nri journal

November/December 1971

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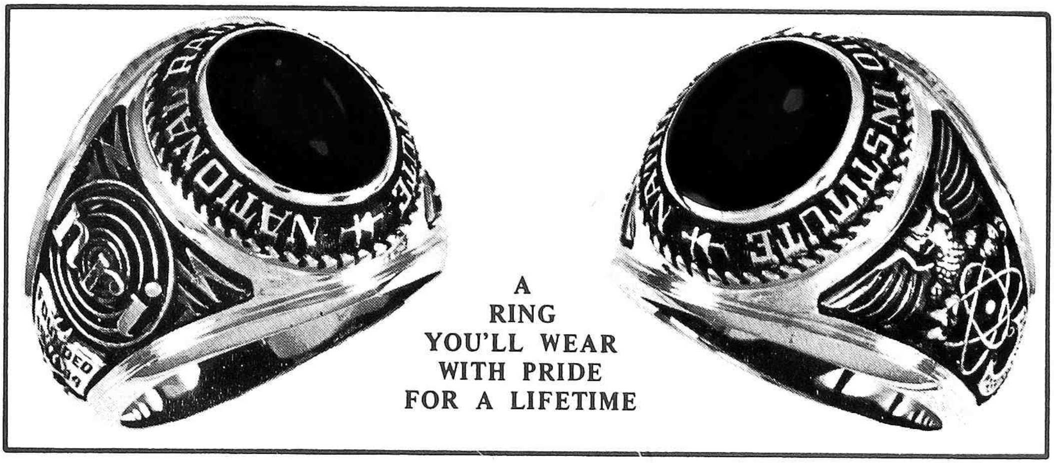

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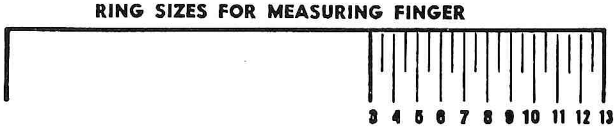

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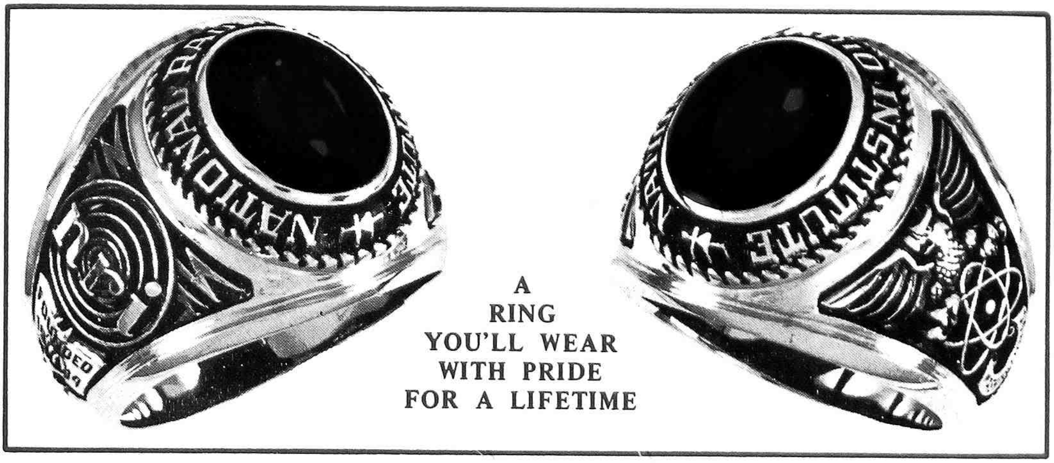

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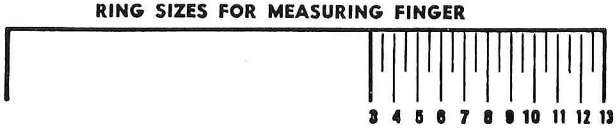

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by Louis E. Frenzel

A PROGRAMMED INSTRUCTION LESSON

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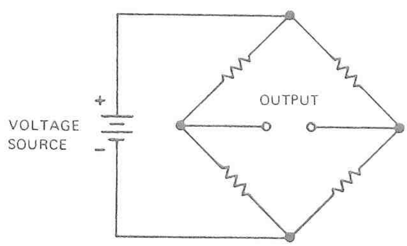

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Notice the unique diamond shape of the bridge. When it is drawn this way it is easy to recognize. Sometimes, however, it is drawn in other configurations and is not so readily recognized. You must look carefully to detect this type of circuit. Based upon this information, which of the circuits below is *not* a bridge circuit?

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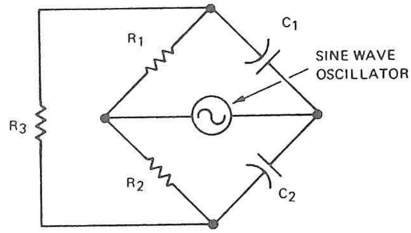

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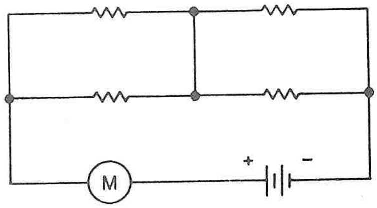

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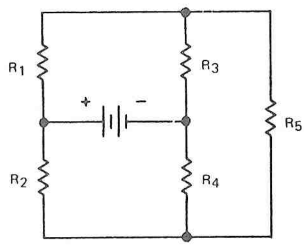

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This differential amplifier circuit increases the level of a signal applied to its input. When a low level sine wave is applied, for example, a larger version will appear at the output. Applying such a signal unbalances the bridge and causes an output signal to appear. The gain of the circuit is determined by the transistor gains, the current level in the transistors, and the value of resistor R_5.

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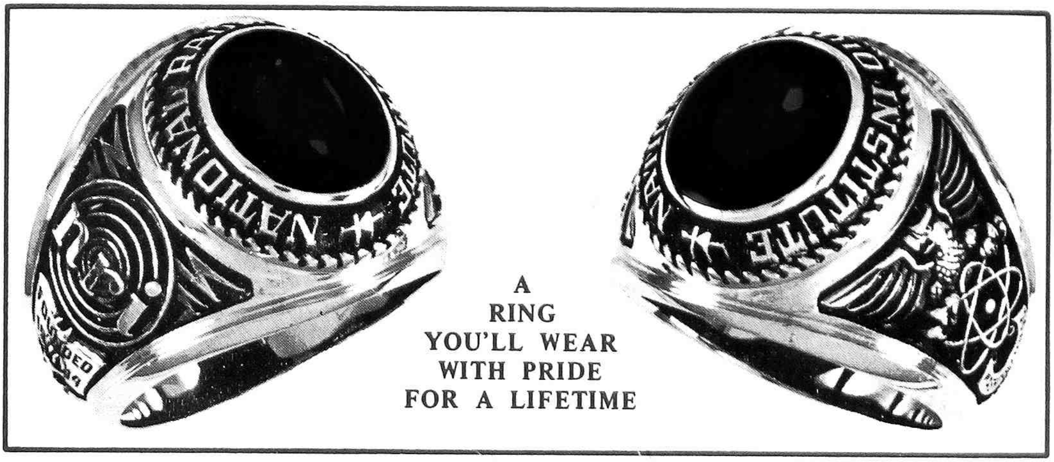

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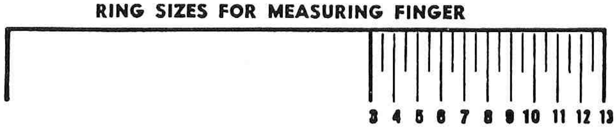

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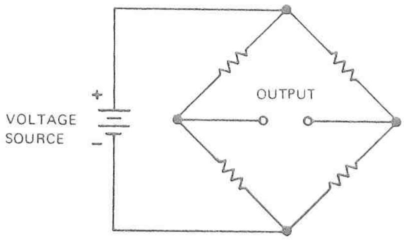

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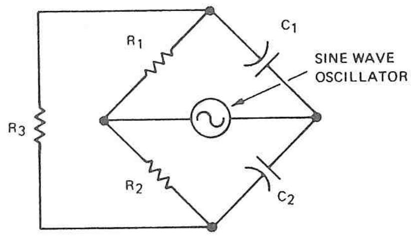

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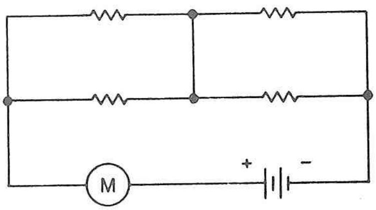

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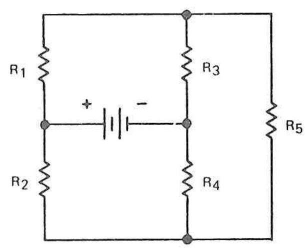

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If the input signal goes positive, Q_1 will conduct more and its resistance will decrease. This causes more voltage to be dropped across R_5. This reduces the emitter-base bias on Q_2, causing it to conduct less and its resistance to increase. With this condition, output point B will be more positive than point A. The conditions of Q_1 and Q_2 are the opposite of this if the input signal goes negative and will, thereby, make point A more positive than point B.

From the foregoing information, choose the most correct statement from those given below.

Go to Frame 8 *The input signal causes the resistance of Q_1 to change to unbalance this bridge.*

Go to Frame 25 *As the input signal is applied, the resistances of Q_1 and Q_2 change in such a way to keep the bridge balanced.*

Go to Frame 39 *As the input signal varies, it causes two elements of the bridge to vary rather than just one as you have seen earlier in other bridge types.*

● ● ●

4 Your answer is correct. Electrons will flow through the load, R_5, from left to right. When E_A = +4 volts and E_B = +5 volts, the left end of R_5 is negative with respect to the right end. Sure both voltages are positive with respect to ground, but E_A is *less* positive, making it negative with respect to E_B. Since electrons flow from a negative point to a more positive point, the direction of current flow is left to right.

If E_B was less than E_A, then the direction of current flow would be reversed. In either case, the bridge is unbalanced when current flows in R_5.

You can always tell if the bridge is balanced by comparing the ratios of the resistors in the voltage dividers. The bridge is balanced if the ratio of R_1 to R_2 equals the ratio of R_3 to R_4 or $R_1/R_2 = R_3/R_4$.

If R_1 = 10k-ohms, R_2 = 25k-ohms, R_3 = 30k ohms, and R_4 = 60k ohms, determine the state of the bridge.

Go to Frame 11 *The bridge is balanced.*

Go to Frame 26 *The bridge is not balanced.*

Go to Frame 31 *The state of the bridge cannot be determined with the information given.*

● ● ●

5 Your choice, change the value of R_4 to 45k-ohms, is not right. In fact, it only makes matters worse by unbalancing the bridge further. You should have determined this by calculating the ratios again. The ratio of R_1/R_2 remains the same at 10k-ohms/25k-ohms = .4. But the new R_3/R_4 ratio is 30k-ohms/45k ohms = .6667. Since the ratios are unequal, the bridge is unbalanced. Go back to Frame 26 and make another selection.

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6 Your answer is not entirely correct. Yes, the bridge will be balanced if $E_1 = E_2$ and $R_1 = R_2$ but this is certainly not the only condition where balance will occur. Remember the ratios of the arms? Go back to Frame 39 and select again.

● ● ●

7 Your answer is incorrect. This circuit *is* a bridge. R_1, R_2, C_1, and C_2 form the bridge arms, and R_3 is a load. The supply is ac supplied by an oscillator. Remember, the question asked which circuit is *not* a bridge. Return to Frame 1 and try again.

● ● ●

8 Your selection is not correct. True, the input signal does cause the resistance of Q_1 to change but it in turn affects the condition of Q_2. Return to Frame 3 and choose the most correct answer.

● ● ●

9 Your answer, E_A is greater than E_B, is not right. To answer this question you need to calculate E_A and E_B from the formulas and data given in Frame 14. This is done as shown:

$$E_A = \frac{E(R_2)}{R_1 + R_2} = \frac{10(100)}{400 + 100}$$

$$E_B = \frac{E(R_4)}{R_3 + R_4} = \frac{10(300)}{1200 + 300}$$

Now, complete these calculations, return to Frame 14 and select the correct answer.

● ● ●

10 Your answer is incorrect. The load signal is not 180° out-of-phase with the input. When Q_1 conducts as the input goes positive, electrons flow from the negative terminal of E_1 through the load and Q_1 back to the positive side of E_1. This makes the load voltage positive with respect to ground. With a negative input, Q_2 conducts and electrons flow from E_2 into Q_2, and then from Q_2 through the load. This makes the load voltage negative with respect to ground. Return to Frame 40, review the circuit operation and then select the correct answer.

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11 Your selection is incorrect. The ratios are not equal, as you can see below:

$$\frac{R_1}{R_2} = \frac{10\text{k-ohms}}{25\text{k-ohms}} = .4$$

$$\frac{R_3}{R_4} = \frac{30\text{k-ohms}}{60\text{k-ohms}} = .5$$

Return to Frame 4 and try again.

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12 Your answer, R_1, R_2, R_6, R_7, is incorrect. Although these components do seem to form a bridge, no active elements are included. Go back to Frame 19 and look again.

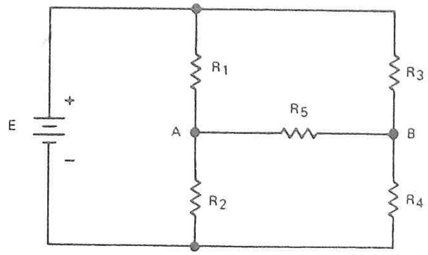
● ● ●

13 Your selection is wrong. You can hear the audio signal in the headphones but only when the bridge is unbalanced. Return to Frame 35 and try again.

● ● ●

14 Your selection is correct. The circuit you chose is *not* a bridge circuit. It is simply a series-parallel resistor circuit connected to a battery power source with a series current meter. The other two circuits are typical bridge circuits. In the circuit on the top both resistors and capacitors are used as the bridge arms. A sine wave oscillator is the ac voltage source. R_3 is a load resistor. The circuit on the bottom is a bridge like the one in Frame 1. A load resistor, R_5, has been added. This circuit could easily be redrawn in the standard diamond form.

Here is another method of drawing the bridge circuit:



If you will look carefully, you will see that the bridge simply consists of two voltage divider circuits connected across a battery. One voltage divider is made up of R_1 and R_2; the other is made up of R_3 and R_4. A load, R_5, is connected between the two voltage divider outputs. By knowing the resistor values and the applied voltage, E, we can calculate the output of each voltage divider, that is, the voltage between point A and ground and between point B and ground. The formula for the voltage divider output is:

$$E_A = \frac{E(R_2)}{R_1 + R_2} \text{ and } E_B = \frac{E(R_3)}{R_3 + R_4}$$

where E_A and E_B are the two voltage divider outputs and E is the applied voltage.

Suppose that the applied voltage E = 10 volts, R_1 = 400 ohms, R_2 = 100 ohms, R_3 = 1200 ohms, and R_4 = 300 ohms. Calculate E_A and E_B and then select the correct answer from those given below.

Go to Frame 9 *E_A is greater than E_B.*
Go to Frame 21 *E_A is less than E_B.*
Go to Frame 32 *E_A equals E_B.*

● ● ●

15 Beautiful! Looks like you have a pretty good understanding of bridges by now. Yes, if the ratio $E_1/E_2 = R_1/R_2$ then the bridge will be balanced. And, of course, at balance no current will flow in the load. If $E_1 = E_2$ and $R_1 = R_2$, then the bridge will be balanced, but this is only one special condition for balance. E_1 does not have to equal E_2 nor does R_1 have to equal R_2. If the ratio $E_1/E_2 = R_1/R_2$ is true, then balance is achieved. The most common way of using this modified bridge is to ground the junction of the voltage sources and one end of the load. Then if the bridge is balanced, the junction of R_1 and R_2 will also be at ground or effectively zero volts.

Suppose that $E_1 = E_2$ = 10 volts and that R_1 = 100 ohms and R_2 = 150 ohms. The load resistance is one megohm. Then, which of the following statements is true?

Go to Frame 20 *No current will flow in the load.*

Go to Frame 34 *Electrons will flow from right to left in the load.*

Go to Frame 40 *Electrons will flow from left to right in the load.*

● ● ●

16 Your answer, 200 ohms, is incorrect. How did you get this? Go back to Frame 22 and take the given values of R_1, R_2, R_3 and put them in the formula $R_x = R_2 R_3 / R_1$. Compute R_x then go to the frame indicated.

● ● ●

17 Your answer is correct. If we change the value of R_2 to 20k-ohms, leaving the other values alone, we will balance the bridge. The ratios become:

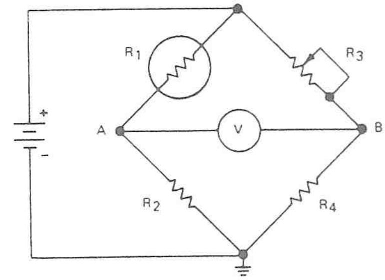
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$\frac{10\text{k-ohms}}{20\text{k-ohms}} = \frac{30\text{k-ohms}}{60\text{k-ohms}}$$

$$.5 = .5$$

As you can see, a simple way of achieving a balanced condition is to make one (or more) of the arms of the bridge a variable resistance. Then, by monitoring the voltage across the load, the variable element can be adjusted until the load voltage is zero. All practical bridge circuits are provided with some means of adjusting one or more arms to achieve balance.

Here is a typical application for a bridge circuit:



Here one of the arms of the bridge (R_1) is a thermistor, a heat sensitive resistor with a negative temperature coefficient. Its resistance increases with a decrease in temperature. This circuit is used for precision temperature measurement. The thermistor is exposed to the environment whose temperature is to be measured. If the temperature changes, the resistance of the thermistor varies and changes the balance condition of the bridge. The voltmeter load indicates the change. It can be calibrated to read directly in degrees of temperature.

Suppose that V is a zero center meter that can indicate a positive (upward deflection) or negative (downward deflection) load voltage. R_3 is a variable resistor that is used to balance the bridge to zero at a temperature of 70°F (room temperature). If the temperature rises, the voltmeter reading will:

Go to Frame 36 *Not change.*
Go to Frame 22 *Show point A positive with respect to point B.*
Go to Frame 38 *Show point A negative with respect to point B.*

● ● ●

18 Your answer is incorrect. Electrons will not flow through R_5 from right to left. Since point A is +4 volts and point B is +5 volts, point A is less positive (more negative) than point B. Electrons always flow from negative to positive. Go back to Frame 32 and have another shot at it.

● ● ●

19 Good work! You are correct. The headphones act as an audible balance detector. As you will recall, when the bridge is balanced no current flows through the load. So, headphones are used to monitor the balance state of the bridge. The operator hears the audio tone when the bridge is out of balance. He then tunes C_1 until the tone is nulled out. When minimum or no tone is heard, the bridge is balanced and the following ratios hold true:

$$\frac{R_1}{X_{C1}} = \frac{R_2}{X_{C2}}$$

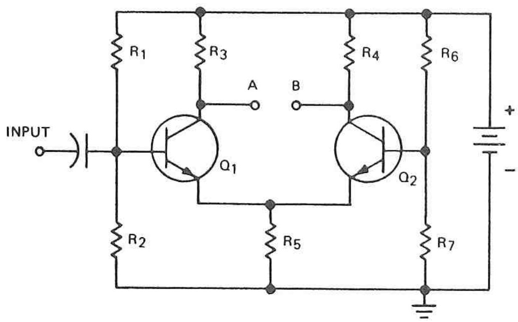
As you can see, the basic bridge balance relationship holds true for any combination of elements in the bridge arms. In fact, we can express this relationship in the most general terms possible, as below:

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

Here Z_1 through Z_4 are impedances of any kind (L, C, R or what have you) used to make up the four bridge arms.

Some very interesting bridge applications result from making one or more of the bridge arms an active element such as a tube or a transistor. Since a conducting tube or transistor is nothing more than a resistance, it makes an excellent bridge arm.

The differential amplifier circuit shown below is a good example.



Which four components in this circuit form an active bridge?
Go to Frame 3 *Q_1, Q_2, R_3, R_4*
Go to Frame 12 *R_1, R_2, R_6, R_7*
Go to Frame 33 *Q_1, Q_2, R_2, R_7*

● ● ●

20 Your answer is incorrect. Come on now. Surely you can determine the balanced or unbalanced condition of a bridge by now. Remember the ratio formulas, then use the given values to figure them out. Return to Frame 15.

● ● ●

21 Your answer is not right. E_A is not less than E_B. Perhaps your calculations for these values were incorrect. Check your calculations against those shown below, then go back to Frame 14 and select the right answer.

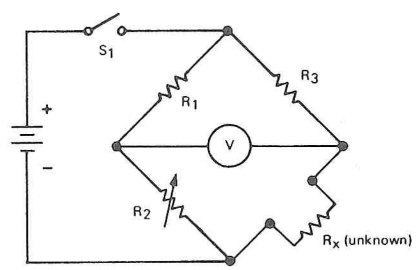
$$E_A = \frac{E(R_2)}{R_1 + R_2} = \frac{10(100)}{400 + 100} = \frac{1000}{500}$$

$$E_B = \frac{E(R_4)}{R_3 + R_4} = \frac{10(300)}{1200 + 300} = \frac{3000}{1500}$$

● ● ●

22 Terrific! Good work. This proves that you understand the bridge circuit. As the temperature increases, the thermistor resistance decreases. This causes more voltage to be developed across R_2. The voltage across R_4 remains the same, so point A is more positive than point B.

A common application of the bridge is in making very accurate resistance measurements. A special instrument for making such measurements is the Wheatstone bridge which is shown below in simplified form:



Here an unknown resistance, R_x, is connected as one of the arms of the bridge. Arm R_2 is made variable. When power is applied by closing switch S_1, the circuit operates. R_2 is adjusted until balance is obtained. At this time, we know that:

$$\frac{R_1}{R_2} = \frac{R_3}{R_x}$$

so we can see that:

$$R_x = \frac{R_2 R_3}{R_1}$$

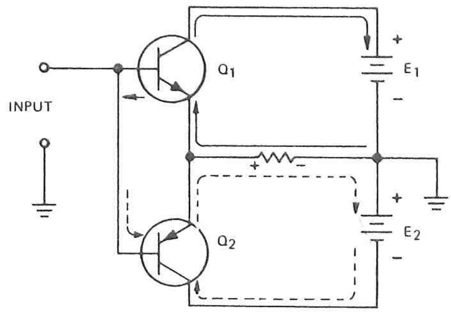
By making R_1, R_2, and R_3 known, accurate resistances, R_x can be computed.

Let R_1 = 1000 ohms and R_3 = 500 ohms. R_2 is adjusted until at balance its value is 2500 ohms. What is the value of R_x?

Go to Frame 16 *200 ohms*
Go to Frame 29 *400 ohms*
Go to Frame 35 *1250 ohms*

● ● ●

23 Correct. When an ac signal is applied to the input, the positive half cycle causes Q_1 to conduct and supply a positive-going signal (with respect to ground) across the load. As the input goes negative, Q_1 cuts off and Q_2 conducts. This causes the output signal across the load to be negative with respect to ground. So, the output signal is in-phase with the input. Q_1 and E_1 supply current to the load during a positive half cycle of the input, and Q_2 and E_2 supply current to the load when the input goes negative. Both transistors never conduct simultaneously, but when the input is zero, both are cut off at the same time. See the current flow for both conditions below.



This circuit is basically an emitter follower or common collector amplifier since the load is in the emitter circuit. But complementary symmetry amplifiers with a common emitter connection can also be constructed.

This concludes your brief study of the bridge circuit and some of its applications. By understanding this important circuit, we hope that your abilities as a technician will be greatly improved.

● ● ●

24 Your answer is incorrect. You must not have been paying attention when you read Frame 32. Better go back and re-read it, then try again.

● ● ●

25 Your answer is incorrect. The bridge is initially balanced when no input signal is applied. When an input appears, the circuit becomes unbalanced. This is the only way that an output can be obtained! Go back, re-read Frame 3, then try again.

● ● ●

26 You are right. The bridge is not balanced. The resistor values given prove it. If $R_1/R_2 = R_3/R_4$, then balance is achieved. With the values given, however, the ratios are not equal, as you can see:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$\frac{10\text{k-ohms}}{12\text{k-ohms}} \neq \frac{30\text{k-ohms}}{60\text{k-ohms}}$$

$.4 \neq .5$ ($\neq$ means not equal to)

So how can a balance be obtained? Which solution below is correct?

Go to Frame 5 *Change the value of R_4 to 45k-ohms.*

Go to Frame 17 *Change the value of R_2 to 20k-ohms.*

Go to Frame 30 *Change the value of the applied voltage.*

● ● ●

27 Your answer is incorrect. You can determine the current level in the circuit by knowing the values of E_1, E_2, R_1, and R_2, but did you really think there would be current in the load with the bridge balanced? Shame on you. Return to Frame 39.

● ● ●

28 Your selection is incorrect. This circuit is most definitely a bridge. The circuit is not drawn in its diamond shape and the positions of the supply and load have been interchanged, but if you study the circuit carefully, you will see that it is a bridge. Return to Frame 1, study the circuits, then select again.

● ● ●

29 Your answer, 400 ohms, is way off. All you have to do is put the given values of R_1, R_2, and R_3 in the formula $R_x = R_2 R_3/R_1$ and crank out the answer. Go back to Frame 22 and do it again.

● ● ●

30 Your answer is wrong. The state of balance of the bridge is in no way affected by the value of the supply voltage. The balance state is strictly a function of the resistor ratios. Go back to Frame 26 and try again.

● ● ●

31 This selection is incorrect. You most certainly can determine the state of the bridge with the information given. Simply use the resistor values given in the ratio formula and compare the results. Go back to Frame 4 and do this, then try again.

● ● ●

32 Your answer is correct. E_A equals E_B. Good work. Your calculations probably looked something like this:

$$E_A = \frac{E(R_2)}{R_1 + R_2} = \frac{10(100)}{100 + 400} = \frac{1000}{500} = 2 \text{ volts}$$

$$E_B = \frac{E(R_4)}{R_3 + R_4} = \frac{10(300)}{1200 + 300} = \frac{3000}{1500} = 2 \text{ volts}$$

This means that the two voltage divider outputs, those voltages across R_2 and R_4, are equal.

Now consider the load resistor R_5. It is connected between points A and B. Since the voltage on both ends of the load resistor is 2 volts, there is no potential difference or voltage across the resistor. Therefore, no current flows through it. When the bridge is in this state, it is said to be balanced. We could easily determine whether the bridge was balanced or not by connecting a voltmeter between points A and B. If the voltage is zero, the bridge is balanced. On the other hand, if the voltage at point A is *not* equal to the voltage at point B, then the bridge is said to be unbalanced. A potential difference will exist across R_5 and current will flow through it.

Suppose that $E_A = +4$ volts and $E_B = +5$ volts. Which of the statements below is true about the bridge circuit?

Go to Frame 4 *Current (electrons) will flow through R_5 from left to right.*

Go to Frame 18 *Electrons will flow through the load from right to left.*

Go to Frame 24 *No current will flow through R_5.*

● ● ●

33 Your answer, Q_1, Q_2, R_2, R_7, is wrong. Return to Frame 19 and, remembering some bridge fundamentals, have another try.

● ● ●

34 Your answer is incorrect. There are several ways of going about determining the direction flow in the load. First, remember that electrons flow from negative to positive. Second, the voltage drop across R_2 will be greater than that across R_1 since R_2 is larger in value. This is true since the current in R_1 is essentially equal to that in R_2. The load resistance is very large so little current flows in it. Now with these facts in mind, return to Frame 15 and pick the correct answer.

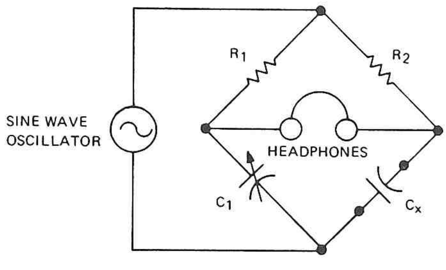
● ● ●

35 Your answer, 1250 ohms, is correct. All you had to do here is to plug the values $R_1 = 1000$, $R_2 = 2500$, and $R_3 = 500$ into the formula $R_x = R_2 R_3 / R_1$ and solve it. The answer is:

$$R_x = \frac{2500 \times 500}{1000} = \frac{1,250,000}{1000} = 1250 \text{ ohms}$$

In most commercial Wheatstone bridges, R_2 is varied in steps by switching in accurate resistor values. R_1 and R_3 are also made variable to provide a wide range of ratios that permit resistances over a wide range to be measured. R_1, R_2, and R_3 are generally stepped by factors of 10 (i.e. .001, .01, .1, 1, 10, 100, 1000, etc.) and calibrated dials are associated with the switches. The switches are varied until a balance is obtained, then the unknown resistor value is indicated by the dials. Resistance values from a fraction of an ohm to many thousands of ohms can be measured with an error of .01% or less.

There are also bridges similar to the Wheatstone which make accurate measurements on coils and capacitors. Two of the arms of the bridge are reactive components and a sine wave signal source replaces the battery. Such a bridge is shown below.



The sine wave signal source applies an audio signal to the bridge. Capacitor C_x has an unknown value. Calibrated capacitor C_1 is varied until a balance is obtained. Then the value of C_x can be read from the dial.

Note that headphones are used as the bridge load. Which of the following statements about them is the most correct?

Go to Frame 2 *The headphones permit the bridge user to monitor the audio signal to determine when the bridge is on.*

Go to Frame 19 *The headphones act as an audible balance detector.*

Go to Frame 13 *The headphones signal the operator with a tone when C_x is equal or proportional to C_1.*

● ● ●

36 Your answer is incorrect. The voltmeter reading *will* change. If the temperature increases, the thermistor resistance will decrease and unbalance the bridge. But in which direction? Go back and re-read Frame 17, then choose the correct answer.

● ● ●

37 Your answer is incorrect. You'd better look at the circuit again. Better still, you should remember that a transistor conducts when its emitter-base junction is forward biased. In an NPN this occurs when the base is positive with respect to the emitter. In a PNP it occurs when the base is negative with respect to the emitter. Go back to Frame 40, re-read it, then select the correct answer.

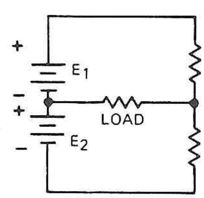
● ● ●

38 Your selection is incorrect. If the temperature rises, the thermistor resistance will decrease. This will make point A more positive with respect to ground. Compare this now to point B and you will have the correct answer. Return to Frame 17 and select it.

● ● ●

39 Your selection is correct. Nice going. In our previous discussions of the bridge, we varied only one element to balance or unbalance the circuit. In the differential amplifier, the input signal directly changes the resistance of Q_1 which in turn varies Q_2. Since two elements are changing and in opposite directions, the resulting unbalance is exactly twice what it would be if only one arm changed. This gives the circuit a gain of 2 over the gain produced by either of the transistors. The overall gain result is known as the differential gain and is due to the bridge arrangement.

There is another way to use the bridge arrangement. It involves replacing two of the bridge arms with power supplies or voltage sources like that shown:



This circuit works like any of the other bridge circuits we have discussed. If this is so, then which of the following statements if the *most* correct?

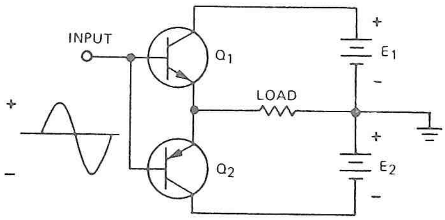
Go to Frame 6 *In order for the bridge to be balanced,* E_1 *must equal* E_2 *and* R_1 *must equal* R_2*.*

Go to Frame 15 *The bridge is balanced if the following ratio is met:* $E_1/E_2 = R_1/R_2$*.*

Go to Frame 27 *The value of the current through the load when the bridge is balanced can be determined by knowing the values of* E_1*,* E_2*,* R_1*,* R_2*, and the load.*

40 Correct. With E_1 equal to E_2 and R_1 not equal to R_2, the bridge is unbalanced, so current will flow in the load. Since R_2 is greater than R_1, the voltage across it will be greater than that across R_1. The load resistance is large, making its current very low so the current in R_1 is very nearly equal to that in R_2. This makes the junction of R_1 and R_2 positive with respect to ground, so electrons flow from left to right.

As in any bridge circuit, R_1 and R_2 can be any component that has an impedance. Transistors, for example, work quite well. E_1 and E_2 can also be used to supply power to the transistors. One type of amplifier circuit using this arrangement is shown below.



This is a push-pull class B power amplifier known as a complementary symmetry circuit. The term complementary comes from the use of transistors with equivalent characteristics but of opposite sex. Q_1 is an NPN, Q_2 is a PNP.

When an ac input signal is applied to the input, one of the transistors will conduct and cause a signal to be developed across the load. When the input goes positive, the emitter-base junction of Q_1 is forward biased so it conducts and a signal appears across the load. Q_2 is cut off at this time. When the input goes negative, Q_1 cuts off and Q_2 conducts, applying a signal across the load.

The beauty of this circuit is that we have push-pull operation without the use of transformers.

Which of the following statements about this circuit is true?

Go to Frame 10 *With an ac input, the output signal across the load is an ac signal* 180° *out-of-phase with the input.*

Go to Frame 23 *With an ac input, the output of this circuit is an ac signal across the load that is in-phase with the input.*

Go to Frame 37 *With an ac input signal, the negative half cycle of the output is supplied by* Q_1 *and* E_2 *and the positive half cycle is supplied by* Q_2 *and* E_2*.*

● ● ●

Unusual IC Audio Power Amplifier

by Harold J. Turner, Jr.

There are many different integrated circuit (IC) audio amplifiers on the market, but most of them share several disadvantages: The IC's used are fairly expensive and not too easily available, often many external components are needed, a complex power supply is sometimes required, and the amplifiers don't have much voltage gain. The simple circuit described here overcomes most of these disadvantages and provides the experimenter with a simple, inexpensive, and easily constructed circuit.

The IC used in this audio amplifier circuit is the popular 723 voltage regulator. This "chip" was originally developed by Fairchild Semiconductor, and is still sold by that firm under the number uA723. However, several other IC manufacturers are also marketing this circuit. You might see it identified as "SN72723," "MC1723," or any of several other numbers, each including the digits "723." To keep things simple in this article, we'll refer to this versatile circuit as the "723." At any rate, the 723 is widely available for $1.50 or less. It is this inexpensive and popular IC that is the heart of the audio amplifier circuit to be described.

"But the 723 is a voltage regulator IC," you might exclaim, "How can it be used as an audio amplifier?" Let's save that question until we have a good understanding of how the 723 is used in its intended application: a power supply voltage regulator circuit.

Fig. 1 is a schematic diagram of what's inside the 723. If you count all the components, you will find that there are no fewer than 3 Zener diodes, 16 transistors, 12 resistors, and 1 capacitor. The circuit itself might appear rather complex, and indeed it is, but the 723 is very easy to understand, once it is broken down into functional blocks.

The 723 consists of 4 basic elements: a reference voltage source, a high-gain differential amplifier, an emitter follower output stage, and a current limiter. Let's take a brief look at each of these four sections to see how they work.

THE REFERENCE VOLTAGE SOURCE

Transistors Q_1 through Q_6, and their associated components, form the voltage reference portion of the IC. The function of this circuit is to provide a highly stable dc reference voltage at one of the IC terminals. The heart of the voltage reference circuit is a precision Zener diode, D_1, which acts together with field-effect transistor Q_1 to supply a highly stable dc reference voltage. Note that while this voltage is highly stable with respect to changes in supply voltage and temperature, it is not particularly accurate. The voltage at the reference terminal (Pin 6 on the dual in-line version) is nominally 7.15 volts, but may vary as much as ±5% among different IC's. On any given IC, however, the reference voltage is as steady as a rock.

The purpose of Q_1 is to provide a constant current through the Zener

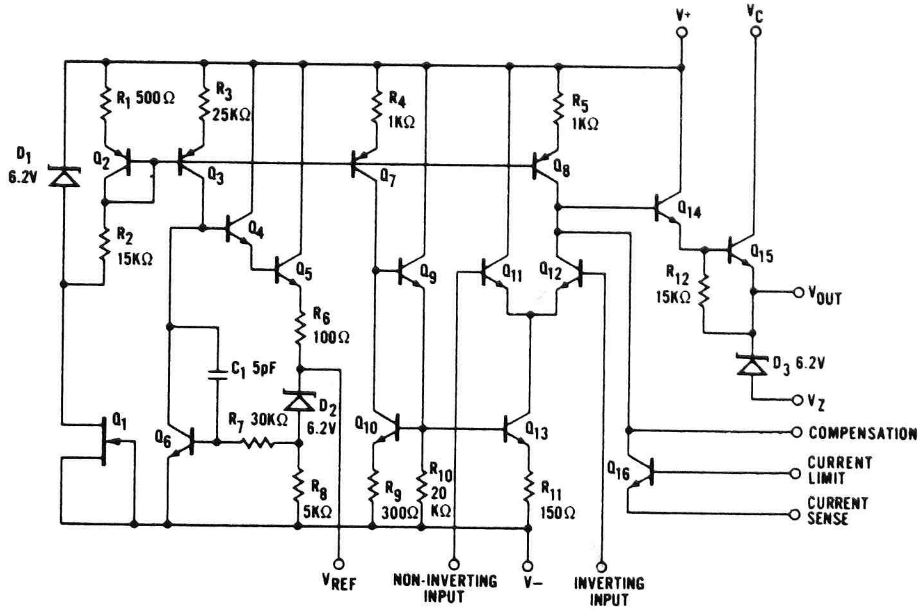


Fig. 1. Internal schematic of a 723 voltage regulator. *(Courtesy Fairchild Semiconductor)*

diode, regardless of the exact amount of supply voltage (which, incidentally, may vary from 9.5 to 40 volts without changing the reference voltage). This is possible because of the use of Q_1 as a constant-current source for the Zener diode. Any Zener will regulate best when current through the Zener is kept constant. The gate of Q_1 is directly connected to its source, so the transistor operates with zero bias. As long as the voltage from source to drain is above the transistor's saturation voltage, the drain current, and therefore the Zener current, will remain constant over large variations in source-to-drain voltage. Fig. 2 shows the characteristic curve of a typical field-effect transistor. Note that the drain current increases as the source voltage is increased, but only up to a certain point, after which the current remains constant. Such a device finds widespread application in instrumentation and control circuits, and, indeed, field-effect transistors are packaged as 2-terminal devices, with their gates internally connected to their sources, and are called "constant-current diodes." After all this discussion on just the Zener and its current source, it seems an anticlimax to state that the remainder of the parts in the reference circuit are used to provide a low output impedance at the reference terminal, but that's about it.

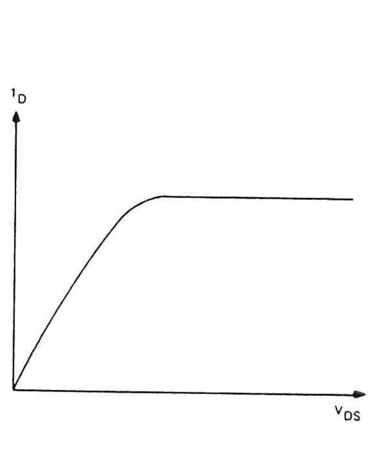


Fig. 2. Characteristic curve of FET.

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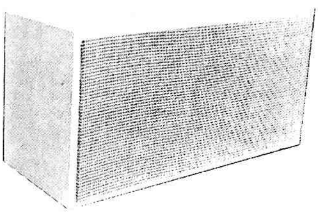

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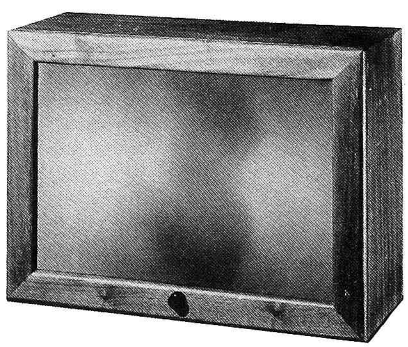

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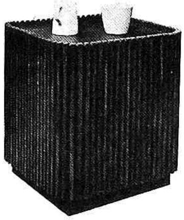

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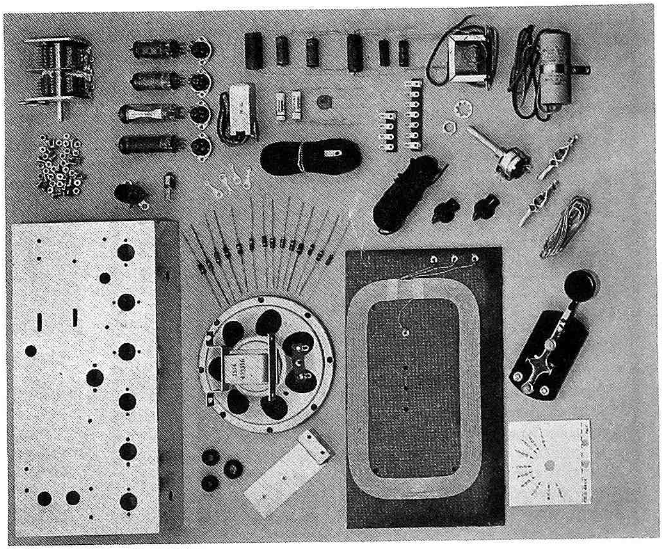

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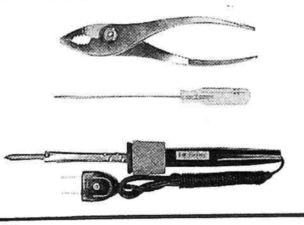

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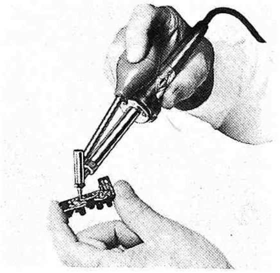

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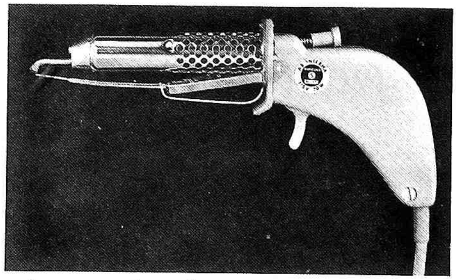

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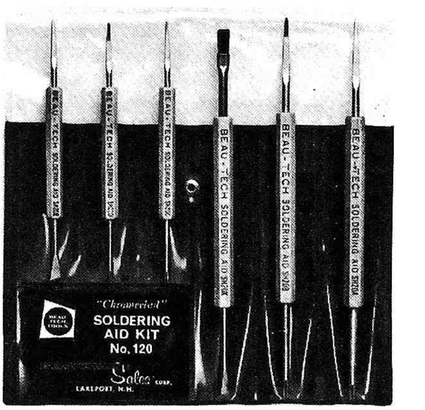

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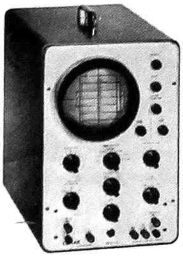

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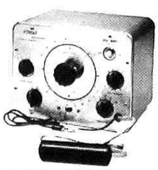
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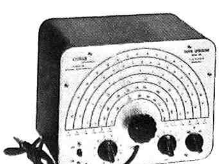
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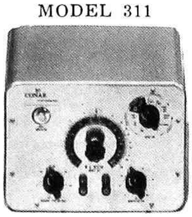
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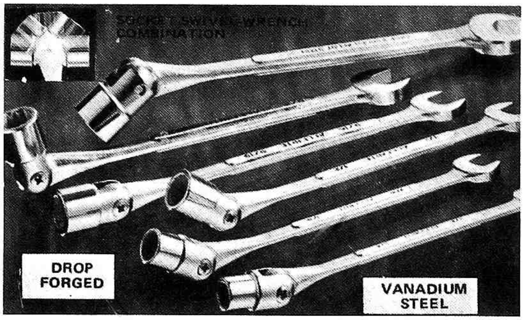

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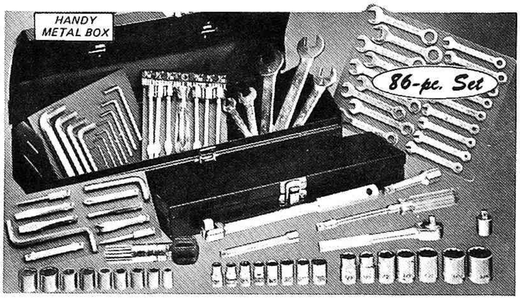

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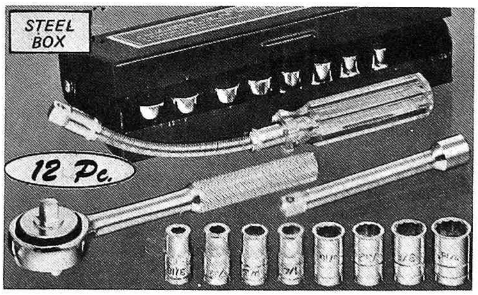

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50.01- 60.00	4.15	5.50		
60.01- 70.00	5.50	6.00	6.40	4.50
70.01- 80.00	7.00	6.50	8.00	5.00
80.01- 90.00	8.00	7.75	10.10	5.00
90.01-100.00	9.00	8.75	12.60	5.25
100.01-110.00	10.00	9.75	14.80	5.50
110.01-120.00	11.00	10.75	16.20	6.00
120.01-130.00	12.00	11.75	17.60	6.50
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DIFFERENTIAL AMPLIFIER

Transistors Q_7 through Q_{13} and associated components form the differential amplifier circuit. This direct coupled amplifier is used to compare the reference voltage with the regulator output voltage, to make sure that they remain in the correct proportions. The output of the differential amplifier is supplied to the emitter-follower output stage.

OUTPUT STAGE

The output emitter-follower is actually 2 transistors, Q_{14} and Q_{15}, which are connected as a Darlington pair. This is the same as using a single transistor having a very high current gain (beta).

CURRENT LIMITER

The fourth and final section consists of a single transistor, Q_{16}, which is used with an external resistor to limit the maximum amount of current that can be drawn from the output of the IC. Fig. 3 is a simplified diagram of the output transistor as it is usually connected to the current limiter transistor. The output transistor, Q_{15}, is used to pass current from the unregulated input voltage to the regulated output voltage, as demanded by the control signal applied to the base of this transistor by the differential amplifier.

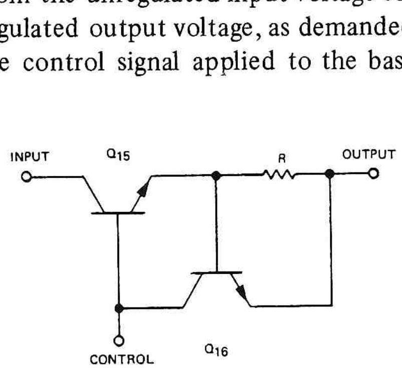


Fig. 3. Simple current limiter circuit.

The collector of the current limiter transistor, Q_{16}, is permanently connected inside the IC to the base of Q_{15}, but the base and emitter connections are brought out separately for a maximum circuit flexibility. In this typical application, the base-emitter junction is connected across an external resistor (R) through which the entire load current must pass. As long as the current drain is low, not much voltage will appear across the resistor.

Remember, no current will flow through the base-emitter junction of Q_{16} until the voltage between these two terminals reaches roughly .6 volt. At this time, then, the current limiter transistor does nothing at all. However, if the output current is increased beyond its intended limits, the voltage applied to the base-emitter junction of Q_{16} increases, and causes collector current to flow. This collector current robs base drive from Q_{15}, and reduces its conduction just enough to stabilize the output current at a safe level. The circuit designer picks the value of the external resistor (R) according to the maximum amount of current to be allowed to be drawn by the load. A large resistor will drop a large voltage at a relatively small current, so the circuit would limit at a low current level. If a large output current is desired, a smaller resistor is chosen. Actually, this last portion of the 723 will not be used in the audio amplifier to be described here, since the addition of the current sampling resistor is very wasteful of audio power output. However, in a typical regulator circuit, the resistor detracts only very little from the efficiency of the regulator, and is a very worthwhile design feature.

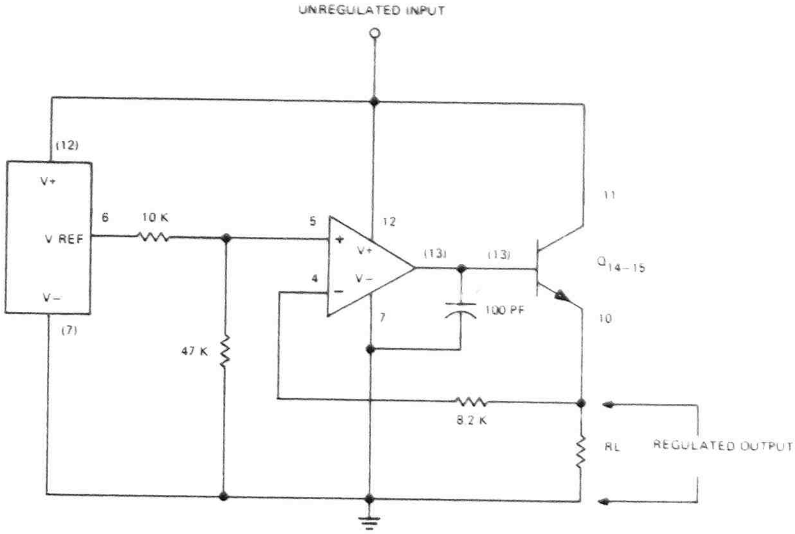


Fig. 4. Basic 723 voltage regulator circuit output – 6 V @ 150 MA maximum.

A TYPICAL 723 REGULATOR CIRCUIT

Now that we have seen how the 723 works, let's see how it is used in a typical power supply voltage regulator circuit. If you will compare Fig. 4 to the internal diagram of the IC, you will see that only four external parts are needed to make the circuit operate: 3 resistors and a small capacitor. The fourth resistor, R_L, represents the load resistance, which is not really a part of the power supply.

In operation, the purpose of the differential amplifier is to keep the voltage difference between its two input terminals at zero, or very close to it. Since the desired output voltage in this case is 6 volts, and the entire output voltage is fed to the inverting (−) input of the amplifier, the reference voltage must be scaled down to 6 volts. This is accomplished by the divider consisting of the 10k-ohm and 47k-ohm resistors.

Ohm's Law will show you that if 7.15 volts is present at Pin 6 of the IC, almost exactly 6 volts will appear at Pin 5. The 8.2k-ohm resistor is equal in resistance to the 10k-ohm resistor and 47k-ohm resistor connected in parallel, and this resistor is needed so that both amplifier inputs "see" the same source resistance. This is done for a minimum output voltage drift with changes in temperature. The two voltage divider resistors are seen by the amplifier input as being connected in parallel because one of them is connected directly to ground, while the other is connected to the reference voltage terminal, which has a very low output impedance: less than 1 ohm.

The output of the differential amplifier is then fed to the base of the output transistor (remember this is really two transistors in a Darlington connection), and the output transistor functions as an emitter-follower to control the output voltage in response to the bias current supplied by the amplifier. The overall result is to make the output voltage completely independent of variations in load current and supply voltage.

The single capacitor plays no real part in the regulator action, but is used simply to limit the high frequency response of the amplifier so that it cannot go into oscillation.

ABOUT THAT AUDIO AMPLIFIER . . .

Now that we have seen how the 723 is used in a typical power supply circuit, let's see how easy it is to turn this circuit into an audio power amplifier. This is just what we have done in Fig. 5. Note the great similarity between figures 4 and 5. The most apparent difference is that we have added an input signal at Pin 5, coupled through a 5 mfd capacitor, and a loudspeaker load, coupled through a large electrolytic capacitor to the load resistor, which in this case happens to be a real resistor. The input signal modulates the dc voltage supplied by the reference circuit, and, since the purpose of the regulator is to keep the output voltage equal to the voltage at Pin 5, the signal certainly will be amplified.

The values shown will yield an output of about 45 milliwatts (.045 watt) into a 16-ohm loudspeaker. The value shown for R_3 will permit full output with an ac input of about 1 volt. To increase the gain, decrease the value of R_3. This will lower the amount of ac feedback applied to the inverting input of the amplifier, so less input voltage will be required to produce full output.

As shown in the schematic, as far as dc is concerned, the IC is connected as a voltage regulator with a 6 volt output. Since the circuit is connected just as it is in a typical power supply application, its performance is equally good. This means that the thermal stability of the amplifier and output stage is extremely good.

This also means that the amplifier can be operated from a dc supply which is not very well filtered. A simple full-wave rectifier and a single input filter capacitor (just a few hundred microfarads) will do very nicely, since the IC does all its own

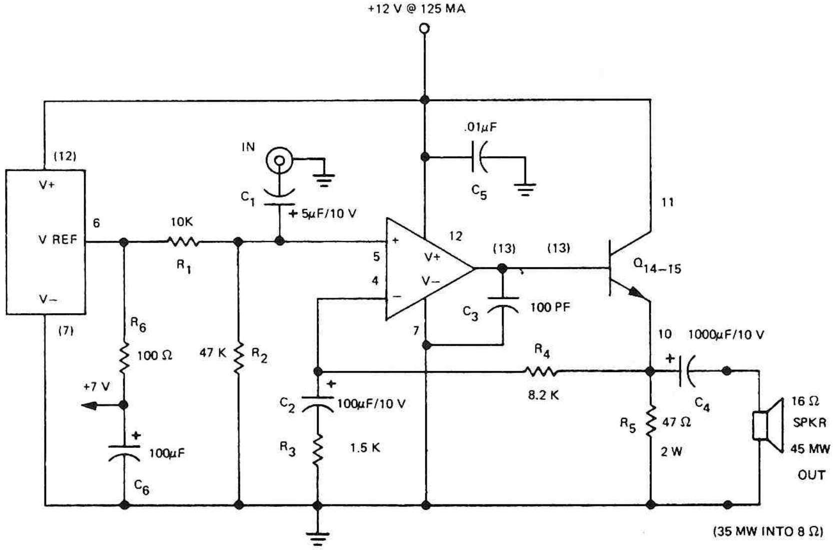


Fig. 5. Typical power supply circuit converted to an audio power amplifier.

filtering without any need for large filter capacitors. The output stage is connected as an emitter-follower, and a sample of the dc output voltage is fed to the inverting input of the error amplifier through R_4. Since no appreciable amount of current is drawn by the amplifier input, there is virtually no dc voltage drop across R_4, so 6 volts dc appears also at the inverting input. At the same time, the 7.15 volt reference voltage is divided by R_1 and R_2 so that approximately 6 volts dc appears at the noninverting input of the differential amplifier. The amplifier will strive to maintain a zero voltage difference between its inputs, so the output voltage will remain constant with variations in supply voltage, loading, and temperature.

Now, we add a signal to our "power supply" circuit. The audio signal is coupled into the noninverting input through a small capacitor (C_1). This audio signal unbalances the amplifier, and the output appears at the emitter of Q_{15}, where it is fed through coupling capacitor C_4 to the loudspeaker. The signal at the emitter of Q_{15} is also fed back to the inverting input of the error amplifier, and, since this is negative feedback, will reduce the gain of the amplifier.

However, the network consisting of C_2 and R_3 serves to control the gain of the amplifier. C_2 is such a large capacitor that it is effectively a short circuit to all audio frequencies, so if the resistance of R_3 is very low, no ac signals will be fed back to the inverting input, so the gain will be at maximum.

The purpose of capacitor C_3 is to roll off the frequency response of the amplifier at very high audio frequencies, to insure stability under all conditions. If you wish, you can add a tone control circuit here by using a somewhat larger capacitor (.01 mfd works nicely) in series with a variable resistor. C_5 is also needed to insure

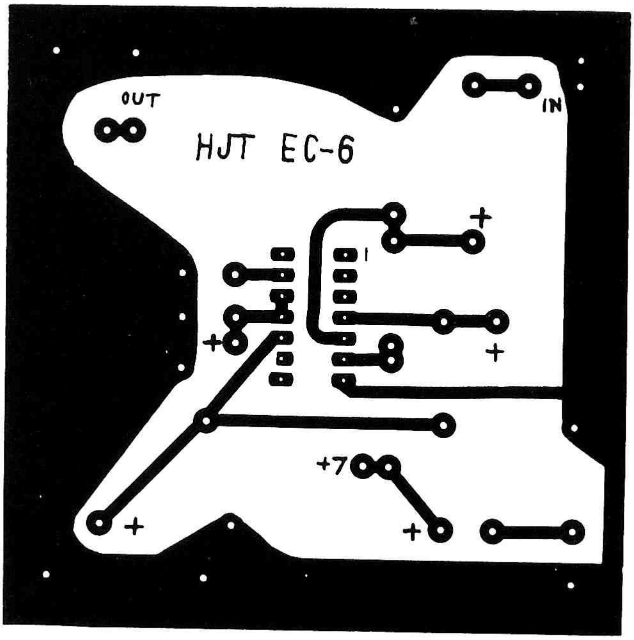


Fig. 6. Actual size foil pattern for 723 audio amplifier.

stability under all possible conditions. This capacitor should be mounted as close to the IC as possible.

The amplifier circuit should be powered from a 12 volt dc source, which should be filtered so that the ripple at the input to the IC does not exceed 2 or 3 volts peak-to-peak. This could be done with a single input filter capacitor of only a few hundred microfarads, provided that full wave rectification is used. If a half-wave rectifier is all that is available, the filter capacitor will have to be somewhat larger, because of the lower ripple frequency.

A full-size foil pattern, suitable for photo-reproduction, is shown in Fig. 6 so that you can make a circuit board for your 723 audio amplifier. Fig. 7 shows how to connect either of two IC "packages" to the dual in-line circuit board pattern. See Fig. 8 for the location of all parts mounted on the circuit board.

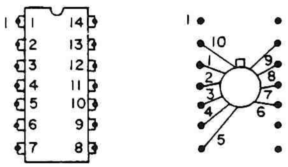


Fig. 7. DIP circuit board pattern that suits either DIP or "TO-5" package.

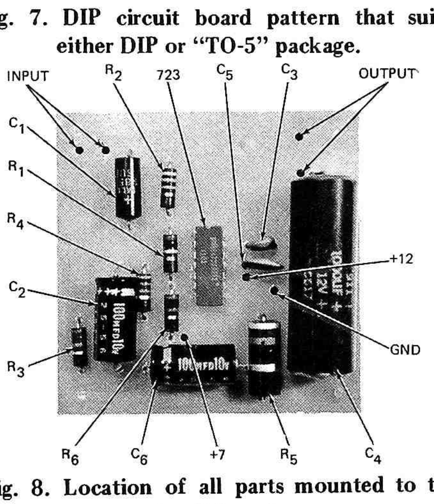


Fig. 8. Location of all parts mounted to the circuit board.

Use the four corner holes on the board to mount the board to a chassis.

HOW WELL DOES IT WORK?

Pretty well, considering all things. First of all, the power input to the circuit is only 1.5 watt. Since the output stage is an emitter-follower, the efficiency is not very high (only about 3%). If a 16-ohm speaker is used, about 45 milliwatts of clean power will be delivered to the load. You can figure on about 35 milliwatts into an 8-ohm speaker. However, the output impedance of the amplifier is very small, and low-frequency response is limited only by the size of the coupling capacitors used. Those specified give excellent low-frequency response. As mentioned before, the high frequency cut-off point is determined only by the size of C_3. With the values specified for this capacitor, the response extends well above the audio spectrum.

As an unexpected bonus, since R_1 and R_2 load the reference voltage terminal very little, at least 10 milliamps of well-regulated and well-metered dc output voltage is available at this point for use elsewhere. Just to be on the safe side, decouple the reference voltage with a single-section R-C filter (R_6, C_6), to make sure that no coupling occurs between the audio amplifier and whatever circuits are powered by the reference voltage. Just be sure to avoid exceeding a total drain of 10 milliamps from the reference voltage pin.

Although this simple amplifier circuit isn't likely to break any leases, it should come in very handy in all kinds of experimental projects, receivers, signal tracers, etc. And for a total cost of under $4, it's really hard to beat!

NRI honors program awards

For outstanding grades throughout their NRI courses of study, the following May and June graduates were given Certificates of Distinction with their NRI Electronics Diplomas.

Highest Honors

Talivaldis Aplocins, Indianapolis IN
Kiros Asfaw, Addis Ababa Ethiopia
Charles Borneman, Baxter Springs KS
William C. Carder, Mobile AL
William E. Cureton, West Union SC
Lester R. Downing, Jeannette PA 15644
Norman Kellis, California MD
George B. Markle, Carlsbad NM
W. Keith Moffat, Ste Agathe Des Monts PQ Canada
Donald P. Peeling, FPO New York
John S. Tanner, Catonsville MD
James J. Tomsen, Dayton OH
Henry W. Washington, Columbus OH

High Honors

Elbert R. Ashbaugh, Jr, APO New York
Carl M. Backer, Washington DC
Walter Charkow, Chicago IL
John E. Connors, East Taunton MA
Larry Allen Cook, Indianapolis IN
George J. Cox, Arlington VA
Stanley L. Fogle, Portland OR
Ralph Richard Gobel, Fairbury NB
John Goelzer, Belgium WI
Major Eugene K. Goodell, Portland ME
Robert Byron Goodvin, Powell River BC Canada
Richard G. Gross, Cheektowaga NY
Alberto Hernandez, Miami FL
Richard C. Hoopes, Pennsville NJ
Erland H. Jacobson, Biloxi MS
Charles W. Jones, Duanesburg NY
TSGT Larry P. Kelly, Wichita KS
George M. Kelnhofer, Milwaukee WI
Carl Layte, Lewisporte, NFLD Canada
Claude Lemarbre, St. Basile Le Grand PQ Canada
Clifford E. Love, Jr., Austell GA
Robert J. Matz, Sellersville PA
Larry M. McClenny, Oakton VA
T. L. McCorckle, Mt. Olive IL
William R. Morris, San Jose CA
Donald L. Nelson, Springfield MO
Harlan D. Ohlson, Ketchikan AK
William B. O'Rourke, Arlington VA
James A. Peters, Riverside CA
Jeffery L. Pittman, FPO San Francisco
John Robert Pope, Clarksville TX
T. R. Rains, Midland TX
George P. Reese, Warren OH
William J. Rickert, Vineland NJ
Paul C. Rohwer, Trenton OH
Joseph T. Schneider, Cocoa Beach FL
Agne L. Schold, Brooklyn NY
Wilson E. Scott, Trenton ONT Canada
Harry S. Simpson, Buford GA
Alan Wayne Smith, Hanover PA
Dale Lee Smith, Baraboo WI
George F. Smith, Annandale VA
Ayers M. Spangler, APO San Francisco
William N. Stewart, Bridgeport AL
J. R. Stone, Heyburn ID
Raymond C. Stucker, Hanover IN
Wayne R. Swann, Preston ID
Charles A. Sweet, Hampton VA
TSGT Kenneth R. Taylor, Homestead FL
Steven E. Tyrrell, Livermore CA
Ray A. Wade, Littleton CO
Arthur Walker, Detroit MI
Bryan L. Wilburn, Florissant MO
Forrest R. Willome, Dover NH
George M. Wrocklage, Norfolk VA
Walter W. Wrobel, Syracuse NY

Honors

Ollie Akins, Attalla AL
Albert C. Allen, Jr., Fort Myers FL
Howard A. Bass, Spokane WA
Harry R. Baumhoegger, St. Louis MO
Jerry F. Bellamy, Bloomfield IN
Charles Cobb Bey, Richmond VA
Hudson A. Bicknell, Indian Head MD
Charles A. Briggs, Jr., Tulsa OK
James J. Brokaw, Lawrence KS
Estel G. Burns, Fort Worth TX
John F. Butler, Dahlonega GA
Franklin D. Cagle, Knoxville TN
Amos H. Carmical, Memphis TN
Max C. Carr, Marietta OH
Charles E. Carter, Jr., New Orleans LA

Jimmy R. Clark, Batesville AR
Mark B. Coy, Upton NY
George Dahlstrom, Stamford CT
Fredrick W. Dawalt, Mentone IN
Renard T. Diggs, Washington DC
Clarence Daniel Ditto, St. Louis MO
William R. Elsaesser, Tetotum VA
Marvin R. Fisher, Memphis TN
Robert A. Franks, Butte MT
Fred F. Frey, Berwick PA
Richard A. Garrett, Richmond VA
Lech Walter Glinski, West Orange NJ
Clyde S. Grangruth, Bigfork MN
Larry Haggard, Oklahoma City OK
Sgt. Willie Paul Hanks, Cannon AFB NM
Ronald Thomas Harshman, Connellsville PA
Eugene P. Howley, Struthers OH
Fredric Arthur Hurdum, Bighamton NY
Ludwig Max Hutzler, Santa Clara CA
Hector O. Jimenex, Bellevue NE
James L. Johnson, Columbia MO
Robert W. Kawlewski, Little Falls MN
Robert N. Kervick, North Wilbraham MA
Michael G. Kohut, Plymouth MI
David O. Kraft, Detroit MI
Robert G. Kraker, Joliet IL
Harvey A. Kreiman, Helena MT
CPOS Daniel T. Krueger, Governors Island NY
Emil J. Krukar, Milwaukee WI
Raymond R. Kucera, Lemont IL
SGT Robert B. Kutz, Fairborne OH
Lawrence R. La Course, Norwich CT
Richard L. La Crosse, Fort Walton Beach FL
Edward P. Lange, Fairfield NJ
Gary Le Fevre, Milwaukee WI
Horst Leidel, Surrey BC Canada
Ivar J. Lindstrom, Bow WA
William B. Loveridge, Jr., Fort Pierce FL
Charles Lovoi, Cape Coral FL
Gary M. Luxenberg, Tucson AZ
Darrel Martin, Jonesboro AR
Joyce Mekeel, Boston MA
Dale Messerschmidt, Fruitport MI
Leonardo R. Migliaccio, Philadelphia PA
Jep S. Mitchell, Wetumpka AL
Arthur A. Moore, Cedar Lake IN
Duane W. Morrison, Casey IA
Max A. Mull, Salisbury MO
William P. Neely, Detroit MI
Patrick O'Brien, Corner Brook NF Canada
Paul J. Ondrus, Laurel MD
Loren E. Page, Phoenix AZ
Sergio H. Paredes R., Brownsville TX
Alton E. Perkins, Fair Oaks CA
Ordway L. Persyn, Whitefish MT
Ray B. Pitts, Zebulon GA
Gary J. Plano, Mohawk NY
Glenroy R. Pryce, Kingston Jamaica WI
Stanley N. Revell, Panama City FL
Harold G. Reynolds, Ft. Payne AL
Harold Roe, Batavia NY
Joseph E. Rosch, Palm Beach Gardens FL
Allen J. Sad, Jr., APO San Francisco
Ernest Saucier, Leominster MA
Maurice L. Savoye, Crystal MN
Eugene H. Schepp, Key West FL
Karl A. Schuster, Brewster NY
Konstantinos Serafim, Toronto ON Canada
Michael T. Silliman, Deansboro NY
Larry Dean Simpson, Tucson AZ
Mahendra Singh, Portland OR
Robert Sisco, N. Lindenhurst NY
William C. Smith, East Liverpool OH
Henry J. Spencer, Joplin MO
Larry O. Steele, Westerville OH
Dr. G. H. Straight, Jacksonville FL
Ronald B. Stroh, Orangevale CA
Arthur P. Timmerman, APO San Francisco
Howard S. Trimble, San Diego CA
John A. Tucker, Hudson KY
Felipe C. Varona, Jr., Lavern CA
Ralph R. Voda, St. Paul MN
George Washington, Buffalo NY
Thedford G. Watson, Hampton VA
Benny H. Whitehead, Maryville TN
Walter J. Zombro, Seattle WA

WANTED

If you have, or know of some way of obtaining, a schematic diagram for a "Syltron" Oscilloscope, Model 4Q5, please contact:

C. T. McKinney
P.O. Box 331
Saegertown, Pa.
16433

In these pages we have listed some people who qualified as "oldtimers," and we have had some teenagers represented also. Perhaps this time we'll start a new trend by listing the youngest amateur. At not-quite-thirteen, WN2BYU appears to be the first entrant. Neil started his course in July of 1970 and is on the air with an all Conar rig. He says he hopes to graduate from the Basic Amateur Radio course in 1971. We're sure you will, Neil, so keep up the good work.

WB2NHM took the time to write and tell us how proud he is of his new General call. Melvin says: "I would like to take the time now to commend NRI on their course, without which I might never have passed the General Test." Our thanks, Mel, for the commendation, and the best of luck to you in the future.

WB4SXM took his General on 8/26/71 and says that thanks to NRI he passed with flying colors while quite a few who sweated along with him did not make it. Thanks.

Frank, WN4UPW, claims to be the "southernmost" Ham in the United States. He says that the base club station, WA4ZUZ, is located 200 yards further south, but "as an *individual* station my WN4UPW is most southerly". Frank works 40 exclusively from Key West as he has been unable to load either his Conar rig or DX60-B on 80 or 15. Sounds like matching problems, OM. Both of those rigs should work FB on 80 and 15. Try an antenna tuner from the ARRL handbook, or do a little "pruning" on the old antenna.

WN4WID is presently without a call as he turned the license in for an appointment to take another exam. Perhaps we will be able to report next time that Ernest is now WB4WID. Here's hoping.

WA6BTE is another young man with a problem. Jim (age 16) wrote mainly to explain to his instructors why he had not been submitting lessons for grading. It seems that he interrupted his studies to "cram" for the General test, which he passed easily. Jim says it was just "Novice-difficulty questions on broader material." How true. Anyway, after getting that A, Jim also got a Swan 350 and got wrapped up in a lot of operating and so on and then found that a friend was going to get his General so, what the heck, might as well go for Advanced! Result: one Advanced Class ticket (friend did not make General — not taking NRI course). There must be a message there somewhere.

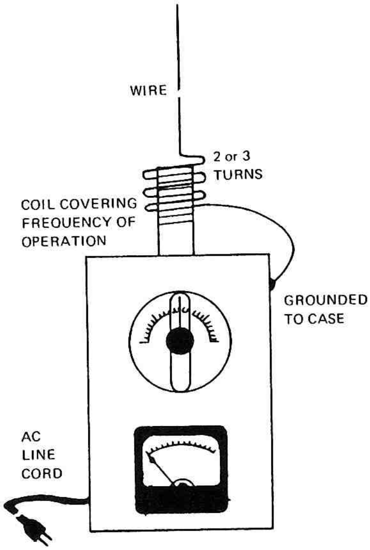
WN91AA runs a Hallicrafters SX62A and a Globe Scout (65 watts). When Dan completes the course rig (Conar) he will crank up the 15 watt mighty mouse to drive his 1/2 wave inverted vee antenna. Sounds good to me.

That's all for the Amateur Course Hams this time. I'm sure there are more of you, as I have been watching the enrollment figures. How about writing us so we can know what you are doing? Here are the other students and grads we've heard from:

Lou	WB2MYN	—	Bronx, NY
Clyde	WB4BDP/HL9TO	C	Osan AFB, Korea
Vince	WN4ULY	N	Vienna, VA
John	WN6CKN	N	Gonzales, CA
Jim	WB6QEM	A	Riverside, CA
Herb	K7LYT*	G	Renton, WA
George	WB8JIX	A	Muskegon, MI
Ronald	WB9CEX/K1JYO	—	Indianapolis, IN
Ronald	VE3CQV	—	Brampton, ON

* Just upgraded — congratulations!

WB2MYN wrote a very nice letter to WN1OCZ in care of me concerning the ac operated field strength meter Norm asked about in the July/August issue. Well, Lou, my secretary has undeniably misplaced Norm's address so for the benefit of *everyone*, we'll reprint your very FB hint here. ". . . suggest using ac powered grid-dipper (GDO) and attaching antenna to it. A two foot length of stiff wire is attached as shown. I use the Knight Kit and it's the most used instrument in the shack, excluding the rig itself, of course.



Diagrams for building one, ideas, etc., are found in Rufus Turner's *How to Use Grid Dip Oscillators,* Rider publication number 245." The GDO should be operated in the *diode* mode rather than oscillating for use as a field strength meter. Thanks a lot for the information, Lou, I'm sure Norm and others will appreciate it.

When WB4BDP is home, he operates from Warner Robins, Georgia. Right now, however, Clyde is operating out of Korea and is just about to take over the base club station, HL9KH, in Osan. Clyde enrolled with NRI in January of this year and hopes to upgrade his Conditional class license just as soon as he can get back stateside. We all hope that will be soon, Clyde.

Vince, WN4ULY, writes to say that it took him thirty-five years to become a Ham, and then only due to the training he got from NRI. That is always nice to hear, especially when the writer is over in Vienna, Virginia (a Washington, D.C. suburb) within a stone's throw of our office. Vince also says that there are 121 Hams in the village of Vienna. Wow!

WB6QEM writes that he, too, owns a Ten Tec rig and is really in love with it. Jim says that it "packs" nicely when camping and puts out an FB signal on 40 using a ten foot high dipole! Once Jim even got a 599 report from a station 400 miles away who was running 500 watts (more about the Ten Tec later).

WB8JIX has quite a track record. All due to George's efforts and NRI's instruction:

April 1970	Third Radiotelephone
January 1971	First Radiotelephone
March 1971	Novice Amateur
August 1971	Advanced Amateur

George says, "Just passed another milestone – got my Advanced class amateur ticket. Would like to extend my thanks to NRI for helping. . ." You're welcome, George, and that's quite a record!

Back in August, Bill Boyer, W3AMG and his YML dropped by the office for an eyeball

QSO. Bill lives up in York, Pa., and hangs out on six using a Communicator III. Every year four radio clubs up in that area have a hamfest (16th annual this year), and Bill wanted me to come up for it. I couldn't make it, so he sent a program of the event to me to show me what I'd missed and it sure looks like a lot of fun. They took in over $4,500 in admissions and gave away prizes amounting to over $600. I should have been there!

Bill, WA3AFI, phoned from Pennsylvania the other day and we had a nice chat. He needed some specs for the Conar scope probe set and fortunately I was able to give them to him. Bill works 80 CW and maybe one of these days I'll be able to raise him with the QRPP rig. I've been trying, you know.

As a matter of fact, I went out the other day and bought the Ten Tec antenna tuner (AC-5) and QRP SWR indicator (AC4) to *really* tune up the rig. So far I have had two contacts for a *total* distance of 122.5 miles on 40 meters. It's fun, but gee it sure would be nice to get a *little* dx out of the rig. After what I have read about QRP, I feel like I must be doing something wrong.

Received too late to get in last month's column was some very interesting information from Gene, WAØEMH, concerning the SX28 receiver and its derivation. Gene says the SX28 started out as a military AN/ARR-7 which came out in the spring of 1945. Gene uses one with his Communications course 2E26 rig and says that the combo makes a real fine cw rig for standby use. He also sent along copies of the manuals for the AN/ARR-7 (which looks *nothing* like any SX28 I ever saw!) which I would be happy to forward to the first two people who write and claim them. Thanks anyway, Gene, but I don't need them.

I guess that's about it for now, gang. We only have one Ham Ad this time, and I'm not even sure the sender is a Ham. But who cares? Make use of the free service, guys, and have a very Merry Christmas!

Vy 73 – Ted – K4MKX

HAM AD

SELL: Heath IG-57A Sweep/Marker Generator – perfect working condition, four months old. Will take best offer! Paul Stanton, Box 20193, Phoenix, AZ, 85036

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Meet Andrew Jobbagy . . .

. . . President-Elect of NRIAA

Andrew J. Jobbagy, your President-elect of the NRI Alumni Association for 1972, was born on May 26, 1908 in Ramsey, Michigan. He received his elementary education in Hungary during World War II and later returned to the United States to finish high school in Flint, Michigan.

In 1927 he decided to become an on-ship radio operator and enrolled in NRI under Mr. J. E. Smith, Sr. After completing the NRI Radio Operator Course in 1928, he entered Loomis Radio College in Washington, D.C., where he learned about television when television was only broadcasting across the room. This electronics training created a new interest in amateur radio and soon Andy was the possessor of amateur license W8DKF.

About that time the depression came along, dampening every hope Andy had of becoming an on-ship radio operator. His challenge switched to servicing televisions and auto radios to bring order out of chaos.

Later Andy attended the Flint Community Junior College night classes on television repair. William DeJenko, instructor, became a very good friend and on numerous occasions helped the Saginaw Valley Chapter solve electronics problems.

Andy has been a member of long standing in the Alumni Association, following the progress of Lou Menne, Ted Rose, and Tom Nolan as Executive Secretary of NRIAA. He has also held all of the Saginaw Valley Chapter positions, including six terms as President.

One of the best positions that Andy held in the Saginaw Valley Chapter was that of publicity director. People still telephone or write to ask for advice with an electronics problem. Andy encourages these people to bring their problems, solved or unsolved, to a meeting so other NRIAA members can exchange ideas on it.

As a traveler, Andy Jobbagy has been a Goodwill Ambassador to various other chapters, including Detroit, San Antonio, and San Francisco. Through correspondence he has made friends with other NRI graduates in places as far away as South Africa and Ghana. Mrs. Jobbagy has always encouraged her husband's interest in NRI and in the NRI Alumni Association. (Editor's Note: She also cooks a Hungarian meal fit for a king as well as a president.)

And The New Vice-Presidents . . .

Your Vice-Presidents for the coming year are:

Mr. Charles L. Traham, Norfolk, Virginia
Mr. John Rote, Fairmont, West Virginia
Mr. William A. Simms, Tucson, Arizona
Mr. Andrew V. Perry, Brooklyn, New York

Good luck, gentlemen, in your new jobs!

• • •

Alumni News

James Wheeler . . . . President
Robert Bonge . . . . Vice-Pres.
Graham Boyd . . . . Vice-Pres.
Br. Bernard Frey . . . . Vice-Pres.
Thomas Schnader . . . . Vice-Pres.
T. F. Nolan, Jr. . . . . Exec. Sec.

DETROIT Chapter Emphasizes Troubleshooting

Fifteen members came to the September 10 meeting of the Detroit Chapter. Several of the members reported on a session on troubleshooting that was conducted by a local radio supply company. The Chapter's emphasis on troubleshooting was continued when members revitalized a radio oscillator by using the signal generator. They also disassembled and cleaned a TV tuner.

Besides carrying out regular business, the

Chapter welcomed three visitors: Mr. Alex Hill, Mr. John Rappa, and Mr. Elmer Rose. Everyone hopes these gentlemen will decide to join the Chapter.

Three films were shown that everyone seemed to enjoy. Also, the Chapter is anxious for Mr. Nolan's visit in October, and Mr. Ray Berus announced that he expects to visit the Los Angeles Chapter soon.

The Chapter is anticipating a very active and informative year with a beginning like this!

FLINT-SAGINAW VALLEY Chapter Stays Up-to-Date on the Latest Models

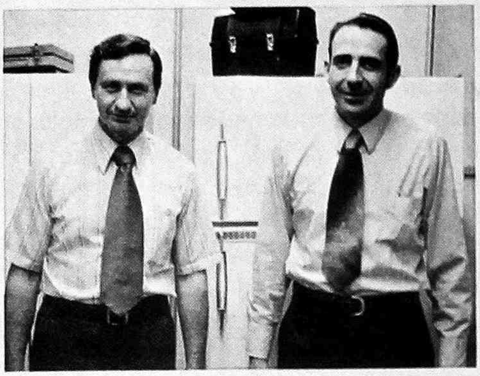
The July meeting of the Flint-Saginaw Valley Chapter was held at the Sheridan Hotel. Mr. John Gilbert, a factory field representative for Magnavox TV, conducted a two-day factory service training clinic. Mr. Gilbert gave a very good lecture on the new receivers and the problems that could arise.

Also in July the Chapter members attended a show put on by RCA to introduce their new TV models.

The Chapter gained one new member in July, Mr. D. Olney White from Yale, Michigan. Mr. White has an FCC Commercial License and will be able to communicate over the air waves with the Chapter.

PITTSBURGH Chapter Has Two Good Speakers

At the September 2 meeting of the Pittsburgh Chapter, Mr. Leuthold, an RCA field technician coordinator, and



Mr. Leuthold (left) and Mr. Strazza (right) spoke at a meeting of the Pittsburgh Chapter.

Mr. Leonard Strazza, service manager for Hamberg Brothers, gave a detailed technical presentation on the new 1972 RCA products including the color receiver chassis CTC54. They described the new remote-controlled, electronically tuned tuner, which has no wafer switches and very few components.

The Chapter hopes to have speakers from Zenith and General Electric for future meetings.

It is with deep regret that the Pittsburgh Chapter reports the deaths of Mr. Howard Tate and Mr. Clement McKelvey. Mr. Tate was elected National Vice-President in 1962. In 1969 he moved to Lexington, Kentucky where he was residing at the time of his death, suddenly, on Sunday, August 22, 1971.

He was a charter member of the Alumni Association in 1953, Treasurer in 1954-1955, Director in 1957, and Vice-President in 1959 and 1960. He was Chairman in 1961 and 1962 and Corresponding Secretary from 1963 to 1968, at which time he moved to Lexington, Kentucky.

Mr. Clement McKelvey was an honorary member of the Pittsburgh Chapter. He was an instructor of electronics at a local trade school and conducted a number of instructive programs for the members of the Pittsburgh Chapter.

The Pittsburgh Chapter will miss both of these good members.

SAN ANTONIO Chapter Continues Good Programs

Members at the August meeting of the San Antonio Chapter saw an excellent demonstration given by Mr. Tom Meir on the use of the B&K Analyst in the repair of television sets. Mr. Meir is an electrical engineer currently employed by Jim Rivet, owner and operator of Rivet's TV. Tom gave a very instructive program; he really knows theory.

A little service note from Earnest Hudson: When a TV has no raster and the B+ boost voltage is reduced to the set's B+ reading, open the wire connecting to the yoke and turn the set on. If the yoke is the culprit, B+ boost voltage will be restored.

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DIRECTORY OF CHAPTERS

CHAMBERSBURG (CUMBERLAND VALLEY) CHAPTER meets 8 p.m. 2nd Tuesday of each month at Bob Erford's Radio-TV Service Shop, Chambersburg, Pa. Chairman: Gerald Strite, RR1, Chambersburg, Pa.

DETROIT CHAPTER meets 8 p.m., 2nd Friday of each month at St. Andrews Hall, 431 E. Congress St., Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Mich. 841-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 7:30 p.m., 2nd Wednesday of each month at Chairman Andrew Jobbagy's shop, G-5507 S. Saginaw Rd., Flint, Mich.

LOS ANGELES CHAPTER meets 8 p.m., third Friday of each month at Graham D. Boyd's TV Shop, 1223 N. Vermont Ave., Los Angeles, Calif., 662-3759.

NEW YORK CITY CHAPTER meets 8:30 p.m. 1st and 3rd Tuesday of each month at 218 E. 5th St., New York City. Chairman: Samuel Antman, 1669 45th St., Brooklyn, N.Y.

NORTH JERSEY CHAPTER meets 8 p.m., last Friday of each month at The Players Club, Washington Square. Chairman: George Stoll, 10 Jefferson Avenue, Kearney, N.J.

PHILADELPHIA-CAMDEN CHAPTER meets 8 p.m., 4th Monday of each month at K of C Hall, Tulip and Tyson Sts., Philadelphia. Chairman: John Pirrung, 2923 Longshore, Philadelphia, Pa.

PITTSBURGH CHAPTER meets 8 p.m., 1st Thursday of each month in the basement of the U.P. Church of Verona, Pa., corner of South Ave. & 2nd St. Chairman: Tom Schnader, RFD 3, Irwin, Pa.

SAN ANTONIO (ALAMO) CHAPTER meets 7 p.m., 4th Friday of each month at Alamo Heights Christian Church Scout House, 350 Primrose St., 6500 block of N. New Braunfels St. (3 blocks north of Austin Hwy.), San Antonio. Chairman: Joe R. Garcia, 8026 Cinch, San Antonio, Tex., 694-3461.

SAN FRANCISCO CHAPTER meets 8 p.m., 2nd Wednesday of each month at the home of J. Arthur Ragsdale, 1526 27th Ave., San Francisco. Chairman: Isaiah Randolph, 60 Santa Fe Ave., San Francisco, Calif.

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8 p.m., last Wednesday of each month at the home of Chairman John Alves, 57 Allen Boulevard, Swansea, Massachusetts.

SPRINGFIELD (MASS.) CHAPTER meets 7 p.m., 2nd Saturday of each month at the shop of Norman Charest, 74 Redfern Dr., Springfield; 4th Saturday at the shop of Chairman Al Dorman, 6 Forest Lane, Simsbury, Conn.

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