	5(6)	....	25 (3)	7460-0013
2N370	20mc RF Amplifier	PNP	D	80 mw	—24	VEB- —0.5	10	100	40(2)	175(2)	10(7)	....	....	....	14 (20mc)	....
2N373	IF Amplifier (Drift)	PNP	D	80 mw	—25	VEB- —0.5	10	85	20(2)1.kc.	175(2)	16(7)	....	....	....	38 (3)	....
2N409	IF Amplifier	PNP	A,B(4)	50 mw	....	—20	....	75	22(2)	110(2)	5(7)	....		....	26 (3)	7460-0013
*2N410	IF Amplifier	PNP	E	50 mw	....	—20	....	75	22(2)	110(2)	5(7)	....	....		26 (3)	7460-0013
*2N413A	IF Amplifier	PNP	F(9)	150 mw	—20	—15	200	85	....	....	10	....	2	....	32 (3)	7460-0014
*2N414A	IF Amplifier	PNP	F(9)	150 mw	—30	—15	200	85	....	....	20	....	4		35 (3)	7460-0014
*2N506	IF Amplifier	PNP	A	50 mw	—40	....	100	85	25	50	125	....	.600	....	....	7460-0013
2N507	IF Amplifier	NPN	A	50 mw	40	....	100	85	25	50	125	....	.600	....	....	7460-0013
2N515	IF Amplifier	NPN	A	50 mw	....	18	10	75	25	50	....	50	2	....	25	7460-0013
2N516	IF Amplifier	NPN	A	50 mw	....	18	10	75	5(2.3)	15(2,3)	....	50	2	....	27 (3)	7460-0013
*2N517	IF Amplifier	NPN	A	50 mw	....	18	10	75	10	60	....	50	2	....	28.5 (3)	7460-0013
*2N544	RF-IF Amplifier (Drift)	PNP	D	80 mw	—18	VEB- —0.5v	10	100	20(2)	175(2)	16(7)	....	....	....	35 (1.5mc)	....
2N624	12.5mc Amplifier (Drift)	PNP	G	100 mw	—30	—20	....	100	20(2)	....	30	20(10)	....	....	22 (12.5mc)	7460-0014
*2N1264	IF Amplifier (Drift)	PNP	D	50 mw	—20	....	10	75	15(2)	....	50	....		....	15 (min)1.5mc	....
2N1266	IF Amplifier	PNP	A	80 mw	....	—10	....	85	10(2)	....	....	100	....	....	20 (min) (3)	7460-0013
OSCILLATOR																
*2N193	Oscillator	NPN	A	50 mw	....	18	50	75	4(2,3)	15(2,3)	....	50	2		....	7460-0013
*2N211	Oscillator	NPN	A	50 mw	....	10	50	75	5(2,3)	15(2,3)	....	20	2	....	....	7460-0013
2N371	20mc Oscillator (Drift)	PNP	D	80 mw	—24	VEB- —0.5	10	100	20(2)	400(2)	10(7)	....	....	....	14 (20mc)	......
2N1265	Audio Oscillator	PNP	A	50 mw	....	—10	100	85	25(2)1.kc	....	....	100	.600	....	37	......

*Available only from authorized Sylvania Distributors.

**For more complete technical data, refer to Engineering Data Service sheets for each type.

GENERAL DATA ON SYLVANIA GERMANIUM TRANSISTORS**

				Maximum Ratings					Characteristics							
									DC Current Gain, hFE		Cutoff Current (ua maximum at rated voltage)		Cutoff Frequency (Minimum Values)			
Type	Application	Class	Outline	Max. Diss. at 25°C Ambient	Max. VCB	Max. VCE	Max. IC(ma)	Max. Junction Temp.(°C)	Min.	Max.	ICBO	ICER(1)	fab(mc)	fae(mc)	Circuit Power Gain db (typical)	Sylvania Socket No.
MIXER-CONVERTER																
2N140	Converter	PNP	A,B(4)	80 mw	....	—20	15	85	22(2)1.kc	110(2)1.kc	5(7)		5		Mixer 18 (min) Gain	7460-0013
*2N168A	Converter	NPN	C	65 mw	15	15	20	85	23(2)	135(2)	5	..	5		25	7460-0013
2N194	Mixer	NPN	A	50 mw	....	18	50	75	5(2,3)	15(2,3)	....	50	2		15	7460-0013
2N194A	Converter	NPN	A	50 mw	....	18	50	75	5(2,3)	15(2,3)	....	50	2	..	23	7460-0013
2N212	Converter	NPN	A	50 mw	....	18	50	75	10(2,3)	30(2,3)	...	50	4		30	7460-0013
2N372	20mc Mixer (Drift)	PNP	D	80 mw	—24	VEB- —0.5	10	100	20(2)	175(2)	10(7)	...	..	.	14 (20mc)	....
2N374	Converter (Drift)	PNP	D	80 mw	—25	VEB- —0.5	10	100	20(2)	175(2)	16(7)	....	....	....	40 (3)	....
2N411	Converter	PNP	A,B(4)	80 mw	....	—20	....	85	22(2)	110(2)	5(7)		7(6)		18	7460-0013
*2N412	Converter	PNP	E	50 mw	....	—20	....	75	22(2)	110(2)	5(7)	...	7(6)	....	18	....
2N1058	Converter	NPN	A	50 mw	....	—18	....	75	10(2)	23(2)	...	50	4		24	7460-0013
AUDIO DRIVER AND MEDIUM POWER																
2N34	Audio Driver	PNP	A	150 mw	—40	—25	100	75	25(2)	125(2)	50	100	..	5 kc	37	7460-0013
2N35	Audio Driver	NPN	A	150 mw	40	25	100	75	25(2)	125(2)	50	100		10 kc	37	7460-0013
2N109	Audio Driver	PNP	A,B(4)	50 mw	—25	....	75	85	50	150	12(11)	....	...	....	....	7460-0013
2N213	Audio Driver	NPN	A	150 mw	40	25	100	85	70(2)	250(2)	50	100		10 kc	40	7460-0013
2N213A	Audio Driver	NPN	A	150 mw	40	25	100	85	100(2)	250(2)	50	100		10 kc	40	7460-0013
2N214	Audio P.P. Output	NPN	A	180 mw	40	25	100	85	50(12)	100	50	100		10 kc	28	7460-0013
*2N217	Audio Driver	PNP	A	....	—25	....	75	85	50	150	12(11)(16)	..		....	....	7460-0013
2N228	Audio Driver	NPN	A	50 mw	40	15	100	75	50	100	100	100		10 kc	24.5	7460-0013
2N229	Audio Driver	NPN	A	50 mw	...	10		75	25(2)	....	....	100	.600	...	37	7460-0013
*2N241A	Medium Power	PNP	H(Rev)	200 mw	..	—30	200	85	50(12)	100	16(—25v)	100(—25v)(14)	....	10 kc(Typ)	36 (Min)	....
*2N270	Audio Driver	PNP	B(13)	150 mw	—25	..	75	85	50	100	....	12(—30v)(11)	....	...	....	7460-0013
2N306	Audio Driver	NPN	A	50 mw	20	15	100	85	25	125	50	100	.600	...	37	7460-0013
*2N321	Audio Output	PNP	L	200 mw	—25	—25	200	85	50(12)	100	16	100(14)	...	10 kc(Typ)	36 (Min)	....
*2N323	Audio Output	PNP	J	140 mw	—16	—16(1)	100	85	50	150	16		0.8		....	7460-0014
*2N381	Push Pull Audio	PNP	J	200 mw	—25	—25	200	85	24(12)	45	20	100	.01		28 (Min)	7460-0014
*2N382	Push Pull Audio	PNP	J	200 mw	—25	—25	200	85	40(12)	76	20	100(14)	..	.01(6)	34	7460-0014
*2N383	Push Pull Audio	PNP	J	200 mw	....	—30	200	85	55(12)	110	20(—25v)	70(14)	....	.01(Typ)	36 (Min)	7460-0014
2N405	Audio Driver	PNP	A	150 mw	—20	—18	35	75	20(2)	80(2)	14(7)	200(10)	.250	...	....	7460-0013
*2N406	Audio Driver	PNP	E	150 mw	—20	—18	35	75	20(2)	80(2)	14(7)	200(10)	.250	..	....	....
2N407	Push Pull Audio	PNP	A,B(4)	150 mw	—20	—18	70	85	50(12)	135	14(7)	250(15)	....	....	33	7460-0013
*2N408	Push Pull Audio	PNP	E	150 mw	—20	—18	70	85	50(12)	135	14(7)	250(15)		....	33	....
*2N527	Audio Driver	PNP	J	225 mw	—45	—30	500	85	72	121	10(16)	600	1.5		....	7460-0014
*2N1008A	Audio Driver	PNP	F (No tab)	400 mw	—40	—40	300	85	40(2)	150(2)	10(—25v)	....	....	.025(Typ)	....	....

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**For more complete technical data, refer to Engineering Data Service sheets for each type.

GENERAL DATA ON SYLVANIA GERMANIUM TRANSISTORS**

					Maximum Ratings			Characteristics								
									DC Current Gain, hFE		Cutoff Current (ua maximum at rated voltage)		Cutoff Frequency (Minimum Values)			
Type	Application	Class	Outline	Max. Diss. at 25°C Ambient	Max. VCB	Max. VCE	Max. IC(ma)	Max. Junction Temp.(°C)	Min.	Max.	ICBO	ICER(1)	fab(mc)	fae(mc)	Circuit Power Gain db (typical)	Sylvania Socket No.
AUDIO DRIVER AND MEDIUM POWER (cont.)																
***2N1009**	Audio Driver	PNP	F	....	—25	—25	20	85	40(2)	....	800 (VCB- —10v	1ma T—85°C)	...	....	.	7460-0014
2N1059	Push Pull Audio	NPN	A	180 mw	20	15	100	75	50(12)	100	50	100(14)	....	10 kc	28	7460-0013
2N1101	Push Pull Audio	NPN	A	180 mw	20	15	100	75	25(12)	50	50	500(14)	...	10 kc	....	7460-0013
2N1102	Push Pull Audio	NPN	A	180 mw	40	25	100	75	25(12)	50	50	100(14)	...	10 kc	..	7460-0013
2N1251	Audio Driver	NPN	A	150 mw	20	15	100	85	70(2)	250(2)	50	100	...	7.5 kc	40	7460-0013
2N1265	Audio Amplifier	PNP	A	50 mw	....	—10	100	85	25(2)	....	....	100	.600	...	37	7460-0013
2N1432	Linear Amp. (Drift)	PNP	G	80 mw	—35	..	10	85	30(2)	120(2)	15(45v)	.		1.5	.	7460-0014
2N1381	Audio Driver	PNP	F	150 mw	—25	...	50	100	30	300	100		..	...		7460-0014
2N1431	Push Pull Audio	NPN	A	180 mw	25	15	100	75	75(12)	150	50(24)	100	..	.01	30	7460-0013
HIGH POWER AUDIO																
2N101/13	Audio Power	PNP	I(rev.)	4.w(17)	—30	—30	1.5A	75	10.5		....	5ma(—15v)	....	....	...	....
2N102/13	Audio Power	NPN	I(rev.)	4.w(17)	30	30	1.5A	75	10.5	...	....	5ma(10)	....	....	...	....
2N143/13	Audio Power	PNP	I(rev.)	4.w(17)	—60	—60	800	75	10.5	...	....	5ma(—30v)	....	....	....	....
2N144/13	Audio Power	NPN	I(rev.)	4.w(17)	60	60	800	75	10.5	....	....	5ma(10)	....	....	....	....
***2N155**	Audio Power	PNP	K	8.5 w(17)	—30	....	3A	85	24	..	1ma	....	...	.010	32	....
***2N156**	Audio Power	PNP	K	8.5 w(17)	—30	...	3A	85	24	....	1ma	1.5(10)	.	.010	32	....
***2N176**	Audio Power	PNP	K	10 w at 80°C(17)	....	—30	3A	90	25(2)	90(2)	3ma	....		.010	35.5	....
***2N235A**	Audio Power	PNP	K	25 w(17)	—40	....	3A	90	50(2)	....	1ma	....	.	.010	34(19	......
***2N235B**	Audio Power	PNP	K	32 w(17)	....	—35	3A	95	60(2,6)	....	....	100ma(6,18)	....	.006	36(19)	....
***2N236B**	Audio Power	PNP	K	35 w(17)	....	—40	3A	95	60(2,6)	..	...	200ma(18)	..	.007	36(20)	......
***2N242**	Audio Power	PNP	K	50 w(17)	—45	—45	2A	100	....	...	....	3ma(18)	.	.007	36(19)	......
***2N250**	Audio Power	PNP	K	25 w(17)	—30	...	3A	85	50(2)		1ma	5ma(18)	...	.006	34(19)	......
***2N255**	Audio Power	PNP	K	6.25 w(17)	—15	..	3A	85	15	...	....	3ma(18)	.100	....	21(19)	....
***2N256**	Audio Power	PNP	K	6.25 w(17)	—30	.	3A	85	15	...	....	3ma(18)	.100	....	25(19)	......
***2N257**	Audio Power	PNP	K	25 w(17)	—40	—25	2A	85	50(2)	..	2ma	5ma(18)	....	.007	33(19)	....
***2N268**	Audio Power	PNP	K	25 w(17)	—80	....	2A	85	35(6)	.	2ma	....	....	.006	28(19)	....
***2N285A**	Audio Power	PNP	K	32 w(17)	....	—35	3A	95	150(2,6)	..	....	2ma(18)	.	.004	.	....
***2N296**	Audio Power	PNP	K	25 w(17)	....	—60	2A	100	20	.	....	2ma(18)	...	.004	....	....
***2N301A**	Audio Power	PNP	K	12 w at 55°C(17)	—60	...	2A	85		..	5ma	300(21)	....	....	35(20)	....
***2N307**	Audio Power	PNP	K	10 w(17)	—35	—35	2A	75	21	.		15ma(18)	...	.0035	...	....
***2N307A**	Audio Power	PNP	K	17 w(17)	—35	—35	2A	75	25	...	....	5ma(18)	...	.005	33(19)	....
***2N350**	Audio Power	PNP	K	10 w at 80°C(17)	—40	....	3A	100	20	60	3ma(16)	....		.005	31.5(20)	....

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GENERAL DATA ON SYLVANIA GERMANIUM TRANSISTORS**

				Maximum Ratings				Characteristics								
									OC Current Gain, hFE		Cutoff Current (ua maximum at rated voltage)		Cutoff Frequency (Minimum Values)			
Type	Application	Class	Outline	Max. Diss. at 25°C Ambient	Max. VCB	Max. VCE	Max. IC(ma)	Max. Junction Temp.(°C)	Min.	Max.	ICBO	ICER(1)	fab(mc)	fae(mc)	Circuit Power Gain db (typical)	Sylvania Socket No.
***2N351**	Audio Power	PNP	K	10 w at 80°C(17)	—40	....	3A	100	25	90	3ma(16)	....		.005	33.5(20)	....
***2N399**	Audio Power	PNP	K	29 w(17)	..	—40	3A	90	40(2,6)	...	1ma(6)	200ma(6,18)		.007	38(19)	....
***2N401**	Audio Power	PNP	K	29 w(17)	..	—40	3A	90	40(2,6)	....	1ma(6)	200ma(6,18)		.007	33.5(19)	....
***2N419**	Power Supply	PNP	K	32 w(17)	.	—45	3A	95	9	44	1ma(6)	200ma(6,18)		...	...	....
***2N420**	Power Supply	PNP	K	34 w(17)	..	—40	5A	100	40		1ma(6)	200ma(18)	.	...	....	....
***2N554**	Audio Power	PNP	K	10 w at 80°C(17)	.	—28	3A	100	30(2,6)			100ma(22)		.008(6)	32(19)	....
COMPUTER — SWITCHING																
2N123	Switching	PNP	F	100 mw	—20	—15	125	85	30	150	6	600(22)	5	..	..	7460-0014
2N312	Switching	NPN	F	100 mw	15	15	200	85	25	75	15	500	tr+td=1.5 us max. t off=3.0 us max.		....	7460-0014
2N356	Switching	NPN	F	100 mw	20	18	500	85	20	50	25	100	3(6)	.	.	7460-0014
2N357	Switching	NPN	F	100 mw	20	15	500	85	20	50	25	100	6(6)		.	7460-0014
2N358	Switching	NPN	F	100 mw	20	12	500	85	20	50	25	100	9(6)	....	....	7460-0014
2N377	Switching	NPN	J	150 mw	25	20	200	100	20	60	10	50	tr+td=2.5 us max. tf=1.0 us max.			7460-0014
2N377A	Switching	NPN	J	150 mw	40	20	200	100	20	60	40	50	tr+td=2.5 us max. tf=1.0 us max.			7460-0014
2N385	Switching	NPN	J	150 mw	25	25	200	100	30	110	10	100	4		...	7460-0014
2N385A	Switching	NPN	J	150 mw	40	25	200	100	30	110	40	50	4		....	7460-0014
2N388	Switching	NPN	J	150 mw	25	20	200	100	60	180	10	50	tr+td=1.0 us max. tf=1.0 us max.			7460-0014
2N388A	Switching	NPN	J	150 mw	25	20	200	100	60	180	40	50	tr+td=1.0 us max. tf=1.0 us max.			7460-0014
2N404	Switching	PNP	F	120 mw	—25	—24	100	85	....		20	..	4	....	....	7460-0014
2N414	Switching	PNP	F	....	—30	—15	200	85	30(2)	90(2)	5(—12)	300(22)	5	....	....	7460-0014
2N425	Switching	PNP	F	150 mw	—30	—20	400	85	20	40	25	.	2.5	...	....	7460-0014
2N426	Switching	PNP	F	150 mw	—30	—18	400	85	30	60	25	.	3	..	....	7460-0014
2N427	Switching	PNP	F	150 mw	—30	—15	400	85	40	80	25	.	5	.	....	7460-0014
2N428	Switching	PNP	F	150 mw	—30	—12	400	85	60	..	25	..	10	....	....	7460-0014
2N438	Switching	NPN	F	100 mw	30	25	...	85	20	....	10(25v)	....	.	2.5	tr=0.7 us, tf=0.5 us	7460-0014
2N439	Switching	NPN	F	100 mw	30	20	...	85	30	.	10	300(22)	5	...	....	7460-0014
2N440	Switching	NPN	F	100 mw	30	15	.	85	40	....	10	300(22)	10	...	....	7460-0014
2N556	Switching	NPN	F	100 mw	25	20	200	85	38	75	25	100	tr=3.5 us max. to=2.0 us max.			7460-0014
2N438A	Switching	NPN	J	150 mw	25	....	200	85	15		10		tr=0.7 us max. tf=0.5 us max.			7460-0014
2N439A	Switching	NPN	J	150 mw	25	...	200	85	30		10		tr=0.5 us max. tf=0.3 us max.			7460-0014
2N440A	Switching	NPN	J	200 mw	25	....	200	85	40	.	10	.	tr=0.3 us max. tf=0.2 us max.			7460-0014
2N519	Switching	PNP	F	100 mw	—25	..	100	85	27		2.5(—1.5v)	....	ts+tf=6. us max.			7460-0014
2N557	Switching	NPN	F	100 mw	20	20	200	85	20	.	25	100	tr=6.5 us max. to=2.5 us max.			7460-0014
2N558	Switching	NPN	F	100 mw	15	15	200	85	20	....	15	100	tr=3.5 us max. to=2.0			7460-0014
2N576	Core Driver	NPN	J	200 mw	20	20	400	100	20	60	20	100	tr+td=2.0 us max. tf=1 us max.			7460-0014

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GENERAL DATA ON SYLVANIA GERMANIUM TRANSISTORS**

				Maximum Ratings					Characteristics							
									DC Current Gain, hFE		Cutoff Current (ua maximum at rated voltage)		Cutoff Frequency (Minimum Values)			
Type	Application	Class	Outline	Max. Diss. at 25°C Ambient	Max. VCB	Max. VCE	Max. IC(ma)	Max. Junction Temp.(°C)	Min.	Max.	ICBO	ICER(1)	fab(mc)	fae(mc)	Circuit Power Gain db (typical)	Sylvania Socket No.
COMPUTER (cont.)																
2N576A	Core Driver	NPN	J	200 mw	40	40	400	100	20	60	40	100(VCE=20v)	tr+td=2.0 us max. tf=1.us max.			7460-0014
2N582	Switching	PNP	F	120 mw	—25	—15	100	71	40	...	5(—12v)		14	....	....	7460-0014
2N585	Switching	NPN	F	120 mw	25	24	200	85	20	....	25	100(24v)	3	..	.	7460-0014
2N587	Switching	NPN	J	150 mw	40	30	200	85	20	.	50	50(30v)	tr=2.0 us max. to=2.us max.			7460-0014
***2N677**	Power Switch	PNP	K	50 w(17)	—50	—30	15A	100	20	60	20ma(23)	200ma(18,24)	tr=15 usec at Ic=10A(6)			...
***2N677A**	Power Switch	PNP	K	50 w(17)	—60	—40	15A	100	20	60	20ma(23)	200ma(18,24)	tf=25 usec at IB=1A(6)			......
***2N677B**	Power Switch	PNP	K	50 w(17)	—90	—70	15A	100	20	60	20ma(23)	200ma(18,24)	(applies to all 2N677)			.. ...
***2N677C**	Power Switch	PNP	K	50 w(17)	—100	—90	15A	100	20	60	20ma(23)	200ma(18,24)	(family types)			.
***2N678**	Power Switch	PNP	K	50 w(17)	—50	—30	15A	100	50	100	20ma(—15v)	T=85°C	tr=15 usec at IC=10A(6)			.. .
***2N678A**	Power Switch	PNP	K	50 w(17)	—60	—40	15A	100	50	100	20ma(—25v)	T=85°C	tf=25 usec at IC=1.0A(6)			. .....
***2N678B**	Power Switch	PNP	K	50 w(17)	—60	—40	15A	100	50	100	25ma(—60v)	T=85°C	(applies to all 2N678 family types)			....
2N679	Switching	NPN	J	150 mw	25	20	200	85	20	.	25	100	ton=5 usec(max.)toff=5 usec(max.)			7460-0014
2N1000	Switching	NPN	F (no tab)	150 mw	40	30	. .	100	25	....	15	300(10)	7.0	. .	.. .	7460-0014
2N1073B	Power Switch	PNP	K	35 w(17)	—120	—120	10A	100	20	60	10(—100v)	50ma		tr=5 us Typ. tf=5 us Typ.		....
2N1114	Switching	NPN	J	150 mw	25	15	200	100	40	180	30	50	7			7460-0014
2N1218	Power Switch	NPN	K	....	45	45	2.A	85	40	160	3ma	4ma	.	7.0	35	....
2N1299	Switching	NPN	J	150 mw	40	20	200	100	35	110	100	100	tr and tf=1.5 usec (each)			7460-0014
2N1302	Switching	NPN	J	150 mw	25	....	300	100	20		6.0	50	3.0	.		7460-0014
2N1304	Switching	NPN	J	150 mw	25	.	300	100	40	200	6.0	50(20v)	5.0	.		7460-0014
2N1306	Switching	NPN	J	150 mw	25	....	300	100	60	300	6.0	50(15v)	10.	.		7460-0014
2N1308	Switching	NPN	J	150 mw	25	....	300	100	80	....	6.0	50(15v)	15.			7460-0014

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NOTES FOR GENERAL DATA ON TRANSISTORS

1. Measured with RBE = 10 K ohms.
2. Small signal current gain, hfe.
3. Measured at 455 kc.
4. Either package may be furnished at manufacturers option.
5. Measured at VCB = 15 volts.
6. Typical value.
7. Measured at VCB = —12 volts.
8. Also has a fourth center-located lead tied to case for shielding.
9. Package may be furnished with or without indexing tab at manufacturers option.
10. Measured with base tied to emitter, ICES.
11. Measured with VEB = —5.
12. Ratings shown are for each unit. Single unit characteristics apply to matched pairs with hFE ratio controlled at IC = 10 and 35 ma.
13. Package diameter = 360" max., package height = .375" max.
14. Measured with RBE = 1 K ohms.
15. Measured with RBE = 75 ohms.
16. Measured with VCB = —30.
17. Adequate heat sink required to maintain mounting base temperature at indicated value.
18. Measured with RBE = 30 ohms.
19. Measured at 2.5 watts output.
20. Measured at 4.0 watts output.
21. Measured with VCB = —32 volts with base tied to emitter, ICES.
22. Measured with base open, ICEO.
23. Measured at half rated voltage.
24. Measured at reduced VCE.

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