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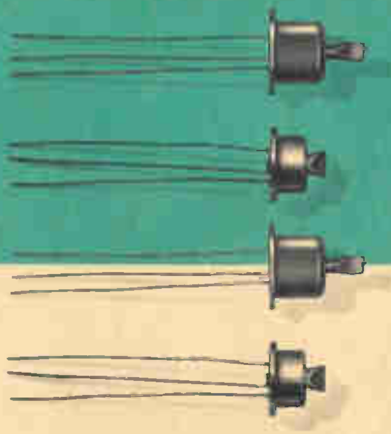

TRANSISTOR MANUAL

• APPLICATIONS • CIRCUITS
• SPECIFICATIONS

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GENERAL ELECTRIC TRANSISTOR MANUAL

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This manual has been prepared to assist the service technician, hobbyist, experimenter, and ham in working with transistors. We have attempted to assemble the information necessary for an understandable working knowledge of the fundamentals and applications of transistors.

The information included covers such topics as Basic Theory, Construction Techniques used to obtain the various types of transistors available, and Principles of Circuit Design, and Specifications, with outline drawings, of all transistors registered with RETMA. Complete explanations of the parameter symbols used are also given. Several Circuit Diagrams, varying from simple amplifiers to high fidelity amplifiers and radios have been included.

Requests for additional information will receive prompt attention if addressed to:

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BASIC SEMICONDUCTOR THEORY

The outer orbit of a germanium atom contains four electrons and a crystal of pure germanium takes the form of a diamond structure as shown in figure 1.

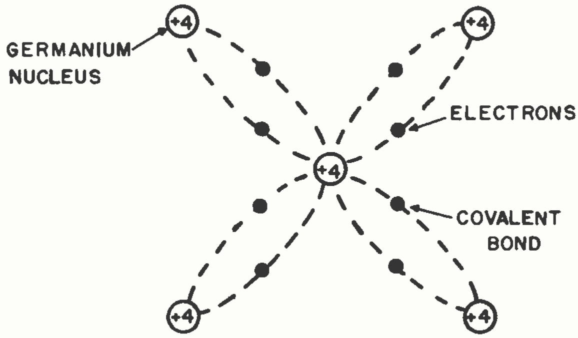


FIGURE 1

The four electrons of each atom form covalent bonds with the adjacent atoms and there are no free electrons. Absolutely pure germanium is therefore a poor conductor. If a voltage is applied to a piece of pure germanium, of the size used in transistors, only a few microamps of current will flow. This current is due to electrons which are broken away from their bonds by thermal agitation and this minute current increases exponentially with temperature.

If an atom with five electrons in the outer orbit such as Antimony or Arsenic is introduced into the crystal, a structure is formed as shown in figure 2. The extra electrons are free to move and under the influence of an electrical field will move toward the positive voltage source. This atom of material other than germanium is called a doping agent and if it results in free electrons in the crystal, the crystal is known as "N" type germanium.

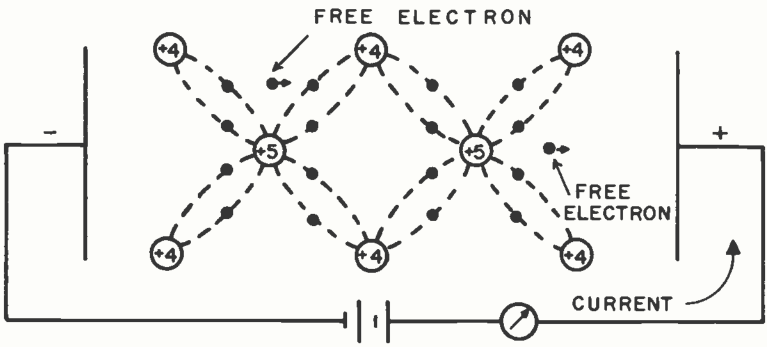


FIGURE 2

If a doping agent is used that only contains three electrons in the outer orbit such as Indium, Gallium or Aluminum, the crystal takes the form of figure 3 where there is a deficiency of one electron and this deficiency is called a hole.

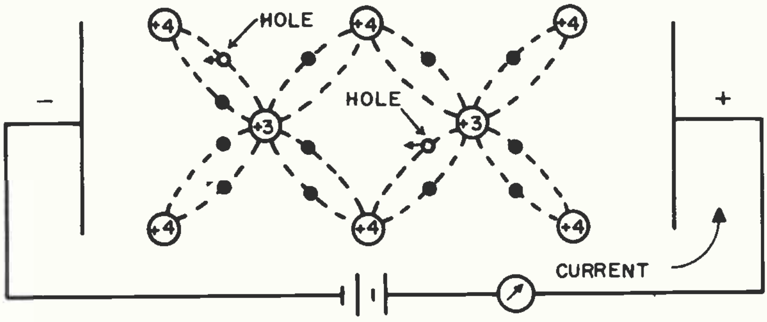


FIGURE 3

Under the influence of an electrical field, electrons will jump into this hole and the hole will appear to proceed towards the negative terminal. This crystal containing a deficiency of electrons is known as "P" type germanium. As far as the external circuit is concerned, it is impossible to differentiate between electron current and hole current. These two modes of conduction are quite distinct however, and are basic to transistor and rectifier theory. With an electrical field of 1 volt/cm in germanium, an electron will move at the rate of 3600 cm/sec whereas a hole will only move at 1700 cm/sec.

If a single crystal of germanium is so doped that it changes abruptly from "N" type to "P" type material and a positive voltage applied to the "P" region and a negative voltage to the "N" region, the situation is as shown in figure 4a.

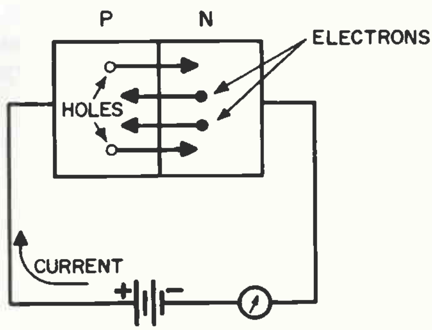


FIGURE 4A

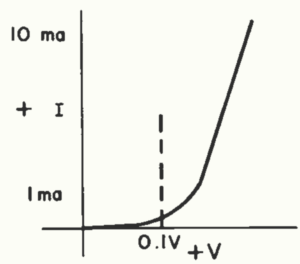


FIGURE 4B

The holes will move to the right across the junction and the electrons will move to the left with the resultant V-I curve shown in figure 4b. If the voltage is applied in the reverse direction, the holes and electrons will both move away from the junction as shown in figure 5a until the electrical field produced by their displacement counteracts the applied electrical field. Under these conditions almost no current will flow in the external circuit and any current that does flow is caused by thermally generated electron hole pairs. The V-I characteristics of a reversed bias junction are shown in figure 5b and it will be noted that the reverse leakage current is essentially independent of voltage up to the point where the junction actually breaks down.

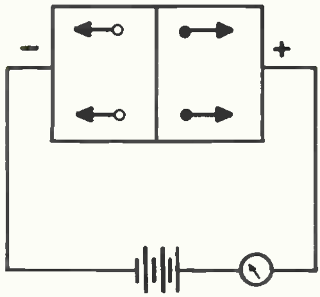


FIGURE 5A

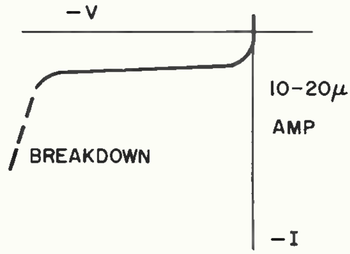


FIGURE 5B

An NPN transistor is formed by a crystal of germanium that is changed from "N" type to "P" type and back to "N" type as indicated in figure 6.

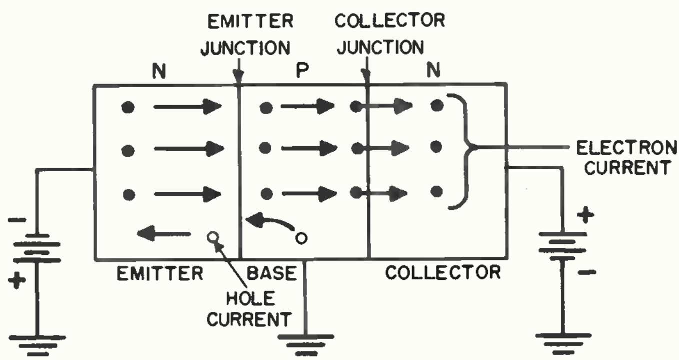


FIGURE 6

With the voltage applied as shown, one N-P junction is forward biased and this is called the emitter junction. The other junction is back biased and this is called the collector junction. The "P" type base region is relatively lightly doped in comparison with the "N" type emitter so that the majority of the current flowing from the emitter to base is electron current and very little of it is hole current. The majority of the electrons that are emitted into the base region diffuse across to the collector junction and pass on to the collector circuit. The ratio of the emitter current to the collector current is called alpha. It is desirable to have alpha as high as possible and this is done by light doping of the base region, using a thin base region on the order of 1 mil, and minimizing the unwanted impurities in germanium that might cause recombination of electrons before they traverse the base region. Alphas of 0.95 to 0.99 are common in commercial transistors. No current (except a small leakage current) will flow in the collector circuit unless current is introduced into the emitter. Since very little voltage (.1 to .5) is needed to cause appreciable current to flow into the emitter, the input power is very low. Almost all the emitter current will flow in the collector circuit where the voltage can be as high as 45 volts. Therefore, a relatively large amount of power can be controlled in an external load and the power gain of a transistor (power out/power in) in the circuit shown is over 1000.

The most common type of junction transistor is the PNP diffused alloyed type. This transistor is made by taking a wafer of "N" type germanium, mounting it on a holder and pressing indium dots into each side. The assembly is then heated in a furnace until the indium melts and the alloys with the germanium forming a "P" layer within the "N" type germanium. The complete assembly is shown by figure 7.

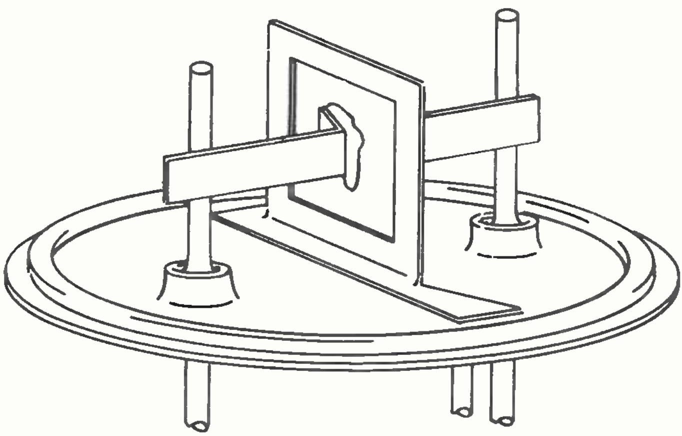


FIGURE 7

This type of transistor has good gain at audio frequencies and is suitable for medium power audio amplifiers since it is possible to pass currents of up to one-half ampere through the transistor. This structure is not as well suited for high frequency amplifiers since the large indium dots produce a high capacitance between collector and base making the unit inherently unstable at high frequencies.

The rate grown transistor is produced by an entirely different technique. A bar of germanium is grown from a bath of molton germanium so doped that the material will change from "P" type to "N" type depending on the temperature and rate of pulling. By suitable growing techniques, 10 to 15 thin "P" type layers are formed in a bar about the size of a cigar. This bar is then sawed up into pieces about 10 mils by 10 mils by 100 mils with the thin "P" layer in the center and long "N" regions on each side. About 7 to 10 thousand transistor bars can be cut from each ingot of germanium. The internal appearance of one of these transistors is shown in figure 8. This transistor has a low collector capacitance and has excellent gain up to several megacycles. It is stable at high frequencies and is ideally suited for the radio frequency section of broadcast receivers. A rate grown transistor also makes an excellent unit for high speed gates and counting circuits.

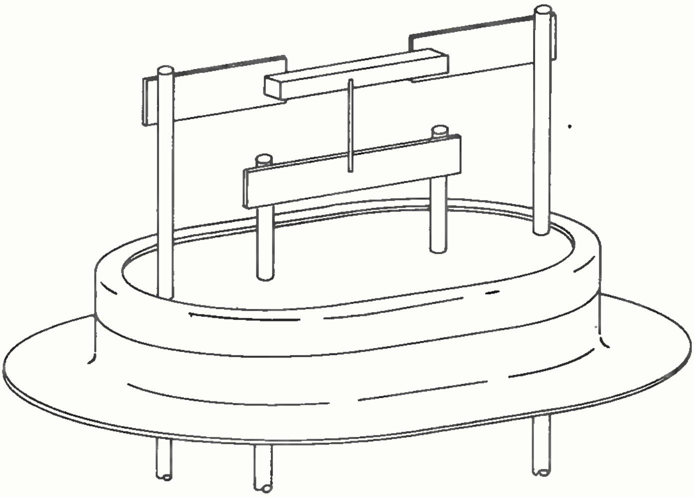


FIGURE 8

The meltback method of transistor construction starts off with a bar of germanium about 10 x 10 x 100 mils. The end of the bar is melted and allowed to refreeze very quickly. By suitable doping of the original material, the junction between the melted portion and the unmelted portion becomes a thin layer of "P" type material and the melted and unmelted portion of "N" type material remains "N" type material. This transistor is essentially a rate grown transistor, but the rate growing is done on an individual small bar rather than on the large germanium ingot. The appearance of a complete meltback triode is shown by figure 9. This fabrication technique has the advantage of obtaining very close control over the base thickness and it is possible to obtain good performance at very high frequencies.

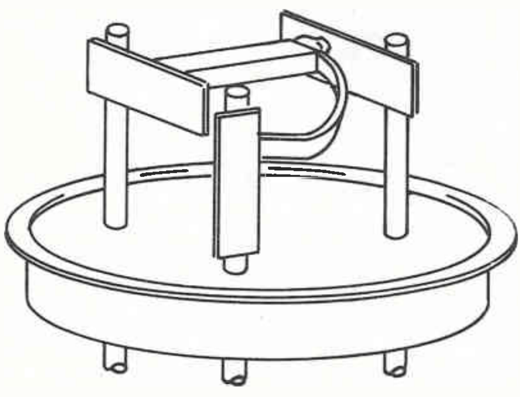


FIGURE 9

By the addition of an extra base connection to a triode, a tetrode is formed. If a current is passed through the base region from one base lead to the other, the active portion of the base region is electrically narrowed and high gain is possible up to 200 mc.

If a suitably made meltback triode is given an additional heat treatment so that the doping agents undergo a diffusion process in the region of the collector junction, a diffused-meltback transistor is formed. This transistor has better high frequency properties than a straight meltback transistor due to the additional control that can be obtained over the impurity distribution.

TRANSISTOR SPECIFICATIONS:

There are many properties of a transistor which can be specified, but this section will only deal with the more important specifications. A fundamental limitation to the use of transistors in circuits is BV_{CER}, the breakdown voltage in the grounded emitter connection. The grounded emitter breakdown voltage is a function of the resistance from the base to the emitter and it is necessary to specify this resistance shown as R in figure 10.

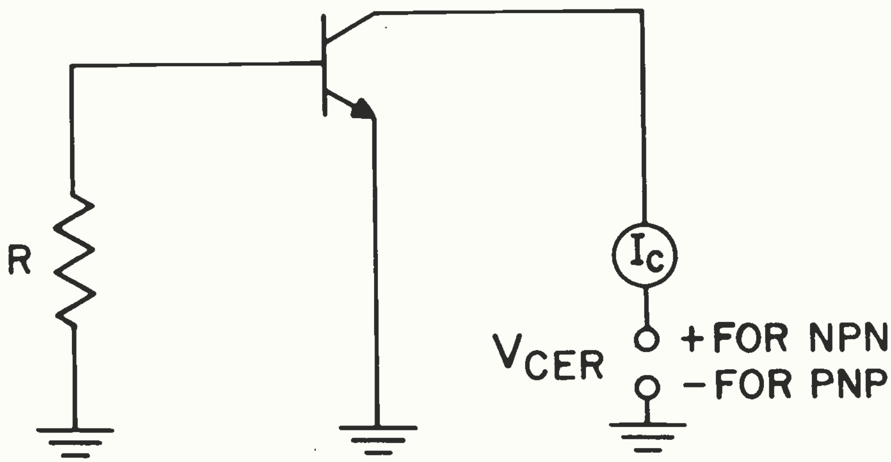


FIGURE 10

Since the breakdown voltage is not sharp, it is also necessary to specify a value of collector current at which breakdown will be considered to have taken place. For example, in PNP audio transistors the collector current is specified to be less than 600 μa with 25 volts applied and the resistance R equal to 10,000 ohms. With NPN transistors, the collector current should be less than 300 μa with 15 volts applied, and the base open-circuited.

A second fundamental property of transistors is the grounded emitter current gain indicated by figure 11. This current gain is known as beta or h_{fe} and is equal to the ratio of an a-c variation in collector current to an a-c variation in base current.

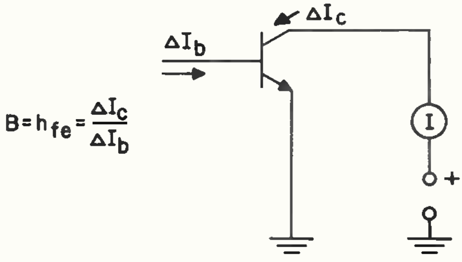


FIGURE 11

This current gain can be specified either for small a-c values of base current or for large values of base current in which case it would be known as h_{FE}, the d-c current gain. The current gain is the most important property of a transistor in determining the gain of audio amplifiers.

With transistors used as radio frequency amplifiers, it is necessary to specify a transformer coupled power gain as indicated in figure 12. The power gain is the ratio of output power to input power under conditions where the input and output impedances are matched by means of the transformers. The input and output impedances must also be specified to select the proper transformer.

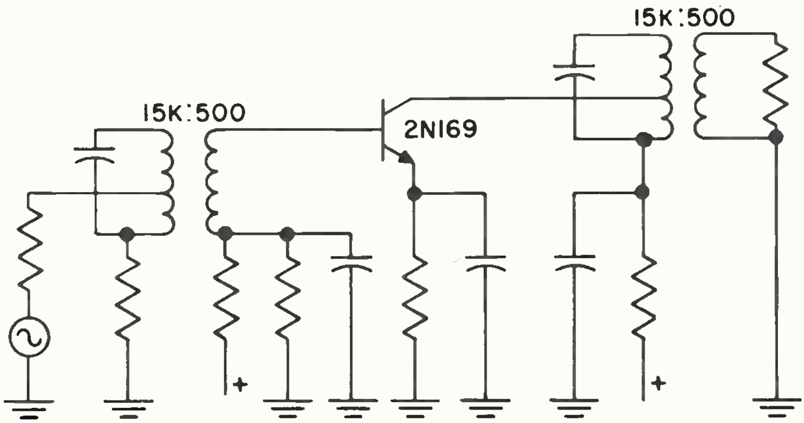


FIGURE 12

Another common transistor specification is the alpha cut-off frequency. This is the frequency at which the grounded base current gain has decreased to 0.7 of its low frequency value. For audio transistors, the alpha cut-off frequency is in the region of 1 mc. For transistors used in the rf section of radios, the alpha cut-off frequency should be 3 to 15 mcs. Other examples of transistor specifications are shown on the specification sheets in the next section of the book.

BIASING:

The best method of biasing a transistor is shown in figure 13.

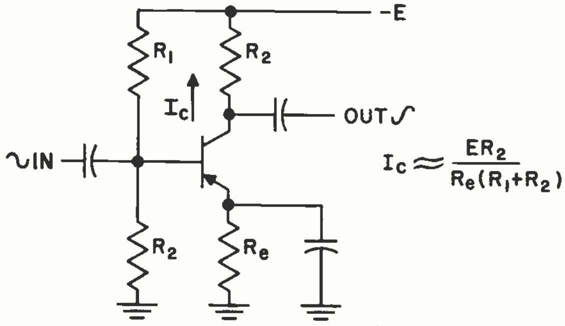


FIGURE 13

A voltage divider consisting of resistors R_1 and R_2 is connected to the base and the resistance R_e is placed in the emitter. Since the emitter junction is forward biased, the current that flows in the emitter circuit is essentially equal to the voltage at the base divided by R_e. To prevent degeneration of the a-c signal to be amplified, the emitter resistance is by-passed with a large capacitance. Good design practice is to make R_2 no larger than 5 to 10 times R_e. A typical value of R_e is 500-1000 ohms.

When the supply voltage is fairly high and wide variations in ambient temperature do not occur, it is possible to use the method of biasing as shown in figure 14. In this circuit, the biasing is done with a resistance R_1 connected from the collector to base. The approximate formula for the collector to emitter voltage is shown in figure 14, and is seen to depend on h_{fe}, the grounded emitter current gain.

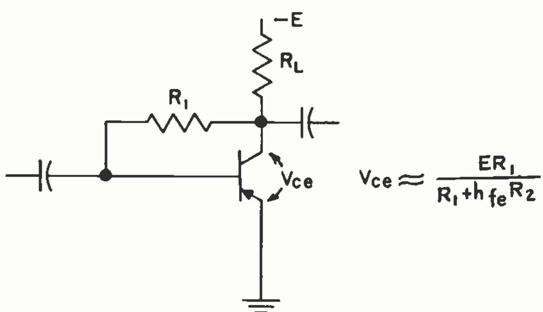


FIGURE 14

This method of biasing requires fairly tight production control over the current gain of the transistors to achieve interchangeability.

A method of biasing which is sometimes used is shown by figure 15. The base is simply connected to the supply voltage through a large resistance which, in essence, supplies a fixed value of base current to the transistor. This method of biasing is

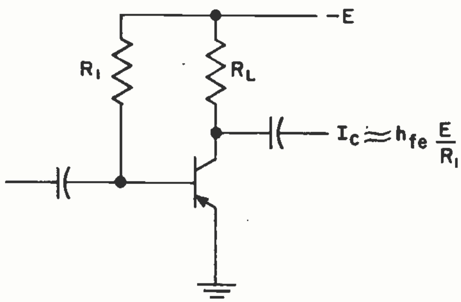


FIGURE 15

extremely dependent upon h_{fe} of the transistor and is not recommended except in circuits where the biasing resistance can be individually adjusted for optimum results.

POWER SUPPLIES:

The low power drain of transistors makes dry batteries practical as a d-c power source for radios and other portable equipment. The necessary d-c voltage can also be obtained from the a-c line with a simple rectifier and filter circuit. An excellent rectifier for this circuit is the 1N92 which is hermetically sealed diffused junction germanium rectifier capable of carrying over 250 ma at room temperature.

For a Class A amplifier, a resistor (1K to 10K) in series with the rectifier will reduce the line voltage to the proper value and a 50 μfd capacitor from the rectifier output to ground will give adequate filtering. An extra R-C filter may be necessary for additional decoupling of the first stages of the amplifier.

The current drain of a Class B push-pull amplifier varies with output power and it is necessary to have a low impedance power supply to prevent distortion. If it is desired to operate a Class B amplifier from the a-c line, a voltage regulator circuit can be used to reduce the apparent impedance of the power supply. A 12 volt regulated power supply is shown in the circuits section of the manual. This circuit uses a step-down transformer and full wave rectifier as a source of unregulated d-c. A power transistor acts as a series regulator and mercury batteries are used for the voltage reference. The battery drain is very small so their life is essentially equal to the shelf life.

TRANSISTOR APPLICATIONS

SINGLE STAGE AUDIO AMPLIFIER

Figure 16 shows a typical single stage audio amplifier using a 2N190 PNP transistor.

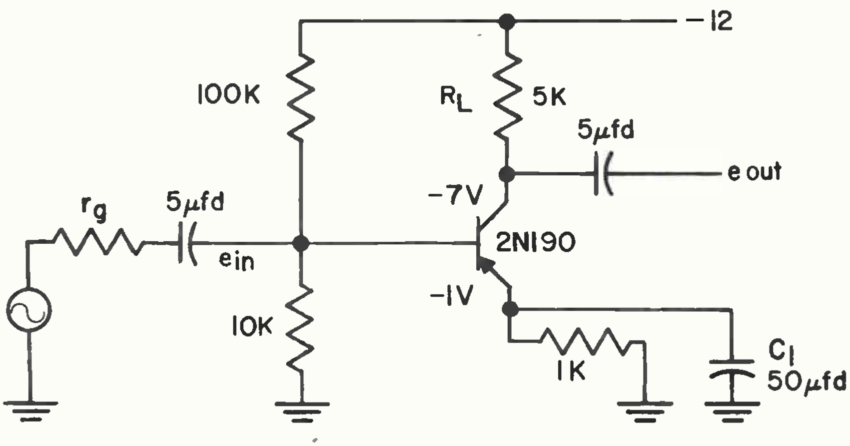
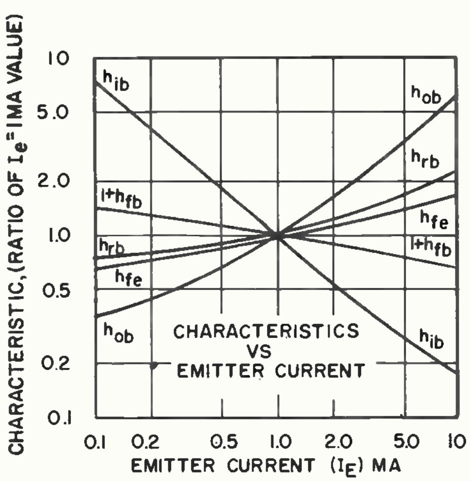


FIGURE 16

With the resistance values shown, the bias conditions on the transistor are 1 ma of collector current and six volts from collector to emitter. At frequencies at which C_1 provides good by-passing, the input resistance is given by the formula: $R_{in} \doteq (1 + h_{fe})\, h_{ib}$. At 1 ma for a design center 2N190, the input resistance would be 37 x 30 or about 1100 ohms. Figure 17 shows typical variations of the parameters at other emitter bias points.

FIGURE 17



The a-c voltage gain $\frac{e_{out}}{e_{in}}$ is approximately equal to $\frac{R_L}{h_{ib}}$. For the circuit shown this would be $\frac{5000}{30}$ or approximately 167.

The frequency at which the voltage gain is down 3 db from the 1 Kc value depends on r_g. This frequency is given approximately by the formula:

$$\text{low } f_{3db} \approx \frac{1+h_{fe}}{6.28(r_g C_1)}$$

TWO STAGE R-C COUPLED AMPLIFIER

The circuit of a two stage R-C coupled amplifier is shown by figure 18. The input impedance is the same as the single stage amplifier and would be approximately 1100 ohms.

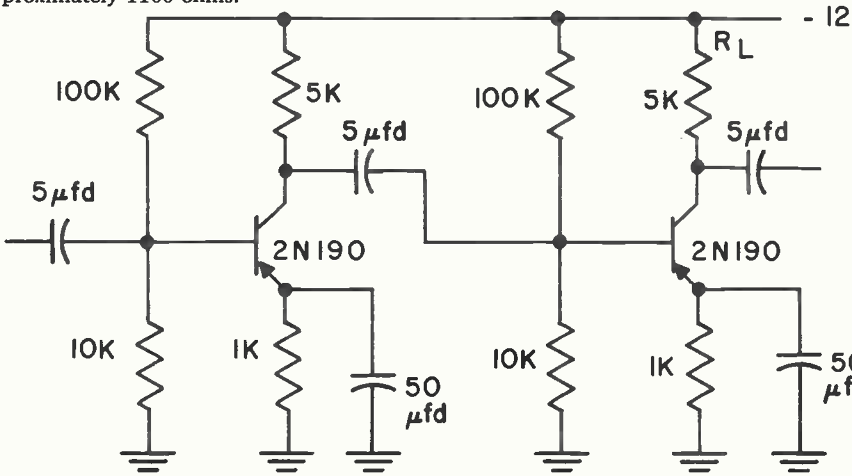


FIGURE 18

The load resistance for the first stage is now the input impedance of the second stage. The voltage gain is given approximately by the formula:

$$A_V \approx h_{fe} \frac{R_L}{h_{ib}}$$

More exact formulas for the performance of audio amplifiers may be found in the bibliography at the end of this manual.

By using an un-bypassed resistance in the emitter of the second stage, a voltage is obtained which is proportional to the output current of the amplifier. If a resistance and a capacitor are connected to this resistor as shown in figure 19, a signal is fed back to the input which is proportional to the output current.

If the feedback capacitor is made very large, the frequency response is essentially flat and the gain is determined only by the ratio of R_1 to R_2. If the capacitor is made small, the feedback current will depend upon the frequency being amplified

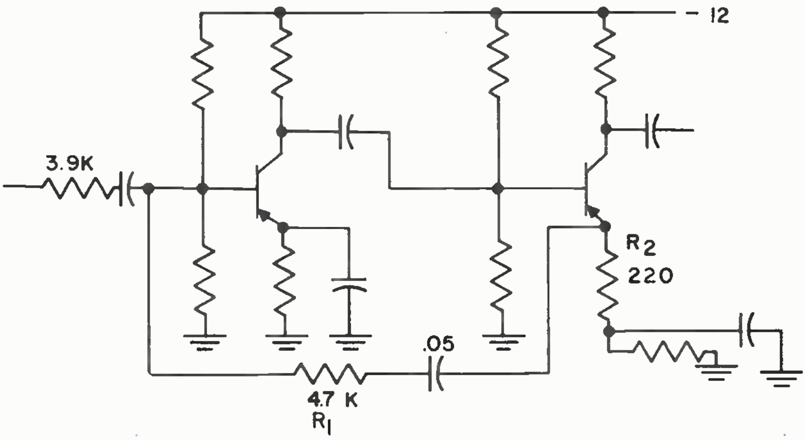


FIGURE 19

and it is possible to obtain a boost of the low frequencies. With the values shown, the two stage amplifier provides approximate frequency compensation for a General Electric Variable Reluctance Pick-up reproducing from records recorded to the RIAA Standards.

SINGLE STAGE CLASS A OUTPUT AMPLIFIER

A Class A output stage is biased as shown on the collector characteristics in figure 20.

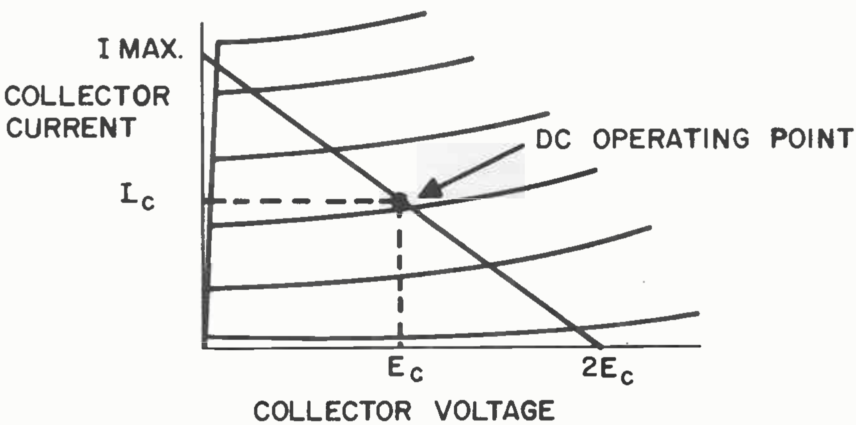


FIGURE 20

The operating point is chosen so that the output signal can swing equally in the positive and negative direction. The proper primary impedance of the transformer depends on how much power must be delivered to the load. This impedance is given by the formula $R_p = \frac{E_c^2}{2P_o}$. A typical circuit is shown in figure 21.

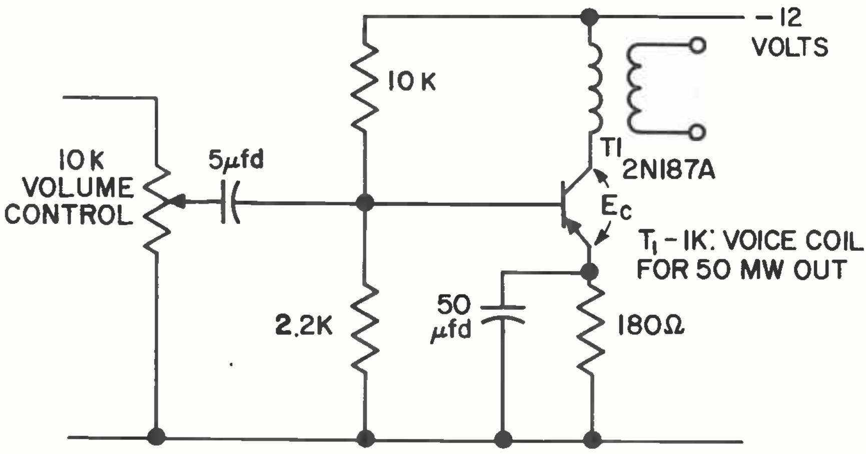


FIGURE 21

The proper collector current bias is given by the formula: $I_c = \frac{2P_o}{E_c}$. In a Class A output stage, the maximum a-c output power that can be obtained is limited to ½ the allowable dissipation of the transistor.

CLASS B PUSH-PULL OUTPUT STAGES

The circuit of a typical Push-Pull Class B output amplifier is shown by figure 22.

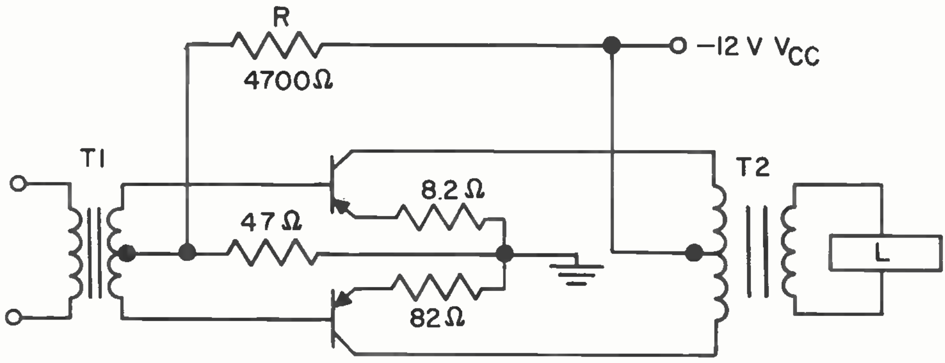


FIGURE 22

The voltage divider consisting of resistance R and the 47 ohm resistor gives a slight forward bias to prevent cross-over distortion. Usually about one-tenth of a volt is sufficient to prevent cross-over distortion and under these conditions the total no signal collector current is about 2 to 3 ma. The 8.2 ohm resistors in the emitter leads stabilize the transistors so that they will not go into thermal runaway when the junction temperature rises to 60°C. Typical collector characteristics with load line are shown in figure 23.

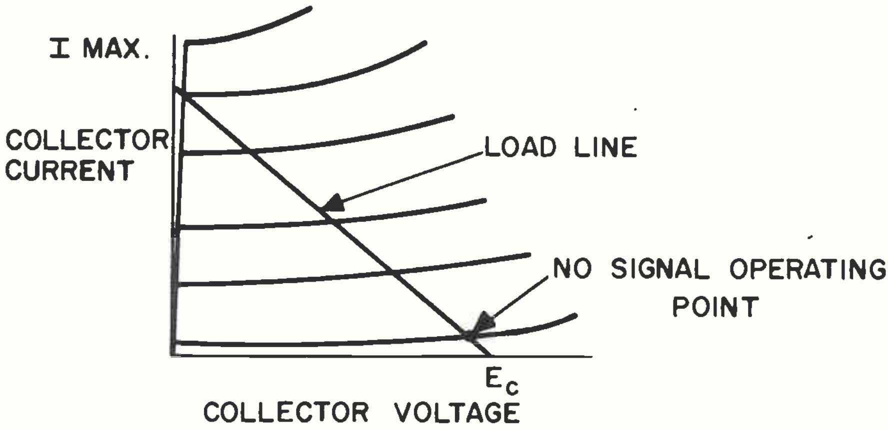


FIGURE 23

The collector to collector impedance of the output transformer is given by the formula: $R = \frac{2E_c^2}{P_o}$.

In a Class B Push-Pull transistor amplifier, the maximum a-c power output is approximately equal to 5 times the allowable dissipation of each transistor. Therefore, by using a transistor such as the 2N187A, it is possible to obtain output powers of 0.8 watt. The power drain of a Class B Push-Pull amplifier depends upon the amplitude of the output signal. A Class B amplifier is therefore much less wasteful of battery power than a Class A output amplifier. For these reasons, Class B transistor amplifiers are used in most transistor radios having output powers of greater than 50 mw. Typical circuit diagrams of Class A and Class B output amplifiers in superheterodyne radios may be found in the back of the book.

IF AMPLIFIERS:

A typical circuit for a transistor IF amplifier is shown by figure 24.

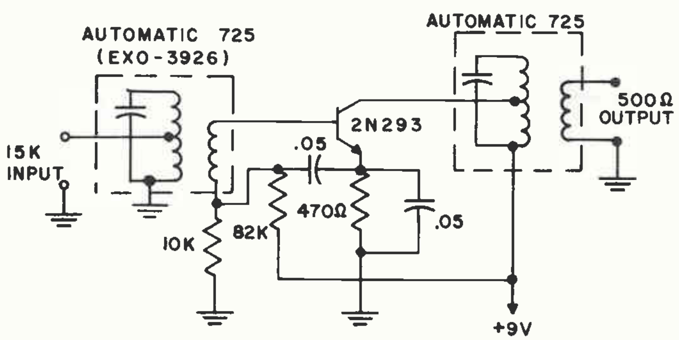
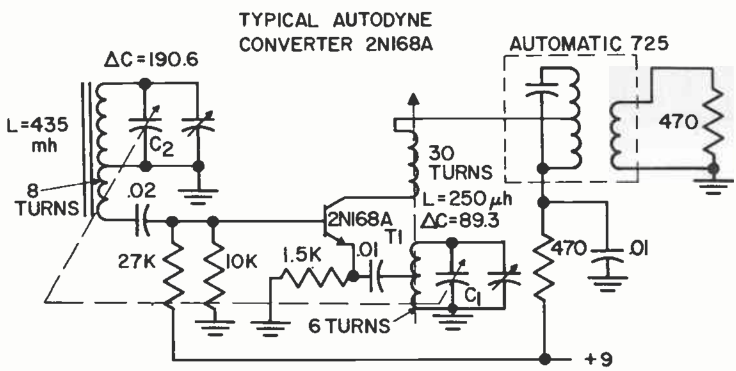


FIGURE 24

The collector current is determined by a voltage divider on the base and a large resistance in the emitter. The input and output are coupled by means of tuned IF transformers. The .05 capacitors are used to prevent degeneration by the resistance in the emitter. The collector of the transistor is connected to a tap on the output transformer to provide proper matching for the transistor and also to make the performance of the stage relatively independent of variations between transistors of the same type. With a rate-grown NPN transistor such as the 2N293, it is unnecessary to use neutralization to obtain a stable IF amplifier. With PNP alloy transistors, it is necessary to use neutralization to obtain a stable amplifier and the neutralization capacitor depends on the collector capacitance of the transistor. The gain of a transistor IF amplifier will decrease if the emitter current is decreased. This property of the transistor can be used to control the gain of the IF amplifier so that weak stations and strong stations will produce the same audio output from a radio. Typical circuits for changing the gain of an IF amplifier in accordance with the strength of the received signal are shown in the circuit section of the manual.

AUTODYNE CONVERTER CIRCUITS

The converter stage of a transistor radio is a combination of a local oscillator, mixer and IF amplifier. A typical circuit for this stage is shown by figure 25.



ANTENNA-DELTA COIL #1-105A OR EQUIVALENT
OSCILLATOR COIL – E. STANWYCH CO. #1129 (MODIFIED) OR EQUIVALENT
CAPACITOR-RADIO CONDENSER #242 OR EQUIVALENT
I.F. TRANSFORMER-AUTOMATIC 725 (EXO-3926) OR EQUIVALENT

FIGURE 25

Transformer T_1 feeds back a signal from the collector to the emitter causing oscillations. Capacitor C_1 tunes the circuit so that it oscillates at a frequency 455 Kc higher than the incoming radio signal. This local oscillator signal is injected into the emitter of the transistor. The incoming signal is tuned by means of capacitor C_2 and after passing through an auto transformer to match the input impedance of the transistor, it is injected into the base. The two signals are mixed by the amplifier and the resultant beat frequency of 455 Kc is selected by the IF transformer and fed into the next stage. For optimum performance the collector current should be 0.6 to 0.8 ma and the local oscillator injection voltage at the emitter 0.15 to 0.25 volts.

EXPLANATION OF PARAMETER SYMBOLS

SMALL SIGNAL & HIGH FREQUENCY PARAMETERS (at specified bias)

Symbols	Abbreviated Definitions	
h_{ob}	Com. base — output admittance, input AC open-circuited	
h_{ib}	Com. base — input impedance, output AC short-circuited	
h_{rb}	Com. base — reverse voltage transfer ratio, input AC open-circuited	
h_{fb}	Com. base	forward current transfer ratio, output AC short-circuited
h_{fe}	Com. emitter	
h_{fc}	Com. collector	
h_{oe}, h_{ie}	Examples of other corresponding com. emitter symbols	
f_{ab}	Com. base	the frequency at which the magnitude of the small-signal short-circuit forward current transfer ratio is 0.707 of its low frequency value.
f_{ae}	Com. emitter	
C_{ob}	Collector to base	Capacitance measured across the output terminals with the input AC open-circuited
C_{oe}	Collector to emitter	
r'_b	Base spreading resistance	
G_e	Com. emitter Power Gain (use G_b for com. base)	
NF	Noise Figure	

SWITCHING CHARACTERISTICS (at specified bias)

t_d	Ohmic delay time	These depend on both transistor and circuit parameters
t_r	Rise time	
t_s	Storage time	
t_f	Fall time	
V_{CE} (SAT.)	Saturation voltage at specified I_C and I_B. This is defined only with the collector saturation region.	
h_{FE}	Com. emitter — static value of short-circuit forward current transfer ratio, $h_{FE} = \frac{I_C}{I_B}$	
h_{FE} (INV)	Inverse h_{FE} (emitter and collector leads switched)	
$h_{\overline{fe}}$	Large-signal value of h_{fe}. Large-signal values of parameters are indicated by proper symbol and subscripts, with addition of a bar over the symbol.	

DC MEASUREMENTS

I_C, I_E, I_B	DC currents into collector, emitter, or base terminal	
V_{CB}, V_{EB}	Voltage collector to base, or emitter to base	
V_{CE}	Voltage collector to emitter	
V_{BE}	Voltage base to emitter	
BV_{CBO}	Breakdown voltage, collector to base junction reverse biased, emitter open-circuited (value of I_C should be specified)	
V_{CEO}	Voltage collector to emitter, at zero base current, with the collector junction reverse biased. Specify I_C.	
BV_{CEO}	Breakdown voltage, collector to emitter, with base open-circuited. This may be a function of both "m" (the charge carrier multiplication factor) and the h_{fb} of the transistor. Specify I_C.	
V_{CER}	Similar to V_{CEO} except a resistor of value "R" between base and emitter.	
V_{CES}	Similar to V_{CEO} but base shorted to emitter.	
V_{PT}	Punch-through voltage, collector to base voltage at which the collector space charge layer has widened until it contacts the emitter junction. At voltages above punch-through, $V_{PT} = V_{CB} - V_{EB}$	
V_{CCB}	Supply voltage collector to base	NOTE — third subscript may be omitted if no confusion results.
V_{CCE}	Supply voltage collector to emitter	
V_{BBE}	Supply voltage base to emitter	
I_{CO}, I_{CBO}	Collector current when collector junction is reverse biased and emitter is DC open-circuited.	
I_{EO}, I_{EBO}	Emitter current when emitter junction is reverse biased and collector is DC open-circuited.	
I_{CEO}	Collector current with collector junction reverse biased and base open-circuited.	
I_{CES}	Collector current with collector junction reverse biased and base shorted to emitter.	
I_{ECS}	Emitter current with emitter junction reverse biased and base shorted to collector.	

NOTE: Subscripts for multi-electrode devices are developed by numeric additions to the subscripts. Similar electrodes may be numbered in sequence from the intended input to the intended output electrodes. Examples: V_{EB2}, V_{IB2}, V_{CB2}, I_{e2}, i_{c2}

NOTE: Reverse biased junction means biased for current flow in the high resistance direction.

The General Electric type 2N43 germanium fused junction transistor triode is a PNP unit particularly suggested for high-gain, low-to-medium power applications. A hermetic enclosure is provided by use of glass-to-metal seals and resistance-welded seams. This transistor is capable of dissipating 150 mw in 25°C free air.

2N43

Outline Drwg. No. 8

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to base), V_{CB}	−45 volts
Collector Current, I_C	−50 ma
Emitter Current, I_E	50 ma
Junction Temperature, T_J	100 °C

AVERAGE CHARACTERISTICS:
(Common Base, T_J = 30°C, f = 270 cps)

	DESIGN CENTER	LIMITS MAX.	LIMITS MIN.	
Collector Voltage	−5.0			volts
Emitter Current	1.0			ma
Output Admittance (input open circuit), h_{ob}	1.0	2.0	0.5	μmhos
Current Amplification (output short circuit), h_{fb}	−0.98	−1.0	−0.97	
Input Impedance (output short circuit), h_{ib}	40	50	30	ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	4×10^{-4}	6×10^{-4}	2×10^{-4}	
Collector Cutoff Current, I_{CO}	10	15	1.0	μa
Output Capacitance, C_c	40	50	30	mmf
Noise Figure (V_c, −1.5V; I_e, 0.5 ma; f, 1KC; BW, 1 ~), NF	22	33	11	db
Maximum Power Gain (Common Emitter)	40	44	37	db
Frequency Cutoff, f_{ab}*	1.0	2.5	0.5	mc
Temp. Rise/Unit Collector Dissipation (in free air)	0.5			°C/mw
Temp. Rise/Unit Collector Dissipation (infinite heat sink)**	0.2			°C/mw

*Frequency at which the magnitude of h_{fb} is 3 db down from its 270 cps value.
**Temperature rise with transistor clamped to metallic heat sink.

2N43A

Outline Drwg. No. 8

The 2N43A is the commercial version of the first military transistor, Air Force Type USAF 2N43A per MIL-T-25096. Many of the stringent mechanical and electrical requirements of MIL-T-25096 are retained in this specification making it ideally suited to any application requiring superior electrical performance, mechanical ruggedness and high reliability. Current amplification is held to relatively narrow limits by accurate process control rather than by selection. The 2N43A will dissipate 150 mw at 25°C and will operate reliably up to 100°C at reduced ratings.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to emitter), V_{CE}	−20 volts
Collector Voltage (referred to base), V_{CB}	−45 volts
Collector Current, I_C	−50 ma
Emitter Current, I_E	50 ma
Junction Temperature, T_J	100 °C

AVERAGE CHARACTERISTICS:
(Common Base, T_J = 30°C, f = 270 cps, V_{CB} = −5 volts, I_E = 1 ma)

	DESIGN CENTER	LIMITS MAX.	LIMITS MIN.	
Output Admittance (input open circuit), h_{ob}	0.5	1.3		μmhos
Current Amplification (output short circuit), h_{fb}	−0.9775	−.985	−0.97	
Input Impedance (output short circuit), h_{ib}	28	33		ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	4×10^{-4}	13×10^{-4}		
Collector Cutoff Current (V_c = −45, I_e = O, T = 25*C), I_{CO}	−5	−10		μa
Emitter Cutoff Current (V_e = −5 v., I_c = O, T = 25*C), I_{EO}	−5	−10		μa
Output Capacitance, C_c	40	50		mmf
Noise Figure (f = 1 kc, BW = 1 cycle), NF	10	20		db
Maximum Power Gain (Common Emitter), 455 KC	15		12	db
Frequency Cutoff, f_{ab}	1.0		.75	mc
Temp. Rise/Unit Collector Dissipation (in free air)	0.5			°C/mw
Temp. Rise/Unit Collector Dissipation (infinite heat sink)*	0.2			°C/mw

*Temperature rise with transistor clamped to metallic heat sink.

4JD1A17

Outline Drwg. No. 8

The General Electric type 4JD1A17 fused junction transistor triode is a PNP unit particularly suggested for high-gain, medium-power applications. A hermetically sealed enclosure is provided by use of glass-to-metal seals and resistance-welded seams.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to emitter), V_{CE}	—20 volts
Collector Voltage (referred to base), V_{CB}	—45 volts
Collector Current, I_C	—50 ma
Emitter Current, I_E	50 ma
Collector Dissipation (25°C)	150 mw
Storage Temperature, T_J*	max. 85 °C min. —55 °C

AVERAGE CHARACTERISTICS:
(Common Base, 25° C, f = 270 cps V_{CB} = —5 volts, I_E = 1 ma)

	DESIGN CENTER	LIMITS MAX.	MIN.	
Output Admittance (input open circuit), h_{ob}	0.5	1.3		µmhos
Current Amplification (output short circuit), h_{fb}	—0.975	—0.9850	—0.9523	
Input Impedance (output short circuit), h_{ib}	28	33		ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	4×10^{-4}	13×10^{-4}		
Collector Cutoff Current (V_{CB} = —45, I_E = O, T = 25°C), I_{CO}	—8	—16		µa
Emitter Cutoff Current (V_{EB} = —5 v., I_C = O, T = 25°C), I_{EO}	—5	—10		µa
Output Capacitance, C_c	40	50		mmf
Noise Figure (f = 1 kc, BW = 1 cycle), NF	10	20		db
Maximum Power Gain (Common Emitter), 455 KC	15		12	db
Alpha Cutoff Frequency, f_{ab}	1.0		.75	mc

*Derate 2.5 mw/°C increase in ambient temperature.
With infinite heat sink, derate 1.0 mw/°C.

2N44

Outline Drwg. No. 8

The General Electric type 2N44 germanium fused junction transistor triode is a PNP unit particularly suggested for intermediate-gain, low-to-medium power applications. A hermetic enclosure is provided by use of glass-to-metal seals and resistance-welded seams. This transistor is capable of dissipating 150 mw in 25°C free air.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to base), V_{CB}	—45 volts
Collector Current, I_C	—50 ma
Emitter Current, I_E	50 ma
Junction Temperature, T_J	100 °C

AVERAGE CHARACTERISTICS:
(Common Base, T_J = 30°C, f =270 cps)

	DESIGN CENTER	LIMITS MAX.	MIN.	
Collector Voltage	—5.0			volts
Emitter Current	1.0			ma
Output Admittance (input open circuit), h_{ob}	1.0	2.0	0.5	µmhos
Current Amplification (output short circuit), h_{fb}	—.955	—.97	—.94	
Input Impedance (output short circuit), h_{ib}	40	50	30	ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	3×10^{-4}	5×10^{-4}	1×10^{-4}	
Collector Cutoff Current, Ico	10	15	1.0	µa
Output Capacitance, C_c	40	50	30	mmf
Noise Figure (V_{CB}, — 1.5V, I_E, 0.5 ma; f, 1 KC; BW, 1 ∼), NF	22	33	11	db
Maximum Power Gain (Common Emitter)	39	43	34	db
Frequency Cutoff, f_{ab}	1.0	2.5	0.5	mc
Temp. Rise/Unit Collector Dissipation (in free air)	0.5			°C/mw
Temp. Rise/Unit Collector Dissipation (infinite heat sink)*	0.2			°C/mw

*Temperature rise with transistor clamped to metallic heat sink.

2N45

Outline Drwg. No. 8

The General Electric type 2N45 germanium fused junction transistor triode is a PNP unit particularly suggested for medium-gain, low-to-medium power applications. A hermetic enclosure is provided by use of glass-to-metal seals and resistance-welded seams. This transistor is capable of dissipating 150 mw in 25°C free air.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to base), V_{CB}	—45 volts

Collector Current, I_C				−50 ma
Emitter Current, I_E				50 ma
Junction Temperature, T_J				100 °C

AVERAGE CHARACTERISTICS: (Common Base, $T_J = 30°C$, f = 270 cps)	DESIGN CENTER	LIMITS MAX.	LIMITS MIN.	
Collector Voltage	−5.0			volts
Emitter Current	1.0			ma
Output Admittance (input open circuit), h_{ob}	1.0	2.0	0.5	μmhos
Current Amplification (output short circuit), h_{fb}	−0.92	−0.94	−0.90	
Input Impedance (output short circuit), h_{ib}	40	50	30	ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	2.5×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	
Collector Cutoff Current, I_{CO}	10	15	1.0	μa
Output Capacitance, C_c	40	50	30	mmf
Noise Figure (V_{CB}, − 1.5V; I_E, 0.5 ma; f, 1 KC; BW, 1 ∼), NF	22	33	11	db
Maximum Power Gain (Common Emitter)	38	43	34	db
Frequency Cutoff, f_{ab}	1.0	2.5	0.5	mc
Temp. Rise/Unit Collector Dissipation (in free air)	0.5			°C/mw
Temp. Rise/Unit Collector Dissipation (infinite heat sink)*	0.2			°C/mw

*Temperature rise with transistor clamped to metallic heat sink.

2N78

Outline Drwg. No. 14

The General Electric 2N78 is a grown junction NPN high frequency transistor intended for high gain RF and IF amplifier service and general purpose applications. The G.E. rate-growing process used in the manufacture of the 2N78 provides the uniform and stable characteristics required for mobile and industrial service.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector to Emitter Voltage (base open)	15 volts
Collector to Base Voltage (emitter open)	15 volts
Collector Current	20 ma
Emitter Current	−20 ma
Collector Dissipation (25°C)*	65 mw
Storage Temperature	85 °C

ELECTRICAL CHARACTERISTICS: (25°C)

Low Frequency Characteristics (Common Base) ($V_{CB} = 5$ V, $I_E = -1$ ma, f = 270 cps)	DESIGN CENTER	LIMITS MAX.	LIMITS MIN.	
Input Impedance (output short circuit), h_{ib}	55	35	75	ohms
Voltage Feedback Ratio (input short circuit), h_{rb}	2×10^{-4}	$.8 \times 10^{-4}$	10×10^{-4}	
Current Amplification (output short circuit), h_{fb}	.983 ($\beta = 50$)	.952 ($\beta = 20$)		
Output Admittance (input open circuit), h_{ob}	.2	.1	.7	μmhos
Noise Figure ($V_{CB} = 1.5$ V, $I_E = -0.5$ ma, f = 1 KC	12		20	db
High Frequency Characteristics (Common Base) ($V_{CB} = 5$ V, $I_E = -1$ ma)				
Alpha Cutoff Frequency, f_{ab}	6	3.7		mc
Output Capacity (f = 2 mc), C_c	4	1	6	μμf
Cutoff Characteristics				
Collector Cutoff Current ($V_{CB} = 15$ V), I_{CO}	1		6	μa
Collector Cutoff Current ($V_{CB} = 5$ V), I_{CO}			2	μa

*Derate 1.1 mw/°C increase in ambient temperature.

2N107

Outline Drwg. No. 8

The General Electric type 2N107 is a diffused junction PNP transistor particularly suggested for students, experimenters, hobbyists, and hams. It is available only from franchised General Electric distributors. The 2N107 is hermetically sealed and will dissipate 50 milliwatts in 25°C free air.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to base), V_{CB}	−12 volts
Collector Current, I_C	−10 ma
Emitter Current, I_E	10 ma
Junction Temperature, T_J	60 °C

AVERAGE CHARACTERISTICS:
(Common Base, $T_J = 30°C$, f = 270 cps
$V_{CB} = -5v$, $I_E = 1$ ma)

Collector Voltage	−5.0 volts
Emitter Current	1.0 ma
Output Admittance (input open circuit), h_{ob}	1,0 μmhos
Current Amplification (output short circuit), h_{fb}	−.95
Input Impedance (output short circuit), h_{ib}	32 ohms
Voltage Feedback Ratio (input open circuit), h_{rb}	3×10^{-4}

Collector Cutoff Current, I_{CO}	10 μa
Output Capacitance, C_c	40 μμf
Noise Figure (V_{CB} = —1.5V; I_E = 0.5 ma; f = 1 KC; BW = 1 cycle), NF	22 db
Frequency Cutoff, f_{ab}	1.0 mc
Temp. Rise/Unit Collector Dissipation (in free air)	0.5 °C/mw
Temp. Rise/Unit Collector Dissipation (infinite heat sink)*	0.2 °C/mw

*Temperature rise with transistor clamped to metallic heat sink.

2N123

Outline Drwg. No. 8

The General Electric type 2N123 is a PNP alloy junction high frequency switching transistor intended for military, industrial and data processing applications where high reliability at the maximum ratings is of prime importance.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector to Emitter Voltage (base open)	—15 volts
Collector to Base Voltage (emitter open)	—20 volts
Emitter to Base Voltage (collector open)	—10 volts
Collector Current	—125 ma
Peak Collector Current (10 μs max.)	—500 ma
Emitter Current	125 ma
Collector Dissipation (25°C)*	100 mw
Peak Collector Dissipation (10 μs max.; 25°C)**	500 mw
Total Transistor Dissipation (25°C)***	150 mw
Storage Temperature	—55 to 85 °C

ELECTRICAL CHARACTERISTICS: (25°C)	DESIGN CENTER	LIMITS MIN.	MAX.	
Switching Characteristics (Common Emitter)				
D.C. Base Current Gain (V_{CE} — 1 v; I_C = 10 ma) I_C/I_B	50	30	150	
Saturation Voltage (I_B = .5 ma; I_C = 10 ma), V_{CB}	.15		0.2	volts
Pulse Response Time (I_C = 10 ma)				
Delay & Rise Time, t_r	.9			μsec
Storage Time, t_s	.5			μsec
Fall Time, t_f	.5			μsec
Cutoff Characteristics				
Collector Cutoff Current (V_{CB} = —20v), I_{CO}	2		6	μa
Emitter Cutoff Current (V_{EB} = —10v), I_{EO}	2		6	μa
Collector to Emitter (Base open, I_C = —0.6 ma), V_{CE}	25	15		volts
High Frequency Characteristics (Common Base) (V_{CB} = —5v; I_E = 1 ma)				
Alpha Cutoff Frequency, f_{ab}	8	5		mc
Collector Capacitance (f = 1 mc), C_c	15			μμf
Voltage Feedback Ratio (f = 1 mc), h_{rb}	8×10^{-3}			
Base Spreading Resistance, r'_b	80			ohms
Low Frequency Characteristics (Common Base) (V_{CB} = —5v; I_E = 1 ma; f = 270 cps)				
Input Impedance, h_{ib}	28			ohms
Voltage Feedback Ratio, h_{rb}	8×10^{-4}			
Current Amplification, h_{fb}	.980	.970		
Output Admittance, h_{ob}	.9			μmbos

Derate for increase in ambient temperature:
*1.67 mw/°C, **8 mw/°C, ***2.5 mw/°C

2N135, 2N136, 2N137

Outline Drwg. No. 8

The General Electric types 2N135, 2N136 and 2N137 are PNP alloy junction germanium transistors intended for RF and IF service in broadcast receivers. Special control of manufacturing processes provides a narrow spread of characteristics, resulting in uniformly high power gain at radio frequencies. These types are obsolete and available for replacement only.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS: (25°C)	2N135	2N136	2N137	
Collector Voltage:				
Common Base (emitter open), V_{CB}	—20	—20	—10	volts
Common Emitter (R_{be} = 100 ohms), V_{CE}*	—20	—20	—10	volts
Common Emitter (R_{be} = 1 megohm), V_{CE}*	—12	—12	— 6	volts
Collector Current, I_C	—50	—50	—50	ma
Emitter Current, I_E	50	50	50	ma
Collector Dissipation**	100	100	100	mw
Storage Temperature	85	85	85	°C
ELECTRICAL CHARACTERISTICS: Design Center Values (Common Base, 25°C, V_{CB} = 5v, I_E = 1 ma)				
Voltage Feed back Ratio (input open circuit, f = 1 mc), h_{rb}	7×10^{-3}	7×10^{-3}	7×10^{-3}	
Output Capacitance (f = 1 mc), C_c	14	14	14	μμf

Alpha Cutoff Frequency, f_{ab}	4.5	6.5	10	mc
Minimum Alpha Cutoff Frequency, f_{ab}	3	5	7	mc min
Collector Cutoff Current (V_{CB} = 6 v, emitter open), I_{co}	5	5	5	μa max
Base Current Amplification (common emitter, f = 270 cps), β	20	40	60	

*Collector to emitter voltage V_{CE} at which I_C increases to .6 ma with the base connected to the emitter through a resistance R_{be}.
**Derate 1.7 mw/°C increase in ambient temperature over 25°C.

2N167

Outline Drwg. No. 14

The General Electric type 2N167 is an NPN high frequency, high speed switching transistor intended for industrial and military applications where reliability is of prime importance.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector to Emitter Voltage (base open)	30 volts
Collector to Base Voltage (emitter open)	30 volts
Emitter to Base Voltage (collector open)	5 volts
Collector Current	75 ma
Emitter Current	75 ma
Collector Dissipation (25°C)*	65 mw
Transistor Dissipation (25°C)**	75 mw
Storage Temperature	85 °C

ELECTRICAL CHARACTERISTICS: (25°C)	DESIGN CENTER	LIMITS MIN.	MAX.	
Switching Characteristics (Common Emitter)				
D-C Base Current Gain (V_{CE} = 1 v; I_C = 8 ma), I_C/I_B	25	17		
Saturation Voltage (I_B = .8 ma; I_C = 8 ma), V_{CE}	0.35			volts
Pulse Response Time (I_c = 8 ma)				
Delay & Rise Time, t_r	.6			μsec
Storage Time, t_s	.6			μsec
Fall Time, t_f	.4			μsec
Cutoff Characteristics				
Collector Cutoff Current (V_{CB} = 15 v), I_{CO}	.8		1.5	μa
Emitter Cutoff Current (V_{EB} = 5 v), I_{EO}	1.0		15	μa
Collector to Emitter Voltage (Base open, I_C = 0.3 ma), V_C		30		volts
High Frequency Characteristics (Common Base) (V_{CB} = 5v; I_E = 1 ma)				
Alpha Cutoff Frequency, f_{ab}	8	5		mc
Collector Capacity (f = 1 mc), C_c	4		8	μμf
Low Frequency Characteristics (Common Base) (V_{CB} = 5v; I_E = −1 ma; f = 270 cps)				
Input Impedance, h_{ib}	40			ohms
Voltage Feedback Ratio, h_{rb}	1.5×10^{-4}			
Base Current Amplification, h_{fb}	.975	.952		
Output Admittance, h_{ob}	.2			μmho

*Derate 1.1 mw/°C increase in ambient temperature.
**Derate 1.25 mw/°C increase in ambient temperature.

2N168A

Outline Drwg. No. 14

The 2N168A is a rate grown NPN germanium transistor intended for mixer/oscillator and IF amplifier applications in radio receivers. Special manufacturing techniques provide a low value and a narrow spread in collector capacity so that neutralization in many circuits is not required. The 2N168A has a frequency cutoff control to provide proper operation as an oscillator or autodyne mixer. For IF amplifier service the range in power gain in controlled to 3 db.

CONVERTER TRANSISTOR SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltage	
Collector to Emitter (base open), V_{CB}	15 volts
Collector to Base (emitter open), V_{CE}	15 volts
Current	
Collector, I_C	−20 ma
Power	
Collector Dissipation at 25°C*, P_c	65 mw
Temperature Range	
Operating and Storage, T_s	−55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS:

Converter Service

Maximum Ratings	
Collector Supply Voltage, V_{CC}	12 volts
Design Center Characteristics	
Input Impedance (I_E = 1 ma; V_{CE} = 5v; f = 455 KC), Z_{in}	350 ohms
Output Impedance (I_E = 1 ma; V_{CE} = 5v; f = 455 KC), Z_{out}	15 K ohms

Voltage Feedback Ratio ($I_E = 1$ ma; $V_{CB} = 5$v; f = 1 mc), h_{rb}	5×10^{-3}
Collector to Base Capacitance ($I_E = 1$ ma; $V_{CB} = 5$v; f = 1 mc), C_{ob}	2.4 $\mu\mu$f
Frequency Cutoff ($I_E = 1$ ma; $V_{CB} = 5$v), f_{ab}	8 mc
Min. Frequency Cutoff ($I_E = 1$ ma; $V_{CB} = 5$v), f_{ab}	5 mc min
Base Current Gain ($I_B = 20_{ma}$; $V_{CE} = 1$v), h_{FE}	40
Minimum Base Current Gain, h_{EE}	23
Maximum Base Current Gain, h_{EE}	135
Conversion Gain, CG_e	25 db
IF Amplifier Performance	
Collector Supply Voltage, V_{CC}	5 volts
Collector Current, I_E	1 ma
Input Frequency, f	455 KC
Available Power Gain, G_e	39 db
Minimum Power Gain in typical IF circuit, G_e	28 db min
Power Gain Range of Variation in typical IF circuit, G_e	3 db
Cutoff Characteristics	
Collector Cutoff Current ($V_{CB} = 5$v), I_{CO}	.5 μa
Collector Cutoff Current ($V_{CB} = 15$v), I_{CO}	5 μa max

*Derate 1.1 mw/°C increase in ambient temperature over 25°C.

2N169A, 2N169

Outline Drwg. No. 14

The 2N169A and 2N169 are rate grown NPN germanium transistors intended for use as IF amplifiers in broadcast radio receivers. The collector capacity is controlled to a low value so that neutralization in most circuits is not required. The power gain at 455 KC is maintained at a 3 db spread for the 2N169A. The 2N169A is a special high voltage unit intended for second IF amplifier service where large voltage signals are encountered. The 2N169 is also intended for low gain IF amplifier and power detector applications.

IF TRANSISTOR SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:	2N169A	2N169	
Voltage			
Collector to Emitter (base open), V_{CB}	25	15	volts
Collector to Base (emitter open), V_{CE}	25	15	volts
Current			
Collector, I_C	–20	–20	ma
Power			
Collector Dissipation at 25°C*, P_c	55	55	mw
Temperature Range			
Operating and Storage, T_s	–55 to 75	–55 to 75	°C
TYPICAL ELECTRICAL CHARACTERISTICS:			
IF Amplifier Service			
Maximum Ratings			
Collector Supply Voltage, V_{CC}	12	12	volts
Design Center Characteristics			
($I_E = 1$ ma; $V_{CE} = 5$v; f = 455 KC except as noted)			
Input Impedance, Z_{in}	500	500	ohms
Output Impedance, Z_{out}	15	15	K ohms
Voltage Feedback Ratio ($V_{CB} = 5$v; f = 1 mc), h_{rb}	10×10^{-3}	10×10^{-3}	
Collector to Base Capacitance (V_{CB}=5v; f=1 mc), C_{ob}	2.4	2.4	$\mu\mu$f
Frequency Cutoff ($V_{CB} = 5$v), f_{ab}	5	5	mc
Base Current Gain ($I_B = 20_{ma}$; $V_{CE} = 1$ v), h_{FE}	72	72	
Minimum Base Current Gain, h_{EE}	36	36	
Maximum Base Current Gain, h_{EE}	220	220	
IF Amplifier Performance			
Collector Supply Voltage, V_{CC}	5	5	volts
Collector Current, I_E	1	1	ma
Input Frequency, f	455	455	KC
Available Power Gain, G_e	36	36	db
Minimum Power Gain in typical IF circuit, G_e	25	25	db min
Power Gain Range of Variation in typical IF circuit, G_e	3	3	db
Cutoff Characteristics			
Collector Cutoff Current ($V_{CB} = 5$v), I_{CO}	5	.5	μa
Collector Cutoff Current ($V_{CB} = 15$v), I_{CO}	5	5	μa max

*Derate 1.1 mw/°C increase in ambient temperature.

2N170

Outline Drwg. No. 14

The 2N170 is a rate grown NPN germanium transistor intended for use in high frequency circuits by amateurs, hobbyists, and experimenters. The 2N170 can be used in any of the many published circuits where a low voltage, high frequency transistor is necessary such as for regenerative receivers, high frequency oscillators, etc. If you desire to use the 2N170 NPN transistor in a circuit showing a PNP type transistor, it is only necessary to change the connections to the power supply.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltage	
Collector to Emitter, V_C	6 volts
Current	
Collector, I_C	20 ma
Power	
Collector Dissipation @ 25°C*, P_c	25 mw
Temperature Range	
Operating and Storage, T_s	—55 to 50 °C

TYPICAL ELECTRICAL CHARACTERISTICS:

High Frequency Characteristics	
(I_E = 1 ma; V_{CE} = 5v; f = 455 KC except as noted)	
Input Impedance (Common Emitter), Z_{in}	800 ohms
Output Impedance (Common Emitter), Z_{out}	15 K ohms
Collector to Base Capacitance (f = 1 mc), C_{ob}	3 $\mu\mu$f
Frequency Cutoff (V_{CB} = 5V), f_{ab}	5 mc
Power Gain (Common Emitter), G_e	24 db
Low Frequency Characteristics	
(I_E = 1 ma; V_{CE} = 5v; f = 270 cps)	
Input Impedance, h_{ib}	55 ohms
Voltage Feedback Ratio, h_{rb}	4×10^{-4}
Current Gain, h_{fb}	.97
Output Admittance, h_{ob}	$.3 \times 10^{-6}$ μmhos
Common Emitter Base Current Gain, h_{fe}	32
Cutoff Characteristics	
Collector Cutoff Current (V_{CB} = 5v), I_{CO}	5 μa max

*Derate 1 mw/°C increase in ambient temperature.

2N186, 2N187, 2N188

Outline Drwg. No. 8

The 2N186, 2N187, and 2N188 are medium power PNP transistors, intended for use as audio output amplifiers in radio receivers and quality sound systems. By unique process controls the current gain is maintained at an essentially constant value for collector currents from 1 ma to 200 ma. This linearity of current gain provides low distortion in Class B circuits, and permits use of any two transistors from a particular type without matching.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltages	
Collector to Base (emitter open)	—25 volts
Collector to Emitter (R_{EB} = 1 K ohm)	—25 volts
Emitter to Base (collector open)	— 5 volts
Collector Current	200 ma
Power	
Collector Dissipation (25°C)*	75 mw
Temperature	
Operating Range	—55 to 60 °C
Storage Range	—55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS: (25°C)

Class B Audio Amplifier Operation	**2N186**	**2N187**	**2N188**	
(Values for two transistors. Note that matching is not required to hold distortion to less than 5% for any two transistors from a type)				
Maximum Class B Ratings (Common Emitter)				
Collector Supply Voltage, V_{CC}	—12	—12	—12	volts
Power Output (Distortion less than 5%), PO_e	300	300	300	mw
Design Center Characteristics				
Input Impedance large signal base to base (ΔI_B = 150 ma), h_{ie}	1200	2000	2600	ohms
Base Current Gain (V_{CE} = —1 v; I_c = 150 ma), h_{FE}	24	36	54	
Collector Capacity (V_{CB} = —5 v; I_E = 1 ma; f = 1 mc), C_{ob}	35	35	35	$\mu\mu$f
Frequency Cutoff (V_{CE} = —5 v; I_E = 1 ma), f_{ab}	.8	1.0	1.2	mc
Class B Circuit Performance (Common Emitter)				
Collector Voltage, V_{CC}	—12	—12	—12	volts
Minimum Power Gain at 100 mw power output, G_e	28	30	32	min db
Cutoff Characteristics				
Maximum Collector Cutoff Current (V_{CB} = —25 v), I_{CO}	16	16	16	max μa
Maximum Emitter Cutoff Current (V_{EB} = —5 v), I_{EO}	10	10	10	max μa

*Derate 1.25 mw/°C increase in ambient temperature within range 25°C to 60°C.

2N186A, 2N187A 2N188A

Outline Drwg. No. 8

The 2N186A, 2N187A, and 2N188A are medium power PNP transistors intended for use as audio output amplifiers in radio receivers and quality sound systems. By unique process controls the current gain is maintained at an essentially constant value for collector currents from 1 ma to 200 ma. This linearity of current gain provides low distortion in both Class A and Class B circuits, and permits the use of any two transistors from a particular type without matching in Class B Circuits.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltages	
Collector to Base (emitter open)	—25 volts
Collector to Emitter (R_{EB} = 1 K ohm)	—25 volts
Emitter to Base (collector open)	— 5 volts
Collector Current	200 ma
Power	
Collector Dissipation (25°C)*	180 mw
Temperature	
Operating Range	—55 to 60 °C
Storage Range	—55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS: (25°C)

Class B Audio Amplifier Operation	2N186A	2N187A	2N188A	
(Values for two transistors. Note that matching is not required to hold distortion to less than 5% for any two transistors from a type)				
Maximum Class B Ratings (Common Emitter)				
Collector Supply Voltage, V_{CC}	—12	—12	—12	volts
Power Output (Distortion less than 5%), PO_e	750	750	750	mw
Design Center Characteristics				
Input Impedance large signal base to base (ΔI_E = 150 ma), $h_{\overline{ie}}$		2000	2600	ohms
Base Current Gain (V_{CB} = —1 v; I_C = 150 ma), h_{FE}	24	36	54	
Collector Capacity (V_{CB} = 5 v; I_E = 1 ma; f = 1 mc), C_{ob}	35	35	35	$\mu\mu$f
Frequency Cutoff (V_{CB} = —5 v; I_E = 1 ma), f_{ab}	.8	1.0	1.2	mc
Class B Circuit Performance (Common Emitter)				
Collector Voltage, V_{CC}	—12	—12	—12	volts
Minimum Power Gain at 100 mw power output, G_e	28	30	32	min db
Class A Audio Amplifier Operation (Common Emitter)				
(E_{cc} = 12v; I_E = 10 ma)				
Power Gain at 50 mw power output, G_e	30	32	34	db
Cutoff Characteristics				
Maximum Collector Cutoff Current (V_{CB} = —25 v), I_{CO}	16	16	16	max μa
Maximum Emitter Cutoff Current (V_{EB} = —5 v), I_{EO}	10	10	10	max μa

*Derate 3 mw/°C increase in ambient temperature within range 25°C to 60°C.

2N189, 2N190, 2N191, 2N192

Outline Drwg. No. 8

The 2N189, 2N190, 2N191, and 2N192 are alloy junction PNP transistors intended for driver service in transistorized audio amplifiers. By control of transistor characteristics during manufacture, a specific power gain is provided for each type. Special processing techniques and the use of hermetic seals provides stability of these characteristics throughout life.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltages	
Collector to Emitter (R_{EB} = 1 K ohm)	—25 volts
Collector Current	50 ma
Power	
Collector Dissipation (25°C)*	75 mw
Temperature	
Operating Range	—55 to 60 °C
Storage Range	—55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS: (25°C)

Audio Driver Class A Operation	2N189	2N190	2N191	2N192	
(Values for one transistor driving a transformer coupled output stage)					
Maximum Class A Ratings (Common Emitter)					
Collector Supply Voltage, V_{CC}	12	12	12	12	volts
Design Center Characteristics					
Input Impedance base to emitter (I_E = 1 ma), $h_{\overline{ie}}$	1000	1400	1800	2200	ohms

Base Current Gain (V_{CB} = −5 v; I_E = 1 ma), h_{fe}	24	36	54	75	
Collector Capacity (V_{CB} = −5 v; I_E = 1 ma), C_{ob}	35	35	35	35	$\mu\mu$f
Frequency Cutoff (V_{CB} = −5 v; I_E = 1 ma), f_{ab}	.8	1.0	1.2	1.5	mc
Noise Figure (V_{CB} = −5 v; I_E = 1 ma; f = 1 KC; BW = 1 cycle), NF	15	15	15	15	db
Audio Circuit Performance (Common Emitter)					
Collector Supply Voltage, Vcc	12	12	12	12	volts
Emitter Current, I_E	1	1	1	1	ma
Minimum Power Gain at 1 mw power output, G_e	37	39	41	43	min db
Small Signal Characteristics (Common Base)					
(V_{CB} = 5v; I_E = 1 ma; f = 270 cps)					
Input Impedance, h_{ib}	29	29	29	29	ohms
Voltage Feedback Ratio, h_{rb}	4×10^{-4}	4×10^{-4}	4×10^{-4}	4×10^{-4}	
Current Amplification, h_{fb}	.96	.973	.98	.987	
Output Admittance, h_{ob}	1.0	.8	.6	.5	μmhos
Cutoff Characteristics					
Maximum Collector Cutoff Current (V_{CB} = 25 v), Ico	16	16	16	16	max μa

*Derate 1.25 mw/°C increase in ambient temperature within range 25°C to 60°C.

2N241, 2N141A

Outline Drwg. No. 8

The 2N241, and 2N241A are medium power PNP transistors intended for use as audio output amplifiers in radio receivers and quality sound systems. By special process controls the current gain is maintained at an essentially constant value for collector currents from 1 ma to 200 ma. This linearity of current gain insures low distortion in both Class A and Class B circuits, and permits the use of any two transistors from a particular type without matching in Class B Circuits.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltages

Collector to Base (emitter open)	−25 volts
Collector to Emitter (R_{EB} = 1 K ohm)	−25 volts
Emitter to Base (collector open)	− 5 volts
Collector Current	200 ma

	2N241	**2N241A**
Power		
Collector Dissipation (25°C)*	100	180 mw
Temperature		
Operating Range	−55 to 60 °C	−55 to 60 °C
Storage Range	−55 to 85 °C	−55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS: (25°C)

Class B Audio Amplifier Operation			
(Values for two transistors. Note that matching is not required to hold distortion to less than 5% for any two transistors from a type)			
Maximum Class B Ratings (Common Emitter)			
Collector Supply Voltage, Vcc	−12	−12	volts
Power Output (Distortion less than 5%), PO_e	300	750	mw
Design Center Characteristics			
Input Impedance large signal base to base (ΔI_E = 150 ma), $h_{\bar{ie}}$	4000	4000	ohms
Base Current Gain (V_{CE} = −1 v; I_c = 150 ma) h_{FE}	73	73	
Collector Capacity (V_{CB} = −5 v; I_E = 1 ma; f = 1 mc), C_{ob}	35	35	$\mu\mu$f
Frequency Cut off (V_{CE} = −5 v; I_E = 1 ma), f_{ab}	1.3	1.3	mc
Class B Circuit Performance (Common Emitter)			
Collector Voltage, V_{cc}	−12	−12	volts
Minimum Power Gain at 100 mw power output, G_e	34	34	min db
Class A Audio Amplifier Operation (Common Emitter)			
(E_{cc} = −12v; I_E = 10 ma)			
Power Gain at 50 mw power output, G_e		35	db
Cutoff Characteristics			
Maximum Collector Cutoff Current (V_{CB} = −25 v), Ico	16	16	max μa
Maximum Emitter Cutoff Current (V_{EB} = −5 v), I_{EO}	10	10	max μa

*Derate 3 mw/°C increase in ambient temperature within range 25°C to 60°C.

2N265

Outline Drwg. No. 8

The 2N265 is an alloy junction PNP transistor intended for driver service in transistorized audio amplifiers. By control of transistor characteristics during manufacture, a specific power gain is provided for each type. Special processing techniques and the use of hermetic seals provides stability of these characteristics throughout life.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Voltages

Collector to Emitter (R_{EB} = 1 K ohm)	−25 volts

Collector Current	50 ma
Power	
Collector Dissipation (25°C)*	75 mw
Temperature	
Operating Range	−55 to 60 °C
Storage Range	−55 to 85 °C

TYPICAL ELECTRICAL CHARACTERISTICS: (25°C)

Audio Driver Class A Operation

(Values for one transistor driving a transformer coupled output stage)

Maximum Class A Ratings (Common Emitter)	
Collector Supply Voltage, V_{CC}	12 volts
Design Center Characteristics	
Input Impedance base to emitter (I_E = 1 ma), h_{ie}	4000 ohms
Base Current Gain (V_{CE} = −5 v; I_E = 1 ma), h_{fe}	110′
Collector Capacity (V_{CB} = −5 v; I_E = 1 ma), C_{ob}	35 μμf
Frequency Cutoff (V_{CB} = −5 v; I_E = 1 ma), f_{ab}	1.5 mc
Noise Figure (V_{CB} = −5 v; I_E = I ma; f = 1 KC; BW = 1 cycle), NF	15 db
Audio Circuit Performance (Common Emitter)	
Collector Supply Voltage, V_{CC}	12 volts
Emitter Current, I_E	1 ma
Minimum Power Gain at 1 mw power output, G_e	45 min db
Small Signal Characteristics (Common Base)	
(V_{CB} = −5v; I_E = 1 ma; f = 270 cps)	
Input Impedance, h_{ib}	29 ohms
Voltage Feedback Ratio, h_{rb}	4×10^{-4}
Current Amplification, h_{fb}	.991
Output Admittance, h_{ob}	.5 μmhos
Cutoff Characteristics	
Maximum Collector Cutoff Current (V_{CB} = 25 v), I_{CO}	16 max μa

*Derate 1.25 mw/°C increase in ambient temperature within range 25°C to 60°C.

2N292, 2N293

Outline Drwg. No. 14

Types 2N292 and 2N293 are rate grown NPN germanium transistors intended for amplifier applications in radio receivers. Special manufacturing techniques provide a low value and a narrow spread in collector capacity so that neutralization in many circuits is not required. The type 2N293 is intended for receiver circuits where high gain is needed. In IF amplifier service the range in power gain is controlled to 3 db.

IF TRANSISTOR SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS	2N292	2N293	
Voltage			
Collector to Emitter (base open), V_{CB}	15	15	volts
Collector to Base (emitter open), V_{CB}	15	15	volts
Current			
Collector, I_C	−20	−20	ma
Power			
Collector Dissipation at 25°C*, P_c	65	65	mw
Temperature Range			
Operating and Storage, T_s	−55 to 85	−55 to 85	°C
ELECTRICAL CHARACTERISTICS**			
IF Amplifier Service			
Maximum Ratings			
Collector Supply Voltage, V_{CC}	12	12	volts
Design Center Characteristics			
Input Impedance (I_E = 1 ma; V_{CB} = 5v; f = 455 KC), Z_{in}	500	350	ohms
Output Impedance (I_E = 1 ma; V_{CB} = 5v; f = 455 KC), Z_{out}	15	15	K ohms
Voltage Feedback Ratio (I_E = 1 ma; V_{CB} = 5v; f = mc), h_{rb}	10×10^{-3}	5×10^{-3}	
Collector to Base Capacitance (I_E = 1 ma; V_{CB} = 5v; f = 1 mc), C_{ob}	2.4	2.4	μμf
Frequency Cutoff (I_E = 1 ma; V_{CB} = 5v), f_{ab}	5	8	mc
Base Current Gain (I_B = 20 ma; V_{CB} = 1v), h_{FE}	25	25	
Min. Base Current Gain, h_{FE}	6	6	
Max. Base Current Gain, h_{FE}	44	55	
IF Amplifier Performance			
Collector Supply Voltage, V_{CC}	5	5	volts
Collector Current, I_E	1	1	ma
Input Frequency, f	455	455	KC
Available Power Gain, G_e	36	30	db
Min. Power Gain in Typical IF Test Circuit, G_e	25	28	db min
Power Gain Range of Variation in Typical IF Circuit	3	3	db
Cutoff Characteristics			
Collector Cutoff Current (V_{CB} = 5v), I_{co}	.5	.5	μa
Collector Cutoff Current (V_{CB} = 15v), I_{co}	.5	.5	μa max

*Derate 1.1 mw/°C increase in ambient temperature over 25°C.
**All values are typical unless indicated as a min or max.

REGISTERED RETMA TRANSISTOR TYPES

For explanation of symbols, ratings and mfg. symbols see page 33.

RETMA No.	Type	Mfr.	Use	Dwg. No.	MAX. RATINGS: Pc mw @ 25°C	BV$_{CE}$	Ic ma	T$_j$ °C	TYPICAL VALUES: h$_{fe}$	f$_{ab}$ mc	G$_e$ db	P$_o$ mw — Class A	Class B	Closest GE
2N22	Pt	WE	SW	1	120	−100	−20	55	1.9α					
2N23	Pt	WE	SW	2	80	−50	−40	55	1.9α					
2N24	Pt	WE	AF	1	120	−30	−25	50	2.2α					
2N25	Pt	WE	AF	1	200	−50	−30	60	2.5α					
2N26	Pt	WE	SW	2	90	−30	−40	55						
2N27	NPN	WE	AF	1	50	35	100	85	100	1				
2N28	NPN	WE	AF	1	50	30	100	85	100	.5				
2N29	NPN	WE	AF	1	50	35	30	85	100	1				
2N30	Pt	GE	Obsolete	3	100	30	7	40	2.2α	2	17			old G11
2N31	Pt	GE	Obsolete	3	100	30	7	40	2.2α	2				old G11A
2N32	Pt	RCA		5	50	−40	−8	40	2.2α	2.7	21			
2N33	Pt	RCA	RF	5	30	−8.5	−7	40		50Mc	Osc.			
2N34	PNP	RCA	AF	6	50	−25	−8	50	40	.6	40			2N190
2N35	NPN	RCA	IF	6	50	25	8	50	40	.8	40		125	2N169A
2N36	PNP	CBS	AF	4	50	−20	−8	50	45		40			2N191
2N37	PNP	CBS	AF	4	50	−20	−8	50	30		36			2N190
2N38	PNP	CBS	AF	4	50	−20	−8	50	15		32			2N189
2N38A	PNP	CBS	AF	4	50	−20	−8	50	18		32			2N189
2N41	PNP	RCA		7	50	−25	−15	50	40		40			2N190
2N43	PNP	GE	AF	8	150	−20*	−50	100	50	1	40	40		2N43
2N43A	PNP	GE	AF	8	150	−20*	−50	100	40	1	40	40		2N43A
2N44	PNP	GE	AF	8	150	−20*	−50	100	20	1	39	40		2N44
2N45	PNP	GE	AF	8	150	−20*	−50	100	12	1	38	40		2N45
2N46	PNP	RCA		7	see 2N41									2N190
2N47	PNP	Phil	AF	13	50	−35	−20	65	38	8	40			2N190 25V
2N48	PNP	Phil	AF	13	50	−35	−20	65	32	8	40			2N189 25V
2N49	PNP	Phil	AF	13	50	−35	−20	65	38	8	40			2N190 25V
2N50	Pt	Cle		1	50	−15	−1	50	2α	3	20			
2N51	Pt	Cle	SW	1	100	−50	−8	50			20			
2N52	Pt	Cle	RF	1	120	−50	−8	50			20			
2N53	Pt	Cle	RF	1	100	−50	−8	50	2α	5	20			
2N54	PNP	W	AF	9	200	−45	−10	60	32	.5	40			2N190 25V
2N55	PNP	W	AF	9	200	−45	−10	60	20	.5	39			2N190 25V
2N56	PNP	W	AF	9	200	−45	−10	60	12	.5	38			2N189 25V
2N57	PNP	W	PWR	12	20W	−60	−.8A		60		14	5W		
2N62	PNP	Phil	Obsolete		50	−35	−20		40					
2N63	PNP	Ray	AF	10	100	−22	−10	85	22	6	39	40		2N107
2N64	PNP	Ray	AF	10	100	−15	−10	85	45	8	41	40		2N191
2N65	PNP	Ray	AF	10	100	−12	−10	85	90	1.2	42	40		2N192

RETMA No.	Type	Mfr.	Use	Dwg. No.	MAX. RATINGS: Pc mw @ 25°C	BVCE	Ic ma	Tj °C	TYPICAL VALUES: hfe	fab mc	Ge db	Po mw — Class A	B	Closest GE
2N68	PNP	Syl	PWR	11	2W/4W	−25	−1.5A	70	40	.4	23	600	5W	
2N71	PNP	W	PWR	21	1W	−50	−250	60		.25	25	400		
2N72	Pt	RCA	Obsolete		50	−40	−20	55		2.5				
2N73	PNP	W	AF SW	9	200	−50					low level			
2N74	PNP	W	AF SW	9	200	−50					high level			
2N75	PNP	W	AF SW	9	200	−50					very low level			
2N76	PNP	GE	AF	8	50	−20	−10	60	20	1	38			2N190
2N77	PNP	RCA	AF	19	35	−25	−15	50	55	.7	44	50		2N191
2N78	NPN	GE	RF	14	75	15	20	85	50	4	22			2N169 or 2N168A
2N79	PNP	RCA	AF	20	35	−30	−50		46	.7	44	50		2N191
2N80	PNP	CBS	AF	4	50	−25	−8	Hi	80					2N192
2N81	PNP	GE	AF	8	50	−20	−15	100	30					use 2N189
2N82	PNP	CBS	AF	15	35	−20	−15	Hi	30					
2N94	NPN	Syl	RF Sw	10	30	20	50	75	30	3	38			{ 2N169A (and
2N94A	NPN	Syl	RF Sw	10	30	20	50	75	40	6	38			2N123 PNP)
2N95	NPN	Syl	Pwr	11	2.5W/4W	25	1.5A	70	40	.4	23	600	5W	
2N97	NPN	GP	IF	10	50	30	10	75	13	1	20			2N169 15V
2N97A	NPN	GP	IF	10	50	40	10	85	13	1	20			2N169A 25V
2N98	NPN	GP	IF	10	50	40	10	75	38	2.5	22			2N169A 25V
2N98A	NPN	GP	IF	10	50	40	10	85	38	2.5	22			2N169A 25V
2N99	NPN	GP	IF	10	50	40	10	75	38	3.5	22			2N169A 25V
2N100	NPN	GP	IF	10	25	25	5	50	100	5	23			2N170 6V
2N101	PNP	Syl	Pwr	28	1W	−25	−1.5A	70			23	600		
2N102	NPN	Syl	Pwr	28	1W	25	1.5A	70			23	600	5W	
2N103	NPN	GP	Genl IF	10	50	35	10	75	5	.75	15			2N170 6V
2N104	PNP	RCA	AF	20	70	−30	−50	70	44	.7	41			2N190 25V
2N105	PNP	RCA	AF	23	35	−25	−15	50	55	.75	42			2N191
2N106	PNP	Ray	AF	10	100	−6	−10	85	45	.8	36	40		2N189
2N107	PNP	GE	AF	8	50	−6	−10	60	20	1	38			2N107
2N108	PNP	CBS	AF Out	16	50	−20	−15						35	
2N109	PNP	RCA	AF Out	20	50	−12	−35	50	70		33	75	150	2N188-2N192
2N111	PNP	Ray	IF	10	100	−6	−5	85	40	3	30			2N135
2N112	PNP	Ray	RF	10	100	−6	−5	85	40	5	32			2N136-2N135
2N113	PNP	Ray	RF	10	100	−6	−5	85	45	10	33			2N137
2N114	PNP	Ray	RF Sw	10	100	−6	−5	85	65	20				2N137 or 2N123
2N117	NPN	TI	Si	10	150	30	25	150	12	4				
2N118	NPN	TI	Si	10	150	30	25	150	24	5				
2N123	PNP	GE	RF Sw	8	100	−20	−125	85	50	8				2N123
2N124	NPN	TI	RF Sw	10	50	10	8	75	18	3				2N168
2N125	NPN	TI	RF Sw	10	50	10	8	75	32	5				2N167
2N126	NPN	TI	RF Sw	10	50	10	8	75	60	5				2N167
2N127	NPN	TI	RF Sw	10	50	10	8	75	130	5				2N167
2N128	PNP	Phil	SB Osc	13	30	−4.5	−5	85	35	60				
2N129	PNP	Phil	SB Osc	13	30	−4.5	−5	85	20	40				
2N135	PNP	GE	IF	8	100	−12	−50	85	20	4.5	29			2N135

2N136	PNP	GE	RF	8	100	−12	−50	85	40	6.5	31			2N136
2N137	PNP	GE	RF	8	100	−6	−50	85	60	10	33			2N137
2N138	PNP	Ray	AF Out		50	−12	−20	40	140		30		50	2N192
2N138A	PNP	Ray	AF Out		50	−45	−100	85	10		29	25	100	2N187 25V
2N139	PNP	RCA	IF	20	35	−16	−15	70	48	4.7	29			2N136-2N135
2N140	PNP	RCA	Osc	20	35	−16	−15	70	45	7	28			2N136
2N141	PNP	Syl	Pwr	26	1.5W/4W	−30	−.8A	65	40	.4	26	600	5W	
2N142	NPN	Syl	Pwr	26	1.5W/4W	30	.8A	65	40	.4	26	600	5W	
2N143	PNP	Syl	Pwr	26	1W/4W	−30	−.8A	65	40	.4	26	600	5W	
2N144	NPN	Syl	Pwr	26	1W/4W	30	.8	65	40	.4	26	600	5W	
2N145	NPN	TI	IF	10	65	20	5	75			33 max			2N169 or 2N292
2N146	NPN	TI	IF	10	65	20	5	75			36 max			2N169 or 2N292
2N147	NPN	TI	Osc	10	65	20	5	75			39 max			2N168A or 2N293
2N148	NPN	TI	lo IF	10	65	16	5	75			35 max			2N169 or 2N292
2N148A	NPN	TI	lo IF	10	65	32	5	75			35 max			2N169A
2N149	NPN	TI	lo IF	10	65	16	5	75			38 max			2N169 or 2N292
2N149A	NPN	TI	lo IF	10	65	32	5	75			38 max			2N169A
2N150	NPN	TI	lo IF	10	65	16	5	75			41 max			2N169 or 2N292
2N150A	NPN	TI	lo IF	10	65	32	5	75			41 max			2N169A
2N155	PNP	CBS	Pwr	27	1.5W/5W	−30	−3A	85	48	.3	33	2W	9W	
2N156	PNP	CBS	Pwr	22	1.5W/5W	−30	−3A	85	40	.3	36	2W	9W	
2N158	PNP	CBS	Pwr	22	1.5W/5W	−60	−3A	85	40	.3	40	2W	17W	
2N159	Pt	Sprague	Sw		80	−50	−10			2				
2N160	NPN	GP	Si IF	10	150	40	25	150	14	4	34			
2N160A	NPN	GP	Si IF	10	150	40	25	150	14	4	34			
2N161	NPN	GP	Si RF	10	150	40	25	150	28	5	37			
2N161A	NPN	GP	Si RF	10	150	40	25	150	28	5	37			
2N162	NPN	GP	Si RF	10	150	40	25	150	38	8	38			
2N162A	NPN	GP	Si RF	10	150	40	25	150	38	8	38			
2N163	NPN	GP	Si RF	10	150	40	25	150	50	6	40			
2N163A	NPN	GP	Si RF	10	150	40	25	150	50	6	40			
2N167	NPN	GE	Sw	14	65	30	75	85	36	8				2N167
2N168	NPN	GE	RF	14	55	15	20	75	20	6	39 max			use 2N293
2N168A	NPN	GE	Osc	14	65	15	20	85	40	8	39 max			2N168A
2N169	NPN	GE	IF	14	55	15	20	75	40	4	35 max			2N169
2N169A	NPN	GE	IF	14	55	25	20	75	30	5	35 max			2N169A
2N170	NPN	GE	RF	14	55	6	20	50	20	4	27			2N170
2N172	NPN	TI	IF	10	65	16	5	75			28			2N168A
2N173	PNP	Dlc	Pwr	18	40W	−60	−7A	90	100	.6		8	20W	
2N174	PNP	Dlc	Pwr	18	40W	−80	−7A	90	45	.2		20	80W	
2N175	PNP	RCA	AF	20	20	−10	−2	50	65	.8	43			2N192
2N176	PNP	Motor	Pwr	27		−12	−600	80			25	3W		
2N178	PNP	Motor	Pwr	27	10W	−12	−600	80	30		29	3W		
2N180	PNP	CBS	AF Out	4	150	−30	−25	75	60	.7	37	3W	300	2N188
2N181	PNP	CBS	AF Out	25	250	−30	−38	75	60	.7	34	110	600	2N188A 25V
2N182	NPN	CBS	IF	4	100	25	10	75	25	3.5				2N167
2N183	NPN	CBS	Sw	4	100	25	10	75	40	7.5				2N167
2N184	NPN	CBS	Sw	4	100	25	10	75	60	12				2N167
2N185	PNP	TI	AF	10	150	−20	−150	50	55		40.5	2	250	2N188A
2N186	PNP	GE	AF Out	8	75	−25	−200	60	24	.8	28		300	2N186
2N186A	PNP	GE	AF Out	8	180	−25	−200	60	24	.8	28		750	2N186A

RETMA No.	Type	Mfr.	Use	Dwg. No.	MAX. RATINGS Pc mw @ 25°C	BVCB	Ic ma	Tj °C	TYPICAL VALUES hfe	fab mc	Ge db	Po mw — Class A	B	Closest GE
2N187	PNP	GE	AF Out	8	75	−25	−200	60	36	1	30		300	2N187
2N187A	PNP	GE	AF Out	8	180	−25	−200	60	36	1	30		750	2N187A
2N188	PNP	GE	AF Out	8	75	−25	−200	60	54	1.2	32		300	2N188
2N188A	PNP	GE	AF Out	8	180	−25	−200	60	54	1.2	32		750	2N188A
2N189	PNP	GE	AF	8	75	−25	−50	60	24	.8	37	1		2N189
2N190	PNP	GE	AF	8	75	−25	−50	60	36	1	39	1		2N190
2N191	PNP	GE	AF	8	75	−25	−50	60	54	1.2	41	1		2N191
2N192	PNP	GE	AF	8	75	−25	−50	60	75	1.5	43	1		2N192
2N194	NPN	Syl	Osc	10	50	15	50	75	7.5	3.5	15			2N169
2N206	PNP	RCA	AF	19	75	−30	−50	85	47	.8	46			2N191
2N211	NPN	Syl	Osc		50	10	50	75	30	3.5				2N293
2N212	NPN	Syl	Osc	10	50	10	50	75	15	6	22			2N293
2N214	NPN	Syl	AF Out	10	125	25	75	70	70	.8	29		200	2N188 (PNP)
2N215	PNP	RCA	AF	19	50	−30	−50	70	44	.7	41			2N191
2N216	NPN	Syl	IF	10	50	15	50	75	15	3	26			2N169
2N217	PNP	RCA	AF	19	50	−25	−70	50	70		33		160	2N192
2N218	PNP	RCA	IF	19	35	−16	−15	70	48	4.7	30			2N135
2N219	PNP	RCA	Osc	19	35	−16	−15	70	45	7	27			2N136
2N220	PNP	RCA	AF	19	20	−10	−2	50	65	.8	43			2N192
2N228	NPN	Syl	AF Out	10	50	25		75	70	.8	26		100	2N169
2N229	NPN	Syl	AF	10	50	12	40	75	25	1.6				2N169
2N230	PNP	Mall	Pwr	27	15W	−30	−2A	85	83	.014 (β)				
2N237	PNP	NAC	AF		150	−45	−20	55	70	1	44			2N192 25V
2N238	PNP	TI	AF	10	50	−20		60			42m			2N191
2N240	PNP	Phil	SB Sw		10	−6	−15		16					
2N241	PNP	GE	AF Out	8	100	−25	−200	60	60	1.2	34		300	2N241
2N241A	PNP	GE	AF Out	8	180	−25	−200	60	60	1.2	34		750	2N241A
2N242	PNP	Syl	Pwr	27		−45	−2A	100	40	5Kc (β)	30	2.5W		
2N247	PNP	RCA	Drift RF	24	35	−35	−10	85	60	30	(37 @ 1.5Mc)			
2N249	PNP	TI	AF Out	17	350	−25	−200	60	45		31	50	500	2N188A
2N250	PNP	TI	Pwr	27	12W	−30	−2A	80	50	6 Kc	34	6W		
2N251	PNP	TI	Pwr	27	12W	−60	−2A	80	50	6 Kc	34	6W		
2N253	NPN	TI	IF	10	65	12	5	75			30			2N293
2N254	NPN	TI	IF	10	65	20	5	75			34			2N293
2N255	PNP	CBS	Pwr	27	1.5W/6.25W	−15	−3A	85	40	.2	23	1W	5W	
2N256	PNP	CBS	Pwr	27	1.5W/6.25W	−30	−3A	85	40	.2	26	2W	10W	
2N257	PNP	Cle	Pwr	27	2W/25W	−20		85	50	7 Kc (β)	30	1W		
2N260	PNP	Cle	Si	4	200	−10	−50	150	16	1.8	38			
2N260A	PNP	Cle	Si	4	200	−30	−50	150	16	1.8	38			
2N261	PNP	Cle	Si	4	200	−75	−50	150	10	1.8	36			
2N262	PNP	Cle	Si RF	4	200	−10	−50	150	20	6	40			
2N262A	PNP	Cle	Si RF	4	200	−30	−50	150	20	6	40			
2N265	PNP	GE	AF	8	75	−25	−50	60	110	1.5	45			2N265
2N268	PNP	Cle	Pwr		2W/25W	−30			7	6 Kc (β)	28			
2N269	PNP	RCA	Sw		35	−20	−100	70	35	4				2N123
2N292	NPN	GE	IF	14	55	15	20	75	80	6	35 max			2N292
2N293	NPN	GE	RF	14	55	15	20	75	35	4	39 max			2N293

EXPLANATION OF SYMBOLS

TYPES AND USES:

Si—Silicon High Temperature Transistors (all others germanium)
Pt—Point contact types
AF—Audio Frequency Amplifier—Driver
AF Out—High current AF Output
Pwr—Power output 1 watt or more
RF—Radio Frequency Amplifier
Osc—High gain High frequency RF oscillator
IF—Intermediate Frequency Amplifier
lo IF—Low IF (262 Kc) Amplifier
Sw—High current High frequency switch
AF Sw—Low frequency switch

RATINGS:

P_c=*Maximum collector dissipation* at 25°C (76°F) ambient room temperature. Secondary designations are ratings with connection to an appropriate heat sink.

BV_{CE}=*Minimum collector-to-emitter breakdown voltage.* GE transistors measured with Base-to-emitter resistance as follows:
10K for AF and AF Out PNP
1 Meg for RF, IF, and Osc PNP
Open circuit for NPN

*BV_{CB}=45 Minimum collector-to-base breakdown voltage (for grounded base applications).

I_C=*Maximum collector current.* (Negative for PNP, Positive for NPN.)

T_j=Maximum centigrade *junction temperature.* P_C must be derated linearily to O mw dissipation at this temperature.

h_{fe}=Small signal base to collector *current-gain,* or Beta (except for Pt Contact types where emitter to collector gain, alpha α, is given).

f_{ab}=*Alpha cut-off-frequency.* Frequency at which the emitter to collector current gain, or alpha, is down to $\sqrt{2}$ or .707 of its low frequency audio value. For some power transistors, the Beta or base-to-collector current-gain cutoff—frequency is given as noted.

G_e=Grounded-emitter *Power Gain.*
AF, AF Out, and Pwr Gain measured at 1 Kc.
RF, IF, and Osc Gains at 455 Kc.
(Sw Gain is dependent on circuit and wave-shape.)
(All measured at typical power output level for given transistor type.)

P_o=Maximum *Power Output* at 5% harmonic distortion, in mw except where noted as watts. Class A single-ended, Class B Push Pull.

MANUFACTURERS:

CBS—CBS-Hytron.
Cle—Clevite Transistor Products.
DLc—Delco Radio Div., General Motors Corp.
GE—General Electric Company.
GP—Germanium Products Corp.
Mall—P. R. Mallory and Company, Inc.
Mar—Marvelco, National Aircraft Corp.
Motor—Motorola, Inc.
Phil—Philco.
Ray—Raytheon Manufacturing Company.
RCA—RCA.
Sprague—Sprague Electronics Company.
Syl—Sylvania Electric Products Company.
TI—Texas Instruments, Inc.
W—Westinghouse Electric Corp.
WE—Western Electric Company.

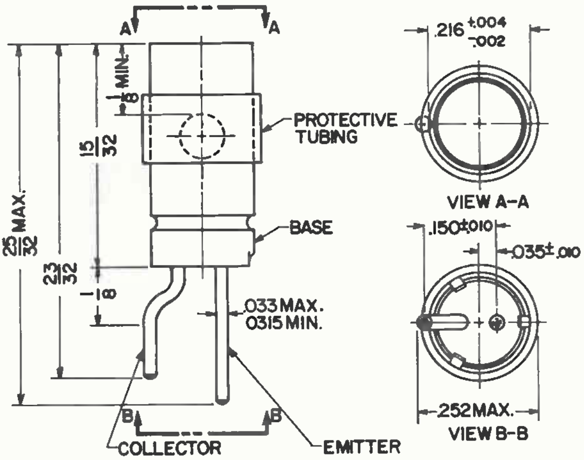
NOTE:

Closest GE types are given only as a general guide and are based on available published electrical specifications. However, General Electric Company makes no representation as to the accuracy and completeness of such information.

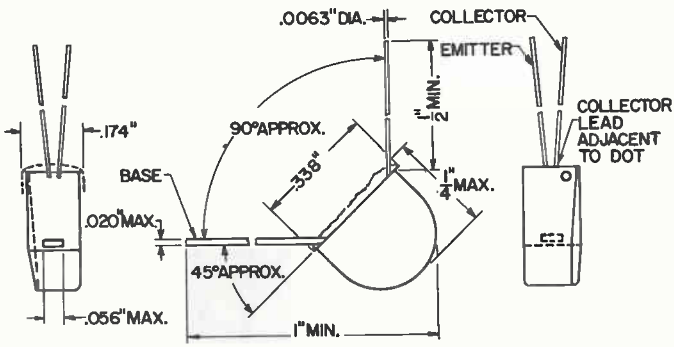
Where the maximum voltage rating of the GE unit is not equal to or greater than the given transistor, the GE rating is also given. Note that physical dimensions vary considerably among manufacturers and may be the limiting factor in some replacement applications.

Since manufacturing techniques are not identical, the General Electric Company makes no claim, nor does it warrant, that its transistors are exact equivalents or replacements for the types referred to.

OUTLINE DRAWINGS



1



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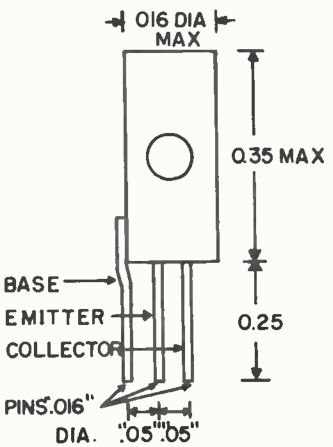

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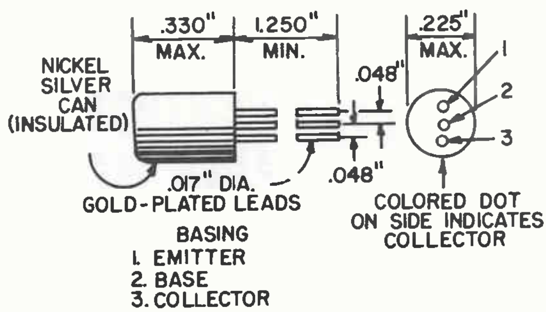

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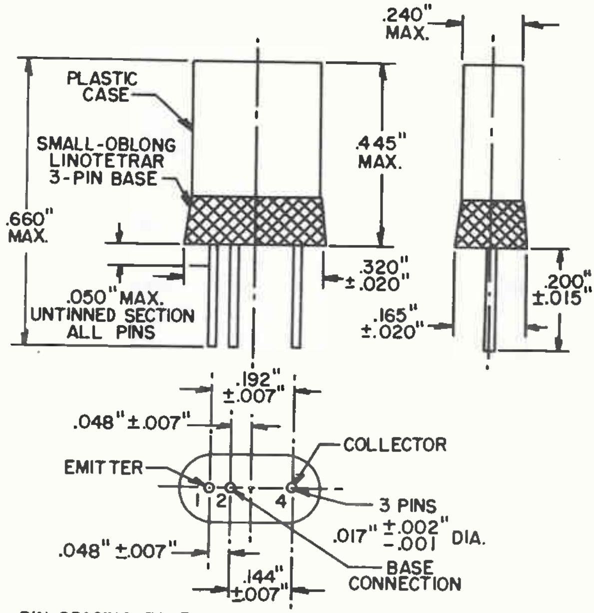
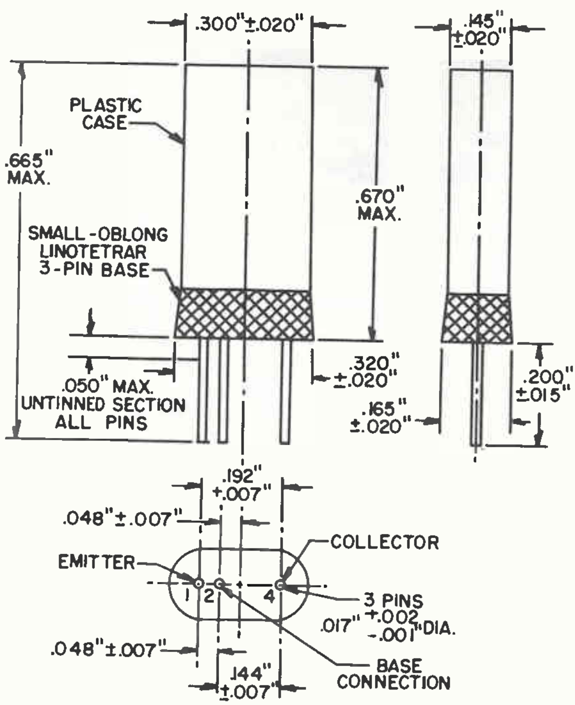


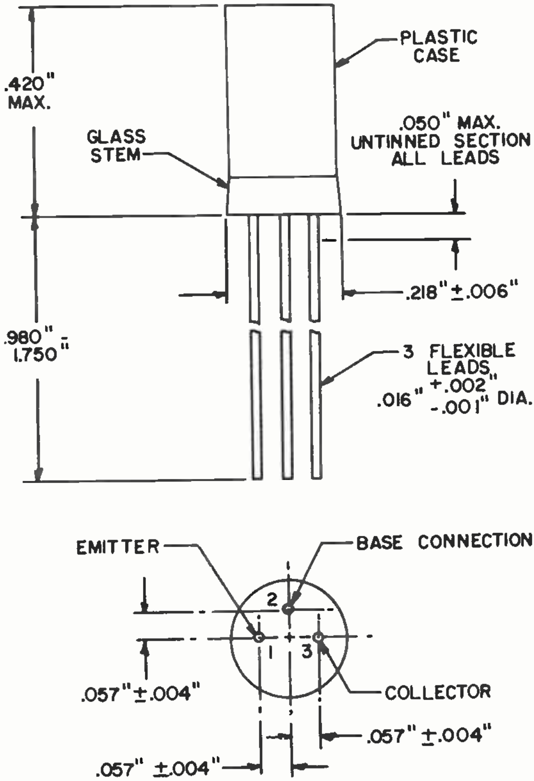
PIN-SPACING TOLERANCES ARE NOT CUMULATIVE

5



PIN-SPACING TOLERANCES ARE NOT CUMULATIVE

6



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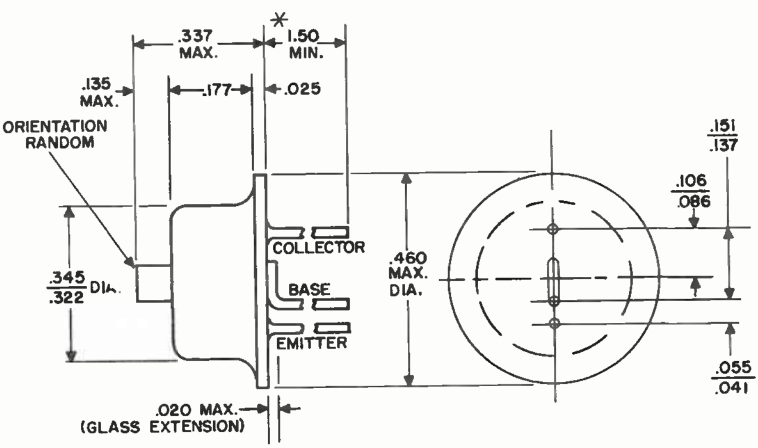
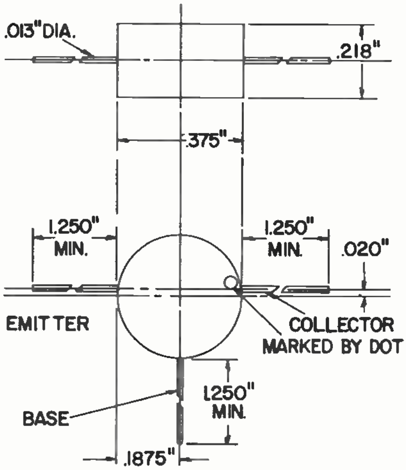
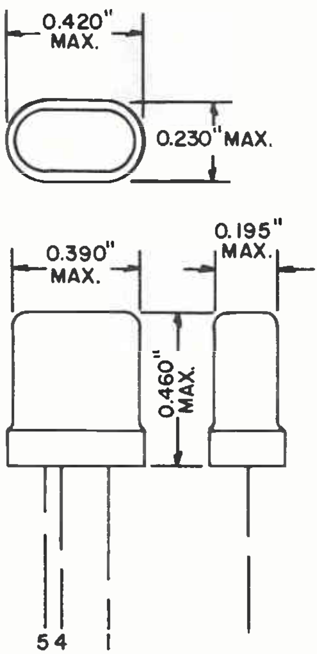


8

* CUT TO 0.200" FOR USE IN SOCKETS.
LEADS TINNED DIA. .018
MOUNTING POSITION – ANY
WEIGHT: .05 OZ.
BASE CONNECTED TO TRANSISTOR SHELL.
DIMENSIONS IN INCHES.

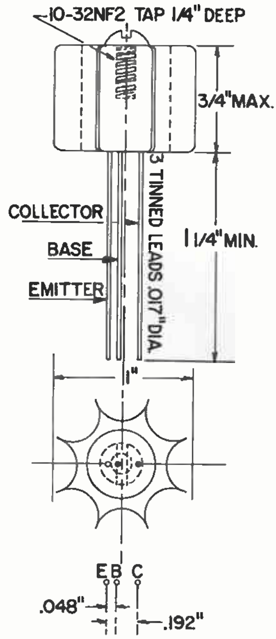


9



(0.016" TINNED FLEXIBLE LEADS.
LENGTH: 1.5" MIN.
SPACING: LEADS 1-4 0.144"
CENTER TO CENTER.
OTHER LEADS 0.048"
CENTER TO CENTER)

10



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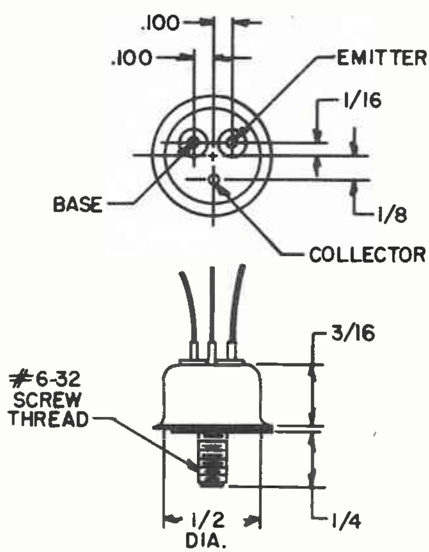
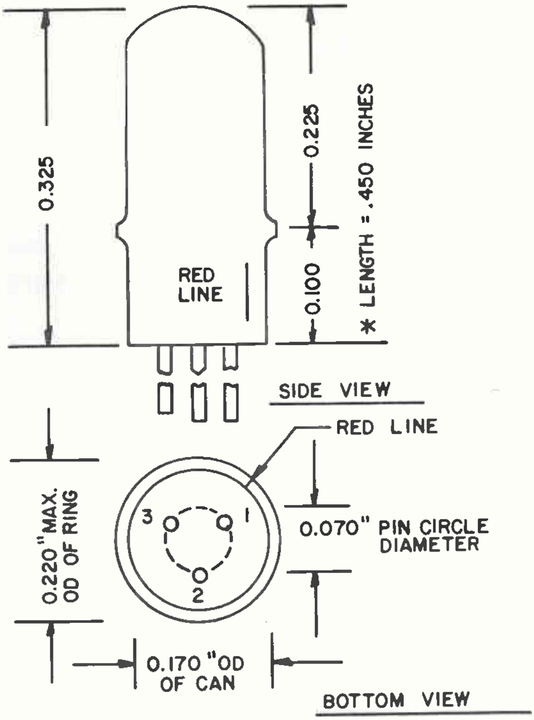
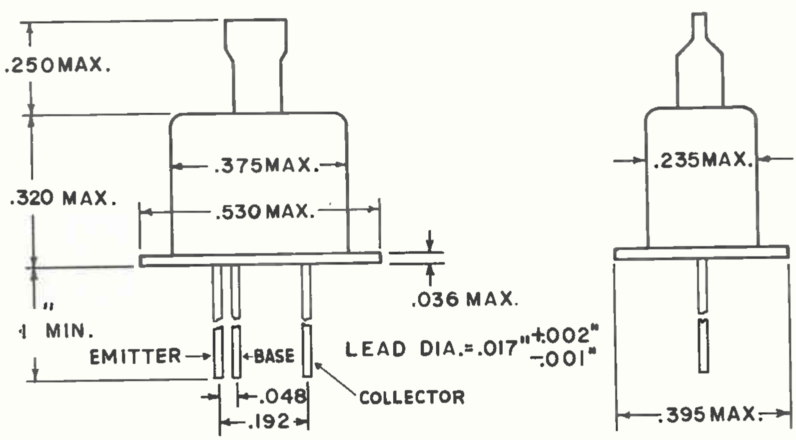


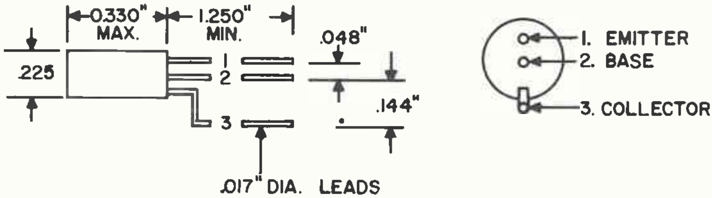
12


0.325
0.225
0.100
* LENGTH = .450 INCHES
RED LINE
SIDE VIEW
RED LINE
3
1
2
0.220" MAX. OD OF RING
0.070" PIN CIRCLE DIAMETER
0.170" OD OF CAN
BOTTOM VIEW

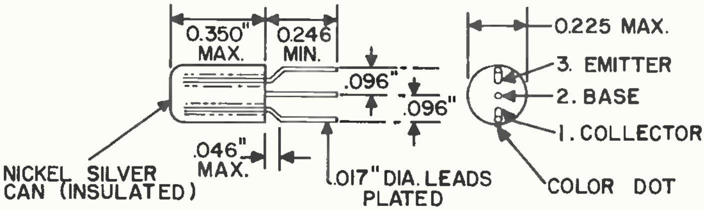
13


.250 MAX.
.375 MAX.
.320 MAX.
.530 MAX.
.036 MAX.
1" MIN.
EMITTER
BASE
COLLECTOR
.048
.192
LEAD DIA. = .017" +.002" -.001"
.235 MAX.
.395 MAX.

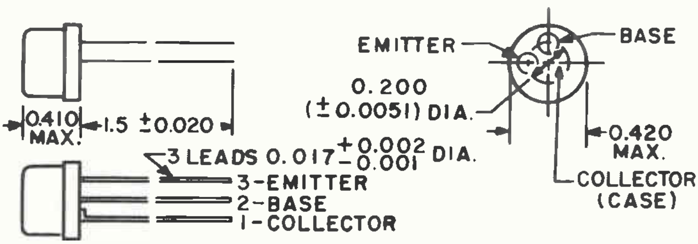
14


0.330" MAX.
1.250" MIN.
.225
.048"
.144"
1
2
3
.017" DIA. LEADS
1. EMITTER
2. BASE
3. COLLECTOR

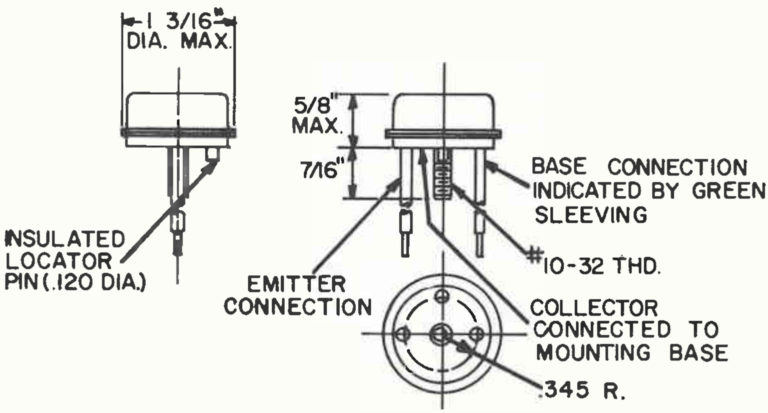
15


0.350" MAX.
0.246 MIN.
.096"
.096"
.046" MAX.
NICKEL SILVER CAN (INSULATED)
.017" DIA. LEADS PLATED
0.225 MAX.
3. EMITTER
2. BASE
1. COLLECTOR
COLOR DOT

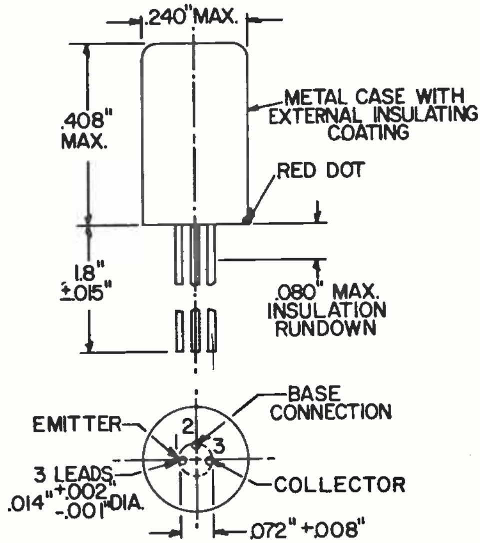
16


0.410 MAX.
1.5 ±0.020
3 LEADS 0.017 +0.002 -0.001 DIA.
3-EMITTER
2-BASE
1-COLLECTOR
EMITTER
BASE
0.200 (±0.0051) DIA.
0.420 MAX.
COLLECTOR (CASE)

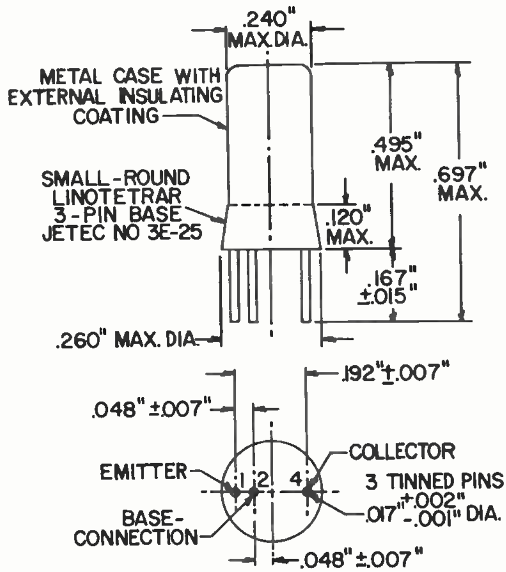
17


1 3/16" DIA. MAX.
INSULATED LOCATOR PIN (.120 DIA.)
5/8" MAX.
7/16"
BASE CONNECTION INDICATED BY GREEN SLEEVING
#10-32 THD.
EMITTER CONNECTION
COLLECTOR CONNECTED TO MOUNTING BASE
.345 R.

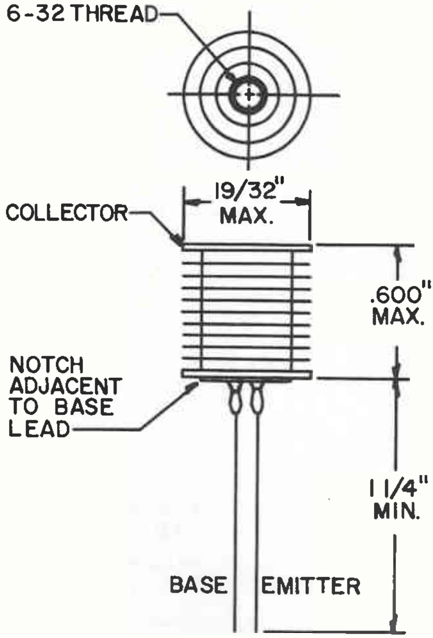
18


.240" MAX.
.408" MAX.
METAL CASE WITH EXTERNAL INSULATING COATING
RED DOT
1.8" ±.015"
.080" MAX. INSULATION RUNDOWN
BASE CONNECTION
EMITTER
3 LEADS .014" +.002" -.001" DIA.
COLLECTOR
.072" ±.008"
1
2
3

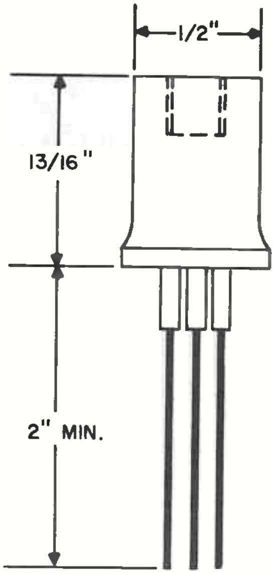
19


.240" MAX. DIA.
METAL CASE WITH EXTERNAL INSULATING COATING
SMALL-ROUND LINOTETRAR 3-PIN BASE JETEC NO 3E-25
.495" MAX.
.697" MAX.
.120" MAX.
.167" ±.015"
.260" MAX. DIA.
.192" ±.007"
.048" ±.007"
COLLECTOR
3 TINNED PINS .017" +.002" -.001" DIA.
EMITTER
BASE-CONNECTION
1
2
4
.048" ±.007"

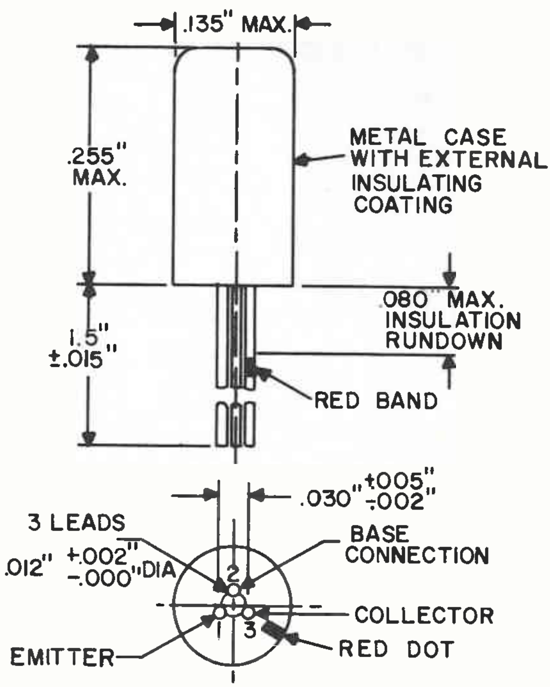
20


6-32 THREAD
COLLECTOR
19/32"
MAX.
.600"
MAX.
NOTCH
ADJACENT
TO BASE
LEAD
1 1/4"
MIN.
BASE
EMITTER

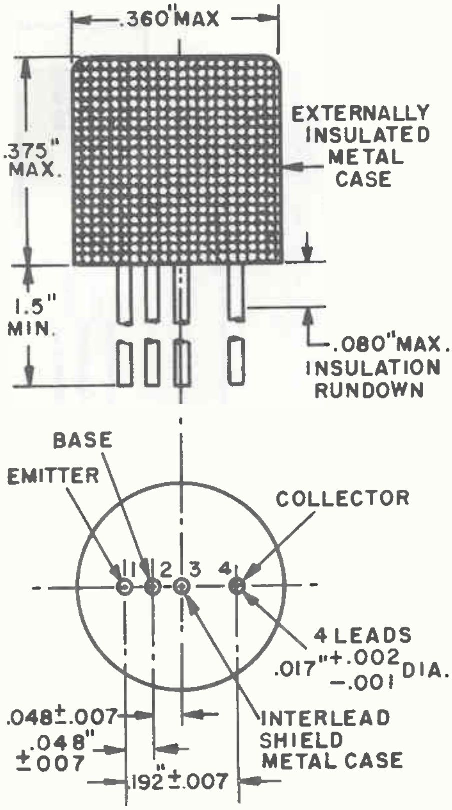
21


1/2"
13/16"
2" MIN.

22

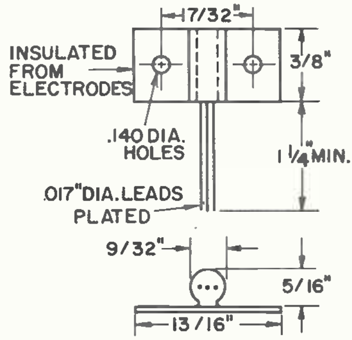

.135" MAX.
.255"
MAX.
METAL CASE
WITH EXTERNAL
INSULATING
COATING
.080" MAX.
INSULATION
RUNDOWN
1.5"
±.015"
RED BAND
.030" +.005" -.002"
3 LEADS
.012" +.002" -.000" DIA
BASE
CONNECTION
2
1
3
COLLECTOR
RED DOT
EMITTER

23



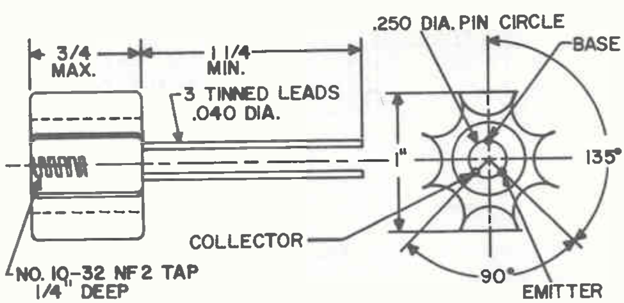
.360" MAX
.375" MAX.
EXTERNALLY INSULATED METAL CASE
1.5" MIN.
.080" MAX. INSULATION RUNDOWN
BASE
EMITTER
COLLECTOR
1 2 3 4
4 LEADS .017" +.002 -.001 DIA.
.048 ± .007
.048" ± .007
.192" ± .007
INTERLEAD SHIELD METAL CASE

24



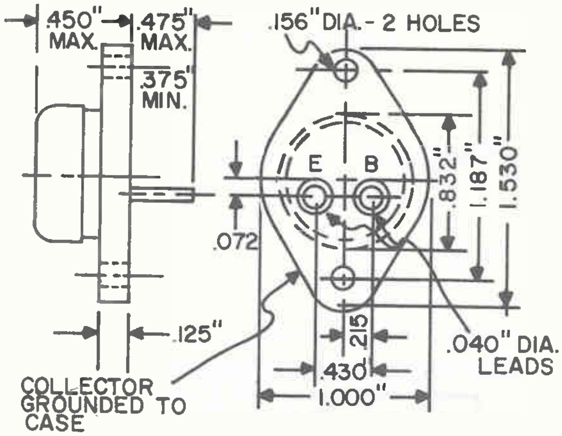
17/32"
INSULATED FROM ELECTRODES
3/8"
.140 DIA. HOLES
1 1/4" MIN.
.017" DIA. LEADS PLATED
9/32"
5/16"
13/16"

25

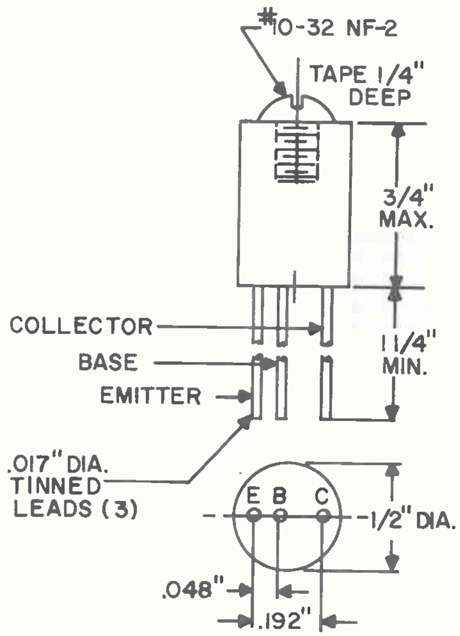


3/4 MAX.
1 1/4 MIN.
.250 DIA. PIN CIRCLE
BASE
3 TINNED LEADS .040 DIA.
1"
135°
COLLECTOR
NO. 10-32 NF2 TAP 1/4" DEEP
90°
EMITTER

26



27



COLLECTOR CONNECTED TO SHELL

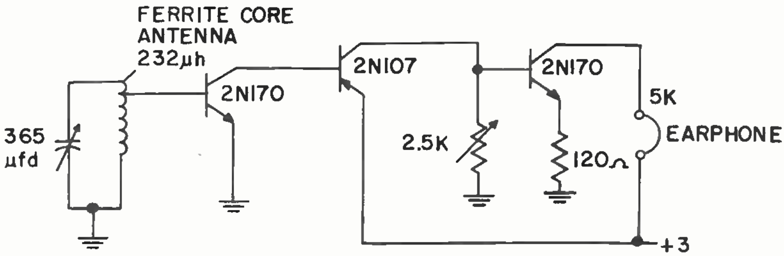
28

CIRCUIT DIAGRAMS

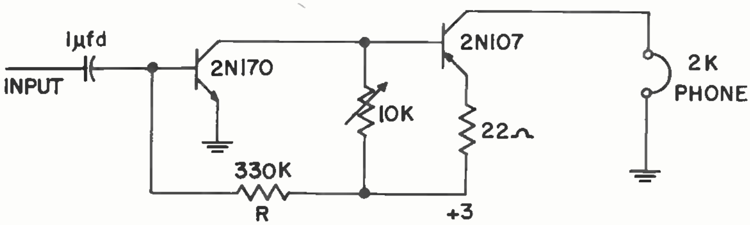
These circuit diagrams are included for illustration of typical transistor applications and are not intended as constructional information. For this reason, wattage ratings of resistors and voltage ratings of capacitors are not necessarily given. Similarly, shielding techniques and alignment methods which may be necessary in some circuit layouts are not indicated.

The description and illustration of the circuits contained herein does not convey to the purchaser of transistors any license under patent rights of General Electric Company. Although reasonable care has been taken in their preparation to insure their technical correctness, no responsibility is assumed by General Electric Company for any consequences of their use.

CIRCUIT DIAGRAMS

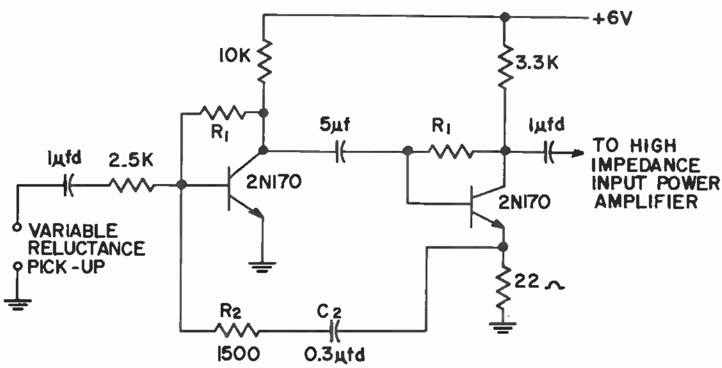


DIRECT COUPLED VEST POCKET RADIO



R SHOULD BE ADJUSTED FOR OPTIMUM RESULTS

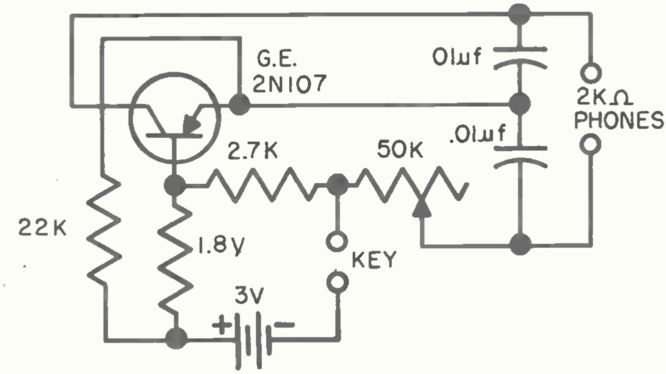
DIRECT COUPLED "BATTERY SAVER" AMPLIFIER



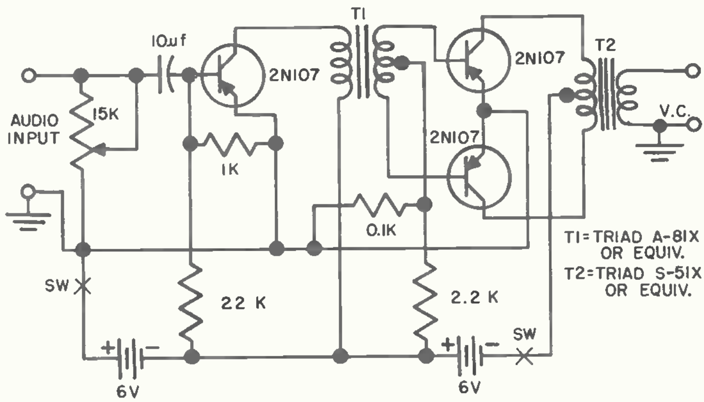
R1 (100K-500K) SHOULD BE CHOSEN TO MAKE COLLECTOR VOLTAGE 2.5 TO 3.5 VOLTS

CHANGING C2 AND R2 WILL VARY COMPENSATION CURVE. VALUES SHOWN GIVE APPROXIMATE COMPENSATION FOR R. I. A. A. RECORDING CHARACTERISTICS

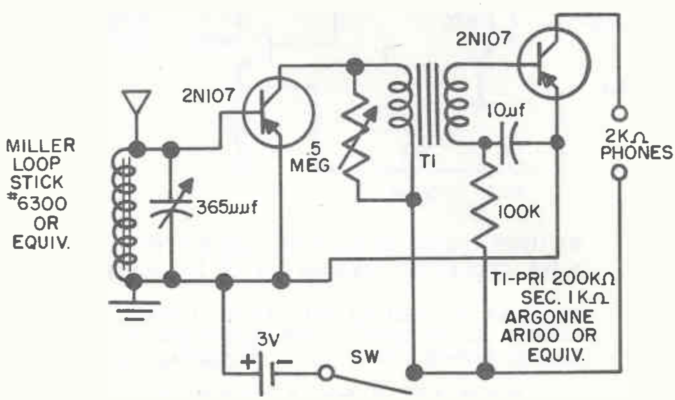
VARIABLE RELUCTANCE
COMPENSATED PRE-AMPLIFIER



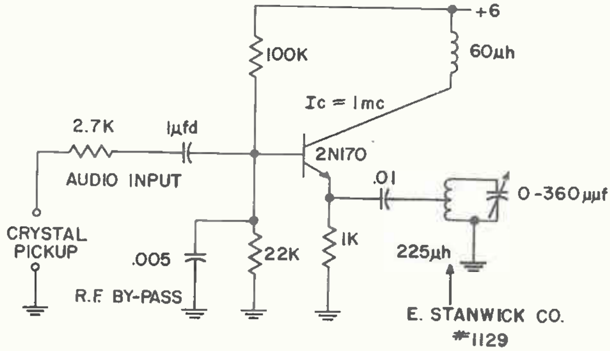
CODE PRACTICE OSCILLATOR



LOUDSPEAKER AUDIO AMPLIFIER

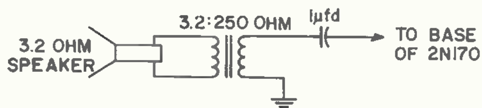


TWO TRANSISTOR RADIO RECEIVER

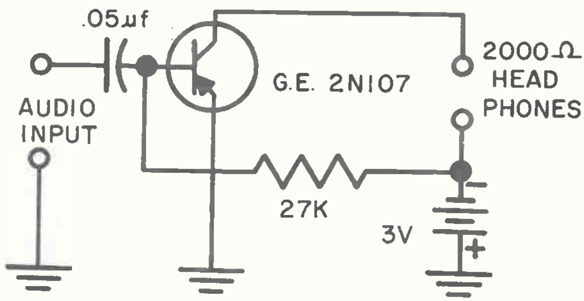


RANGE 6 - 20 FEET

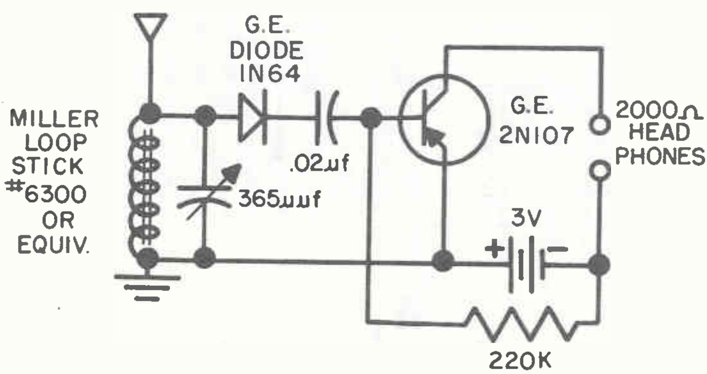
NOTE: FOR "MIKE" INPUT USE FOLLOWING CIRCUIT IN PLACE OF CRYSTAL PICKUP AND RESISTOR



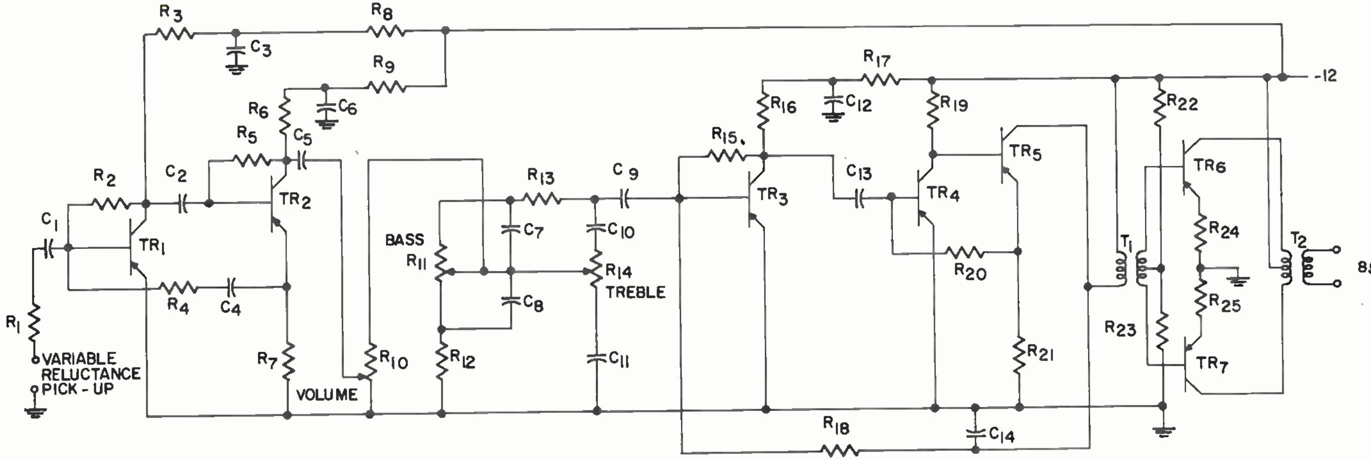
PHONOGRAPH — OSCILLATOR



SIMPLE AUDIO AMPLIFIER



SIMPLE RADIO RECEIVER



R1 — 3900 OHMS
R2, R5, R15 — 220,000 OHMS
R3, R6, R16, R19 — 18,000 OHMS
R4, R22 — 4700 OHMS
R7 — 220 OHMS
R8, R9, R12, R17 — 1000 OHMS
R10 — 100,000 OHMS

R11, R14 — 50,000 OHMS
R13 — 10,000 OHMS
R18 — 5,000,000 OHMS
R20 — 160,000 OHMS
R21 — 500 OHMS
R22 — 4700 OHMS
R23 — 30 OHMS.

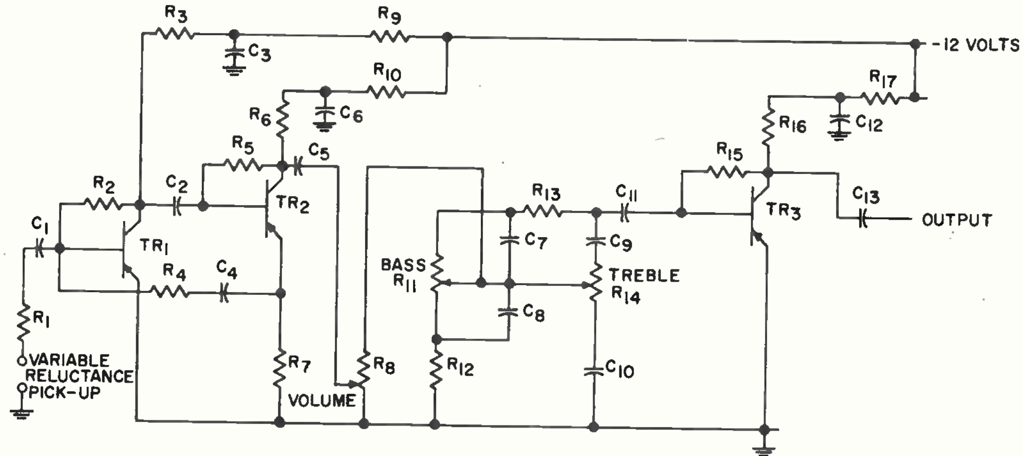
T1 NEW ENGLAND #2130
OR ARGONNE #AR500
5K:3K C.T.

R24, R25 — 82 OHMS
C1, C2, C5, C9, C13 — 5μf
C3, C6, C12 — 50μf
C4 — .05μf
C7 — .02μf
C8 — .2μf

C10 — .008μf
C11 — .08μf
C14 — .0047μf
TR1, TR2, TR3, TR4, TR5 — P-N-P JUNCTION TRANSISTOR GE. 2N190
TR6, TR7 — 2N188A

T2 NEW ENGLAND #2130
OR ARGONNE #AR500
125CT : 8

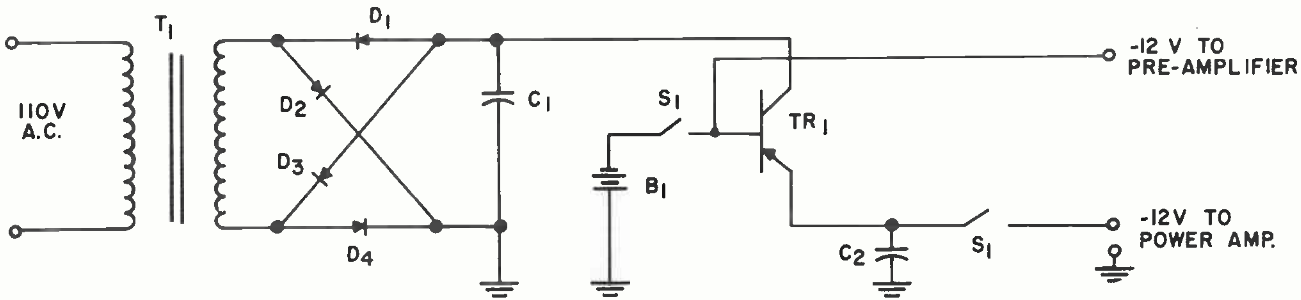
TRANSISTORIZED HI-FI AMPLIFIER



R_1,	3900 OHM, 1/2 W. RES.
R_2, R_5, R_{15}	220,000 OHM, 1/2 W. RES.
R_3, R_6, R_{16}	18,000 OHM, 1/2 W. RES.
R_4,	4700 OHM,
R_7,	220, OHM, 1/2 W. RES.
R_8,	100,000 OHM, 2W. POT.
$R_9, R_{10}, R_{12}, R_{17}$	1000 OHM, 1/2 W. RES.
R_{11}, R_{14}	50,000 OHM, 2W LINEAR TAPER POT.
R_{13}	10,000 OHM, 1/2 W. RES.

$C_1, C_2, C_5, C_{11}, C_{13}$	5μfd., 12V. ELEC. CAPACITOR
C_3, C_6, C_{12},	50μfd., 25V. ELEC. CAPACITOR
C_4,	.05μfd., CAPACITOR
C_7,	.02μfd., CAPACITOR
C_8,	.2μfd., CAPACITOR
C_9,	.01μfd., CAPACITOR
C_{10},	.1μfd., CAPACITOR
TR_1, TR_2, TR_3	"P-N-P" JUNCTION TRANSISTOR (G.E. 2N190)

TRANSISTORIZED HI-FI PREAMPLIFIER



TR1 - POWER TRANSISTOR (MOUNT ON HEAT SINK) C.B.S. 2N256, 2N156 OR EQUIVALENT.

S1 - D. P. S.T.

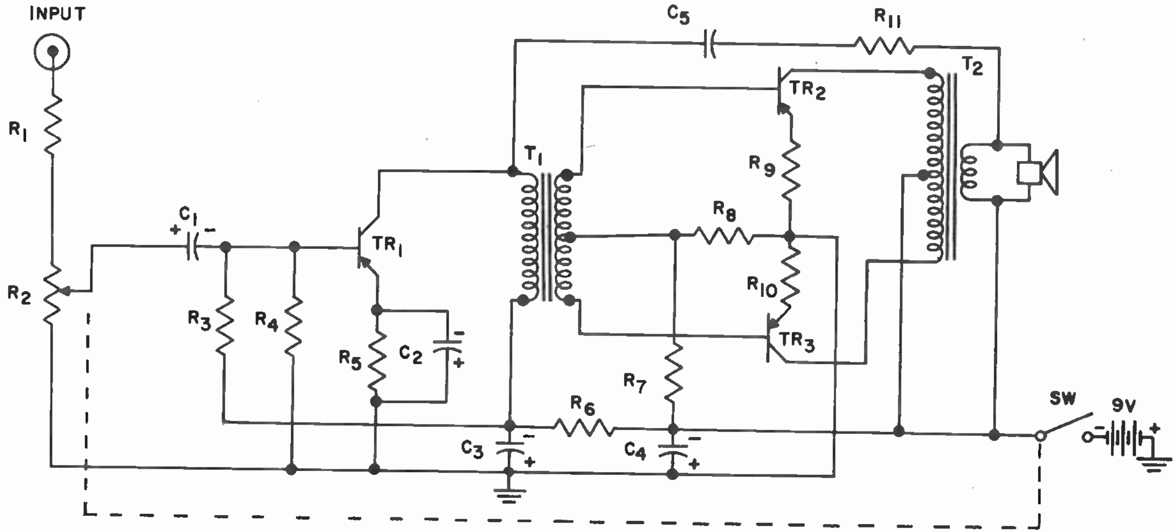
T1 - STANCOR P-6469 117VAC TO 25.2 OR EQUIVALENT

D1, D2, D3, D4 - GENERAL ELECTRIC IN91 GERMANIUM RECTIFIERS

C1, C2 - 50 µfd, 50 VOLT

B1 - 3, 4 VOLT MERCURY CELLS IN SERIES, MALLORY TR-233R OR EQUIVALENT

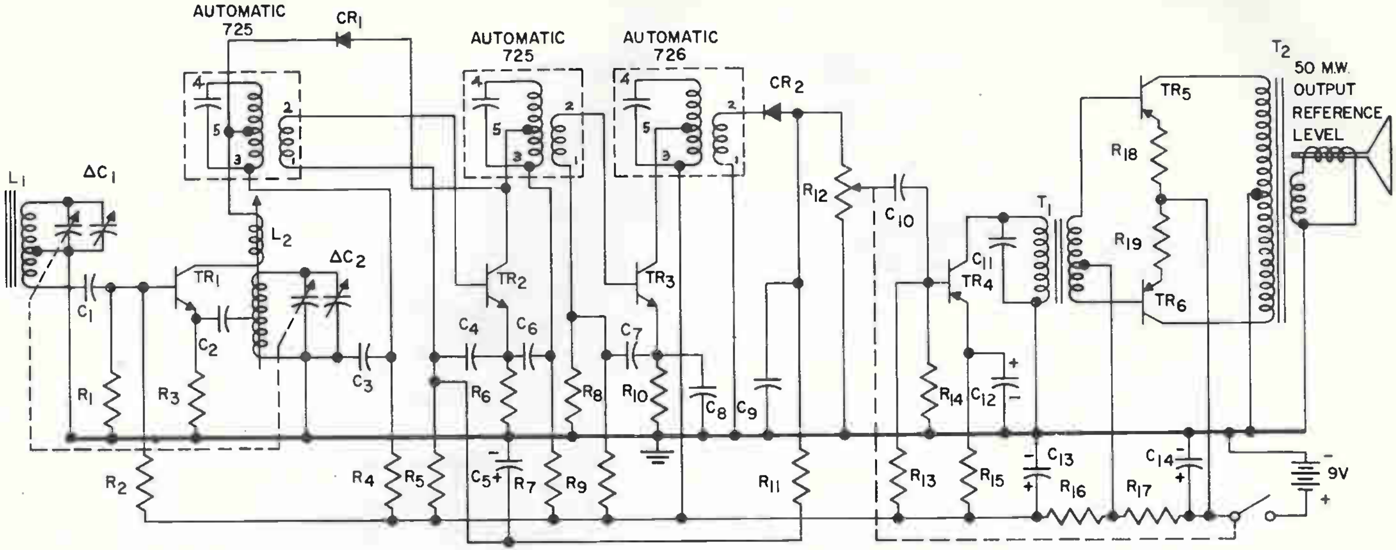
HI-FI AMPLIFIER REGULATED POWER SUPPLY



R_1,	220,000 OHM
R_2,	VOLUME CONTROL 10,000 OHM 1/2 W AUDIO TAPER
R_3,	68,000 OHM
R_4,	10,000 OHM
R_5,	470 OHM
R_6,	220 OHM
R_7,	1800 OHM
R_8,	33 OHM
R_9, R_{10},	8.2 OHM

C_1	6 μfd, 12V
C_2	100 μfd, 3V
C_3, C_4,	50 μfd, 12V
C_5,	.02 μfd
TR_1,	G.E. 2N192 OR 2N265
TR_2, TR_3,	G.E. 2N241A
T_1	6KΩ/5KΩ CT
T_2	200 Ω CT/ V.C.

THREE TRANSISTOR PHONO AMPLIFIER



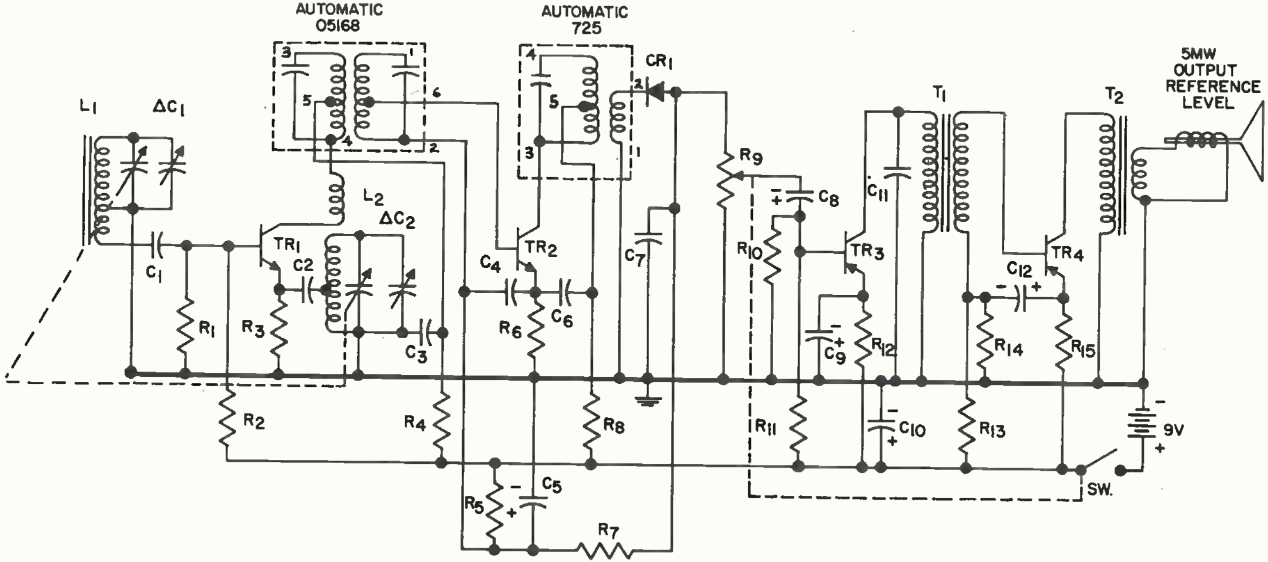
R1, R8, —— 10,000 OHM
R2, —— 27,000 OHM
R3, —— 1500 OHM
R4, R10, R15, —— 470 OHM
R5, —— 68,000 OHM
R6, —— 330 OHM
R7, —— 3300 OHM
R9, —— 82,000 OHM
R11, —— 2700 OHM
R12, — VOLUME CONTROL
10,000 OHM ½ W AUDIO TAPER,
R13, —— 4700 OHM

R14, —— 56,000 OHM
R16, —— 220 OHM
R17, —— 33 OHM
R18, R19, —— 8.2 OHM
C1, —— .02 μfd,
C2, C3, —— .01 μfd,
C4, C6, C7, C8, —— .05 μfd
C5, C10 —— 6 μfd, 12V
C9, —— .05 μfd,
C11, —— .003 μfd,
C12, C13, C14, — 50 μfd, 12V,

TR1, —— G.E. 2N168A CONVERTER,
TR2, —— G.E. 2N293 1ST I.F.
TR3, —— G.E. 2N169 2ND I.F.
TR4, —— G.E. 2N192 DRIVER
TR5, TR6, — G.E. 2N188A AUDIO
T1, —— 10,000/2000 Ω CT
T2, —— 500 Ω CT/V.C.
* L1, —— 435 μh ± 10%
* L2, —— 250 μh ± 10%
CR1, CR2, — DR117, IN64G, OR CK706.A
* ΔC1 — 190.6 } R/C MODEL 242
* ΔC2 — 89.3 }

* FOR FURTHER INFORMATION SEE PAGES 58, 59

SIX TRANSISTOR SUPERHETERODYNE BROADCAST RECEIVER

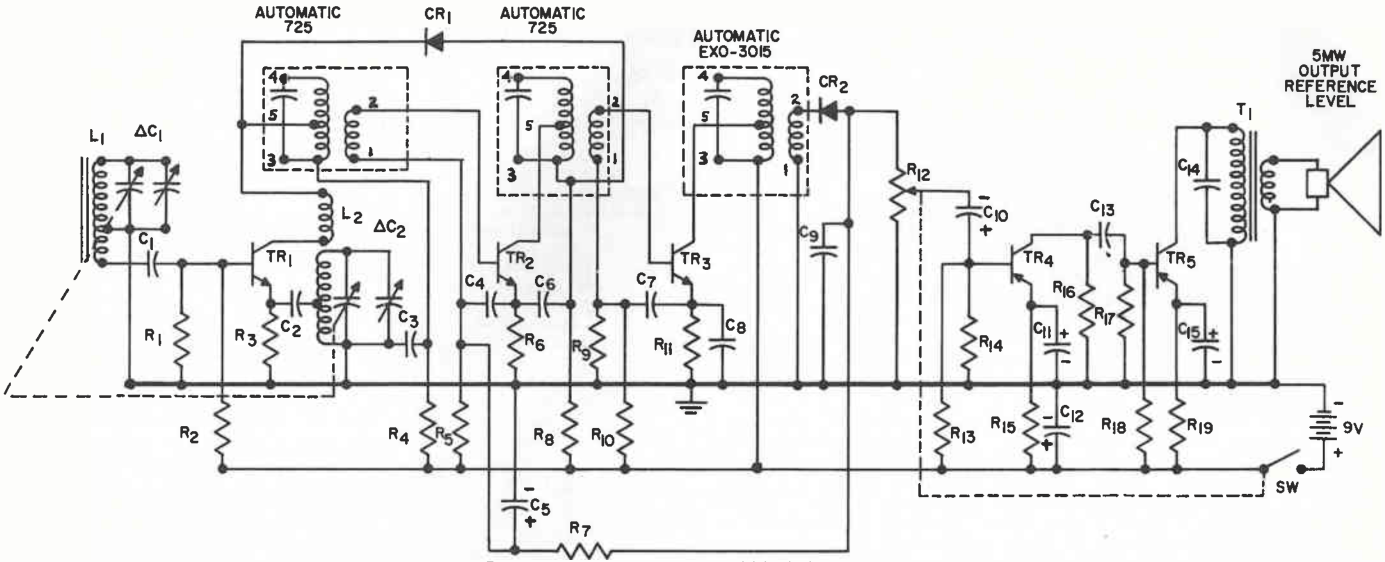


R1, R11, —10,000 OHM
R2, —27,000 OHM
R3, —1500 OHM
R4, R8, —470 OHM
R5, —120,000 OHM
R6, —330 OHM
R7, —12,000 OHM
R10, —47,000 OHM
R12, R13, —1000 OHM
R14, —5600 OHM
R15, —68 OHM
R9, —VOLUME CONTROL 10,000 1/2W AUDIO TAPER
* L1, —435 μh ±10%
* L2, —250 μh ±10%

C1, C4, C6, —.05μfd
C2, C3, —.01μfd
C5, —15μfd, 12V
C7, C11, —.02μfd,
C8, —6μfd, 12V
C9, C10, C12, —50μfd, 12V
CR1, —DR117, IN64G, OR CK706A
TR1 —G.E. 2N168A CONVERTER
TR2 —G.E. 2N293 I.F.
TR3 —G.E. 2N192 DRIVER
TR4 —G.E. 2N241A AUDIO
T1 —20KΩ/600Ω
T2 —500 Ω/V.C.
* ΔC1, —190.6 } R/C MODEL 242
* ΔC2, —89.3 }

* FOR FURTHER INFORMATION SEE PAGES 58,59

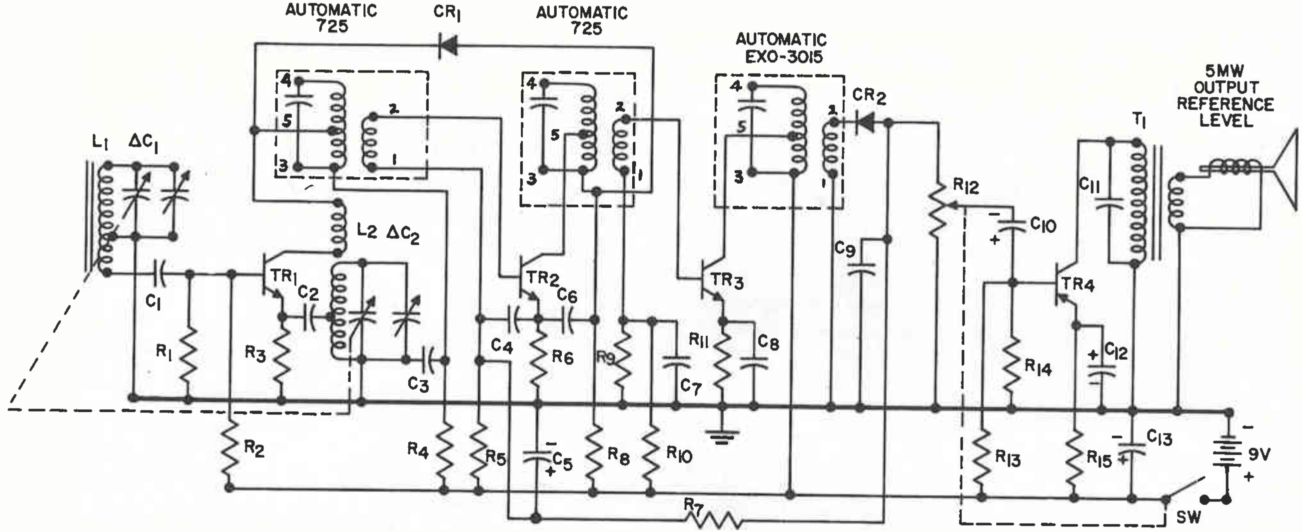
FOUR TRANSISTOR SUPERHETERODYNE BROADCAST RECEIVER



R_1, R_9, — 10,000 OHM	R_{14}, — 56,000 OHM	TR_1, - G.E. 2N168A CONVERTER
R_2, — 27,000 OHM	R_{17}, — 5600 OHM	TR_2, - G.E. 2N293 1ST I. F.
R_3, — 1500 OHM	R_{18}, — 1000 OHM	TR_3, - G.E. 2N169 2ND I. F.
R_4, R_{11}, R_{15}, — 470 OHM	R_{19}, — 68 OHM	TR_4, - G.E. 2N265 DRIVER
R_5, — 68,000 OHM	C_1, — .02 μfd	TR_5, - G.E. 2N188A OUTPUT
R_6, — 330 OHM	C_2, C_3, — .01 μfd	T_1, — 500Ω/VC.
R_7, — 2700 OHM	C_4, C_6, C_7, C_8, C_9, C_{14}, — .05 μfd	* L_1 — 435 μh ± 10%
R_8, R_{16}, — 3300 OHM	C_5, — 15 μfd, 12V	* L_2 — 250 μh + 10%
R_{10}, — 82,000 OHM	C_{10}, C_{13}, — 6 μfd	CR_1 CR_2 DR117, IN64G, OR CK706A
R_{12}, — VOLUME CONTROL 10,000 OHM 1/2 W AUDIO TAPER	C_{11}, C_{15}, — 100 μfd, 12V	* ΔC_1, — 190.6 } R/C MODEL 242
R_{13}, — 4700 OHM	C_{12}, — 50 μfd, 12V	* ΔC_2, — 89.3 } R/C MODEL 242

* FOR FURTHER INFORMATION SEE PAGES 58, 59

FIVE TRANSISTOR SUPERHETERODYNE BROADCAST RECEIVER

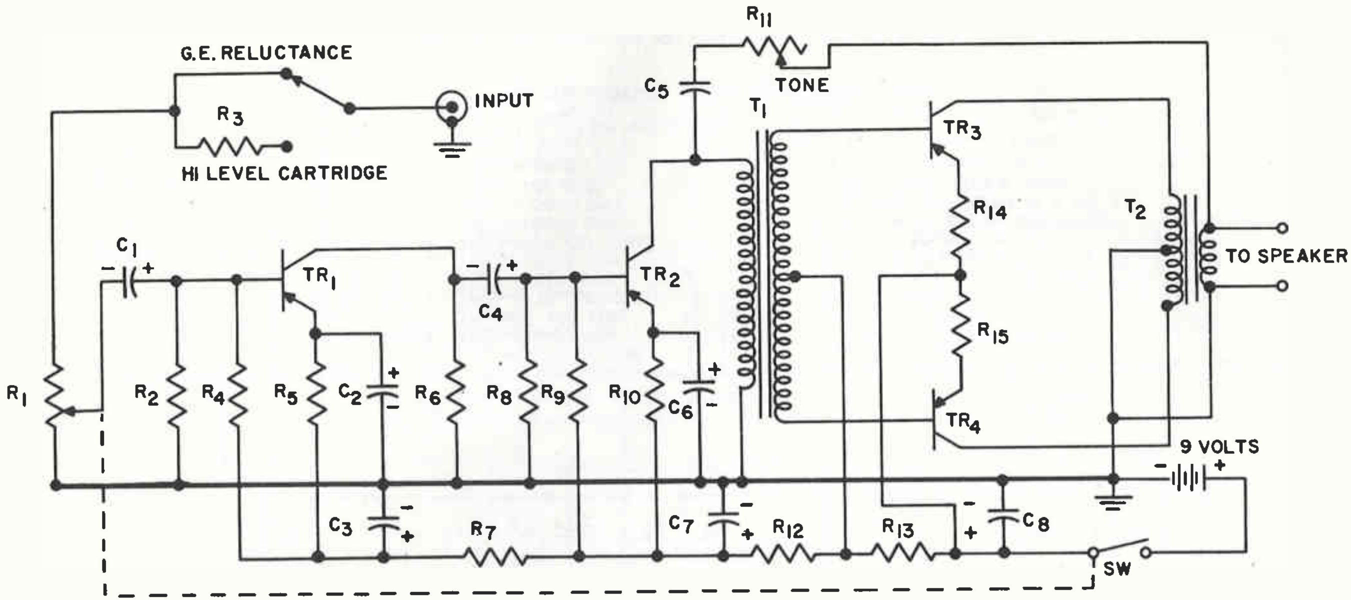


R1, R7, R9, — 10,000 OHM
R12, — VOLUME CONTROL 10,000 OHM
1/2W AUDIO TAPER
R2, — 27,000 OHM
R3, — 1500 OHM
R4, R11, — 470 OHM
R5, — 39,000 OHM
R6, — 330 OHM
R8, — 1800 OHM
R10, — 68,000 OHM
R13, — 1000 OHM
R14, — 5600 OHM
R15, — 68 OHM
T1, — 500Ω / V.C.
* ΔC1, — 190.6 } R/C MODEL 242
* ΔC2, — 89.3 }

C1, — .02μfd
C2, C3, — .01μfd
C4, C6, C7, C8, C9, — 05μfd
C5, — 15μfd, 12V
C10, — 6μfd, 12V
C11, — .1μfd
C12, — 100μfd, 12V
C13, — 50μfd, 12V
TR1, — G.E. 2N168A CONVERTER
TR2, TR3, — G.E. 2N293 1st & 2nd I.F.
TR4, — G.E. 2N241A AUDIO
* L1, — 435μh, ±10%
* L2, — 250μh, ±10%
CR1, CR2, — DR117, IN64G, OR CK706A

* FOR FURTHER INFORMATION SEE PAGES 58, 59.

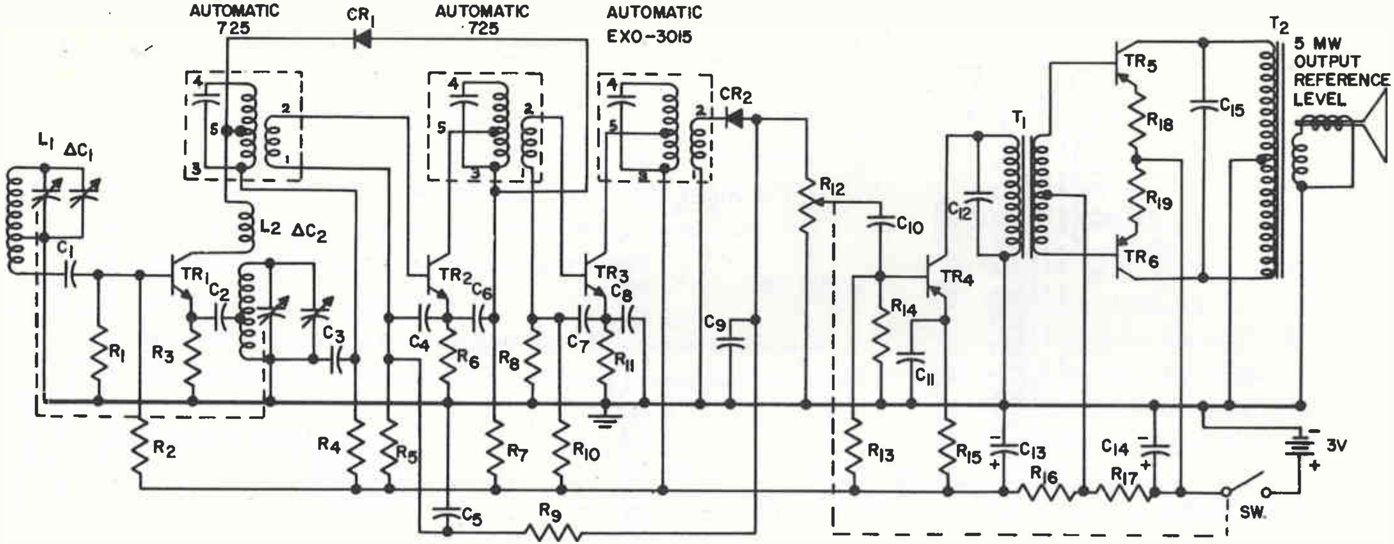
FOUR TRANSISTOR SUPERHETERODYNE BROADCAST RECEIVER



R1, —— 5000 OHM VOLUME CONTROL 1/2 W AUDIO TAPER
R2, —— 150,000 OHM
R3, —— 470,000 OHM
R4, —— 10,000 OHM
R6, R9, — 4700 OHM
R7, —— 1000 OHM
R8, —— 33,000 OHM
R11, —— 25,000 OHM
R12, —— 220 OHM
R5, R10, — 470 OHM

R13, —— 47 OHM
R14, R15, —— 8.2 OHM
C1, C3, C7, C8, — 50μfd, 12V
C2, C6, —— 50μfd, 3V
C4, —— 15μfd, 12V
C5, —— .02μfd
TR1, TR2, — G.E. 2N191
TR3, TR4, — G.E. 2N188A
T1, —— 4K/2.6K CT.
T2, —— 200Ω C.T./V.C.

FOUR TRANSISTOR PHONO AMPLIFIER



R1, R8 — 10,000 OHM
R2, — 33,000 OHM
R3, R11, — 470 OHM
R4, — 270 OHM
R5, — 12,000 OHM
R6, — 330 OHM
R7, — 1500 OHM
R9, — 2700 OHM
R10, — 18,000 OHM
R13, — 4700 OHM
R14, — 15,000 OHM
R15, — 390 OHM
R16, — 100 OHM
R17, — 39 OHM
R18, R19, — 5.0 OHM
R12, — VOLUME CONTROL 10,000 OHM 1/2 W. AUDIO TAPER

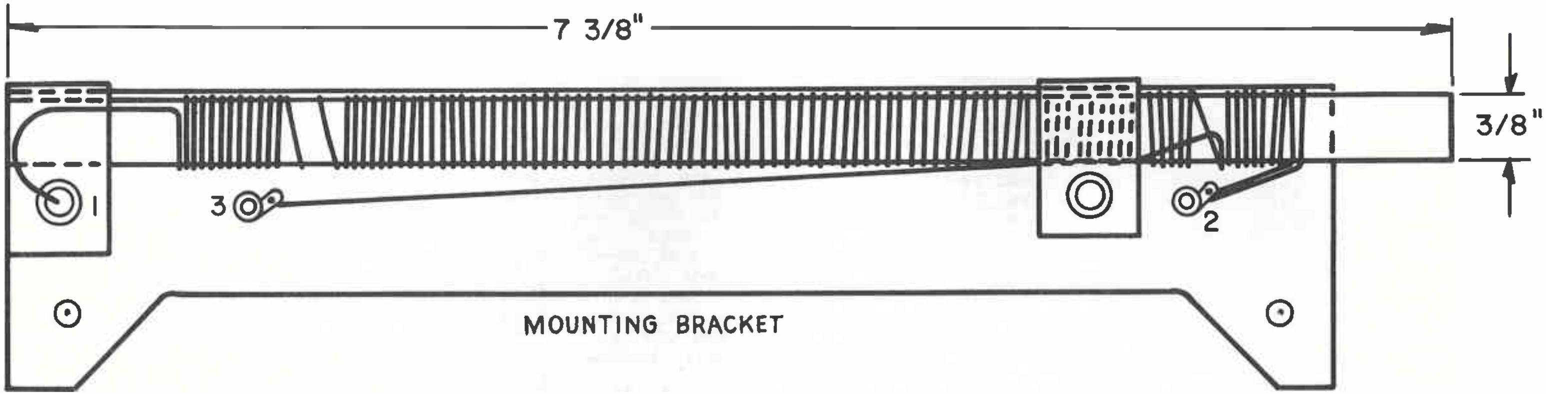
C1, — .02μfd
C2, C3, — .01μfd
C4, C6, C7, C8, C9, — .05μfd
C5, C10, — 6μfd, 6V
C11, C13, C14, — 50μfd, 6V
C15, — 0.1μfd
TR1 — G.E. 2N168A CONVERTER
TR2 — G.E. 2N293 1st I.F.
TR3 — G.E. 2N169 2nd I.F.
TR4 — G.E. 2N192 DRIVER
TR5, TR6, — G.E. 2N188 AUDIO
T1 — 2600/2600 Ω CT.
T2 — 300 Ω CT/V.C.
* L1, — 435μh ± 10%
* L2, — 250μh ± 10%
CR1, CR2, — DR117, IN64G, OR CK706A
* ΔC1, — 190.6 } R/C MODEL 242
* ΔC2, — 89.3 }

* FOR FURTHER INFORMATION SEE PAGES 58, 59

THREE VOLT BROADCAST RECEIVER

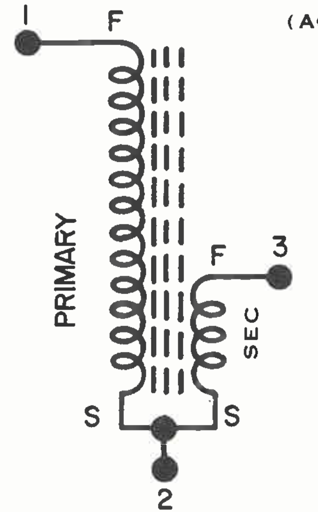
CAN BE POWERED BY SUN OR FLASHLIGHT BATTERIES

FERRITE ROD ANTENNA



SPECIFICATIONS:

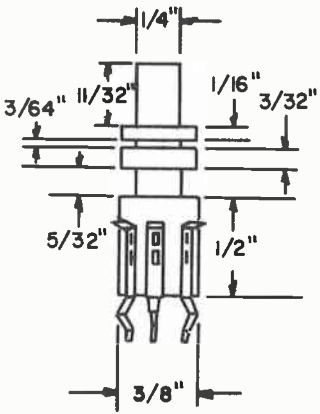
1. Core Material To Be Ferramic Q or Approved Equivalent
2. Winding Direction Clockwise When Viewed From Start Of Prim.
3. Secondary 6 Turns bifilar wound
4. Distributed Capacity To Be 5 mmfd Maximum
5. Primary Inductance 435 μhenries approximately
6. Unloaded Q of Primary 200 Min. When Measured At 790 KC/S
7. Ferrite Rod, Winding And Assembly Shall Be Wax Impregnated
8. Assembly Shall Be Flash Dipped



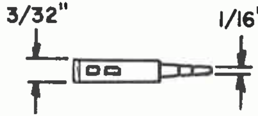
(ACTUAL SIZE)

OSCILLATOR COIL

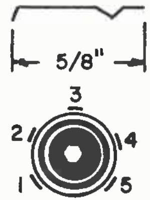
ED STANWYCK COIL COMPANY #1265 OR EQUIVALENT

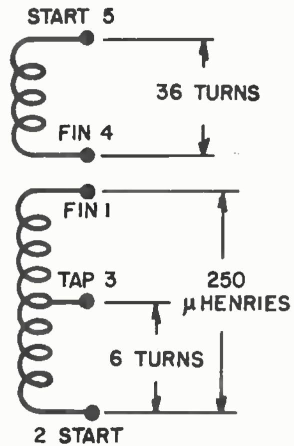


COIL DIMENSIONS



LUG DETAIL





INDEX DETAIL

SPECIFICATIONS:

1. Wire To Be #5/44 Heavy Easysol Bonded
2. Inductance of Primary To Be 250 µh Nom.
3. Core Adjustment Range ±10%
4. Distributed Capacity To Be 7 mmfd Maximum
5. Q at 790 KC/S To Be 100 ±10%
6. Primary To Be Tapped At 6 Turns
7. Secondary Winding To Be 36 Turns ± 1 Turn
8. Coil To Be Wax Impregnated & Flash Dipped
9. Coil Form To Be Cosmolite Or Appr. Equiv.
10. Collar To Be Cemented Securely To Form
11. All Materials To Be Acid Free

VARIABLE CONDENSER

RADIO CONDENSER COMPANY, MODEL 242 OR EQUIVALENT

$\Delta C_{RF} = 190.6 \quad C_{min.} = 7.6$

$\Delta C_{OSC} = 89.3 \quad C_{min.} = 6.8$

TRANSISTOR RADIOS

SHOWING CLOSEST GE REPLACEMENT TRANSISTORS

MANUFACTURER & MODEL	V BATT	CONVERTER	IF	IF	DET.	AF	POWER	
Bulova 270C	9V	CK766 GE 2N136	2N112A 2N135	— —	1N295 1N64	2N132 2N192	2N138A 2N241A	
Bulova 270/277	9V	2N112 GE 2N136	2N112 2N135	— —	CK706A 1N64	2N132 2N192	2N138 (2) 2N192 (2)	
CBS TR 250	21V/12V	GE 2N136	2N135	2N135	4JD1A26	—	2N44	
CBS TR 260	9V	2N172 GE 2N169	2N146 2N169	2N146 2N169	1N60 1N64	310 2N192	2N189 (2) 2N189 (2)	Note 2 Note 1
Dewald K 701 & 702 Dewald	9V	2N112 GE 2N136	2N112 2N135	2N112 2N135	1N295 1N64	2N109 2N192	2N109 (2) 2N188 (2)	
Dumont 1210	9V	2N168A GE 2N168A	2N168 2N293	2N168 2N293	Diode 1N64	CK882 2N192	CK888 (2) 2N188 (2)	Note 3
Emerson 842	4V	830 GE 2N169	2N146 2N169	2N146 2N169	Diode 1N64	310 2N192	353 (2) 2N188 (2)	Note 2 Note 1
Emerson 855	9V	2N172 GE 2N169	2N146 2N169	2N146 2N169	1N195 1N64	2N109 2N192	2N109 (2) 2N188 (2)	Note 2
GE 675 Ebony, 676 Ivory 677 Red, 678 Aqua	13½ 13½	Early Prod 2N136 Late Prod 2N135	2N137 2N135	2N135 2N135	2N78 1N87	— 2N169	2N44 2N44	Note 4 Note 5
GE P715 Beige, P716 Black	3V	GE 2N168A	2N169	2N169	1N87	2N192	2N241 (2)	
GE P720 Ginger, P721 Champagne	6V	GE 2N168A	2N293	2N169	1N87	2N191	2N188A (2)	
Hallicrafters TR 88 El Diablo	6V	2N112 GE 2N136	2N112 or 2N135	2N139 2N135	None None	2N109 or 310 2N192	2N109 (2) or 352 (2) 2N188 (2)	
Magnavox AM2 Companion (CR 729 AA)	4V	2N172 GE 2N169	2N146 2N169	2N146 2N169	1N295 1N64	310 2N192	353 (2) 2N188 (2)	Note 2 Note 1
Motorola 56 T1	9V	2N172 GE 2N169	2N146 2N169	2N146 2N169	R35 2N191	— —	354 2N188	Note 2 Note 1

Motorola 6 x 31	6V	GE 2N168A	2N293	2N292	Diode	2N189 or 2N190	2N186 or 2N187	
Motorola 6 x 32	12V	GE 2N293	2N168A	2N169	Diode	2N191 or 2N192	2N188 or 2N241	
RCA 7BT-9J	9V	235 GE 2N168A	234 2N169	234 2N169	1N295 1N64	2N109 2N192	2N109 (2) 2N188 (2)	
Raytheon 8 T P 1		CK760 CK759 GE 2N136 2H135	CK760 2N135	CK760 2N135	CK721 2N191	CK721 2N191	CK721 (2) 2N188 (2)	Oscillator
Raytheon FM101A	6V	2N113/14 2N112/13 GE 2N136 2N135	2N112 2N135	2N112 2N135	2N112 2N135	CK721/22 2N191	CK721/22 (2) 2N188	Oscillator
Raytheon T—100 Series		2N112/13 GE 2N136	2N112 2N135	2N112 2N135	Diode 1N64	2N132 2N192	2N138 2N192	
Regency TRL	22½	223 GE 2N169	222 2N169	222 2N169	1N69 1N64	— —	210 2N169A	Note 1
Sentinel 369P	4V	2N172 GE 2N169	2N146 2N169	2N146 2N169	1N295 1N64	310 2N192	353 (2) 2N188 (2)	Note 2 Note 1
Sonic TR 700 Capri	9V	GE 2N168A GE 2N168A	2N168 2N293	2N169A 2N169	1N64 1N64	2N191 2N190	2N188A (2) 2N187 (2)	Note 3
Traveler	13½	GE 2N136	2N135	2N135	4JD1A26	—	2N187A	
Westinghouse 7	9V	2N172 GE 2N169	2N146 2N169	2N146 2N169	880 2N169	310 2N192	2N185 (2) 2N188A (2)	Note 2
Zenith 500	6V	2N94 GE 2N169	2N94 2N169A	2N94 2N169A	1N295 1N64	2N35 2N169A	2N35 (2) 2N169A	Note 1
Zenith 800	12V	GE 2N168A	2N168	2N169A	1N295	2N190	2N188A (2)	Note 3

*This list includes transistor production radios for which information is currently available. It is primarily for information and is intended only as a general guide for replacements.

The radio battery should be replaced with a fresh unit before checking transistors. If necessary to replace transistors, some selection may be necessary in order to obtain optimum performance since transistors of various manufacturers are made by slightly different processes and are not precisely interchangeable.

NOTES:

1. Remove any neutralization loops around IF circuits before operating with GE NPN transistors.
2. In some radios where the 2N146 is shown in both IF stages, one 2N145 and one 2N147 may be found instead in these stages.
3. The 2N293 may be used to replace the 2N168 in IF stages.
4. The 2N169 may be used to replace the 2N78 in AF stages.
5. The 2N186A may be used to replace the 2N44 in AF output stages.

NOTES

NOTES

NOTES

READING LIST

The following list of semiconductor references gives texts of both elementary and advanced character. Obviously, the list is not inclusive, but it will guide the reader to other references.

Coblenz, A., Owens, H., *Transistors and Applications*
(McGraw-Hill)

Garner, L., *Transistor Circuit Handbook*
(Coyne)

Krugman, L., *Fundamentals of Transistors*
(Rider)

Lo, A. W., Endres, R. O., Zawels, J., Waldhauer, F. D., Cheng, C. C., *Transistor Electronics*
(Prentice-Hall)

Shockley, W., *Electrons and Holds in Semiconductors*
(Van Nostrand)

Shea, R. F., et al., *Principles of Transistor Circuits*
(Wiley)

Shea, R. F., *Transistor Audio Amplifiers*
(Wiley)

Turner, R. P., *Transistors—Theory and Practice*
(Gernsback)

SEMICONDUCTOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC

ELECTRONICS PARK • SYRACUSE 1, N. Y.

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