University of Toronto

Seminars in Electronic Music

Summer 1966

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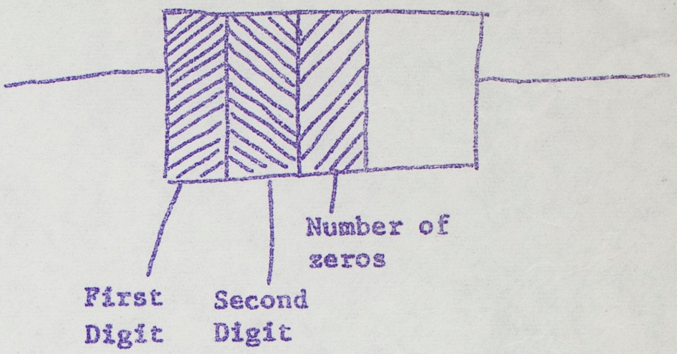
	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:00 AM - 10:00 AM	ROBB - TIDY				
10:00 AM - 11:00 AM	CIAMAGA SEMINAR				
11:00 AM - 1:00 PM	IVEY - WEIDENAAR				
1:00 PM - 3:00 PM	ROBINSON - TCHERPNIN				
3:00 PM - 4:00 PM	LE CAINE SEMINAR				
4:00 PM - 5:00 PM					
5:00 PM - 6:00 PM		MAINTENANCE			
6:00 PM - 8:00 PM	OLIVEROS - PARENT				
8:00 PM - 10:00 PM	PIPER - SCHAEFER				

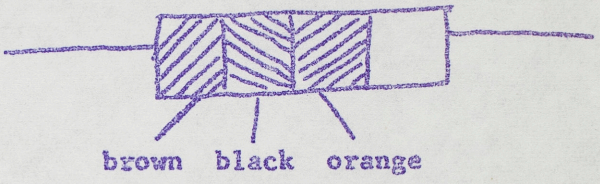


COLOR CODE FOR RESISTORS

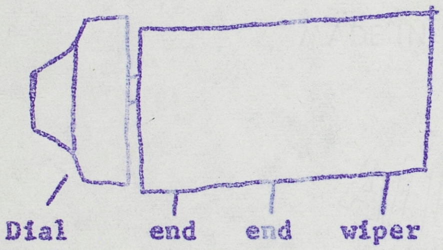
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

SILVER 5% accurate
Gold 10% accurate

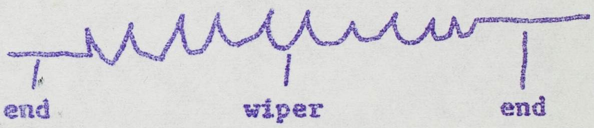
for instance:



Resistance = 10,000 ohms



the 10-turn helipot



1. Write the digit which appears in the window.

2. Write two numbers for the movable dial.

3. Divide the resulting number by 1000 and multiply it by the total resistance.

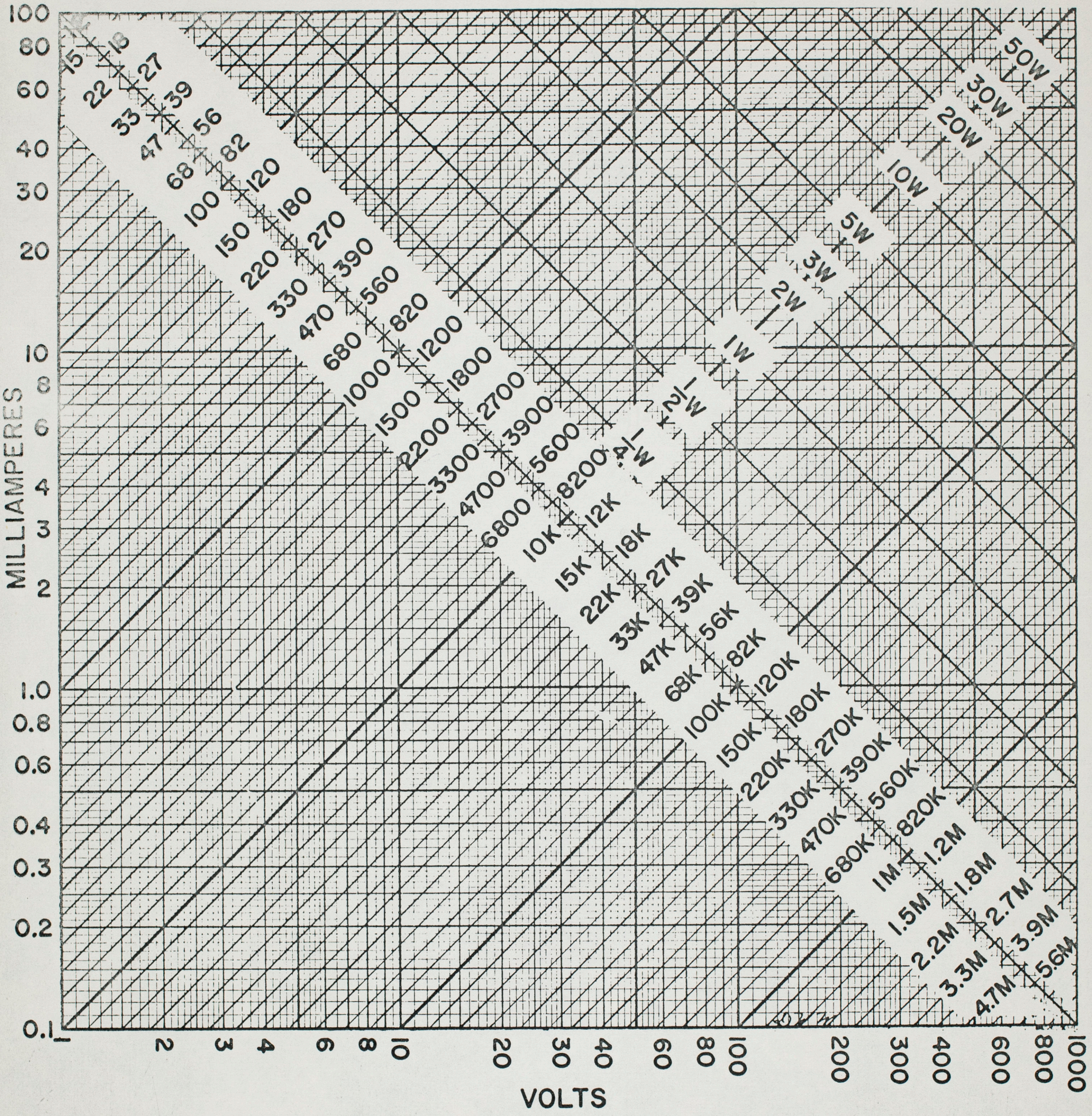


Chart 2—10. Nomogram for conversion between voltage, current, power and resistance.

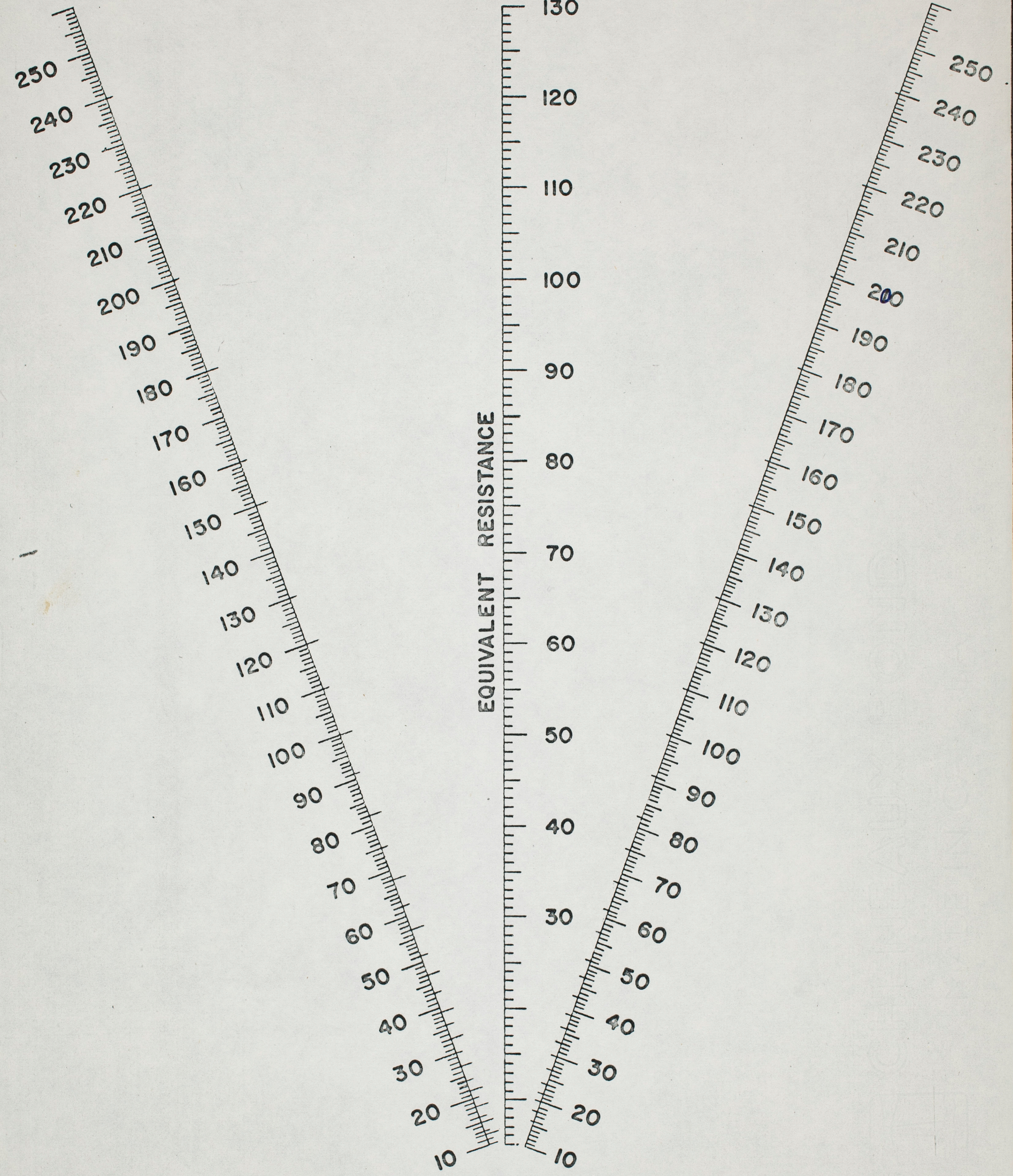


Chart 3—4. How to find the equivalent value of resistors in parallel. This chart can also be used for finding the equivalent value of capacitors in series.

Students taking course 1081 (The Scientific Basis of Music) for credit should hand in the following problems (if they have not done so already) before Friday, Aug 19.

Analytic Geometry		#9 or #10
Sets - problems 1		#1 and #2
problems 2		#2
problems 3		#1 or #6
Electricity	problems 1	#7
	problems 2	#1 and #4

Laboratory 2 #1 or Laboratory 4 #1
Laboratory 5 #1, #2, and #4.
Laboratory 6 #5
Laboratory 7 any problem
Laboratory 8 #1 and #3
Laboratory 9 #3

~~Reber~~ Reverberation time!

$$R.T. \quad \frac{0.05V}{aS}$$

V volume in cubic ft.

a average absorption coefficient

S total surface area

$$a = \frac{aS_1 + aS_2 + aS_3}{S_1 + S_2 + S_3}$$

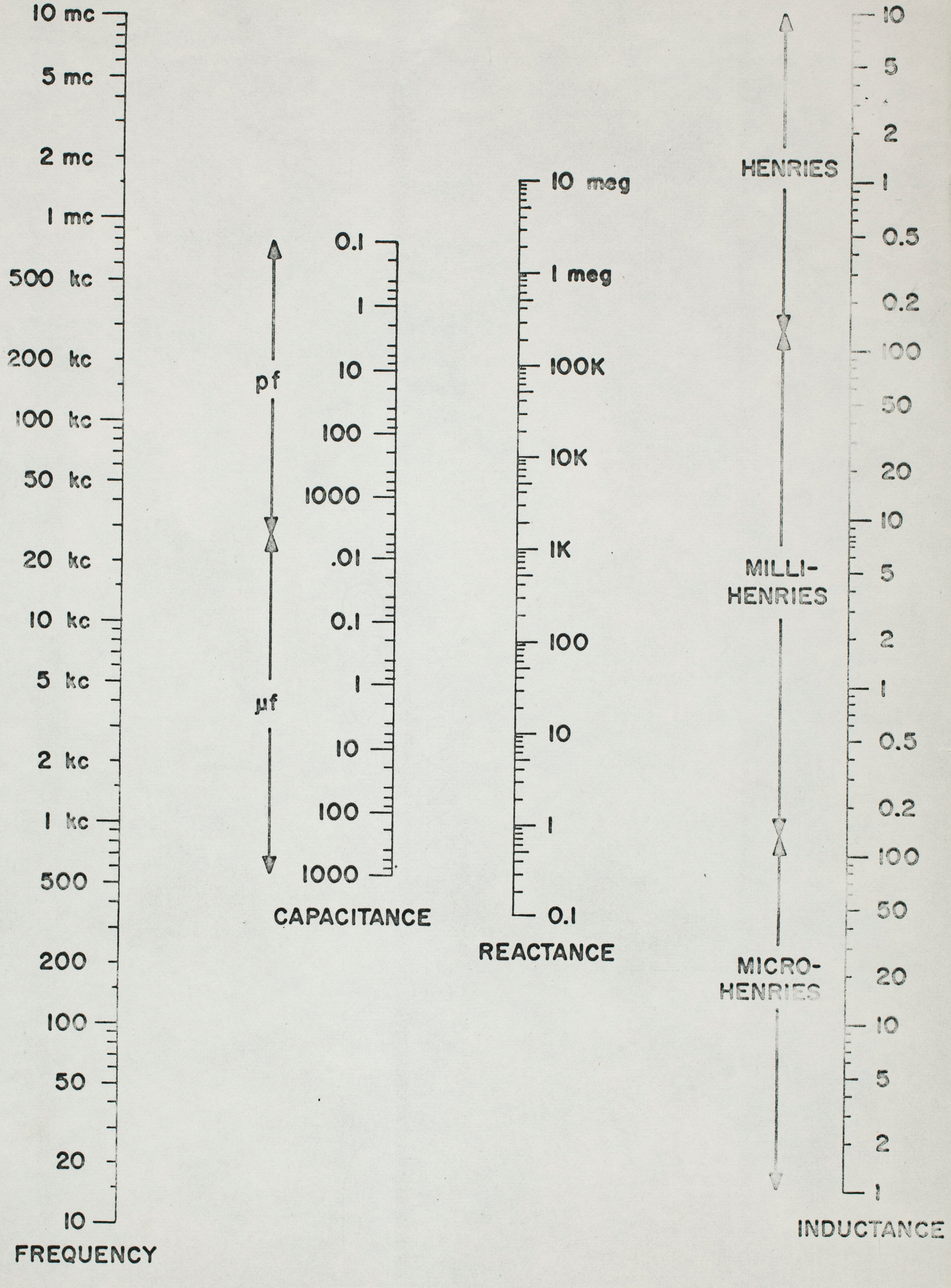


Chart 3—5. Chart to determine inductive or capacitive reactance, or resonance.

<u>Some Notes on Learning</u>

1. The two basic activities of the brain are memory and association.

2. Try to isolate "pure memory" or "nonsense memory" from the task of relating information. Do not use mnemonics. Memorize when feeling lethargic, develop a web of associations between the "facts" in a subject when feeling mentally alert.

3. "Blocks" or undue difficulties in problem solving arise from gaps in the web of associations which block routes which should be easy to travel. Uncertainty about the "facts" also cause difficulty.

4. The presentation of entirely unrelated material "U" after the learning of material "A" tends to make the material "A" inaccessible. The presentation of related material "R" may cause positive or negative transfer. Positive transfer occurs where the relations learned in "A" apply directly to "R". Negative transfer occurs where similarities cause confusion.

5. Confusion between facts in a subject is a routine misadventure in learning. Remove it by extra memorizing of the facts <u>without</u> concentrating on the confusion itself which should be forgotten as soon as possible.

6. "Active forgetting" of the gestalt theorists (see Kohler Chapters IV, VIII, and IX) Memories are altered to obtain "good" or "stable" organization. An incomplete word will be remembered as a complete word; ideas will be omitted or re-arranged according to the wishes of the subject.

Kohler -	"Gestalt Psychology"	(Liveright)
Hebb -	"The Organization of Behavious"	(Wiley)
Vinacke -	"The Psychology of Thinking"	(McGraw-Hill)

$\frac{E}{R} = \frac{IR}{R}$ Volts x Amp = watts $R = \frac{E}{I}$

$\frac{P}{V} = \frac{IV}{V}$ $I = \frac{P}{V}$

220 | 4400 (20) / 220

ELECTRICITY - Problems - 1

(1) The heating element in an electric oven has a power rating of 4.40 kilowatts. If the potential difference between the ends of the element is 220 volts, find (a) the current through the element, (b) the resistance of the element.   20 amps / 11 Ω

(2) A battery charging circuit contains a battery and a resistor. The total power supplied is 200 watts. If 40 watts is used to provid e the necessary chemical action to recharge the battery and if the charging current is 4.00amps
find (a) the resistance of the resistor   10 Ω
(b) the potential difference between the ends of the resistor.   50 Ω ?

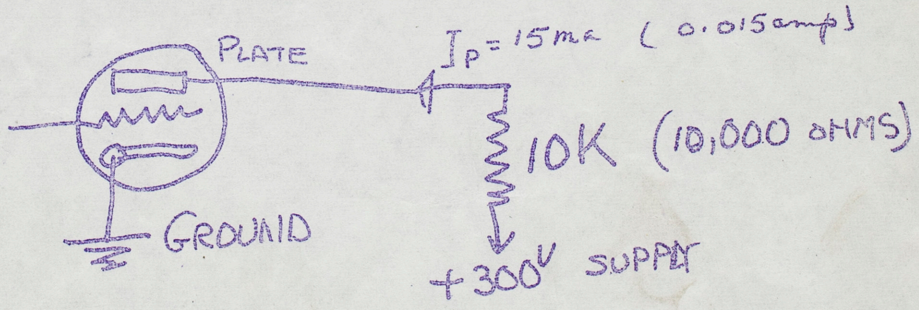
(3) A dc electric motor is connected to 110 volt mains and draws a current of 2.00 amp when it is running at normal speed. Under these conditions it delivers 160 watts of mechanical power and frictional losses amount to 20 watts. What is its (ohmic) resistance, i.e. the resistance which would be measured on a lowcurrent bridge if the current was insufficient to cause the armature to move?   10 Ω

(4) Radio resistors come in a wide range of sizes from a few ohms to several megohms and with various power ratings. The power rating is the maximum power the resistor can safely dissipate as heat. Calculate maximum values of current through and potential difference across resistors of 10 ohms, 1000 ohms 50,000 ohms and 2 megs for power ratings of 1/2, 2, and 5 watts

(5) The power expended as heat in an ordinary toaster is 550 watts. The current through the heating element is 5.00 amps. What is the resistance of the heating element? $R = \frac{110V}{5}$ R = 22 Ω

(6) An electron (charge 1.6 x 10^{-19} coulomb) moves from a point at -5.00 volts to another point 1.00 cm away which is at a potential of plus 5.00 volts. Find the potential energy lost by the electron: (b) the average force experienced by the electrone (F in newtons equals w/s joules and metres)

(7) In the triode shown the plate current is 15 ma. (milliamperes) What is the potential difference between plate and ground?   I



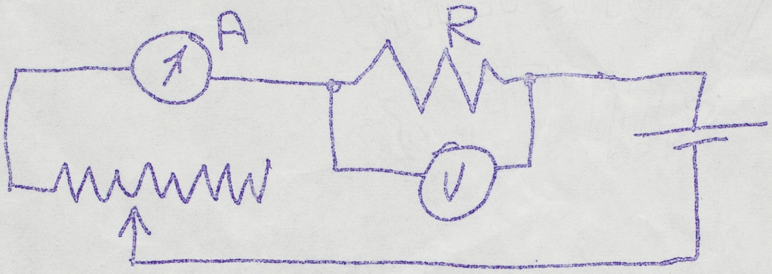
ELECTRICITY - Problems - 2

1. Resistors of 8,12 and 24 ohms are connected first in series then in parallel. Find the equivalent resistance in each case.

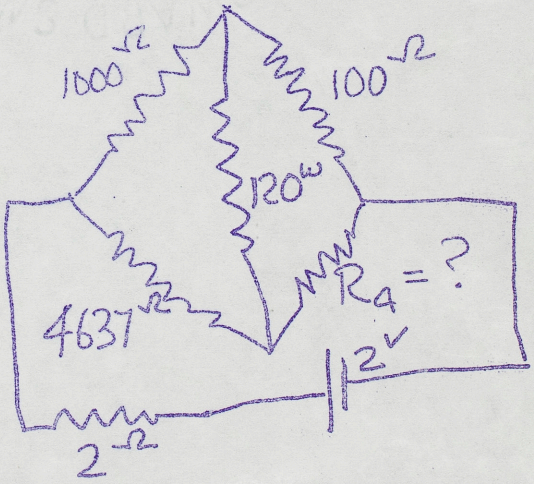
2. Resistors of 40, 100, and 80 ohms are connected in series and a potential difference of 110 volts is established across the combination. What is the potential difference across the 100 ohm resistor?

3. A storage battery has an emf of 6.3 volts and an internal resistance of 0.0160 ohms. What is the output voltage for currents of 1.00 amps 30.0amps, 200 amp?

4. A resistor of large conductance is measured with the ammeter-voltmeter method using the circuit shown. The potential difference across the resistor is 150 millivolts when the circuit current is 5.43 amp. The resistor is now removed and the rheostat is adjusted until the voltmeter reads 300 mv. and the ammeter 2.00 milliamp. Find the conductance of the resistor and the resistance of the voltmeter.



5. In the bridge circuit shown below, the current through the 120 ohm resistor is zero. Other values (resistance) as shown What is the resistance of R_4 ?



6. In a wheatstone bridge circuit similar to that shown above, the ratio arms have resistors of 1,10, 100, or 1000 ohms total resistance. The third arm is adjustable by 1 ohm steps up to a maximum of 10,000 ohms. What range of resistance values can be measured if four-figure accuracy is required?

ELECTRICITY - Formulae - 1

$V = \frac{W}{Q}$ $W = QV$

V is the voltage in volts
W is the work done in joules
Q is the charge in coulombs

$I = \frac{Q}{t}$

I is the current in amperes
Q is the charge in coulombs passing a point in t seconds

$R = \frac{V}{I}$, $V = IR$, $I = \frac{V}{R}$

R is the resistance in ohms
V is the voltage in volts
I is the current in amperes

$P = I^2R$

P is the power produced in watts in a resistor of which
R is the resistance in ohms
V is the voltage in volts

$P = I \cdot V$

1 calorie - 4.18 joules
1 calorie is the heat required to raise 1 gram of water 1 degree C

$W = Pt$

W is the work in watt-seconds (joules)
P is the power in watts
t is the time in seconds

$F = \frac{W}{s}$, $W = Fs$

F is the force in newtons
W is the work in joules
s is the distance in metres

Resistors in series: $R = R_1 + R_2 + R_3$

Resistors in parallel: $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

$R = \frac{12}{\frac{1}{1000}} = 12{,}000$

$12 \times \frac{1000}{1}$

4 in parallel

Yellow 47000 Ω 5% accurate

Violet

orange

Silver

330,000

5400

Green

Yellow

Red

700,000 Ω

Violet

Black

yellow

$P = I^2 R$

$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{\frac{1}{2}}{R}}$

$= \frac{0.707}{\sqrt{R}}$

LABORATORY - (1)

1) Write down the resistance of each resistor on card 1 and card 2 as indicated by the color code on the body.

2) Write down the wattage heat dissipation you would get in each of the resistors on card 2 when each is connected to a 12 volt supply. Which should be the hottest resistor, the lowest resistance valued one or the highest? Verify by connecting to a power supply and touching.

$P = \frac{E^2}{R}$

#5 = hottest and lowest

3) Calculate, then measure the current for resistors 1 to 4 on card 2 when each is connected across the 12 volt supply.

Lab – 4) Measure each resistor on card 2 by the ammeter method. Would the ammeter go in series or parallel? Draw the circuit.

Lab 5) (a) Measure the resistance of the following combinations of the resistors in series (card 2) 8 and 9 ; 5, 6 and7 ; 1 and 2 .
(b) Calculate the resistance from the values you obtained in question 4.

laboratory - !

6) Measure the resistance of the combinations in question 5 of resistors putting them in parallel instead of in series.

? 7) Calculate the total resistance in the circuit when a 50 microamp meter is used as a voltmeter
(a) 10 volts full scale
(b) 5 volts full scale
(c) 0.5 volts full scale.
If the meter resistance is 3000 ohms what external resistor would be needed in each case? Draw the circuit.

$I = \frac{E}{R}$

60K

8) How would you connect a resistor to a 12 volt supply to approximate a constant current supply? What value would it have if the current is to be 0.2 milliamperes? Draw the circuit.

9) If you use the constant current supply to force current through resistors, which values will cause the current to deviate from the approximately "constant" value most, large or small resistors? In the supply of question 8 what value will cause the current to deviate 10 percent?

10) Using the constant current supply of question 8 and the 0.5 volt voltmeter of question 7 measure the first five resistors on card 2 by using Ohm's Law.

IMPORTANT PRECAUTION: Before connecting the supply make a solid reliable connection between the voltmeter and the resistor.

Laboratory - 2 Sheet 1

TRANSISTOR CHARACTERESTICS ----COMMON BASE

1) Plot a family of curves of collector current in milliamperes versus collector--to-base volts with emitter current as parameter.

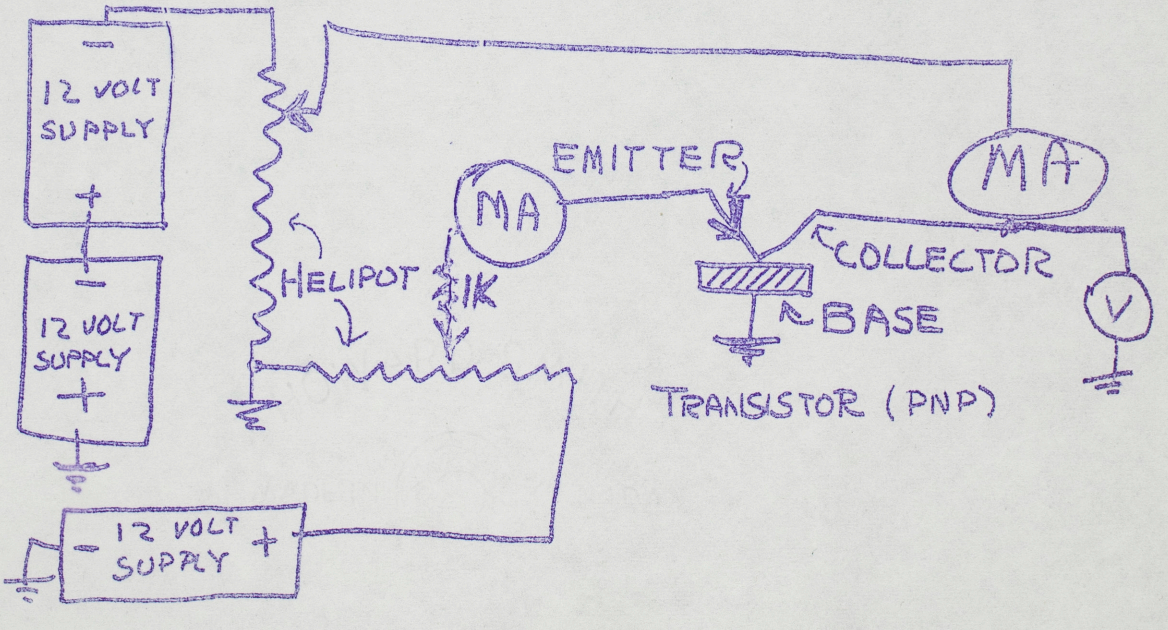
The graph paper should be laid out with collector-to-base voltage in the horizontal direction with zero volts at the left. To get a good clear graph, use inch accented with ten divisions to the inch. Let each inch equal two volts so that with 12 inches of paper you get 24 volts full scale on the paper. The vertical scale should start at the same zero. This time let one inch equal one milliamp so that ten inches gives 10 ma.

To draw the first curve, let the emitter current be 0 ma i.e. set the helipot to the bottom.

To draw the second curve, let the emitter current be 2 ma. Get this current by adjusting the emitter helipot (see cct dia gram) You will find that all the detail is in the early part of the curve so plot the greatest number of points here. Each point is plotted by picking a value of collector voltage, setting it up by adjusting the helipot, then reading the value of collector current which the transistor gives. These two values form an "ordered pair" which is transferred as a point to the graph paper as in analytical geometry. Note that the two values are an ordered pair, and don't make the common mistake of interchanging the axes, i.e. plotting the value of current where the voltage should go. You may want to use a more sensitive meter voltage range on this part of the curve to get better readin gs.

This procedure should be continued for 4 ma 6 ma 8 ma and 10 ma of emitter current drawing a completely separate curve for each value of emitter current. EACH CURVE SHOULD BE LABELLED "8 ma" etc. The result will be a family of curves which define the relation between emitter current, collector current and collector voltage.

Laboratory 2 sheet 1 of two sheets



Laboratory 2 - sheet 2

TRANSISTOR CHARACTERISTICS ---- COMMON BASE   Explanation of circuit diagram

The circuit diagram given on sheet 1 shows two twelve volt power supplies at the extreme left which are connected in series. By a "series connection" is meant that the positive of one supply is connected to the negative of the other. There are now two terminals left unconnected.... one positive and one negative. The voltage between these two terminals is the sum of the voltages given by the individual power supplies. This should, of course, be checked with a voltmeter. Should you make a mistake and connect a negative on one power supply with a negative on the other, then the two voltages would subtract instead of adding. In this case the voltage read on a meter would be zero. (in where the two voltages are equal)

The 24 volts obtained by the series connection of the two twelve volt power supplies is now applied to a helipot, 500 ohm resistance would be suitable. Note that the symbol for "ground" or "earth" is simply a convenient way of referring to a commonly used reference point which is usually considered for convenience to be at "zero" volts.

The output of the helipot which is obtained froma brush which moves along the coil of resistance wire can now be varied from zero volts to a maximum of 24 volts (negative).

This output goes to the collector THROUGH A MILLIAMETER. This means that the milliameter is connected in the circuit in series so that all the collector current has to pass through the meter. The meter is then used to measure the collector current.

On the extreme right is a voltmeter which is used to measure the collector voltage (referred to ground) Note that it is in parallel with the collector to ground circuit.

Another helipot and another power supply which this time supplies a positive voltage of variable amount to the emitter circuit which contains a 1 k series resistor to control the current. The current is controlled by varying the voltage applied as described above. It is measured by a milliammeter which is in series with the emitter, again as described above.... although there in connection with the collector circuit.

IMPORTANT Check the operation of the helipots with voltmeters before the transistor is plugged in. Make sure that you know which end of the helipots gives zero voltage.
SET BOTH HELIPOTS TO ZERO VOLTAGE...... then plug in the transistor.

Laboratory 2 - Sheet 2 of 2 sheets

ANALYTIC GEOMETRY

(Calloway Page 73 to 93)

Distance between two points (x1 y1) and (x2 y2) is

$$\sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

$$\text{Slope of a line} = m = \frac{y2 - y1}{x2 - x1} = \frac{y1 - y2}{x1 - x2}$$

If m is positive, the line rises as we proceed from right to left.

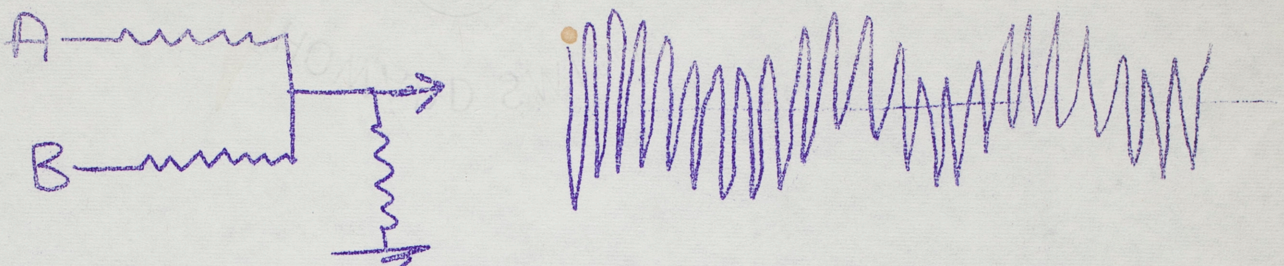
Problems:

1. Find the distance between points (3 -4) and (-8, 2)
2. Find the coordinates of the midpoint of the line segment whose endpoints are (x1, y1) and (x2, y2)
3. Draw a line segment P1, P2 passing through (3, -2) and having a slope of -5/4.
4. Show that the line joining (4, 6) and (2, 1) is parallel to the line joining (8, 12) and (4, 2)
5. Show that the three points (2, 3) (6, -3) and (-2, 9) are collinear.
6. Sketch the locus of the equation 1. $y = -2x^2 + 3$

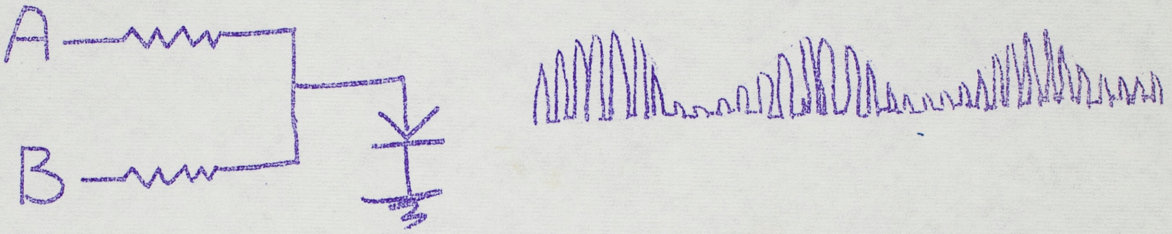
   2. $9x^2 + 16y^2 = 144$
7. Find the intercepts of the curve $y = x^2 - 4$ on both axes.
8. For what values of c do members of the family $ax + by = c$ pass through the origin?
9. Discuss the equation $y^2 = (x - 2)(x - 3)(x - 4)$ by considering (1) intercepts, (2) symmetry with respect to each axis, (3) limiting values, if any, of each variable, (4) whether the locus is an open or closed curve. Sketch the curve.
10. Sketch the family of curves $y^2 = ax$ by giving the parameter a values chosen to make the relation clearest, that is, to help the viewer imagine curves with values of the parameter a which are not actually shown.

Laboratory -10 Ring Modulator (without transformer)

Mixing of two signals in a linear circuit produces a simple addition pattern on an oscilloscope as shown



The linear circuit produces no modulation products, however if a diode is introduced so that the pattern is divided in two, one part being suppressed, modulation products appear.



The output of the simple circuit shown with one diode contains in addition to the modulation products the original signals. For many purposes it is better not to have these.

The ring modulator in the accompanying diagram applies one signal to all four diodes in the same phase through four 10 K resistors. The two diodes on the right are connected in a opposite direction to the two diodes on the left. Note: The arrow shown on diodes indicates the direction of conventional current flow. Sometimes color bands are used instead of an arrow. In this case the actual direction is not important as long as the two diodes on the right are connected the opposite direction from the two diodes on the left.

The other signal (signal B or the "control signal") is applied to all four diodes but two diodes are driven in the opposite phase to the other two. The two phases are obtained in the phase splitter shown at bottom right.

Output is taken from all four diodes, but two are connected in phase opposition in a differential amplifier. Instead of the differential amplifier a phase splitter similar to the one shown at the bottom could be used along with a resistor adding circuit.

Balancing with respect to signal B (the control signal) and with respect to signal A can be done by adjustment of the amplitudes out of the phase splitter and by adjustment of the differential amplifier. Neither of these adjustments is shown.

The colored dots refer to a set of oscillograms taken at the points in the circuit indicated.

BOOKS at the LIBRARY

Wittgenstein, Ludwig "Remarks on the foundations of mathematics"
Basil Blackwell, Oxford, 1956

Scott, J. "Ahistory of mathematics from antiquity to the beginning of the nineteenth century"
London, Taylor and Francis, 1958

Whitehead, Alfred North "An introduction to mathematics"
Oxford University press 1958

James, Glen and James Robert C. "Mathematics Dictionary"
Van Nostrand, 1959 (second edition)

Seashore, Carl E. "Psychology of Music" (1938)
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Rinehart & Co. Inc. Toronto 1951

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H arper 1961

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Gernsback Library 1958

Haynes, N. "Transistor circuits for magnetic recording"
Indianapolis, H.W. Sams 1964

Tremaine, Howard M. "Passive Audio network design"
Indianapolis H.W. Sams 1964

BOOKS FOR DETAILLED STUDY

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Addison-Wesley Publishing Company 1964

Adelfio, S.A. "Principles and applications of Boolean algebra"
N.Y. Hayden Book Co.

Marshall J.S. "Physics"
Macmillan Co. N.Y. 1957

0

1

(a) An urn contains 10 black balls and 10 white balls, identical except for color. You choose "black" or "white." One ball is drawn at random, and if its color matches your choice, you get $10, otherwise nothing. Write down the maximum amount you are willing to pay to play the game. The game will be played just once.

(b) A friend of yours has available many black and many white balls, and he puts black and white balls into the urn to suit himself. You choose "black" or "white." A ball is drawn randomly from this urn. Write down the maximum amount you are willing to pay to play this game. The game will be played just once.

2

A drawer contains red socks and black socks. When two socks are drawn at random, the probability that both are red is ½. (a) How small can the number of socks in the drawer be? (b) How small if the number of black socks is even?

(a) 3 socks
(b) 4 socks

3

Three men are blindfolded and told that either a red or a green hat will be placed on each of them. After this is done, the blindfolds are removed. Each man is asked to raise a hand if he sees a red hat and to leave the room as soon as he is sure of the color of his hat. All three men raise a hand, but for several seconds no man leaves. Finally, one man, more astute than the rest, gets up and goes out. What color was his hat and how did he reason it out?

4

Draw a circuit using four switches to turn a device on and off
(a) so that the device is on if any of the four switches is on
(b) so that the device is off if any of the four switches is off
(c) so that each of the four switches will turn the device on or off no matter what the setting of the other switches may be.

Parallel (a)
Series (b)

5

A tungsten lamp when normally lighted takes a current of 1 amp at 100 volts. What is its resistance when running? Approximately what would its resistance be when cold?

100 Ω

$R = \frac{E}{I}$ Voltage / Amp

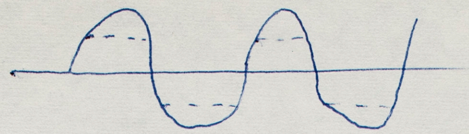
6

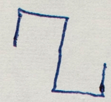
What is the permissible recording level at 10 KC in terms of the standard recording level (0 decibels) at 400 cps. when recording at a speed of 15 inches per second?

−10 because highs boosted

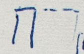
If you were recording a group of sine waves all of the same level 10,000 cps 10,050 cps 10,100 cps. how would the effect of recording at too high a level show most noticeably on the record?

IM distortion? 50 cps difference tone





odd harmonics
from sine



Pulse from sine

Laboratory - 5   A practical grounded emitter amplifier.

The pair of resistors on the left biasses the base in the forward direction. The 1800 ohm resistance of the potentiometer provides DC feedback which stabilizes the operating point. The variable tap on the potentiometer is bypassed to ground through the emitter bypass capacitor of 180 microfarads. When the tap is at the grounded end of the 1000 ohm potentiomter the minimum amount of gain is obtained (and the maximum AC feedback) When the wiper is at the emitter end of the potentiometer the maximum gain is obtained (no AC feedback).

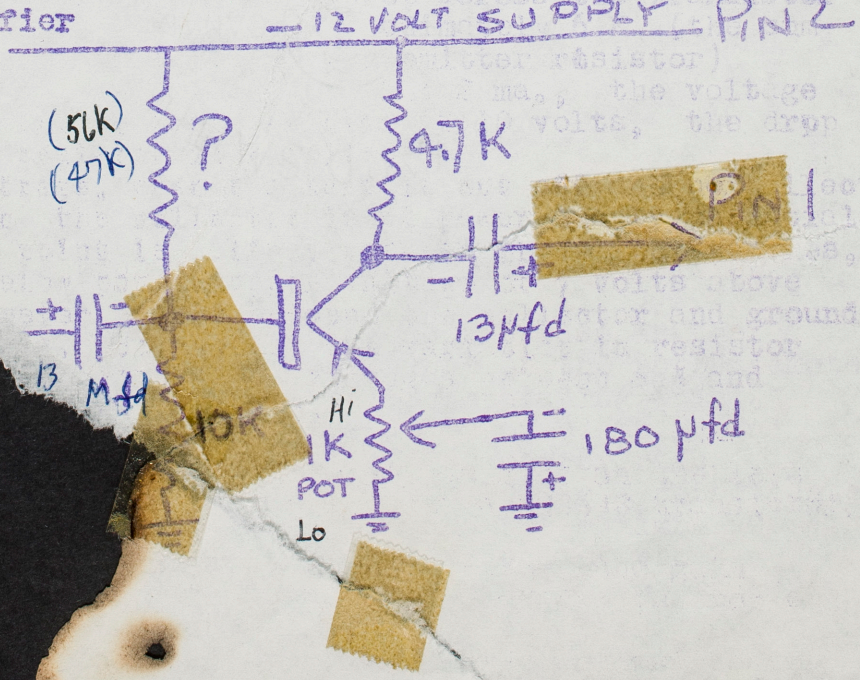
DC VOLTAGES in the emitter-collector circuit: When the wiper of the 1K Potentmr is at the grounded end of the potentiometer (in the low-gain position) and the maximum forward drive is a pplied to the base, the voltage drop across the transistor is small, the total resistance is approdimately 6 K (the sum of the collector load resistor and the emitter resistor) For a 12 volt supply, the current is them 2 ma., the voltage drop across the collector load resistor is 10 volts, the drop across the emitter resistor is 2 volts.
At the opposite extreme, when the base is cut off and no collector current flows, then the collector is at power supply potential. The best operating point is halfway between these two extremes, that is 5 volts below power supply voltage or 7 volts above ground. A dc voltmeter placed between the collector and ground would measure 7 volts. Because of the variation in resistor values and transistor parameters, voltages between 6.5 and 7.5 would be considered acceptable.

1) Find the value of the top base bias resistor on the left which gives the proper operating point for a 2N3638 transistor.

2) After installing the proper resistor measure the gain (a) wiper of emitter pot at ground end (b) middle (c) top end

3) Increase the input voltage until the waveform just begins to flatten. Measure this voltage and estimate the maximum undistorted output. (volts rms)

4) Borrow an amplifier and connect two in cascade. Measure the gain of each separately and the gain of the two in cascade.

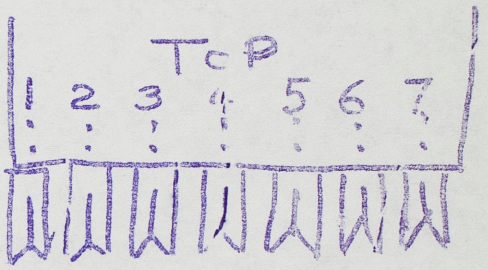


Wiring circuits on vectorboard cards

Manufacturer's data on"vector" products and fork connectors (Elco) were given on a set of xeroxed sheets.
Vectorboard can be easily cut to any size with shears, and practically any size of card can be used.

There are many advantages to using a small number of standard sizes of card in any studio or project. Pin spacing and function should also be standardized so that units can be interchanged and so that the maximum use can be got out of one unit. The pin locations and functions listed below are entirely arbitrary. The "small standard" (one of three sizes, small, medium and large) will take seven fork connectors as shown below. In the case of the two larger sizes, the first seven pins are treated in a similar way. Other pins are used as the occasion demands.

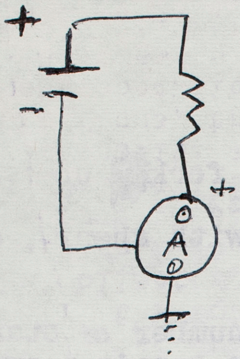
Left side:
#1 red output
#2 purple power supply
#3 green } not assigned
#4 blue }
#5 yellow input
#6 orange control
#7 black ground



Testing of circuits will be done by plugging them into a test strip which makes as many connections as possible through the fork connectors. The "top" side of the card will still be accessible for measuring voltages and making other connections. For the simpler circuits all components should be on top to make it easier to check the wiring and locate reference points.

To begin with, it is advisable to lay out the components so that they look as much as possible like the circuit diagram.
Needless to say, the circuit diagram should be drawn in such a way that the wiring is as simple as possible.
Power supply bus should be at the top, ground bus should be at the bottom. ("bus" is an abbreviation of "omnibus" and means a conductor which "carries all currents")
If you find the lay-out confusing, place a piece of writing paper on the vector card before inserting the pins and mark the more important ones. If the unit does not work, most of the checks will be measurements of AC or DC voltage at various points in the circuit. These will be speeded up if the key points are easy to locate.

When wiring very complicated circuits it will be necessary to wire and place components on both sides of the board. The layout will necessarily be hard to follow. Sometimes it is advisable to note on the circuit diagram how to locate the key points.



user of electricity

convention

connect radio to car battery + goes to +

db $20 \cdot \log 10 \frac{E}{E \text{ standard}}$

6db 2:1 universal

10db 3:1

20db 10:1

$10 \log \frac{P_1}{P_{ref}}$

20 watt amplifier only gives 3db more gain than 10 watt

Laboratory - 6   An emitter follower

When the voltage on the base is raised (moved in the forward direction) the base current is increased and the current in the emitter-collector circuit is increased much more rapidly. The voltage across the emitter resistor (load resistor) is thereby raised ... in other words it "follows" the base voltage. Similarly, a downward movement in base voltage reduces the current through the emitter resistor and causes the emitter voltage to drop... in other words it "follows" the base voltage.

When the emitter resistor plus load presents a low resistance to the transistor, more current flows and the voltage relations remain practically the same (up to a point). Thus the emitter follower has a low output impedance.

When moderate values of emitter load are used, the emitter follower has a high input impedance.

The emitter follower is useful as an output device in studio equipment because the low impedance enables it to drive many inputs at the same time and prevents electrostatic pickup of hum and other unwanted signals.
It is useful as an input device because it offers a very light load (high resistance load) to the device which drives it.

1) In th e circuit shown, what is the impedance presented to the base by the two bias resistors shown? (imagine the base temporarily disconnected)

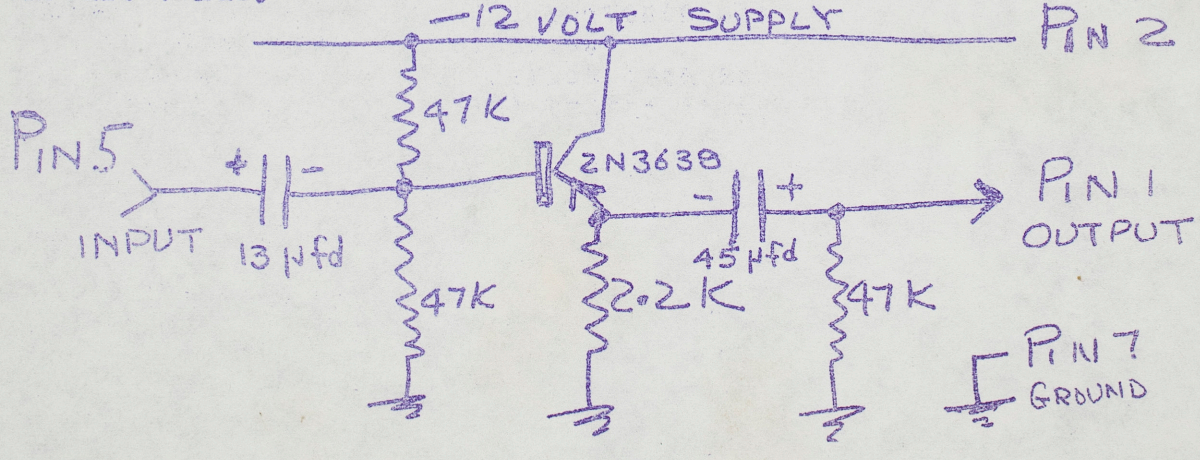
R+R?

2) In the same situation as question 1, what would be the open circuit voltage before the base is connected?

3) On the complete wired circuit connected to the power supply but without input or output connections, what is the measured DC voltage on the base? on the emitter?

4) Measure the voltage gain of the circuit. What determines the voltage gain in this circuit?

5) Put a very small signal on the input (about 0.1 volts rms) at a frequency of 1000 cps. and measure the output impedance by connecting various resistors across the output until you find one which reduces the output voltage to half its open circuit value.



SETS definitions - 1

$x \in A$ x is a member (or element) of the set A

$x \notin A$ x is not a member (or element) of the set A

Venn diagram : a [redacted] representation on a drawing of the relations between two or more sets.

Universal set the set containing all the members of a class.

Particular set a set containing not all the members of a class.

$B \subset A$ B is a subset of A when all members of set B also belong to set A

$B \subseteq A$ If every element of B is a member of A and there is at least one element of A which is not a member of B A is a proper subset of B

Roster of Bracket notation: All the members of a set are listed between brackets.. as A = (1,5,7)
Alternative form:
E = (x | x is an even positive integer)
This means "E is the set of all x's such that x is an even positive integer"

$\emptyset$ the empty set

A = B every member of set A is a member of set B

$P \leftrightarrow Q$ P is equivalent to Q when their elements can be paired in a unique fashion... that is, when they are in one-to-one correspondence.

Disjoint : If two non-empty sets have no elements in common they are said to be disjoint.

$C = A \cap B$ C is the intersection of sets A and B when the set C contains all the elements common to A and B

$C = A \cup B$ C is the union of sets A and B when set C contains all the elements of A plus the elements of B

$C = A \times B$ (read C equals A cross B) C is the set of all ordered pairs whose first members are elements of A and whose second members are elements of B

Mapping into — When each element of a set A can be connected once with some element of P the association is called a mapping of the set A into the set P

Image — when the element a is associated with the element p then p is the image of a. Written $\alpha a = p$. A different mapping might be represented by $\beta a = s$. (α = "alpha")

Mapping onto — If α is a mapping of the set A into a set P then α is called a mapping of the set A onto P if for each element y in P there is at least one element x in A such that $\alpha x = y$

One-to-one mapping: A mapping of a finite set onto another finite set is one-to-one if and only if (1) each element of B is the image of some element of A, and (2) no two distinct elements of A have the same image in B. This is possible only if the two sets have the same number of elements.

A mathematical operation: a mathematical operation on a nonempty set S is defined as a mapping of $S \times S$ into S

A mathematical system: any nonempty set S together with one or more specified operations on S.

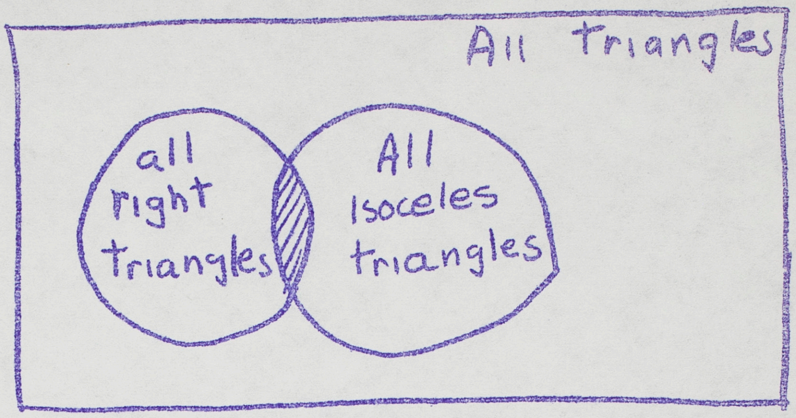
Relation — a relation is a set of ordered pairs.

xRy means "x has the relation R to y"
Reflexive: of the form xRx
symmetric xRy implies yRx
transitive if xRy is true and yRz then xRz is true.
Asymmetric if xRy is true then yRx is false.

Definition of a function in terms of set theory:
(Calloway p.74) Given two nonempty sets A and B a **function** is a subset F of $A \times B$ with the property that no two distinct ordered pairs belonging to F have the same first element.

SETS...problems - 1

1) Explain why the two subsets in the diagram below are represented by overlapping circles:



2) What is the total number of ways of forming sets by taking all, some, or none of a set of n objects?
How many non-empty subsets can be formed of a set of n elements?
How many proper subsets can be formed from a set of n elements?

3) Show that th ere is a one-to-one correspondence between the letters of the alphabet and the set of symbols in the Morse code (telegraph code).

4) Sh ow that the members of a string quartet and their instruments are equivalent sets.

5) Show that there is a one-to-one correspondence between the set of unit fractions (1/1 1/2 1/3 1/4 etc) and the set of positive integers.

6) Draw Venn diagrams to show that: (a) all elements of the set P are elements of the set Q and some elements of the set Q are not elements of the set P

(b) $A \supset B$

(c) $A \subset B$ and $B \subset C$

(d) All elements of R are elements of T , All elements of S are elements of T , R and S have no elements in common and some elements of T are not elements of either R or S.

7) By means of a Venn Diagram show that if $A \subset B$ and $B \subset A$ then A and B are identical, that is $A \equiv B$

SETS   problems - 2

1) Give an example of a familiar set which is the union of two familiar sets.

2) Give an example of a familiar set which is the intersection of two familiar sets.

3) If P is a set containing 4 elements and Q is a set containing 9 elements (nine) what can be said about the number of elements

(a) in $P \cup Q$

(b) in $P \cap Q$

4) Explain why P is a subset of $P \cup Q$

5) Explain why $P \cap Q$ is a subset of P

6) Suppose that R is the set of all points inside a rectangle and S is the set of all points on a circle lying inside the rectangle. Find: (a) $R \cap S$

(b) $R \cup S$

7) Prove that $A \cup (B \cup C) = (A \cup B) \cup C$ Draw a Venn Diagram.

The parentheses indicate which operations are to be performed first.

8) Prove that $A \cap (B \cap C) = (A \cap B) \cap C$

9) Given $P = \{a, b, c\}$ and $Q = \{x, y\}$ write the list of elements in the set $P \times Q$.

10) If R is a set containing m distinct elements and S is a set containing n distinct elements how many elements is there in the set $R \times S$? Explain.

11) If P, Q, and R are three sets prove that

$$P \times (Q \cup R) = (P \times Q) \cup (P \times R)$$

SETS problems - 3

1) In each of the following you are given two sets: the first is mapped into the second. Draw a chart, using arrows, showing each mapping.

(a) $P = \{p_1, p_2, p_3, p_4\}$ $Q = q_1, q_2, q_3$

$\alpha p_1 = q_2$ $\alpha p_2 = q_3$ $\alpha p_3 = q_3$ $\alpha p_4 = q_1$

(b) $R = \{r_1, r_2\}$ $S = \{s_1, s_2, s_3\}$

$\beta r_1 = s_2$ $\beta r_2 = s_2$

(c) $M = \{3, 6, 9,\}$ $N = \{2, 5, 8\}$

$\gamma 9 = 2$, $\gamma 6 = 5$, $\gamma 3 = 8$

2) For each mapping in question 1 , state the number of ways in which the first set can be mapped into the second set.

3) If R = (a,b,c,) and S = (u,v,) how many mappings of R into S are there? How many mappings of R onto S are there?

4) If R is a set having m elements and S is a set having m elements wh at can you say about the number of mappings of of R onto S if $m < n$?

5) Given a mathematical system consisting of a set S S = (x,y,z,w) and an operation defined as follows:

*	x	y	z	w
x	w	x	y	z
y	x	y	z	w
z	y	z	w	x
w	z	w	x	y

(a) Read the complete mapping represented by this operation. Write it out in image notation.
(b) How many possible operations are there on set S ? (do not multiply out your answer).

6) Given a set consisting of the integers S = (1,2,3,4,....) Draw up a table similar to the one above defining the operation of multiplication.

~~FAIRCHILD~~ 2N 3638

PNP HIGH CURRENT SWITCH

DIFFUSED SILICON PLANAR EPITAXIAL TRANSISTOR

The 3638 is a PNP silicon PLANAR epitaxial transistor designed for digital applications at current levels to 500 milliamperes. The high gain-bandwidth product f_T, at high currents makes it an excellent unit for line driving and memory applications.

ABSOLUTE MAXIMUM RATINGS

Storage temperatures	-55 deg. C to plus 125 deg. C.
Operating junction temperature	plus 125 deg C max.
Lead temperature	260 deg. C max.

Total dissipation at 25 degree case temperature (with sink) 0.7 watt

Total dissipation at 25 degree free air temp. 0.3 watt.

Maximum Voltages and Current

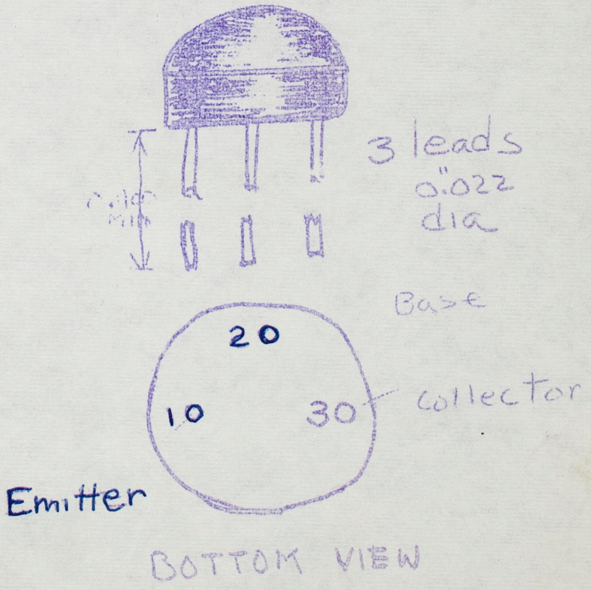
V CBO	Collector to base voltage	- 25 volts
V CES	Collector to emitter voltage	- 25 volts
V CEO	Collector to emitter high curr	- 25 volts
V EBO	Emitter to base voltage	- 4.0 volts
I C	Collector current steady state	500 ma.

Electrical Characteristics

High frequency current gain 1.0 to 1.5 a 100 megacycles

h_{FE}	DC pulse current gain 30 to 70	
BV_{CBO}	Collector to base breakdown voltage	-25 volts
BV_{CES}	Collector to emitter breakdown voltage	-25 volts

1 Emitter
2 Base
3 Collector



FAIRCHILD
2N 3638

Laboratory - 4   transistor in the grounded emitter connection

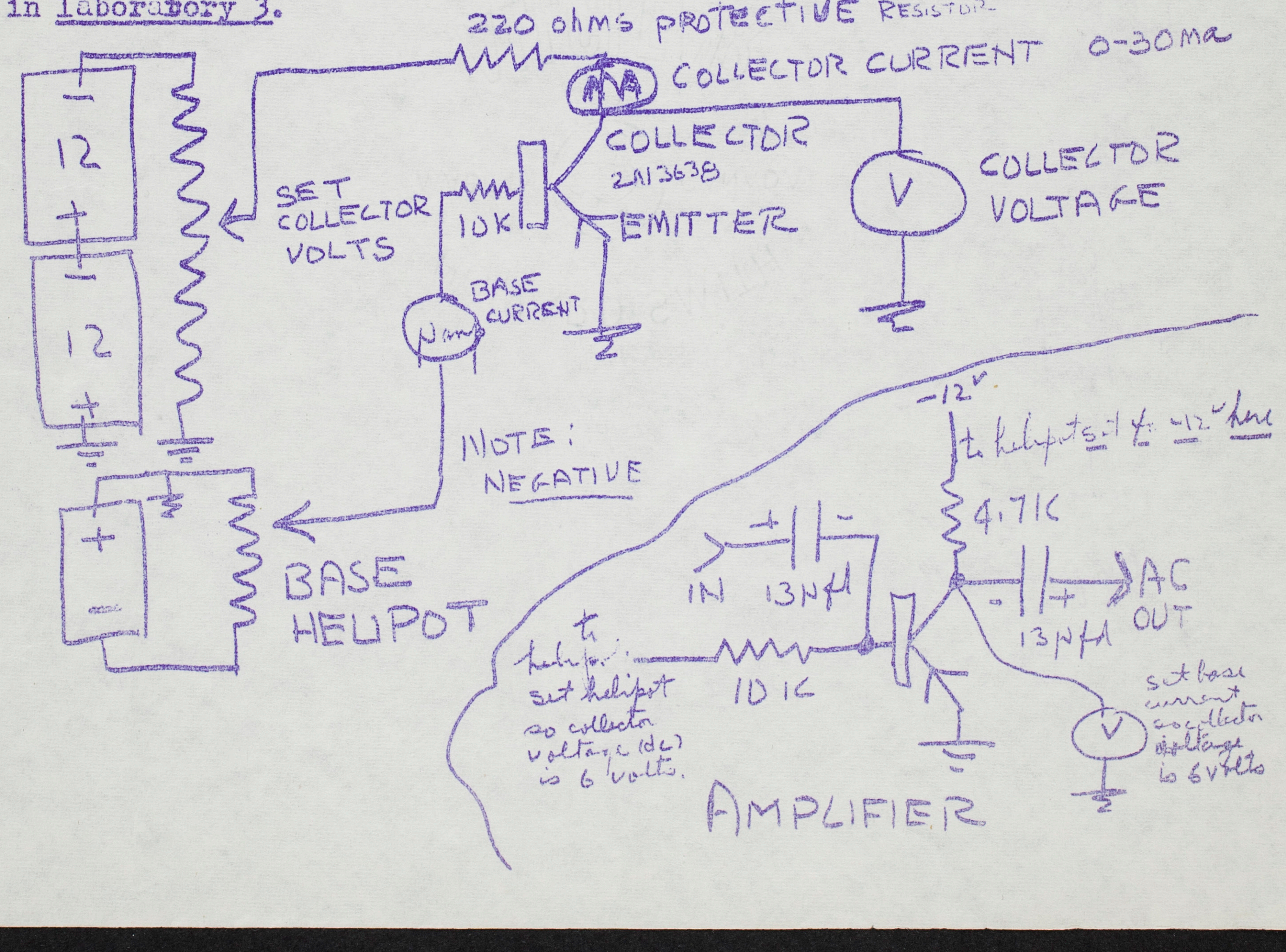
1) In the circuit shown below plot a family of curves of collector current (in milliamperes) versus collector-to-emitter voltage (volts) .... the parameter being base current.

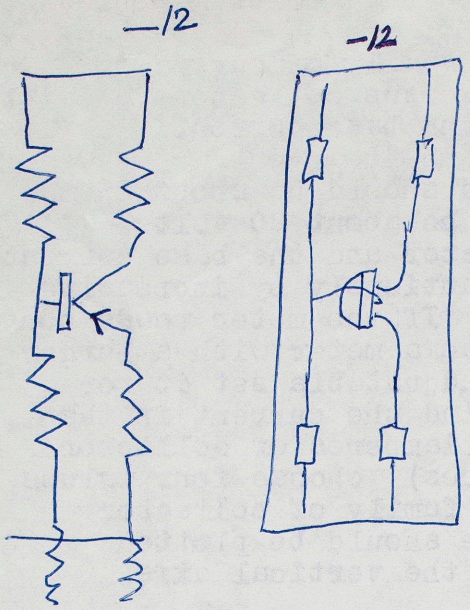
The range of collector current covered should be about 25 ma. The range of collector voltage should be about 20 volts. Start with about 6 volts on the collector and the base current at zero. Increase the base current cautiously by increasing the setting of the helipot from zero. If the meter reads too high or off-scale on the high side, use a meter with a larger full-scale rating or if the meter is adjustable set it for a higher full scale rating. When you find the current in the base circuit which gives about 25 milliamperes of collector current, (it will be in the microamperes) choose four values of base current which give a nice family of collector volt-ampere curves. Collector voltage should be plotted horizontally and collector current on the vertical axis.

2) Using a constant collector voltage of 12 volts (negative) plot collector current versus base volts.

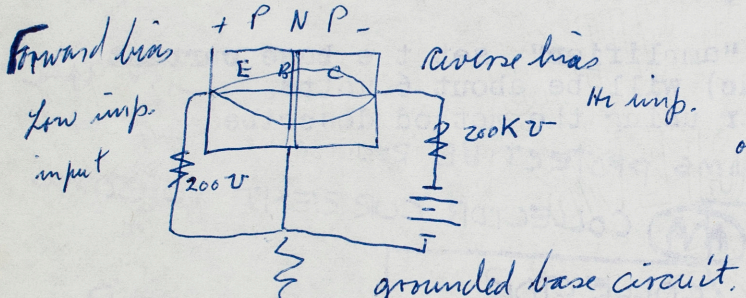
3) Using a constant collector voltage of 12 volts (negative) plot base current versus base volts making sure the collector current is never more than 25 ma.

4) In the lower circuit marked "amplifier" set the base current so that the collector voltage (dc) will be about 6 volts. −12v supply
Measure the gain of the amplifier using the method described in laboratory 3.

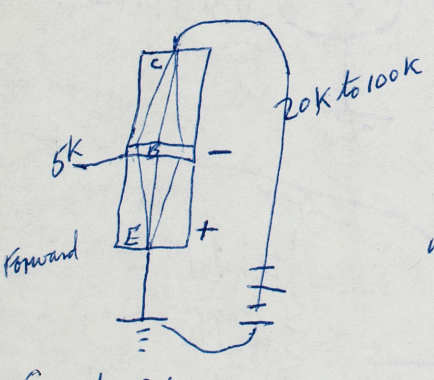




Holes



grounded base circuit.



output to input
without transformer.

Ground Reference voltge

Laboratory - 7 Feedback Amplifier

The feedback amplifier shown on the accompanying sheet consists of two stages in cascade. Inverse feedback is applied through the two resistors in the red box from the output (collector) of the second stage to the emitter of the first stage.
The amplifiers are direct coupled. DC stability is obtained by connecting the first base through a 150 K resistor to the bypassed emitter of the second stage.

1) Measure the maximum and minimum gain of the amplifier.

2) Measure the frequency response with the network shown at the bottom left of the diagram connected in place of the two gain control resistors in the red box. Be sure that the amplifier is not being overloaded anywhere in the frequency range measured.

Use 3 deck semi log paper and plot the frequency response in decibels.

3) Measure the frequency response with the network on the right substituted for the box.

Laboratory - 8 equalizers

(1) Design an RC equalizer which is flat from 20 cps to 200 cps then falls off at 6 db per octave for the remainder of the audio band (the higher frequencies).

(b) Build the equalizer and measure its performance by connecting the input directly to the signal generator and the output directly to the voltmeter.
Draw the frequency characteristic on 3-deck semi-log graph paper. Show the output ona decibel scale.

(2) (a) Design an RC equalizer with a ch aracteristic which rises at 6 db per octave up to 500 cps and is flat from there on up.

(b) Build and measure as in (1).

Design, build and measure an RC equalizer which is flat from 0 to 200 cps, has a 6 db per octave drop to 2000 cps then flattens out again. Plot the frequency response as in (2).

(4) Design, build and measure an adjustable series resonant circuit equalizer to correct a 10 db resonant peak in an audio system located at 1 kilocycle.

(5) Give an example of a parallel-resonant circuit equalizer or filter.

(5) (b) Build the circuit and measure the frequency response.

TYPE 2N3819
BULLETIN NO. DL-S 658047, AUGUST 1965

SILECT† FIELD-EFFECT TRANSISTOR

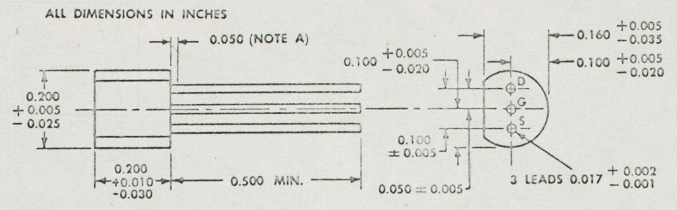
For Industrial and Consumer Small-Signal Applications

- Low C_{rss}: ≤ 4 pf
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure of Merit)
- Cross Modulation Minimized by Square-Law Transfer Characteristics

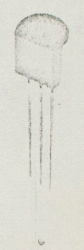
mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process‡ developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C method 106B. The transistor is insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTE A: Lead diameter is not controlled in this area



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 v
Drain-Source Voltage	25 v
Reverse Gate-Source Voltage	−25 v
Gate Current	10 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	200 mw
Storage Temperature Range	−55°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

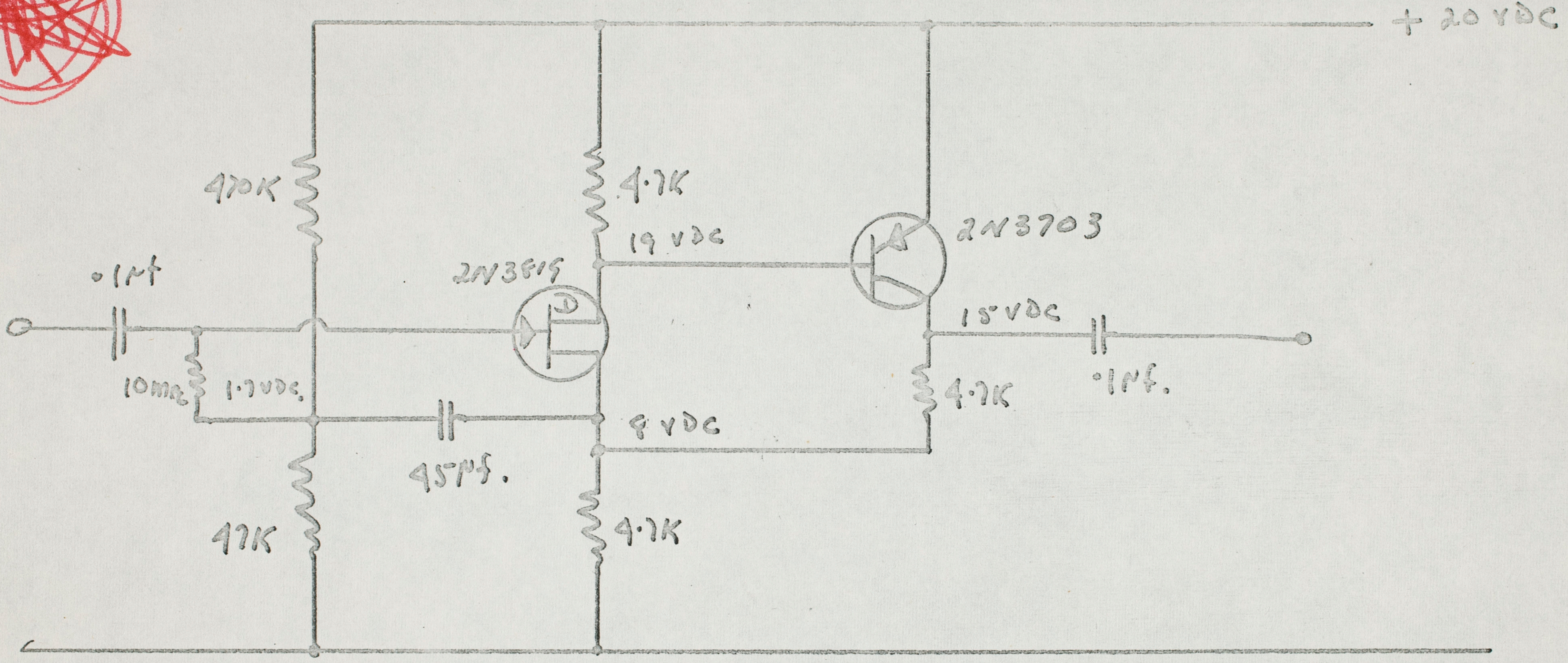
*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu a$, $V_{DS} = 0$	−25		v
I_{GSS}	Gate Cutoff Current	$V_{GS} = -15$ v, $V_{DS} = 0$		−2	na
		$V_{GS} = -15$ v, $V_{DS} = 0$, $T_A = 100°C$		−2	μa
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ v, $V_{GS} = 0$, See Note 2	2	20	ma
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ v, $I_D = 200\ \mu a$	−0.5	−7.5	v
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ v, $I_D = 2$ na		−8	v
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 kc, See Note 2	2000	6500	μmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 kc, See Note 2		50	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 Mc		8	pf
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			4	pf
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 100 Mc	1600		μmho

NOTES: 1. Derate linearly to 125°C free-air temperature at the rate of 2 mw/C°.
2. These parameters must be measured using pulse techniques. PW ≈ 100 msec, Duty Cycle ≤ 10%.
*Indicates JEDEC registered data.
†Trademark of Texas Instruments Incorporated
‡Patent Pending

PRINTED IN U.S.A.
TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 5012 • DALLAS 22, TEXAS

F.E.T. HIGH INPUT IMPEDANCE 6db gain Amp.

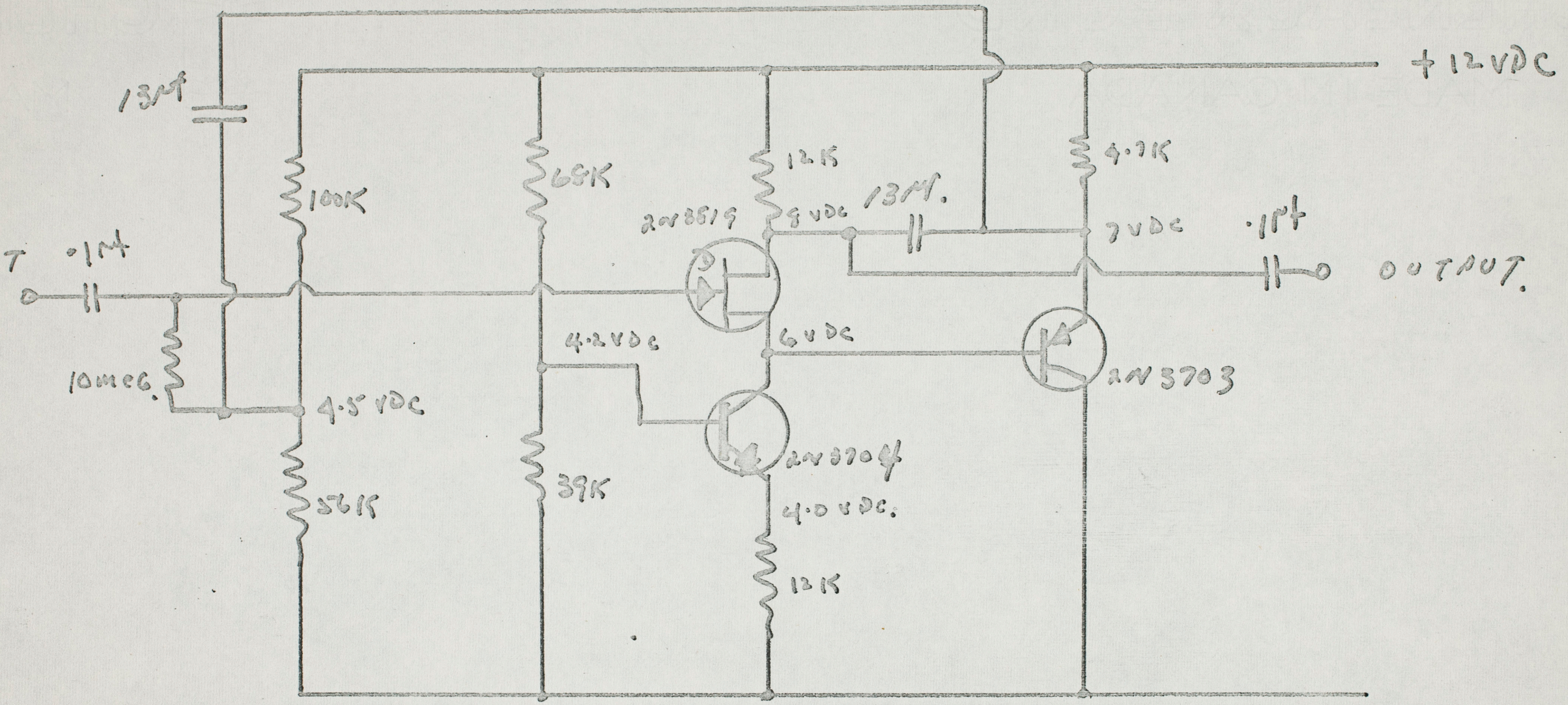


GAIN = 6db.

Input R at 1KC = 30 MEG Ω

" " " 10KC = 3 " "

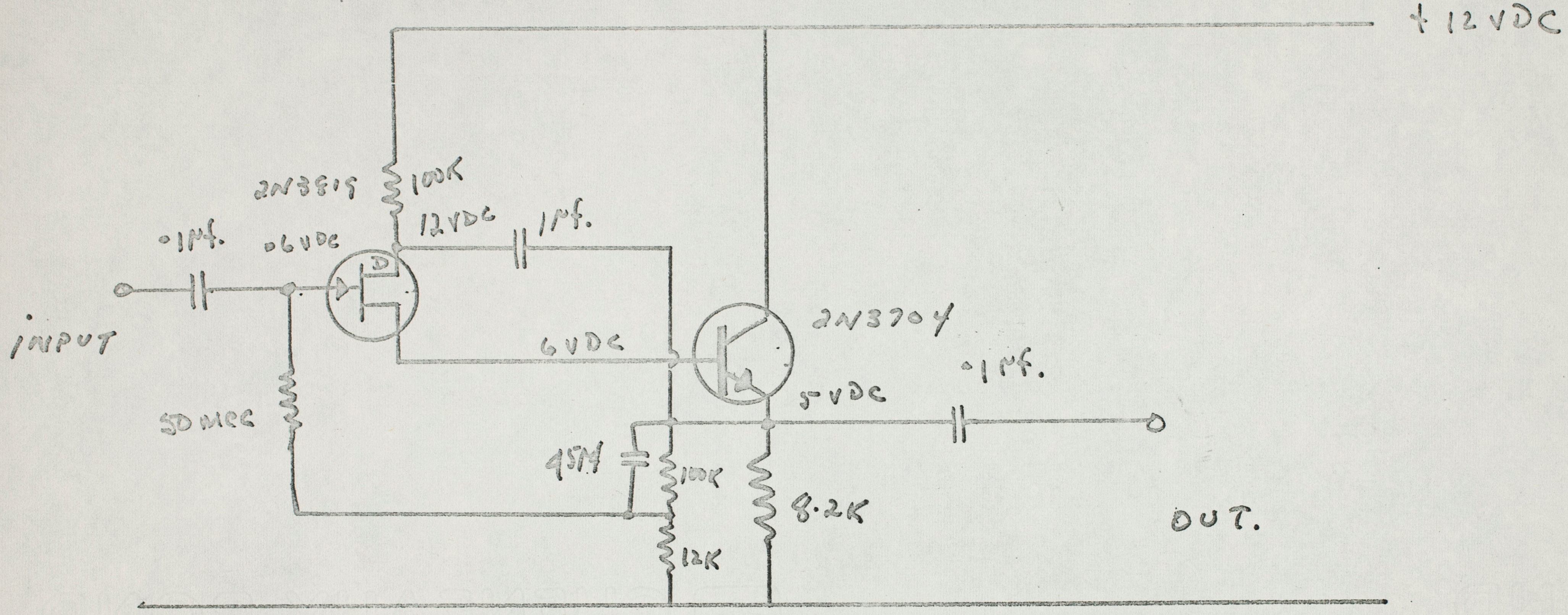
F.E.T. HIGH INPUT IMPEDANCE UNITY GAIN AMP.



GAIN < 1

Input R at 1KC = 70 MEG Ω

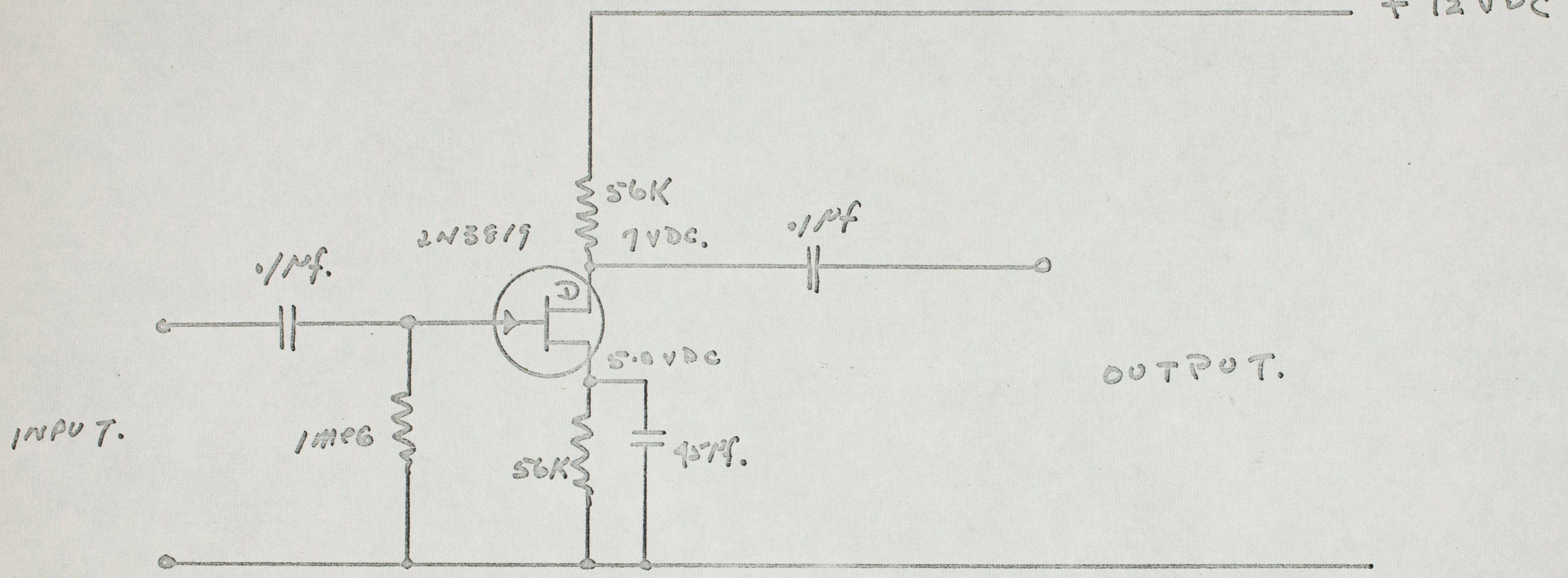
F.E.T. HIGH INPUT IMPEDANCE
UNITY GAIN AMP.



GAIN = ·98

Input R = at 100 CPS = 700 Meg Ω
" 1KC = 70 Meg Ω
" 10K = 7 Meg Ω

F.E.T. COMMON SOURCE AMP.

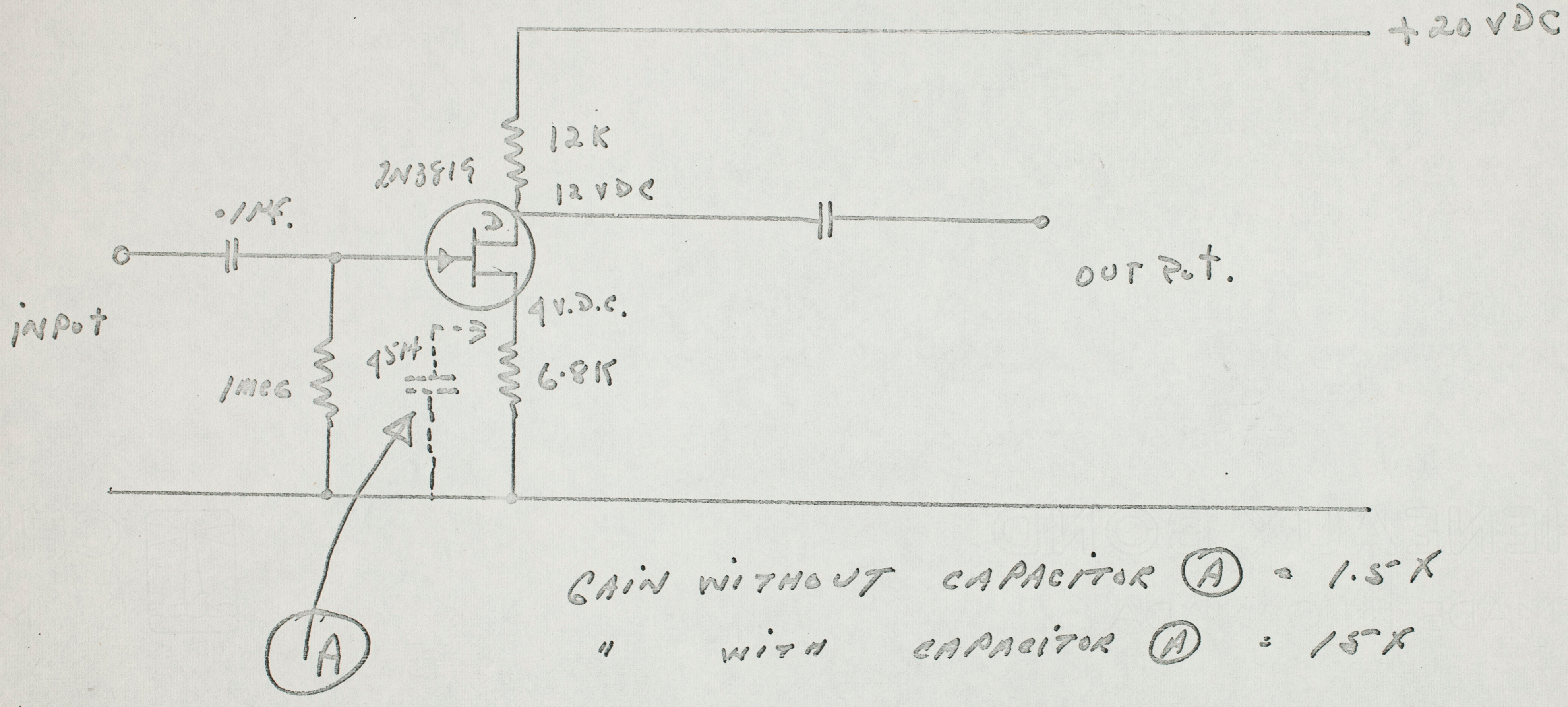


GAIN = 20X

Input R = 500KΩ

Bandwidth 20CPS TO 7 15KC.

F.E.T. COMMON SOURCE AMP.

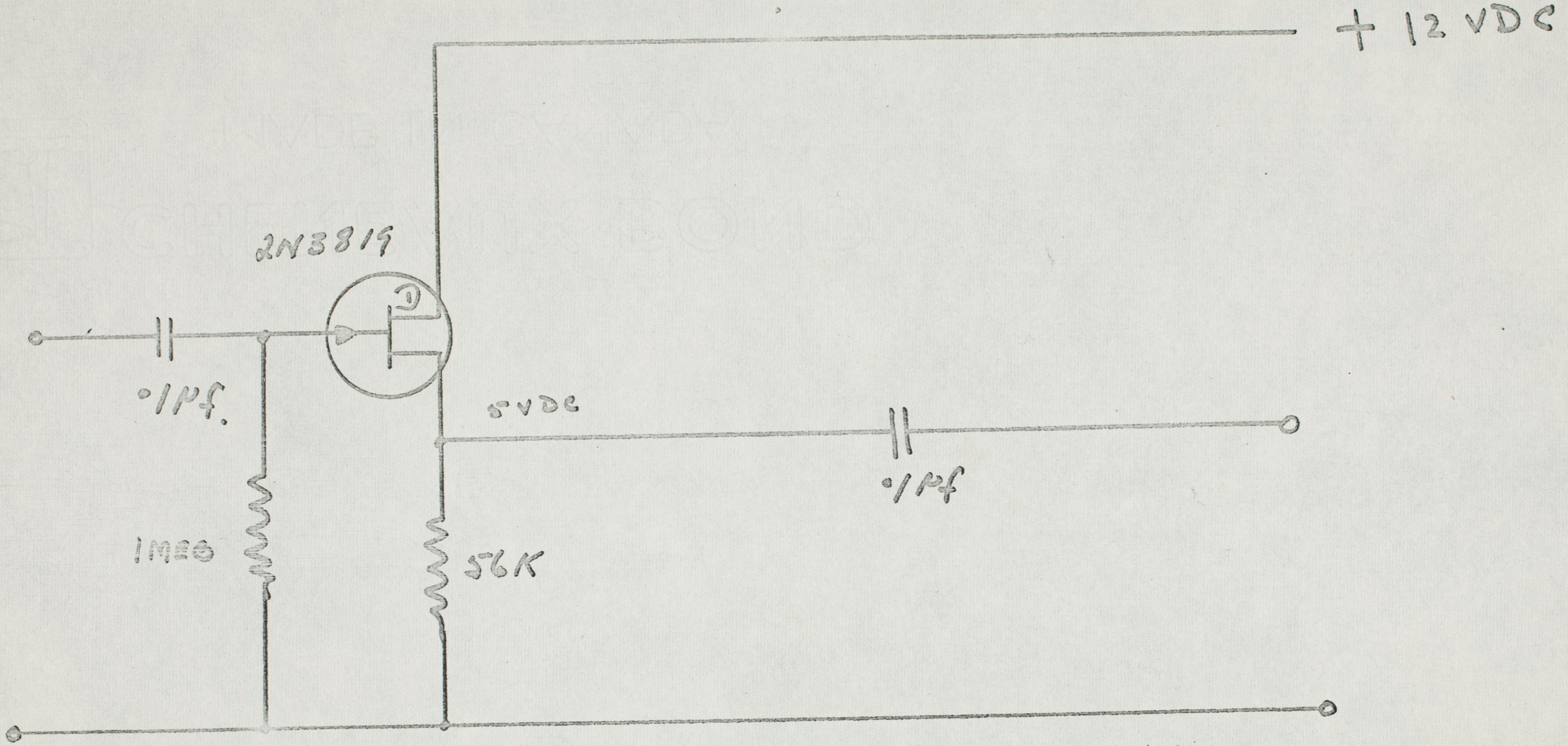


GAIN WITHOUT CAPACITOR (A) = 1.5 X

" WITH CAPACITOR (A) = 15 X

Input R = 500 KΩ

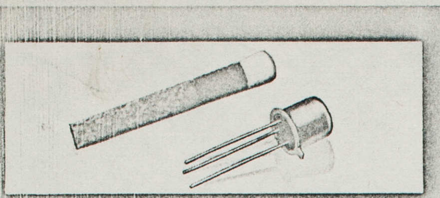
F.E.T. SOURCE FOLLOWER



GAIN = < 1 OR ·98

Input R 500K Ω

Bandwidth 20 CPS TO > 20 KC.

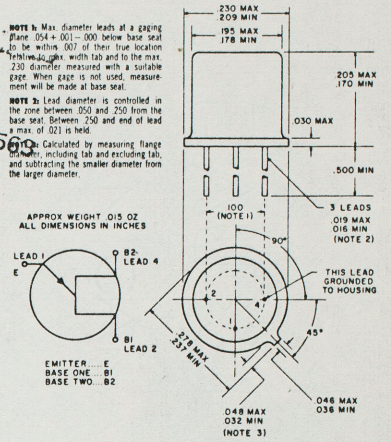


Unijunction TRANSISTORS

P N SILICON TYPES 2N2646 2N2647

The General Electric 2N2646 and 2N2647 Silicon Unijunction Transistors have an entirely new structure resulting in lower saturation voltage, peak-point current and valley current as well as a much higher base-one peak pulse voltage. In addition, these devices are much faster switches.

The 2N2646 is intended for general purpose industrial applications where circuit economy is of primary importance, and is ideal for use in firing circuits for Silicon Controlled Rectifiers and other applications where a guaranteed minimum pulse amplitude is required. The 2N2647 is intended for applications where a low emitter leakage current and a low peak point emitter current (trigger current) are required (i.e. long timing applications), and also for triggering high power SCR's.



absolute maximum ratings: (25°C)

Power Dissipation (Note 1)	300 mw
RMS Emitter Current	50 ma
Peak Emitter Current (Note 2)	2 amperes
Emitter Reverse Voltage	30 volts
Interbase Voltage	35 volts
Operating Temperature Range	−65°C to +125°C
Storage Temperature Range	−65°C to +150°C

electrical characteristics: (25°C)

PARAMETER		2N2646 Min.	2N2646 Typ.	2N2646 Max.	2N2647 Min.	2N2647 Typ.	2N2647 Max.	
Intrinsic Standoff Ratio ($V_{BB} = 10V$)	η	0.56	0.65	0.75	0.68	0.75	0.82	
Interbase Resistance ($V_{BB} = 3V, I_E = 0$)	R_{BBO}	4.7	7	9.1	4.7	7	9.1	KΩ
Emitter Saturation Voltage ($V_{BB} = 10V, I_E = 50$ ma)	$V_{E(SAT)}$		2			2		volts
Modulated Interbase Current ($V_{BB} = 10V, I_E = 50$ ma)	$I_{B2(MOD)}$		12			12		ma
Emitter Reverse Current ($V_{B2E} = 30V, I_{B1} = 0$)	I_{EO}		0.05	12		0.01	0.2	μa
Peak Point Emitter Current ($V_{BB} = 25V$)	I_P		0.4	5		0.4	2	μa
Valley Point Current ($V_{BB} = 20V, R_{B2} = 100\Omega$)	I_V	4	6		8	11	18	ma
Base-One Peak Pulse Voltage (Note 3)	V_{OB1}	3.0	6.5		6.0	7.5		volts
SCR Firing Conditions (See Figure 26, back page)								

NOTES:

1. Derate 3.0 MW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.
2. Capacitor discharge—10μfd or less, 30 volts or less.
3. The Base-One Peak Pulse Voltage is measured in the circuit below. This specification on the 2N2646 and 2N2647 is used to ensure a minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.
4. The intrinsic standoff ratio, η, is essentially constant with temperature and interbase voltage. η is defined by the equation:

$$V_P = \eta V_{BB} + V_D$$

Where V_P = Peak Point Emitter Voltage
V_{BB} = Interbase Voltage
V_D = Junction Diode Drop (Approx. .5V)

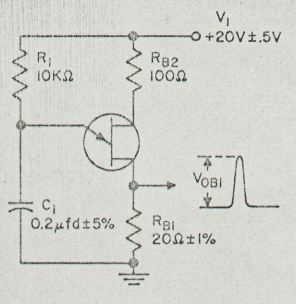


FIGURE 1

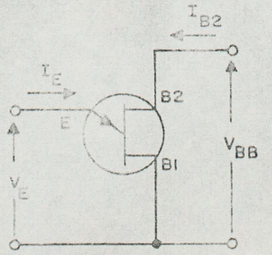


FIGURE 2

Unijunction Transistor Symbol with Nomenclature used for voltage and currents.

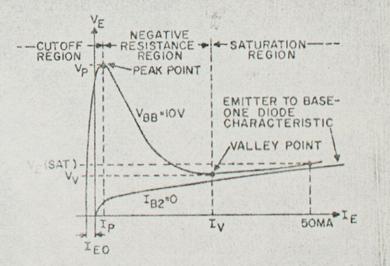
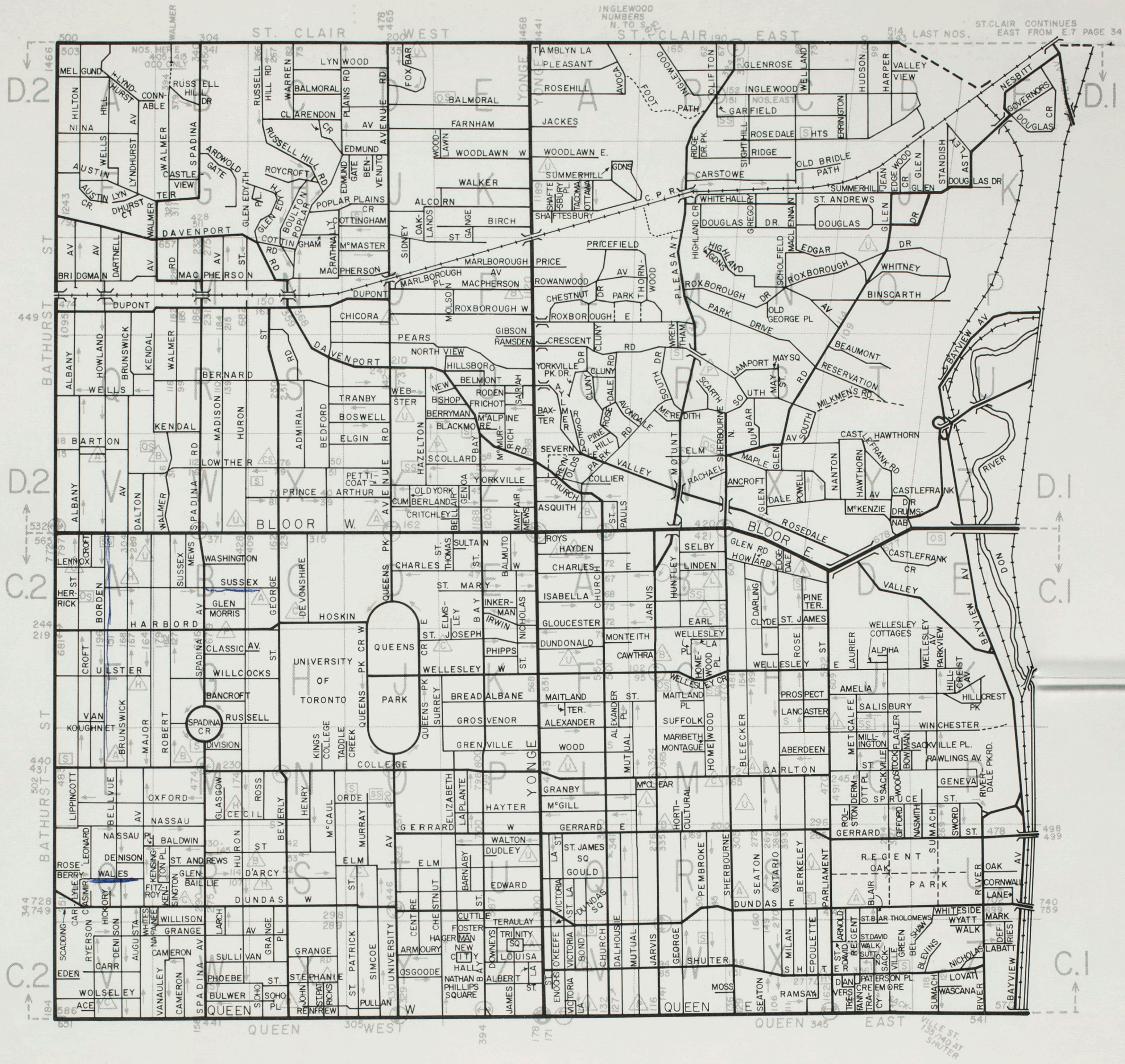


FIGURE 3

Static Emitter Characteristics curves showing important parameters and measurement points (exaggerated to show details).



D. 2

Admiral Rd.	S-X
Albany Av.	L-V
Alcorn Av.	J-K
Ardwold Gate	G
Austin Cr.	F
Austin Ter.	F-G
Avenue Rd. To 478/465	D-Y
Balmoral Av.	C-E
Barton Av. To 15/18.	V
Bathurst St. 785 to 1273	A-V
Bay St. 1188/1203 to End	Z
Bedford Rd.	N-X
Bellair St.	Z
Belmont St.	U
Benvenuto Pl.	J
Bernard Av	R-T
Berryman St.	T-U
Birch Av.	K
Bishop St.	U
Blackmore St.	U
Bloor St. W. To 532.	V-Z
Boswell Av.	S-T
Boulton Dr.	H-N
Bridgman Av.	L-M
Brunswick Av 291/306 to End	L-V
Castleview Av.	G
Chicora Av.	N-O
Clarendon Av.	C-D
Clarendon Cr.	C-H
Connable Dr.	A
Cottingham Rd.	N
Cottingham St.	H-K
Cumberland St.	Y-Z
Dalton Rd.	V
Dartnell Av.	L
Davenport Rd. To 670/671	F-Z
Dupont St To 449/474	L-O
Edmund Av.	J
Edmund Gate	J
Elgin Av.	X-Y
Farnham Av.	D-E
Foxbar Rd.	D
Frichot Av.	U
Gange Av.	K
Genoa St.	Z
Gibson Av.	U
Glen Edyth Dr.	H
Glen Edyth Pl.	H
Hazelton Av.	T-Y
Hillsboro Av.	U
Hilton Av.	A-F
Howland Av.	L-V
Huron St 411/430 to End	M-W
Kendal Av.	M-R
Lowther Av.	V-Y
Lyndhurst Av.	A-F
Lyndhurst Ct.	F
Lynwood Av.	C-D
MacPherson Av.	M-P
Madison Av.	M-W
Marlborough Av.	O-P
Marlborough Pl.	O
Mayfair Mews	Z
McAlpine St.	U
McMaster Av.	O
McMurrich St.	U-Z
Melgund Rd.	A
Molson St.	P
New St.	U
Nina St.	A
Northview Ter.	U
Oaklands Av.	J
Pears Av.	S-U
Poplar Plains Cres.	H-J
Poplar Plains Rd.	C-N
Prince Arthur Av.	X-Y
Ramsden Park Rd.	U
Rathnally Av.	H-N
Roden Pl.	U
Roxborough St. W.	O-P
Roycroft Dr.	H
Russell Hill Dr.	B
Russell Hill Rd. To 266/267	C-H
St. Clair Av W. To 499	A-E
St. George St. 125/164 to End	N-X
Sarah St.	U
Scollard St.	Y-Z
Sidney St.	O
Spadina Rd To 340/343	B-W
Tranby Av.	S-T
Walker Av.	K
Walmer Rd To 394/415	B-W
Warren Rd. To 73/82.	C
Webster Av.	T
Wells St.	Q
Wells Hill Av.	A-F
Woodlawn Av. W.	K
Yonge St 792 to 1468	E-Z
Yorkville Av.	Y-Z

D. 1

Ancroft Pl.	X
Asquith Av.	V
Astley Av.	E-K
Avoca Av.	A
Avondale Rd.	Q
Aylmer Av.	Q
Baxter St.	Q
Bayview Av.	U-Z
Beaumont Rd.	T
Binscarth Rd.	O-P
Bloor St. E. To 678.	V-Z
Carstowe Rd.	G-H
Castle Frank Dr.	Y
Castle Frank Rd.	Y
Chestnut Pk. Rd.	L-M
Church St. 657/685 to End	V
Clifton Rd. To 62/67	B
Cluny Av.	Q
Cluny Dr.	L-Q
Collier St.	V
Crescent Rd.	Q-S
Dale Av.	X-Y
Douglas Cr.	E
Douglas Dr.	G-K
Drumsnab Rd.	Y
Dunbar Rd.	S-X
Edgar Av.	N-O
Edgewood Cr.	J
Elm Av.	W-X
Errington Av.	C
Garfield Av.	B-C
Glen Rd. 11/26 to End	J-X
Glenrose Av.	B-C
Governor's Rd.	E
Gregory Av.	H
Harper Av.	D
Harper Gdns.	D
Hawthorn Av.	Y
Hawthorn Gdns.	Y
Highland Av.	M-N
Highland Cr.	G
Highland Gdns.	M
Hudson Dr.	D
Inglewood Dr. 77/80 to End	B-D
Jackes Av.	A
Jean St.	J
Lamport Av.	S
MacLennan Av.	C-N
Maple Av.	X-Y
May Sq.	S
May St.	S
McKenzie Av.	Y
Meredith Cr.	R
Mount Pleasant Rd. To 323/324	B-W
Nanton Av.	Y
Nesbitt Dr.	E
Old Bridle Path	H
Old George Pl.	N
Ottawa St.	F
Park Dr (Reservation)	M-T
Park Rd.	R-V
Pine Hill Rd.	V
Pleasant Blvd.	A
Powell Av.	X
Price St.	L
Pricefield Rd.	F-L
Rachael St.	W-X
Reynolds Pl.	V
Ridge Dr.	G-H
Ridge Dr. Pk.	G
Rosedale Rd.	Q
Rosedale Hts Dr.	B-D
Rosedale Valley Rd.	Q-Y
Rosehill Av.	A
Rowanwood Av.	L-M
Roxborough Dr.	M-P
Roxborough St. E.	L-M
St. Andrews Gdns.	H-J
St. Clair Av. E. To 1000/1001	A-D
St. Paul's Sq.	V
Scarth Rd.	R
Scholfield Av.	N
Severn St.	V
Shaftesbury Av.	F-G
Shaftesbury Pl.	F
Sherbourne St. N.	S-X
Sighthill Av.	C-H
South Dr.	R-T
Standish Av.	D-J
Summerhill Av.	F-J
Summerhill Gdns.	F-G
Tacoma Av.	F
Tamblyn La.	A
Thornwood Rd.	M
Valley View	D
Welland Av.	C
Whitehall Rd.	G-H
Whitney Av.	O-P
Woodlawn Av. E.	F
Wrentham Pl.	M-R
Yonge St. 735 to 1441	A-V
Yorkville Pk. Dr.	Q

C. 2

Ace La.	V
Albert La.	Z
Albert St.	Z
Armoury St.	Y
Augusta Av.	L-V
Baldwin St.	Q-S
Balmuto St.	E
Bancroft Av.	G
Barnaby Pl.	U
Bathurst St 179 to 793	A-V
Bay St. 397/422 to 1186/1201	E-Z
Bellevue Av.	L-Q
Beverley St.	N-X
Bloor St. W. To 565.	A-E
Borden St.	A-L
Breadalbane St.	K
Brunswick Av. To 289/304	A-L
Bulwer St.	W
Cameron Pl.	W
Cameron St.	W
Carlyle St.	Q
Carr St.	V
Casimir St.	Q
Cecil St.	M-N
Centre Av.	T-Y
Charles St. W.	D-E
Chestnut St.	T-Y
Classic Av.	G-H
College St To 431/438	L-P
Croft St.	A-L
Cuttle Pl.	Z
D'Arcy St.	R-S
Denison Av.	Q-V
Denison Sq.	Q
Devonshire Pl.	C
Division St.	M
Downey's La.	Z
Dudley Pl.	U
Dundas St. W. To 738/741	Q-U
Eden Pl.	V
Edward St.	T-U
Elizabeth St.	P-Z
Elm St.	S-U
Elmsley Pl.	E-K
Fitzroy Ter.	R
Foster Pl.	Z
Gerrard St. W.	T-U
Glasgow St.	M
Glenbaillie Pl.	R
Glen Morris St.	B
Grange Av.	V-X
Grange Pl.	S-X
Grange Rd.	X
Grenville St.	P
Grosvenor St.	P
Hagerman St.	Z
Harbord St. To 69/70	A-C
Hayter St.	P
Henry St.	N-S
Hickory St.	Q
Hoskin Av.	C-D
Huron St. To 409/428	B-W
Inkerman St.	E
Irwin Av.	E
James St.	Z
John St. 153/164 to End	X
Kensington Av.	R
Kensington Pl.	R
Kings College Rd.	N
Laplante Av.	P-U
Larch St.	R-W
Leonard Av.	Q
Lippincott St.	A-L
Louisa St.	Z
Major St.	A-L
McCaul St.	N-X
Murray St.	T-O
Napanee St.	R-W
Nassau Pl.	Q-R
Nassau St.	L-M
Orde St.	N-O
Osgoode St.	Y
Oxford St.	L-M
Phipps St.	K
Phoebe St.	W-X
Pullan Pl.	Y
Queen St. W. To 586.	V-Z
Queen's Pk Av.	D
Queen's Pk. Cr. E.	D-O
Queen's Pk. Cr. W.	D-O
Renfrew Pl.	X
Robert St.	B-M
Roseberry Av.	Q
Ross St.	N
Russell St.	G-H
Ryerson Av.	V
St. Andrews St.	R
St. George St. To 123/162	C-N
St. Joseph St.	J-K
St. Mary St.	E
St. Nicholas St.	E-K
St. Patrick Sq.	X
St. Patrick St.	T-Y
St. Patrick's Market	X
St. Thomas St.	E
Scadding Ct.	Q
Simcoe St 162/173 to End	T-Y
Soho Pl.	X
Soho St.	X
Spadina Av. 160/165 to End	B-W
Spadina Cr.	G-M
Stephanie St.	X
Sullivan St.	W-X
Sultan St.	E
Surrey Pl.	K-P
Sussex Av.	A-C
Sussex Mews	B
Taddle Creek Rd.	N
Teraulay St.	Z
Trinity Sq.	Z
Ulster St To 95/114.	F
University Av. 331/332 to End	O-Y
Vanauley St.	W
VanKoughnet St.	F
Wales Av.	Q
Walton St.	U
Washington Av.	B
Wellesley St. W.	J-K
White's La.	Q
Willcock's St.	G-H
Willison Sq.	W
Wolesley St. To 100/107	V
Yonge St. 180 to 790	E-Z

C. 1

Aberdeen Av.	N-O
Alexander Pl.	F
Alexander St.	F
Alpha Av.	J
Amelia St.	J-K
Arnold Av.	Y
Bayview Av.	Z
Belshaw Pl.	Y
Berkeley St. 122/149 to End	N-X
Blair Av.	T-Y
Bleecker St.	C-N
Blevins Pl.	Z
Bloor St. E. To 687.	A-E
Bond St.	Q-V
Bowman St.	P
Carlton St.	L-P
Castle Frank Cr.	D-E
Cawthra Sq.	G
Charles St. E.	A-B
Church St. 129/138 To 655/684.	A-V
Clyde St.	C
Cornwall St.	U
Creemore Av.	Y
Dalhousie St.	Q-V
Danvers Av.	Y
Darling Av.	C-H
Defries St.	Z
Dermott Pl.	O
Dundas Sq.	V
Dundas St. E. To 779/780	Q-U
Dundonald St.	F
Earl St.	B
Edgedale Rd.	C
Flagler St.	O
Geneva Av.	P
George St. 156/161 to End	R-W
Gerrard St. E To 500/501	Q-U
Gifford St.	O-T
Glen Rd. To 9/24.	C
Gloucester St.	A-B
Gould St.	Q
Granby St.	L
Hayden St.	A
Hillcrest Av.	K
Hillcrest Park	K
Homewood Av.	G-M
Homewood Pl.	G
Horticultural Av.	M
Howard St.	C-D
Huntley St.	B
Isabella St.	A-B
Jarvis St. 118/147 to End	B-W
Labatt Av.	Z
Lancaster Av.	H
Laurier Av.	J
Linden St.	B
Lovatt Pl.	Z
Maitland Pl.	G
Maitland St.	F-G
Maitland Ter.	F
Maribeth Av.	M
Mark St.	Z
McClear Pl.	M
McGill St.	L
Metcalfe St.	J-O
Milan St.	S-X
Millington St.	O
Montague St.	M
Monteith St.	F
Moss Pk. Pl.	W
Mutual St.	G-W
Nasmith St.	P-U
Nicholas Av.	Z
Oak St.	S-U
O'Keefe La.	Q-V
Ontario St. 106/113 to End	C-X
Parkview Av.	K
Parliament St. 165/179 to End	D-Y
Paterson Pl.	Y
Pembroke St.	R-W
Pine Ter.	D
Poulette St.	S-X
Prospect St.	H
Queen St. E. To 590.	V-Z
Ramsay La.	X
Rawlings Av.	P
Regent St.	T-Y
River St.	P-Z
Riverdale Park Rd.	P
Rolston Av.	O
Rose Av.	C-H
Rosedale Valley Rd.	D-K
Roy's Sq.	A
Sackville Green	Y
Sackville Pl.	O
Sackville St. 101/102 to End	J-Y
St. Bartholomews St.	Y
St. David St.	Y
St. David Walk	Y
St. Enoch Sq.	V
St. James Av.	C-D
St. James Sq.	Q
Salisbury Av.	J-K
Seaton St.	N-X
Selby St.	B
Sherbourne St. 129/138 to End	C-X
Shuter St.	V-Z
Spruce Ct.	O
Spruce St.	P
Suffolk St.	G
Sumach St. 72/75 to End	K-Z
Sutton Av.	Y
Sword St.	P-U
Tracy St.	Y
Trefann St.	Y
Victoria St. 120/121 to End	Q-V
Victoria St. La.	Q-V
Wascana Av.	Z
Wellesley Av.	K
Wellesley Cottages	J
Wellesley Cr.	G
Wellesley La.	G
Wellesley Pl.	G
Wellesley St. E.	F-K
Whiteside Pl.	Z
Winchester St.	N-K
Wood St.	L
Woodstock Pl.	O
Wyatt Walk	Z
Yonge St. 173 to 733	A-V

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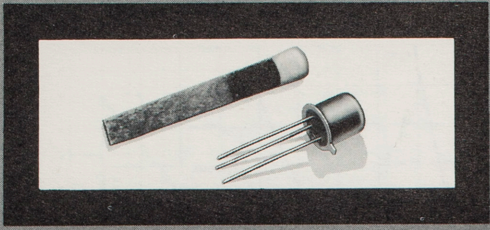


Unijunction TRANSISTORS

PN SILICON TYPES 2N2646 2N2647

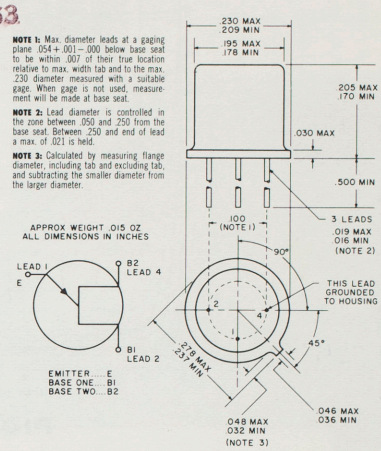
The General Electric 2N2646 and 2N2647 Silicon Unijunction Transistors have an entirely new structure resulting in lower saturation voltage, peak-point current and valley current as well as a much higher base-one peak pulse voltage. In addition, these devices are much faster switches.

The 2N2646 is intended for general purpose industrial applications where circuit economy is of primary importance, and is ideal for use in firing circuits for Silicon Controlled Rectifiers and other applications where a guaranteed minimum pulse amplitude is required. The 2N2647 is intended for applications where a low emitter leakage current and a low peak point emitter current (trigger current) are required (i.e. long timing applications), and also for triggering high power SCR's.

NOTE 1: Max. diameter leads at a gaging plane .054 + .001 − .000 below base seat to be within .007 of their true location relative to max. width tab and to the max. .230 diameter measured with a suitable gage. When gage is not used, measurement will be made at base seat.

NOTE 2: Lead diameter is controlled in the zone between .050 and .250 from the base seat. Between .250 and end of lead a max. of .021 is held.

NOTE 3: Calculated by measuring flange diameter, including tab and excluding tab, and subtracting the smaller diameter from the larger diameter.



absolute maximum ratings: (25°C)

Power Dissipation (Note 1)	300 mw
RMS Emitter Current	50 ma
Peak Emitter Current (Note 2)	2 amperes
Emitter Reverse Voltage	30 volts
Interbase Voltage	35 volts
Operating Temperature Range	−65°C to +125°C
Storage Temperature Range	−65°C to +150°C

electrical characteristics: (25°C)

PARAMETER		2N2646 Min.	2N2646 Typ.	2N2646 Max.	2N2647 Min.	2N2647 Typ.	2N2647 Max.	
Intrinsic Standoff Ratio ($V_{BB} = 10V$)	η	0.56	0.65	0.75	0.68	0.75	0.82	
Interbase Resistance ($V_{BB} = 3V, I_E = 0$)	R_{BBO}	4.7	7	9.1	4.7	7	9.1	KΩ
Emitter Saturation Voltage ($V_{BB} = 10V, I_E = 50$ ma)	$V_{E(SAT)}$		2			2		volts
Modulated Interbase Current ($V_{BB} = 10V, I_E = 50$ ma)	$I_{B2(MOD)}$		12			12		ma
Emitter Reverse Current ($V_{B2E} = 30V, I_{B1} = 0$)	I_{EO}		0.05	12		0.01	0.2	μa
Peak Point Emitter Current ($V_{BB} = 25V$)	I_P		0.4	5		0.4	2	μa
Valley Point Current ($V_{BB} = 20V, R_{B2} = 100\Omega$)	I_V	4	6		8	11	18	ma
Base-One Peak Pulse Voltage (Note 3)	V_{OB1}	3.0	6.5		6.0	7.5		volts
SCR Firing Conditions (See Figure 26, back page)								

NOTES:

1. Derate 3.0 MW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.
2. Capacitor discharge—10μfd or less, 30 volts or less.
3. The Base-One Peak Pulse Voltage is measured in the circuit below. This specification on the 2N2646 and 2N2647 is used to ensure a minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.
4. The intrinsic standoff ratio, η, is essentially constant with temperature and interbase voltage. η is defined by the equation:

$$V_P = \eta V_{BB} + V_D$$

Where V_P = Peak Point Emitter Voltage
V_{BB} = Interbase Voltage
V_D = Junction Diode Drop (Approx. .5V)

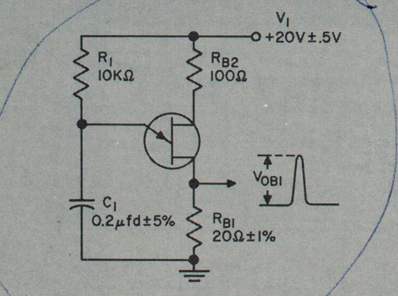


FIGURE 1

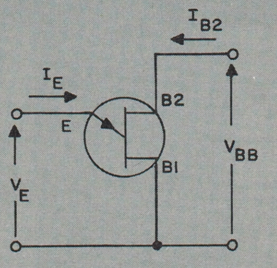


FIGURE 2
Unijunction Transistor Symbol with Nomenclature used for voltage and currents.

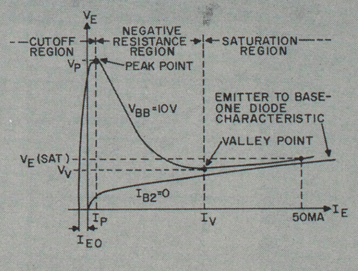


FIGURE 3
Static Emitter Characteristics curves showing important parameters and measurement points (exaggerated to show details).

$T_A = 125°C$

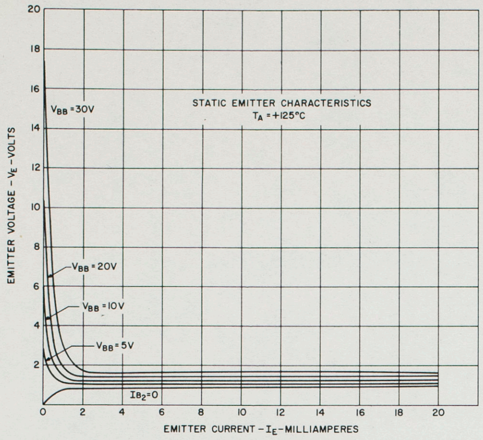


FIGURE 4

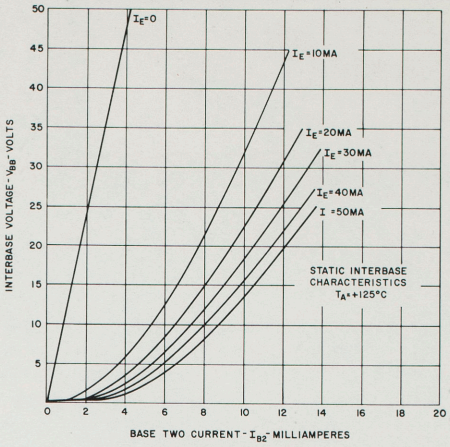


FIGURE 5

$T_A = 25°C$

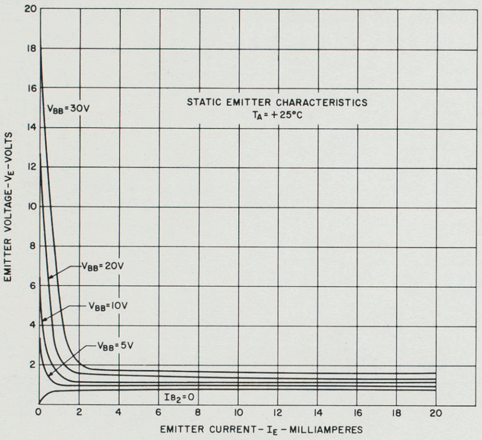


FIGURE 7

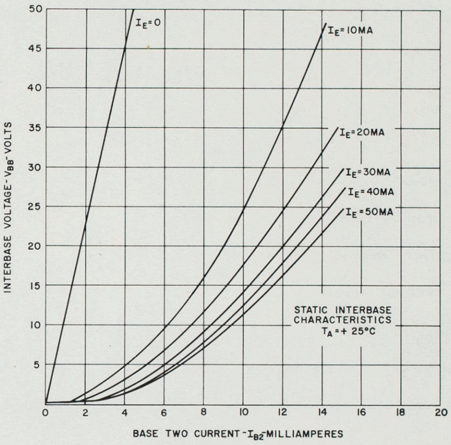


FIGURE 8

$T_A = -55°C$

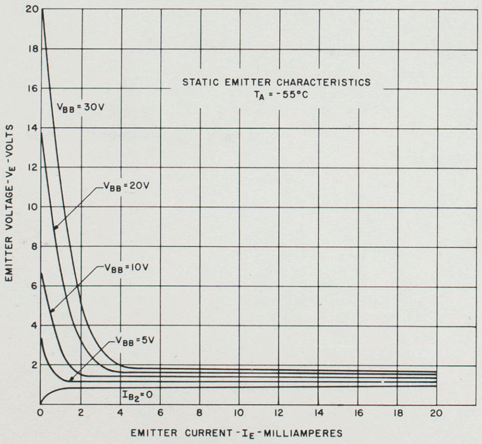


FIGURE 10

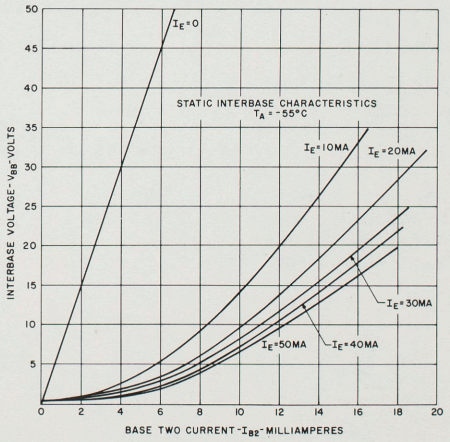


FIGURE 11

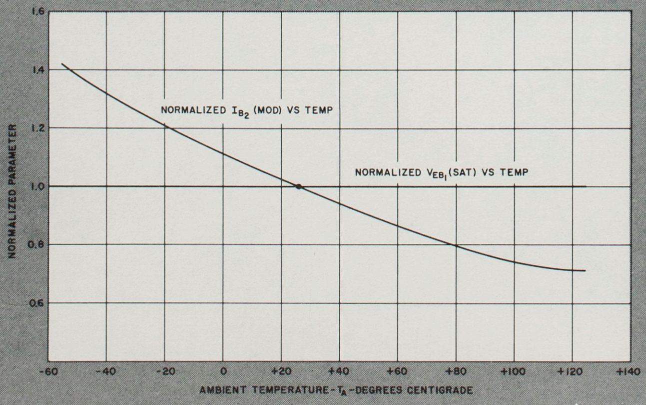


FIGURE 16

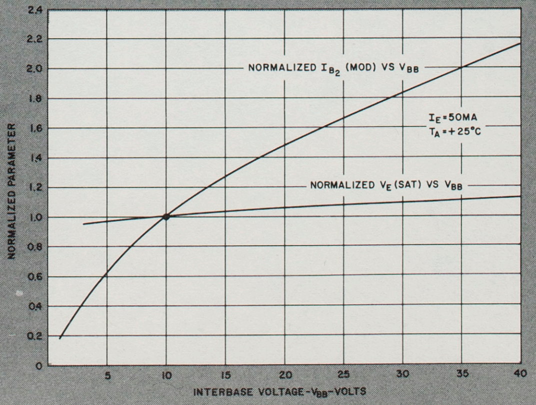


FIGURE 17

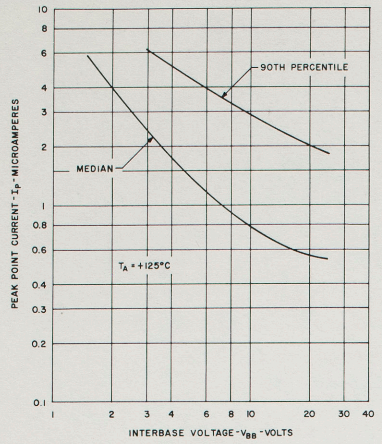


FIGURE 6

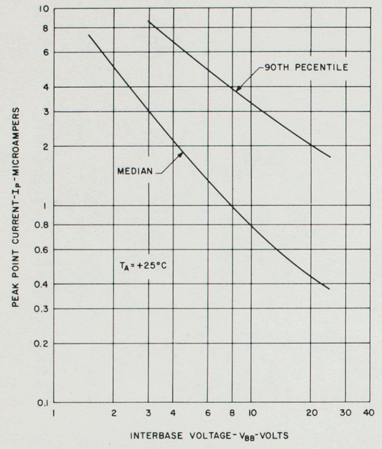


FIGURE 9

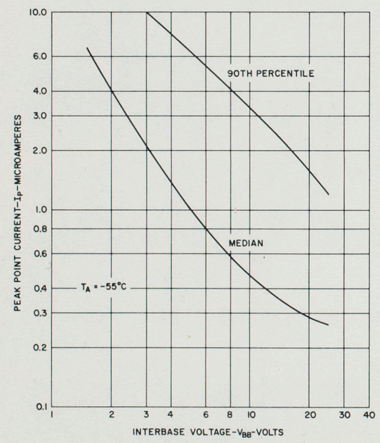


FIGURE 12

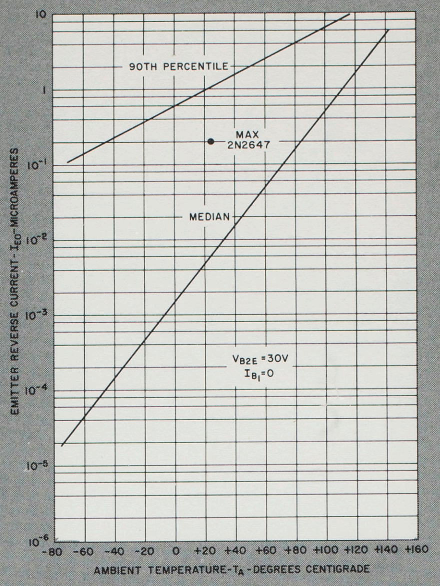


FIGURE 13

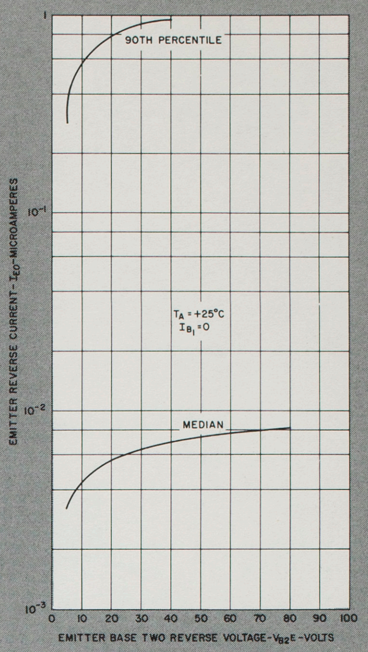


FIGURE 14

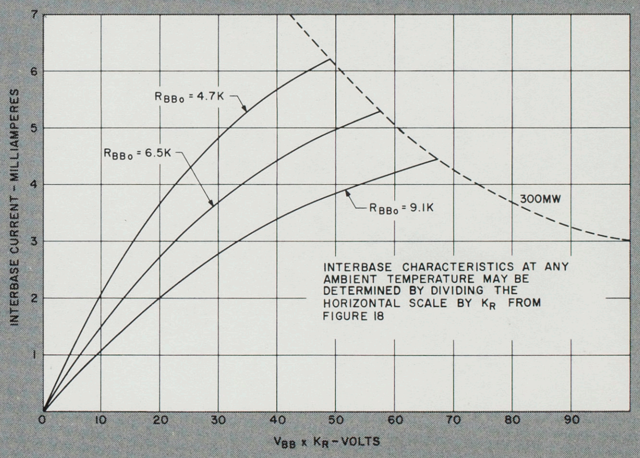


FIGURE 15

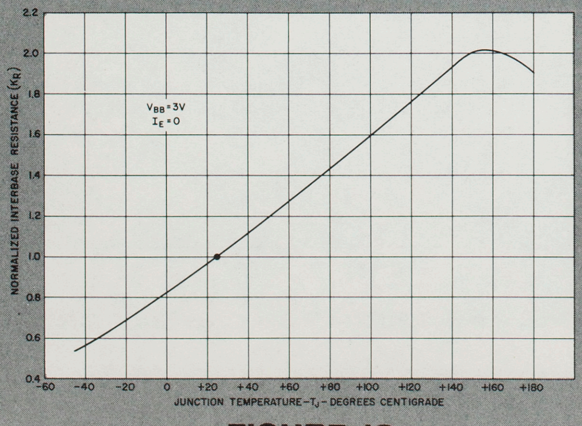


FIGURE 18

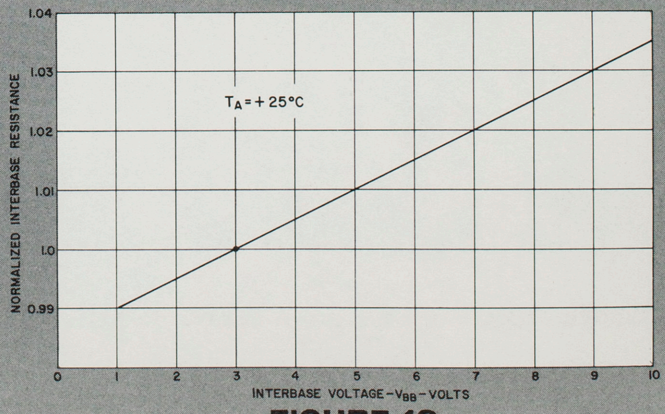


FIGURE 19

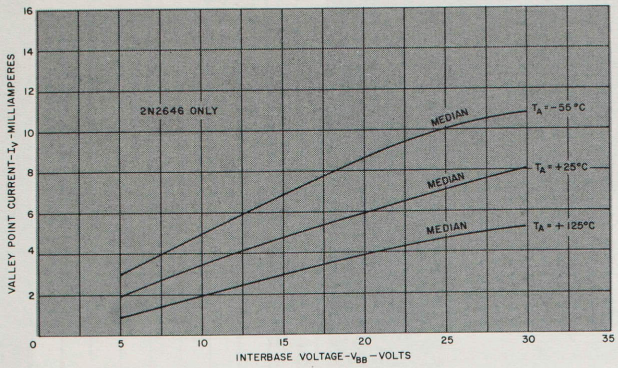


FIGURE 20

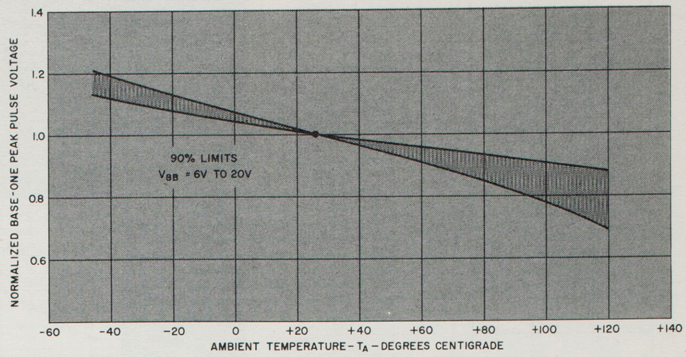


FIGURE 21

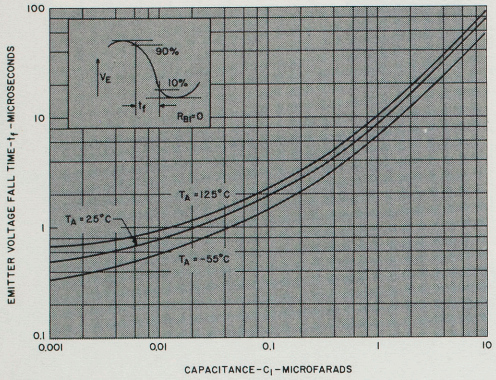


FIGURE 22

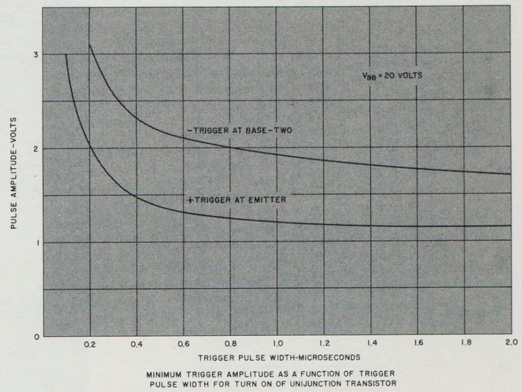


FIGURE 23

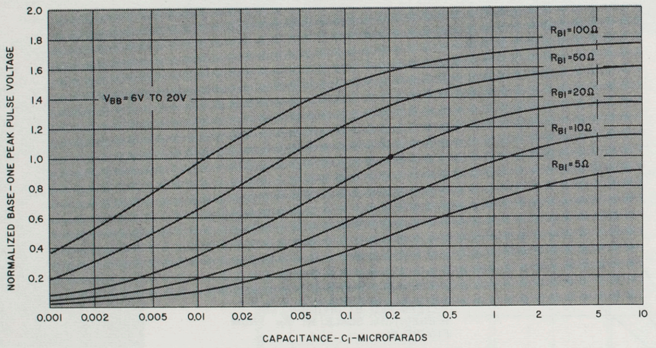


FIGURE 24

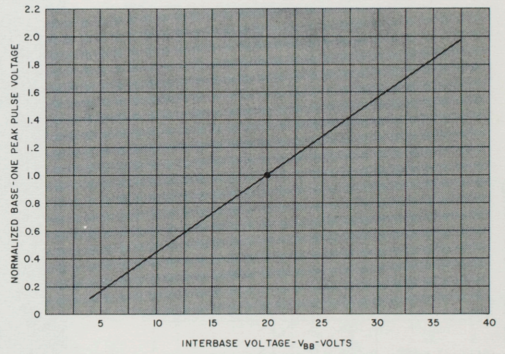
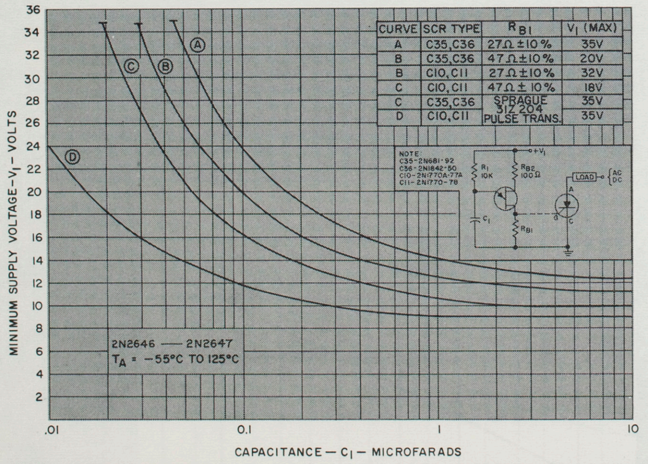
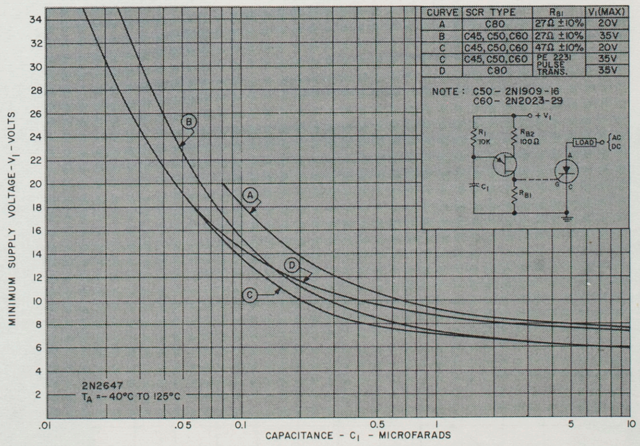


FIGURE 25



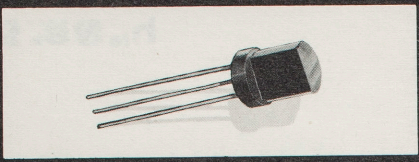
CURVE	SCR TYPE	R_{B1}	V_1 (MAX)
A	C35,C36	27Ω ±10%	35V
B	C35,C36	47Ω ±10%	20V
B	C10,C11	27Ω ±10%	32V
C	C10,C11	47Ω ± 10%	18V
C	C35,C36	SPRAGUE 31Z 204 PULSE TRANS.	35V
D	C10,C11		35V

FIGURE 26A-Both types- Lo &Med. SCR's



CURVE	SCR TYPE	R_{B1}	V_1(MAX)
A	C80	27Ω ±10%	20V
B	C45, C50, C60	27Ω ±10%	35V
C	C45, C50, C60	47Ω ±10%	20V
C	C45, C50, C60	PE 2231 PULSE TRANS.	35V
D	C80		35V

FIGURE 26B-2N2647-Hi Current SCR's



General Purpose TRANSISTORS

PLANAR EPITAXIAL PASSIVATED

NPN

SILICON TYPES

2N2713
2N2714

The General Electric 2N2713 and 2N2714 are epoxy encapsulated planar epitaxial passivated NPN silicon transistors specifically manufactured for general purpose commercial applications. They are particularly useful in output stages where low saturation voltage is desirable. They may also be used to advantage in switching applications due to their low storage time, good beta holdup to beyond 150 ma and low $V_{CE(SAT)}$.

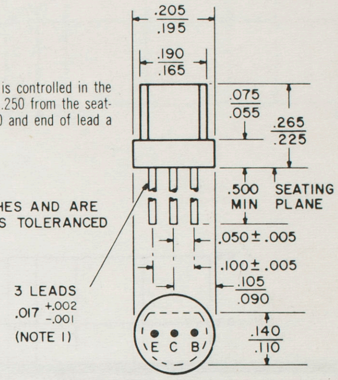
absolute maximum ratings: (25°C) (unless otherwise specified)

Voltages			
Collector to Emitter	V_{CEO}	18	volts
Emitter to Base	V_{EBO}	5	volts
Collector to Base	V_{CBO}	18	volts
Current			
Collector* (Steady State)	I_C	200	mA
Dissipation			
Total Power (Free air @ 25°C)**	P_T	200	mW
Total Power (Free air @ 55°C)**	P_T	120	mW
Temperature			
Storage	T_{STG}	−55°C to +125	°C
Operating	T_J	+100	°C

*Determined from power limitations due to saturation voltage at this current.
**Derate 2.67 mw/°C increase in ambient temperature above 25°C.

NOTE 1: Lead diameter is controlled in the zone between .070 and .250 from the seating plane. Between .250 and end of lead a max. of .021 is held.

ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED



electrical characteristics: (25°C)

DC CHARACTERISTICS

		Min.	Typ.	Max.	
Collector Cutoff Current ($V_{CB} = 18V$)	I_{CBO}			0.5	μA
($V_{CB} = 18V$, $T_A = 100°C$)	I_{CBO}			15	μA
Emitter Cutoff Current ($V_{EB} = 5V$)	I_{EBO}			0.5	μA
Forward Current Transfer Ratio ($V_{CE} = 4.5V$, $I_C = 2$ mA)					
2N2713	h_{FE}	30		90	
2N2714	h_{FE}	75		225	
Collector Saturation Voltage ($I_B = 3$ mA, $I_C = 50$ mA)	$V_{CE(SAT)}$			0.30	volts
Base Saturation Voltage ($I_B = 3$ mA, $I_C = 50$ mA)	$V_{BE(SAT)}$			1.3	volts

LARGE SIGNAL CHARACTERISTICS

		Min.	Typ.	Max.	
Input Impedance $\left(\frac{V_{BE2} - V_{BE1}}{I_{B2} - I_{B1}}\right)$; where condition "1" is $I_B = .05$ mA and condition "2" is $I_B = .5$ mA, $V_{CE} = 1V$)	h_{IE}		200		ohms

SWITCHING SPEEDS (See Figure 1)

		Min.	Typ.	Max.	
Delay Time	t_d		60		ns
Rise Time	t_r		85		ns
Storage Time	t_s		85		ns
Fall Time	t_f		40		ns

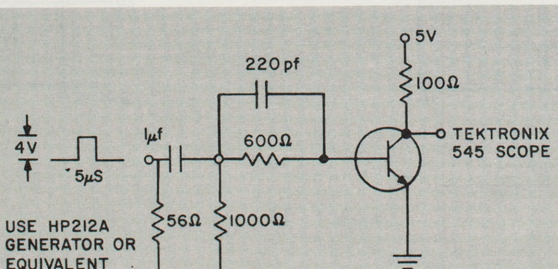
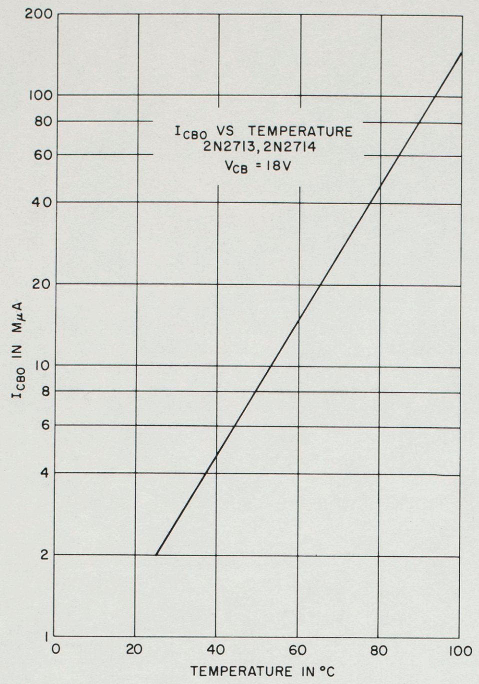
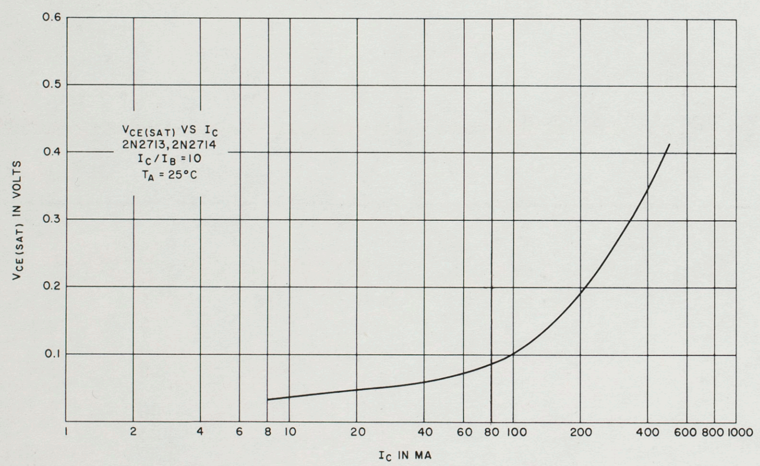
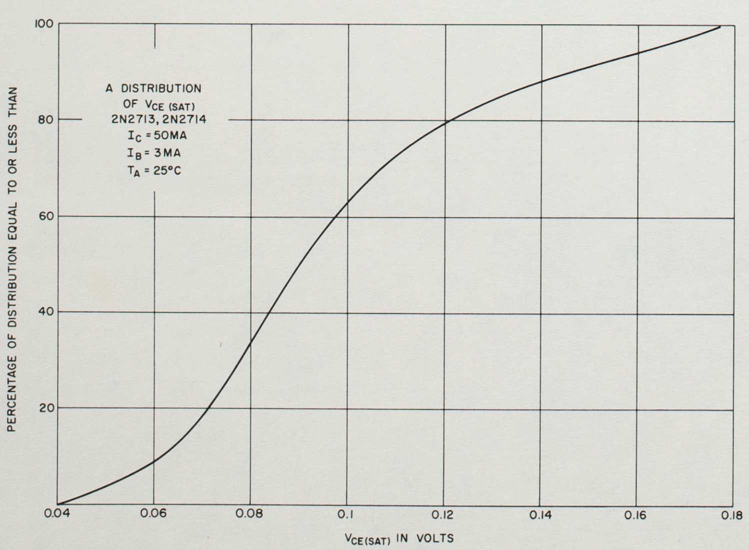


FIGURE I SWITCHING CIRCUIT

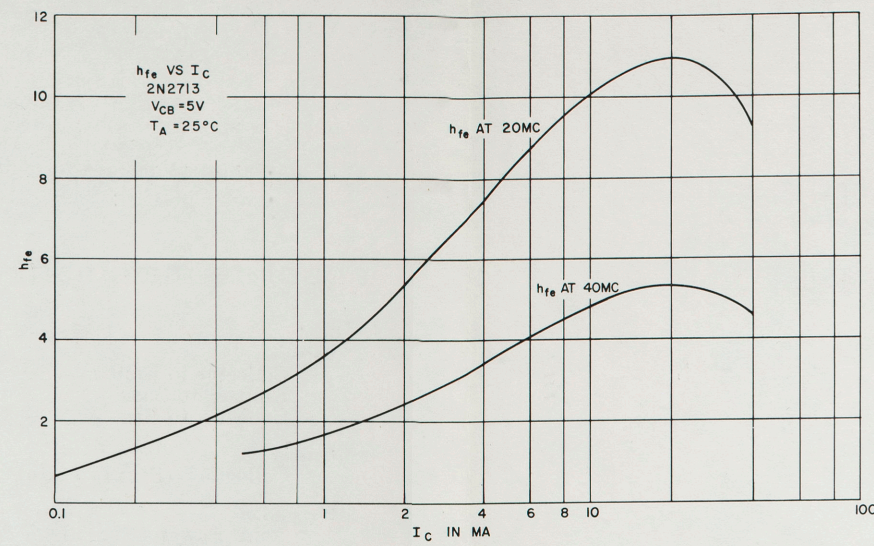
TYPES 2N2713, 2N2714



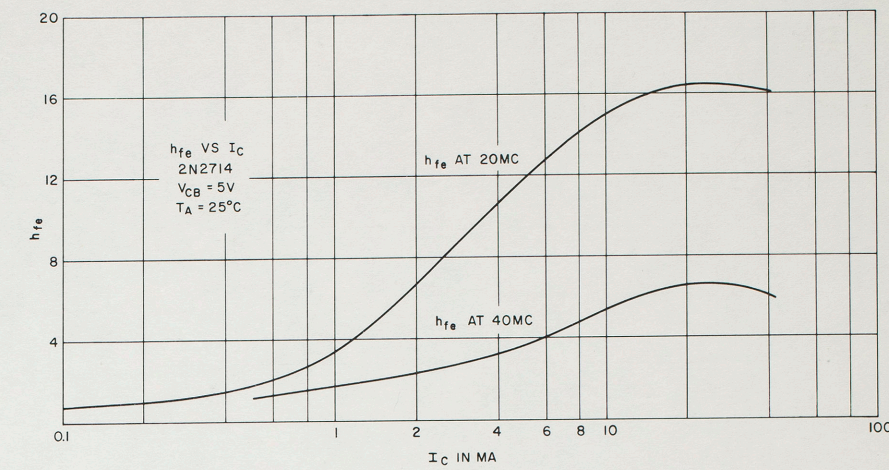




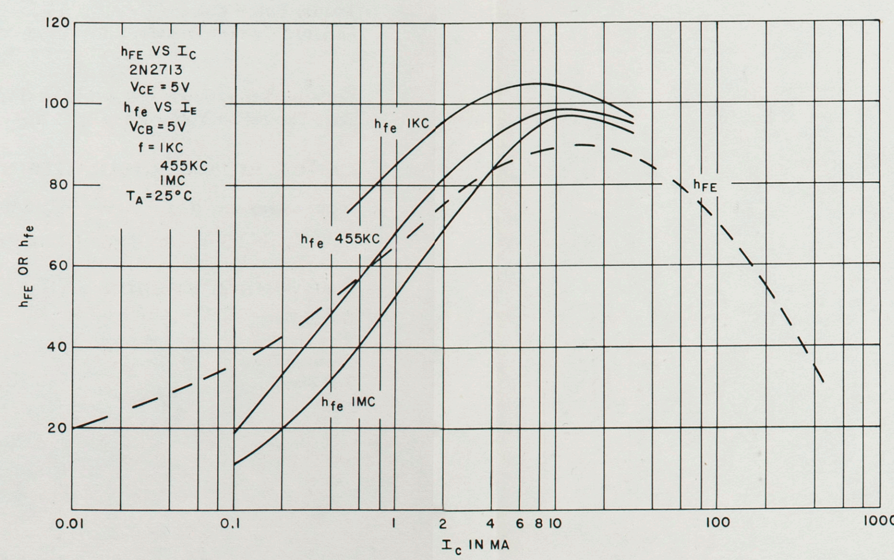
h_{fe} vs. I_C - TYPE 2N2713



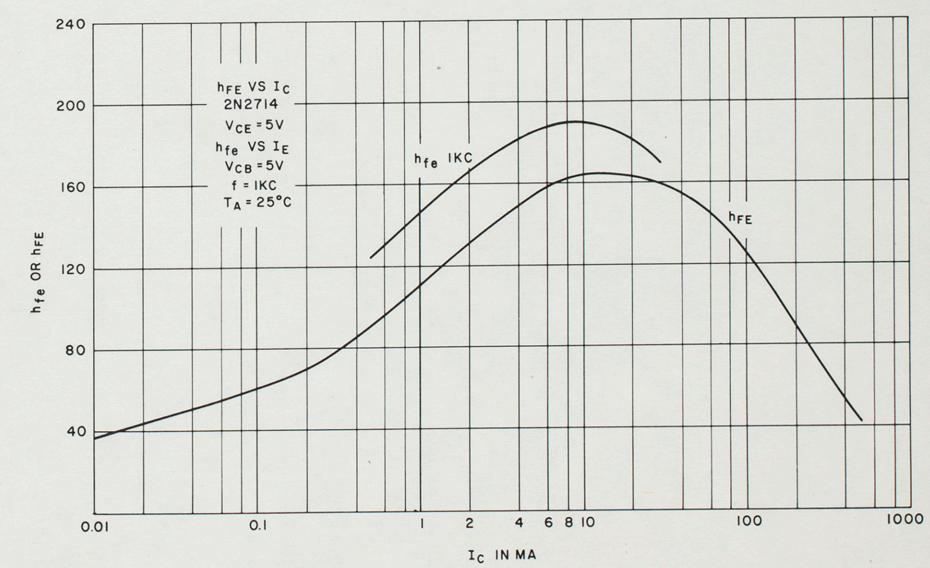
h_{fe} vs. I_C - TYPE 2N2714



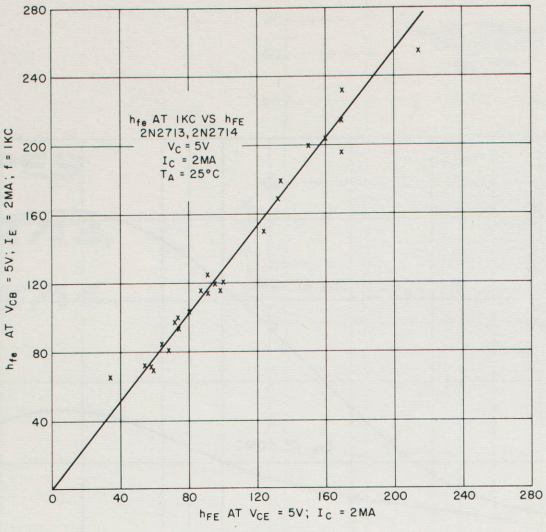
h_{fe} or h_{FE} vs. I_C - TYPE 2N2713

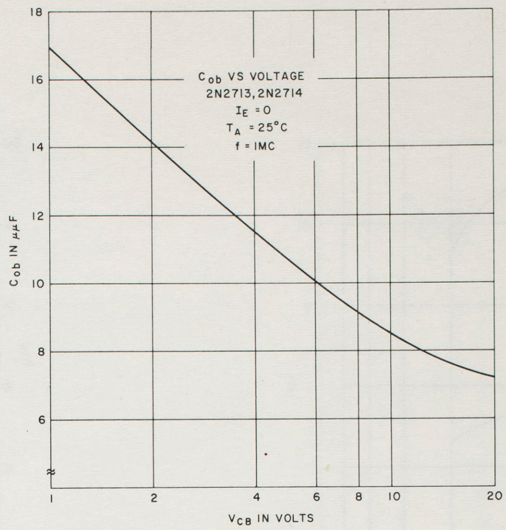


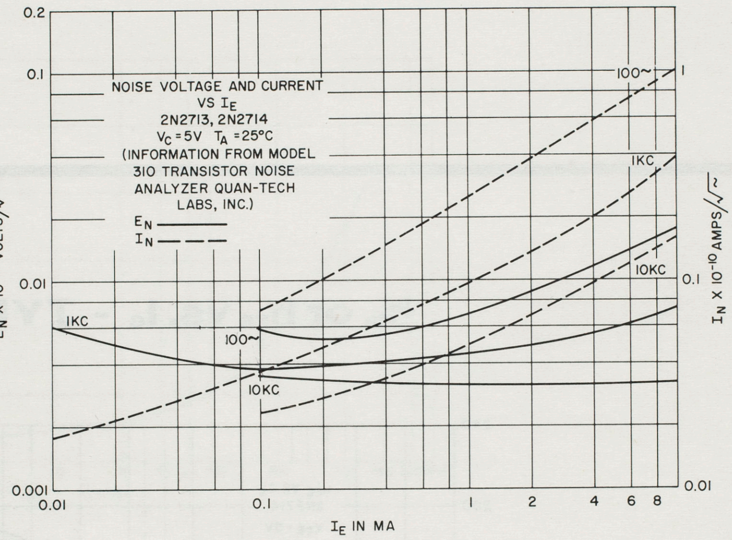
h_{fe} or h_{FE} vs. I_C - TYPE 2N2714

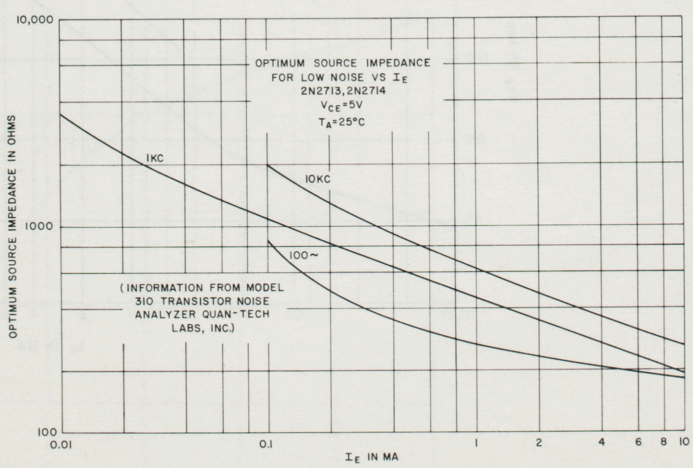


TYPES 2N2713, 2N2714









PRINTED IN U.S.A.

2N3703

SILECT† TRANSISTORS

Encapsulated in Silicone Plastic For Such Applications As

- **Medium-Power Amplifiers** • **Class B Audio Output** • **Hi-Fi Drivers**

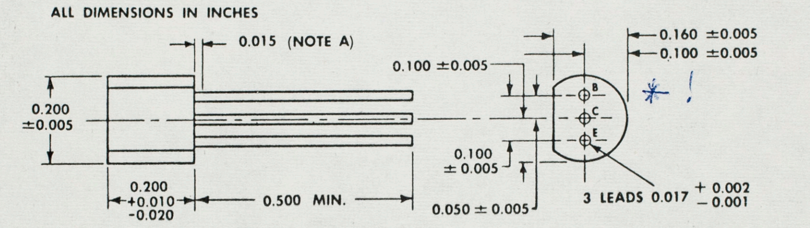
Recommended

For Complementary Use With

TI411 thru TI414

mechanical data

These transistors are encapsulated in a high-temperature, thermosetting silicone-plastic compound specifically designed for this purpose, using a highly mechanized process‡ developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202B method 106A.
The transistors are insensitive to light.



NOTE A: Lead diameter is not controlled in this area

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS03	TIS04
Collector-Base Voltage	−40 v	−50 v
Collector-Emitter Voltage (See Note 1)	−25 v	−30 v
Emitter-Base Voltage	−5 v	−5 v
Collector Current	←−200 ma→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←300 mw→	
Operating Free-Air Temperature Range	−55°C to +125°C	
Storage Temperature Range	−55°C to +150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.

2. Derate linearly to 125°C free-air temperature at the rate of 3 mw/C°.

†Trademark of Texas Instruments Incorporated.

‡Patent Pending.

PRELIMINARY DATA SHEET:
Supplementary data will be published at a later date.

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 5012 • DALLAS 22, TEXAS

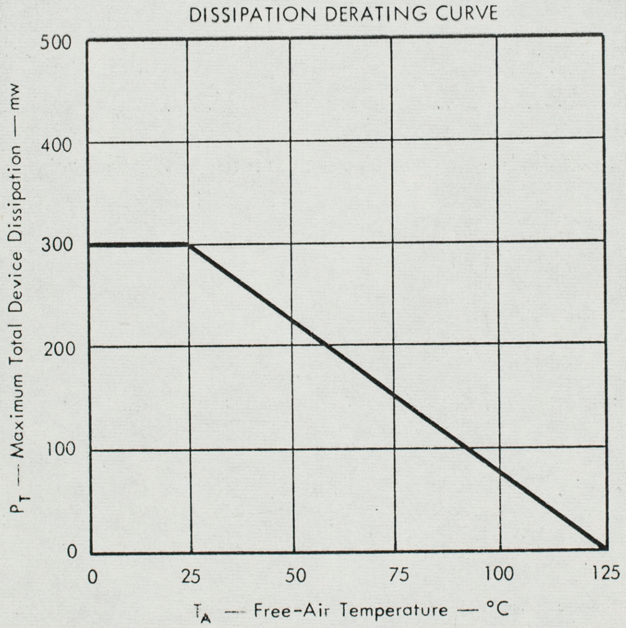
electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			TIS03 MIN	TIS03 MAX	TIS04 MIN	TIS04 MAX	UNIT
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = -100\ \mu a$,	$I_E = 0$		−40		−50		v
BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma,	$I_B = 0$,	See Note 3	−25		−30		v
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu a$,	$I_C = 0$		−5		−5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ v,	$I_E = 0$			−0.5		−0.5	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ v,	$I_C = 0$			−0.5		−0.5	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ v,	$I_C = -50$ ma,	See Note 3	60	300	30	150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ v,	$I_C = -50$ ma,	See Note 3		−1		−1	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -5$ ma,	$I_C = -50$ ma,	See Note 3		−2.5		−2.5	v
f_T	Transition Frequency	$V_{CE} = -5$ v,	$I_C = -50$ ma,	See Note 4	100		100		Mc
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ v,	$I_E = 0$,	f = 1 Mc		12		12	pf

NOTES: 3. These parameters must be measured using pulse techniques. PW ≈ 300 μsec. Duty Cycle ≤ 2%.

4. To obtain f_T, the $|h_{fe}|$ response with frequency is extropolated at the rate of −6 db per octave from f = 20 Mc to the frequency at which $|h_{fe}| = 1$.

THERMAL CHARACTERISTICS



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VECTOR PRODUCTS AVAILABLE AT CESCO

870 YONGE ST.

TORONTO.

BILL WIDCHUK 921-5111

MATERIAL SPECIFICATIONS

NATURAL PHENOLIC - tan color, Grade XXXP (Mil-P-3115B) 1/16" and 3/32" thick. (B, F, & G patterns, 1/16" only.) Economical, cold punching type, temperature 250° F max. Furnished as standard unless otherwise specified.

GLASS-SILICONE - white color, Grade G-7 (Mil-P-997B) punched in 1/16" thickness only. Temperature 450° F max. Add "W" to catalog number to obtain.

EPOXY-GLASS - greenish-white color, Grade G-10 (Mil-P-18177) punched in 1/16" thickness only. Temperature 300° F max. Add "WE" to catalog number to obtain.

EPOXY-PAPER - attractive ivory color, per MIL-P-22324, type PEE. Available in 1/16" and 3/32" thickness. (B, F & G patterns 1/16" only.) Quality and price between phenolic and epoxy-glass. Cold punching, temperature 250° F max. Add "EP" to catalog number to obtain.

COPPER CLAD - has 2 oz. (.003") copper on one or both sides of epoxy-glass laminate 1/16" thick. Per Mil-P-13949B, type FL-GE. Other board materials can be supplied with moderate set-up charge.

MAXIMUM BOARD WIDTH - for phenolic or epoxy paper is 20" for patterns A, F & G. The glass laminates can be punched to 20" on A & F patterns. The maximum board width for patterns B, C, & D is 6", with any listed material. Maximum width for H & G patterns, epoxy glass, 10". Maximum length 34 1/2" for glass-silicone and epoxy-glass, and 38" for all other listed materials.

TOLERANCE ON LENGTH & WIDTH IS ± 0.007" PER INCH OF OVERALL DIMENSION

THICKNESS +/16 ± .008"—3/32 ± .010.

ORDERING INFORMATION

MATERIAL	CATALOG NO.	PATTERN	LENGTH	WIDTH	THICKNESS	NO. OF HOLES
XXXP PHENOLIC	32A3	A	8.51"	.82	1/16"	32 x 3
	64A18	A	16.99	4.80	1/16	64 x 18
	72A33	A	19.11	8.77	1/16	72 x 33
	32AA5	A	8.51	1.35	3/32	32 x 5
	32AA7	A	8.51	1.88	3/32	32 x 7
	32AA9	A	8.51	2.41	3/32	32 x 9
	32AA18	A	8.51	4.80	3/32	32 x 18
	64AA18	A	16.99	4.80	3/32	64 x 18
	64AA32	A	16.99	8.51	3/32	64 x 32
	64AA132	A	35.01	16.99	3/32	64 x 132
	45B30	B	8.51	5.69	1/16	45 x 30
	90B30	B	16.97	5.69	1/16	90 x 30
	* 85C24	C	16.99	4.80	1/16	85 x 23
	* 85G24	G	16.99	4.80	1/16	(85 x 23) x 2
	95G43	G	19.00	8.60	1/16	(95 x 43) x 2
	95G87	G	19.00	17.40	1/16	(95 x 86) x 2
	95G175	G	19.00	35.00	1/16	(94 x 175) x 2
EPOXY-PAPER	7AA5EP	A	1.88	1.35	3/32	7 x 5
	11AA7EP	A	2.94	1.88	3/32	11 x 7
	32AA7EP	A	8.51	1.88	3/32	32 x 7
	32AA18EP	A	8.51	4.80	3/32	32 x 18
	64AA18EP	A	16.99	4.80	3/32	64 x 18
	64AA32EP	A	16.99	8.51	3/32	64 x 32
	* 85F24EP	F	16.99	4.80	1/16	85 x 23
	* 85F42EP	F	16.99	8.51	1/16	85 x 42
	* 85G24EP	G	16.99	4.80	1/16	(85 x 23) x 2
	* 85G42EP	G	16.99	8.51	1/16	(85 x 2) x (42&41)
EPOXY-GLASS	64A18WE	A	16.99	4.80	1/16	64 x 18
	* 85G24WE	G	16.99	4.80	1/16	(85 x 23) x 2
	170H48WE	H	17.00	4.80	1/16	170 x 47
EPOXY-GLASS COPPER CLAD (2 OZ.) 1 SIDE	849-1	F	4 1/2	3	1/16	20 x 14
	850-1	F	6 1/2	4 1/2	1/16	30 x 22
	85F42WEC1	F	16.99	8.51	1/16	85 x 42
	42F22WEC1	F	8 1/2	4 1/2	1/16	42 x 22
	42G22WEC1	G	8 1/2	4 1/2	1/16	(42 x 22) x 2
EPOXY-GLASS COPPER CLAD (2 OZ.) 2 SIDES	849-2	F	4 1/2	3	1/16	20 x 14
	850-2	F	6 1/2	4 1/2	1/16	30 x 22
	85F42WEC2	F	16.99	8.51	1/16	85 x 42
	42F22WEC2	F	8 1/2	4 1/2	1/16	42 x 22
	42G22WEC2	G	8 1/2	4 1/2	1/16	(42 x 22) x 2

For Hole Diameter & Spacing See Table Other Side * Special Borders

FIT STANDARD PRINTED CIRCUIT RECEPTACLES FOR CARDS

The P.C. Plugbord has all the advantages of Vector Plugbord as described in New Product Bulletin 67.

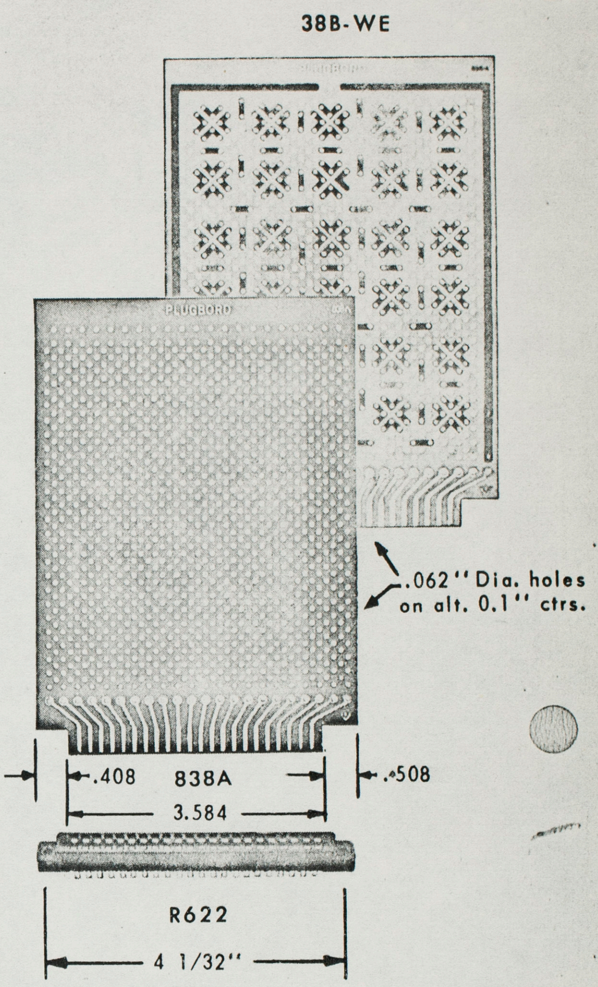
The major difference in the Vector P.C. Plugbord is the 2 oz. copper contact strip etched on the leading edge of the board. This permits using the P.C. Plugbord in many existing printed circuit receptacles.

The standard individual etched contacts are 0.062" wide and spaced on 0.156" centers. (Note: The individual contact strips can be made 0.090" wide and spaced on 0.156" centers to special order.) Vector P.C. Plugbords 838, A & B-WE will fit the most frequently used standard printed circuit receptacles such as the Elco, Amphenol and Cinch types. For customer convenience, Vector stocks printed circuit receptacles as their R622 and R644 for P.C. Plugbords 838, A & B-WE respectively In the 838B Plugbord additional etched copper pads and lines are provided around certain holes to facilitate soldering in component leads as shown in the figure. The square V patterns are especially useful for transistor leads since hole spacing matches JETEC standards (all holes are 1/16" dia. on alternate intersections of a 0.1" grid.)

The circuit layout and P.C. Plugbord use is performed in the same manner as described in New Product Bulletin 67.

For best connections to the individual etched contacts, it is suggested that a terminal be mounted in the hole around which is a 1/8" dia. "pad" at the end of the contact strip. It is also suggested that when soldering a component lead to this terminal the solder be allowed to flow onto the copper pad to make good contact with the contact strip. Terminals available for this use are T28, T18 and T15.23 eyelets.

The new Printed Circuit Test Jacks No. 119437, manufactured by Unicite Division of United-Carr Fastener Corporation, are well adapted for Plugbord use because of the 0.4" spacing on the contact legs. Jacks may be readily inserted in the Plugbord without drilling holes.



ORDERING INFORMATION

CATALOG NUMBER	DESCRIPTION
838 P.C. Plugbord*	4.5" X 6.5" - 43 etched contacts, total two sides.
838 A P.C. Plugbord †	4.5" X 6.5" 22-2 oz. etched contacts one side.
838 BWE P.C. Plugbord*	4.5" X 6.5" 22-2 oz. contacts and etched pad layout one side.
838 C P.C. Plugbord	4.5" X 6.5" 2oz. overall copper one side with holes as 838A but no plug pattern.
838 D P.C. Plugbord	4.5" X 6.5" 2oz. overall copper both sides with holes as 838 but no plug pattern.

* Fits R622 Receptacle (22 contacts) † Fits R644 Receptacle (44 contacts)

VARIATIONS

For Epoxy-Glass Board add WE after catalog number.
For 1/16" holes on 0.2" X 0.2" Grid add F to cat. no.
Special sizes to order.

ACCESSORIES

CATALOG NUMBER	DESCRIPTION
T-28	Push-in Terminal (See Bulletin 68)
T-18	Forked turned Terminal (See Bulletin 65)
15.23	Eyelets - 1/16" barrel X 3/32" length under head.
R173-G	0.1" Grid Layout Paper - 50 sheets per pad.

SPECIFICATIONS

Board

838, 838A 1/16" Epoxy-Paper
838B-WE 1/16" Epoxy-Glass
838C, 838D 1/16" Epoxy-Paper W/2 oz. copper clad.

Contacts

Material is 2 oz. copper. The standard P.C. Plugbords shown below are coated with a water dip lacquer to prevent the copper contacts from tarnishing. Lacquer may be easily removed with lacquer thinner. Special plating of the copper contacts can be provided to order.

Receptacle

Insulator Material: General purpose phenolic. Contacts: Phosphor Bronze - 0.0002 silver and 0.00002 (approx.) gold flashed.

TERMINALS TO FIT .062 DIA. HOLES

DESIGNED FOR COMPACT ASSEMBLIES

The T28 Push-in Terminal is a very small contact designed for miniature circuitry where the well known T9.4 Push-in might be too large. It is easily inserted into 1/16" round holes and needs no staking operation. Ideal for the experimenter, it is also well suited for use in printed circuits and other production applications.

ECONOMICAL & EASILY INSTALLED

1. Low Cost: The T28 Push-in is stamped from beryllium copper sheet, heat treated and fused tin plated. This provides strength and springy action. It is priced below turned type terminals and may be re-used, if desired, by pulling it out of the board.

2. Compactly Designed - Yet Hold Up to Six Leads: The T28 looks neat; yet, using upper and lower portions, as many as six leads may be connected to it in the three possible directions. See Fig. 1. Notice the serrations in the main slot which grip small component leads, including transistor leads.

3. Optional Hand Staking Possible: Although no staking is required it may be staked if desired. Fig. 2 illustrates one staking method. Here the small end of the terminal has been flared using "flats" or needle nose pliers. This prevents it from pulling out. After flaring, the small end of the terminal may be cut if it is not needed with a pair of cutting pliers.

Fig. 3 illustrates another staking method wherein the small end of the terminal is cut off. Note how the edges of the terminal flare.

4. Easily Inserted: Terminals can be inserted by use of a 1/2 or 1 w. resistor with the wires cut about 9/16" long on one side and entirely off on the other side. The short wire is inserted in the terminal and on through the hole. A special tool, Vector P-91, is available which is better and may be used either by hand or it may be inserted in a drill press or arbor press for more convenient operation. Vectorbord Type B, F or G is recommended for use with this terminal.

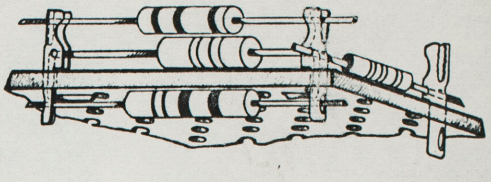


FIG 1

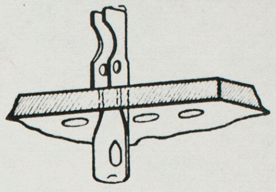


FIG 2

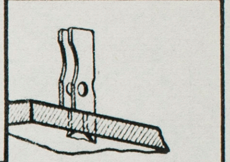
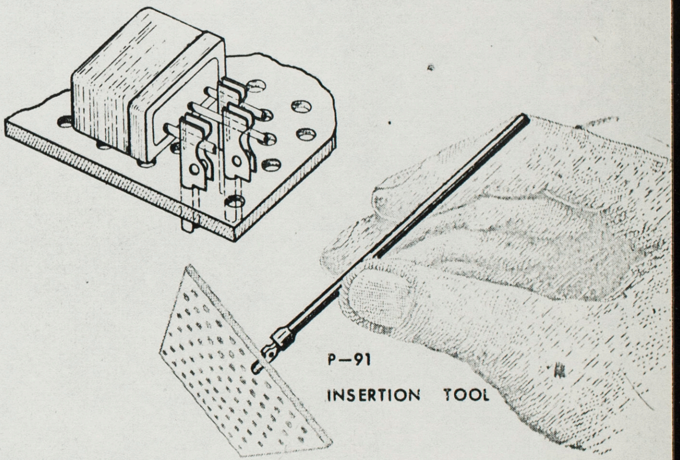


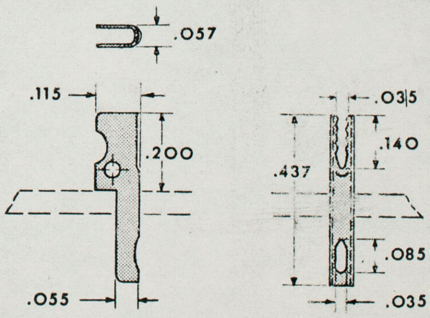
FIG 3



P-91
INSERTION TOOL

SPECIFICATIONS

Cat. No.	Description	Material	Plating	Std. Package
T28	Push-in Terminal	Beryllium copper heat treated	Fused Tin	Bags of 100. Bulk, 1000 & over.
P-91	Insertion Tool for T28	Steel	Cadmium Plated	1



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IF IT'S NEW . . . IF IT'S NEWS . . . IT'S FROM ELCO

SERIES 5000
BOARD TO BOARD
PRINTED CIRCUIT CONNECTORS

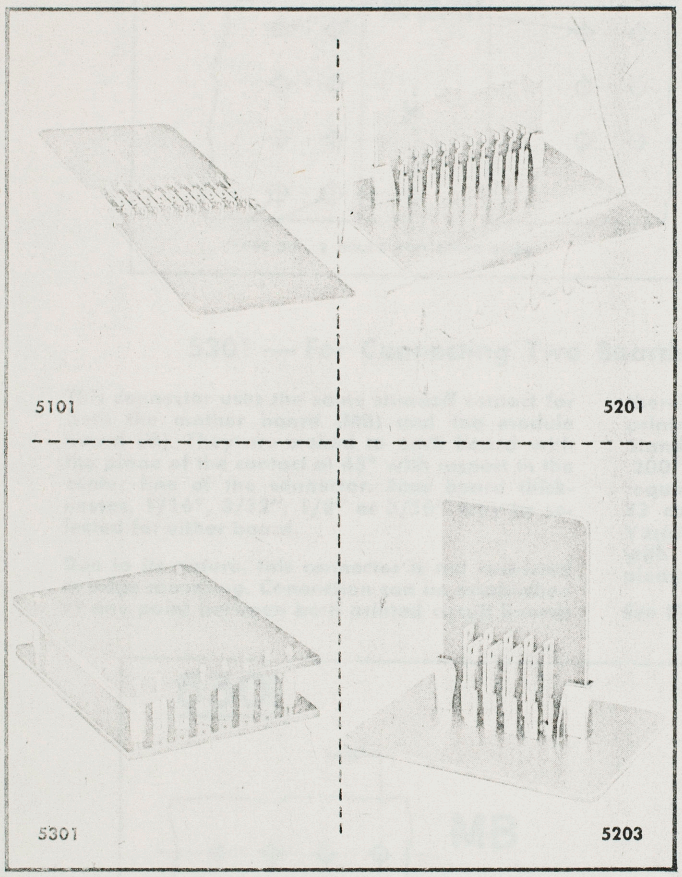


FIGURE 1

CONTACT STRIPS

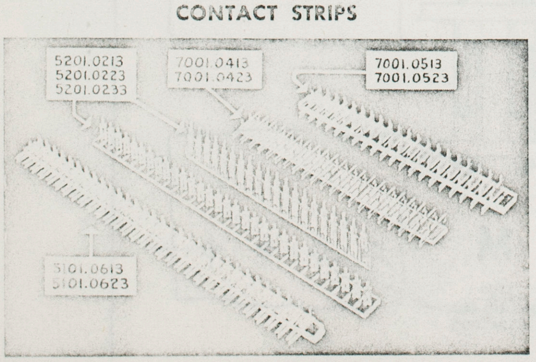


FIGURE 2

The well-established "Varicon Principle" with a forklike contact construction, having 4 mating coined surfaces, is used in the new 5000 series printed circuit connector family pictured in Figure 1 to the left.

The contacts are supplied in disposable plastic strips as shown in Figure 2. Standard spacing of contacts in strips is .200". Other spacings can be supplied on request; several non-standard spacings are already tooled. Maximum number of contacts which can be supplied on a single strip at .200" spacing is 61. For reasons of economy it is recommended that strips be ordered with exact number of contacts required.

Staking of the contacts to the printed circuit board is made in accordance with modern mass-production techniques, with special staking tools described in detail in our Staking Bulletin. These tools are available from Elco Corporation either unmounted, for application to customer die set, or completely mounted in an Elco die set, as desired.

Staking of contacts to the printed circuit board, and thereby to the printed circuit line assures a solid, low resistance contact, rigidly held in place. Dip soldering the board automatically makes an additional connection between contact and board, thus creating an unsurpassed reliability for the joint. Over 65 pounds are required to tear a contact from the board if staked and soldered, 50 pounds if staked only, and 25 pounds if only soldered.

For small-size modules, brackets can be supplied separately, as shown in Figure 8. It is recommended that larger modules be guided by integral parts of the equipment.

This new "Printed Circuit Connector Family" gives the printed circuit equipment designer complete flexibility in creating his equipment limited only by his imagination. He may select:

A. Any number of contacts.

B. Any spacing between contacts.

C. Any contact location pattern.

D. Any board thickness.

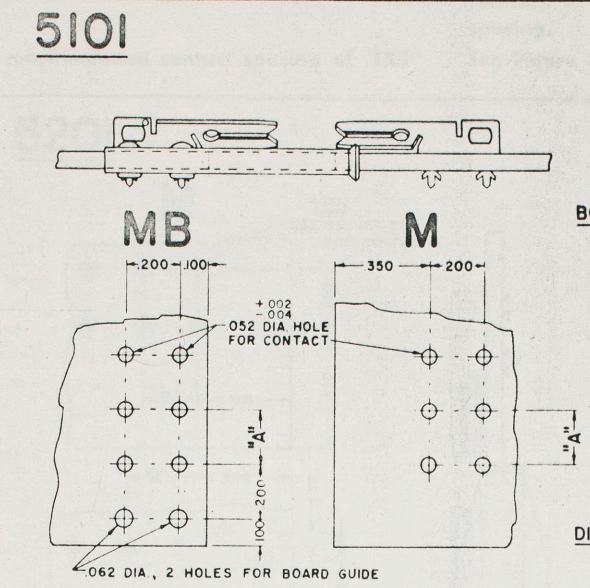
E. Any board material.

F. Any angle of connecting two boards.

ELCO CORPORATION, "M" Street below Erie Avenue, Philadelphia 24, Penna., CUmberland 9-5500

5101 — For Connecting Two Boards in Tandem, On A Common Plane

For both mother board (MB) and module board (M), this connector uses the same contact which is bent 45° with respect to the board surface. The contacts are thereby mated at 90° to each other. Two board thicknesses, 1/16" or 3/32", may be selected for either board. Contacts for other board thicknesses on request. See Figure 3 for typical punchout pattern.



BOARD THICKNESS	CONTACT NO.
1/16	5101.0613
3/32	5101.0623

DIMENSION "A": .125 MINIMUM

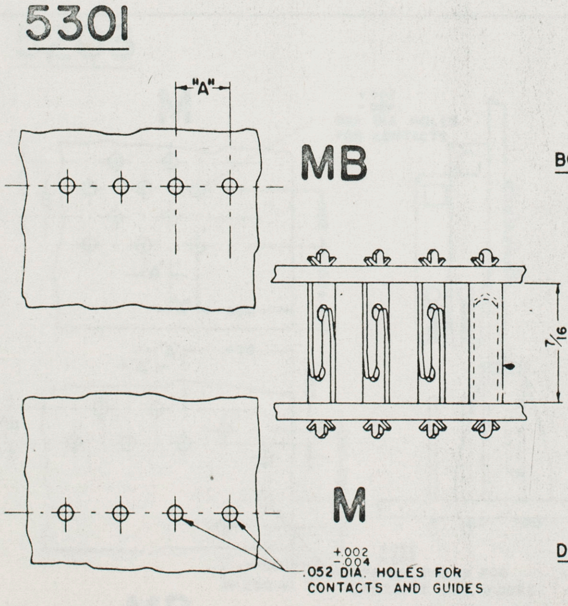
FIGURE 3

5301 — For Connecting Two Boards Parallel to Each Other

This connector uses the same standoff contact for both the mother board (MB) and the module board (M). They are staked to each board with the plane of the contact at 45° with respect to the center line of the connector. Four board thicknesses, 1/16", 3/32", 1/8" or 3/16" may be selected for either board.

Due to its nature, this connector is not restricted to edge mounting. Connection can be established at any point between both printed circuit boards thereby eliminating the necessity of carrying the printed circuit lines to the edge of the board. Standard contact strips have contacts in line at .200" spacing. Special patterns can be made on request. Double leg contacts 5003.0213, 23, or 33 can be used for spacing exceeding .250". Variation of distance between boards is possible with special contacts. For further information, please call or write.

See Figure 4 for typical punchout pattern.



BOARD THICKNESS	CONTACT NO.
1/16	5201.0213
3/32	5201.0223
1/8	5201.0233
3/16	5201.0273

DIMENSION "A": .125 MINIMUM

FIGURE 4

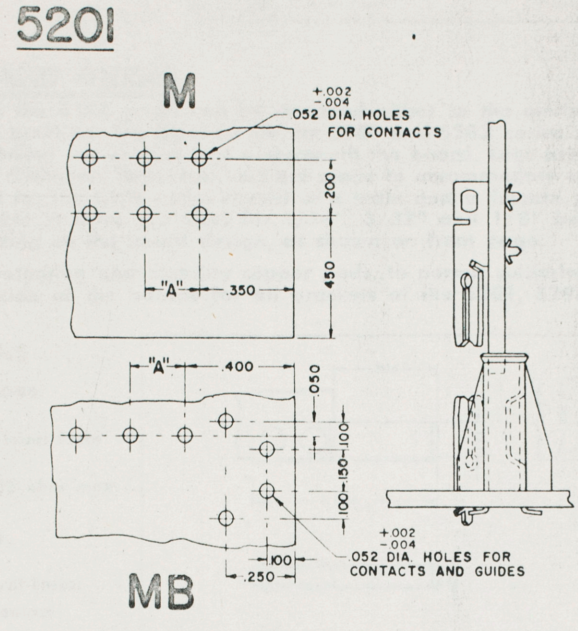
5201 — For Connecting Two Boards Perpendicular to Each Other, Using One Row of Contacts

On the mother board, (MB), the stand-off contact is used, staked with the plane of the contact at 45° with respect to the center line of the connector. Contacts for three mother board thicknesses are available; 1/16", 3/32" and 1/8". The module board requires the 45° bent contact, which is available for 1/16" and 3/32" thick boards.

When the closest recommended contact spacing of .125" is used, the minimum airgap between adjacent contacts when mated is .031".

The closest recommended spacing of module boards is .250" plus desired airgap between contact at one board and contact tail at adjacent board. To increase airgap, contacts of adjacent boards can be offset 1/2 contact spacing.

See Figure 5 for typical punchouts.



BOARD THICKNESS	CONTACT NUMBER
1/16	5101.0613
3/32	5101.0623

BOARD THICKNESS	CONTACT NUMBER
1/16	5201.0213
3/32	5201.0223
1/8	5201.0233

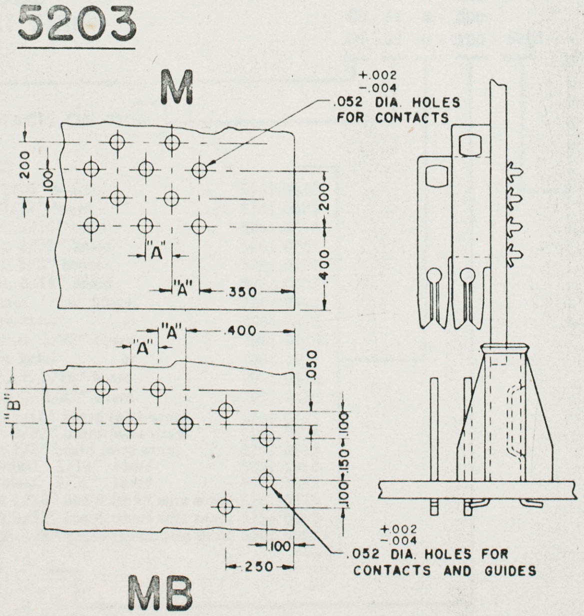
DIMENSION "A": .125 MINIMUM

FIGURE 5

5203 — For Connecting Two Boards Perpendicular to Each Other, Using Two Rows of Contacts

On the mother board (MB), two rows of stand-off contacts are used. Contact spacing for each row is .200". The two rows are spacing .125" apart. On the module board (M), lower and upper tier straight contacts are used. Each tier has contacts spaced .200" apart, with the upper tier contacts mounted between adjacent lower tier contacts, resulting in a final .100" contact spacing for this connector . . . lower tier and upper tier contacts on separate strips, stand-off contacts on one common strip in two rows.

See Figure 6 for typical punchouts.



BOARD THICKNESS	CONTACT NUMBER
1/16	7001.0413 or 7001.1513 or 7001.0513
3/32	7001.0423 or 7001.1523 or 7001.0523

BOARD THICKNESS	CONTACT NUMBER
1/16	5201.0213
3/32	5201.0223
1/8	5201.0233

DIMENSION "A": .100 MINIMUM
DIMENSION "B": .125

FIGURE 6

CONTACTS

With the 4 contacts shown in Figure 7 all the connectors described in this bulletin can be made.

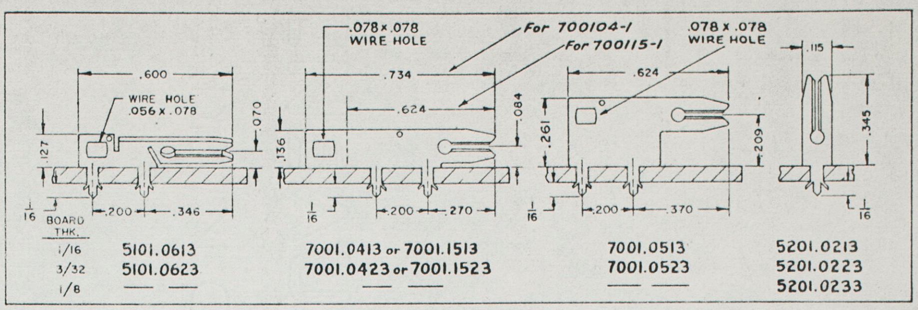


FIGURE 7

BRACKETS AND GUIDES

The bracket for the 5101 series can be mounted either to the mother or module board with eyelets, which are furnished with the brackets. The brackets for the 5201 and 5203 series are for mounting to the mother board. They are fastened by bending the bracket legs underneath the board. Legs are of one length suitable for board sizes of 1/16", 3/32" or 1/8" thickness. These brackets are made to accommodate either 1/16" or 3/32" module boards. Guide pins and receptacles for the 5301 series consist of a male and a female part. They have a tail for staking to the board, and are available in three tail sizes for 1/16", 3/32" and 1/8" boards. Two or more guides may be used at any location depending on the board design, as shown on front page.

For maximum retention and stability copper pads, to permit soldering of the bracket legs, should be provided at the printed circuit side of the boards for all brackets of the 5201, 5203 and 5301 series.

SPECIFICATIONS

Contacts: Phosphor Bronze

Finish: Gold Flash over Silver Plate

Contact Resistance: .002 ohm max.

Current Rating: 5 Amps

Insertion and Withdrawal Force:
Average 8 ozs. per contact

Contact Life: Unchanged after 5000 insertions and withdrawals

Insulation Resistance and Voltage Breakdown
Depends on board material and contact spacing

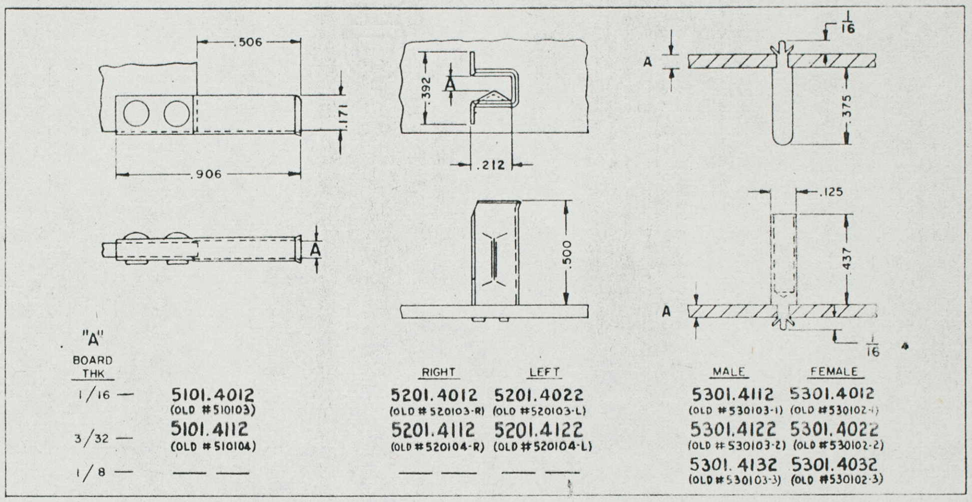


FIGURE 8

ORDERING CODE FOR CONTACT STRIPS

CS - 15 - H - .200
CS - 14 - K - .200
CS - 29 - D - .100 - 5203

CONTACT STRIP

NUMBER OF CONTACTS ON STRIP
1 to 60

TYPE OF CONTACT

A.	45° contact for 1/16" board	5101.0613
B.	45° contact for 3/32" board	5101.0623
C.	Stand-off contact, 1/16" board	5201.0213
D.	Stand-off contact, 3/32" board	5201.0223
E.	Stand-off contact, 1/8" board	5201.0233
F.	Stand-off contact, 3/16" board	5201.0273
G.	Lower board contact, 1/16" board	7001.0413
H.	(without wire hole) or	7001.1513
I.	Lower board contact, 3/32" board	7001.0423
J.	(without wire hole) or	7001.1523
K.	Upper board contact, 1/16" board	7001.0513
L.	Upper board contact, 3/32" board	7001.0523
M.	Stand-off contact 1/16" board (wire wrap)	5201.0513
N.	Stand-off contact 3/32" board (wire wrap)	5201.0523
P.	Stand-off contact 1/8" board (wire wrap)	5201.0533
Q.	Lower board contact, 1/16" board	5001.1913
R.	Lower board contact, 3/32" board	5001.1923
S.	Stand-off contact 1/16" board (short wire wrap)	5201.0573
T.	Stand-off contact 3/32" board (short wire wrap)	5201.0583
U.	Stand-off contact 1/8" board (short wire wrap)	5201.0593

SPACING
.200 Standard
.100 for 5203 series only

PATTERN: This additional specification is required only if stand-off contacts 5201.0213, 23, 33, or 73 or 5201.0513, 23, 33, 73, 83 and 93 are ordered.

5201 Series: 1 row of contacts mounted at a 45° angle
45° \ \ \ \ \ \ \ \

5203 Series: 2 straight rows of contacts .125 apart
— — — — — —
— — — — — —

5208 Series: 1 straight row of contacts
1 row — — — — — — —

5211 Series: 2 straight rows of contacts .240 apart
2 rows — — — — — — —
— — — — — — —

EXAMPLE: For 29 Contact Module and Mother Board 5203 Series Connector, specify as follows:

1. CS-15-H-.200
Contact strip with 15 lower board contacts without wire hole, .624" long, #7001.1513, for 1/16" module board, contacts at .200" spacing, for 5203 Series.
2. CS-14-K-.200
Contact strip with 14 upper board contacts, .624" long #7001.0513 for 1/16" module board, contacts at .200" spacing for 5203 Series.
3. CS-29-D-.100-5203
Contact strip with a total of 29 contacts, stand-off type, #5201.0223 for 3/32" mother board, mounted on strip in two rows, .125" apart, one row 15 contacts, the other 14 contacts as .100 spacing for 5203 Series pattern.

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