503 CODE OSCILLATOR

3rd KIT

1964

Graymark®
ELECTRONICS

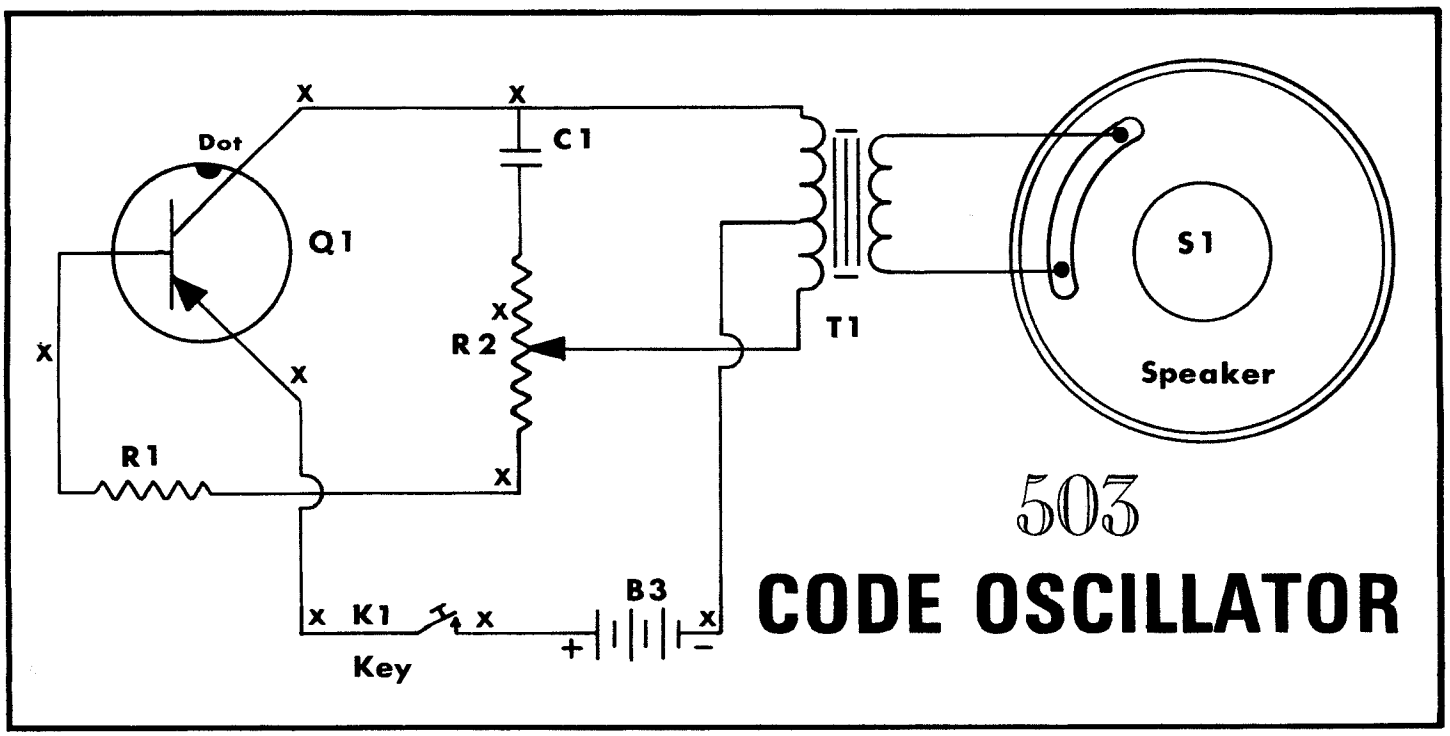
INTRODUCTION

You have chosen an excellent project which will help you get started in the space-age of ELECTRONICS. Great opportunities exist in this fast growing field, both in the form of a vocation as well as a hobby. You will find the study of electronics and the construction of this project interesting and a fascinating experience.

There is at present, a revolution in the electronics industry: that of converting from electron tubes to transistors. You, as a student, are a part of this exciting age. Your understanding of transistor operation will make you a valuable person in the field of electronics. There is a demand for people who have a desire to learn more in this lucrative field.

This portable transistorized oscillator makes an ideal project for learning the International Morse Code. Under FCC regulations, to be eligible to receive an amateur license, you must be able to send and receive code. The novice license requires a speed of five words per minute and the general license requires thirteen words per minute. The International Morse Code and practice hints are listed on pages 12 and 13 of this booklet.

503 CODE OSCILLATOR



PROGRESS CHART

The progress chart allows you to keep your own record of progress on this project. DO NOT proceed to the next experiment until the previous one has been graded and initialed by your instructor.

STUDENT'S INITIALS	DATE		STEPS OF PROCEDURE	GRADE	TEACHER'S INITIALS
		A	Inventory		
		B	Soldering Experiment		
		C	Breadboard Experiment		
		D	Oscillator Experiment		
		E	External Speaker Experiment		
		F	Signal Generator Experiments		
		G	Burglar Alarm Experiment		
		H	Code Oscillator Experiment		
		I	Circuit Board Construction		
		J	Performance Test		

PARTS LIST
503 CODE OSCILLATOR

____	P-1	Plastic Case	____	B-1 Battery holder
____	P-2	Printed Circuit Board	____	Spade lug (2)
____	C-1	Capacitor, disc. .01	____	Tacks 1/2" long (9)
____	R-1	Resistor, 1800 ohms	____	Parallel cord, stranded
____	R-2	Potentiometer, 10K	____	Hook-up wire 5" long
____	Q-1	Transistor		
____	T-1	Transformer		
____	S-1	Speaker, 8 ohms		
____	K-1	Key, telegraph		
____	K-2	Knob, round, black		

RP 1971

INSTRUCTION GUIDE

On the next several pages you will find directions and circuit explanations on how to construct the 503 CODE OSCILLATOR. Remember: This is only a guide to understanding electronics, the biggest challenge is up to YOU. You must ask questions about circuit theory that you do not understand and develop the curiosity to seek the answers from the many reference books available to you in your school and public libraries. Do you accept the challenge?

(A) INVENTORY

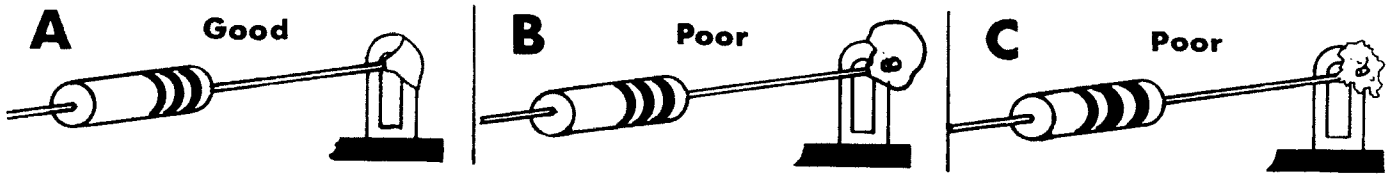
On page three you will find a complete parts list for the 503. Be sure you can correctly name and identify each component as you are checking them against the parts list. Take your time and watch for both quality and quantity. When the parts inventory is complete, have your instructor initial your progress chart.

(B) SOLDERING EXPERIMENT

Before you actually start construction on the 503 you will have to pass a soldering test. Almost 70% of all problems on the 503 are directly related to poor soldering. All soldering joints must be clean and shiny; rough volcanic appearing joints will cause trouble and almost always mean service problems.

- Soldering iron between 40-100 watts
- Well tinned soldering tip
- Use only ROSIN CORE SOLDER
- Use NO separate flax or paste
- Keep the tip clean
- Tin all leads

From your instructor obtain several used components and wire for which to practice making proper soldering joints. When you have completed four perfect solder joints, have your instructor grade and initial your progress chart.



Above are three examples of solder joints. Study them and see if you can make your joints look like Example A. Example B is a poor solder joint caused by too much solder and a dirty terminal and lead. Example C is also a poor solder joint caused by either not enough heat, or the lead was moved before the solder solidified.

_____ **1.** Make sure that the leads and connecting terminals are clean.
_____ **2.** Tin the end of the wire or component lead.
_____ **3.** Bend the lead around the terminal to form a mechanical connection.
_____ **4.** Place the soldering tip against the opposite side of the lead.
_____ **5.** Place the solder against the wire lead and terminal, NOT against the soldering iron. The solder should immediately melt and flow over the entire connection. Do not use too much solder; use only enough to cover the joint.

6. Do not move the lead until the solder has SOLIDIFIED (hardened). If the wire moves, it will form a crystallized joint that has a dull, grey color which will cause service problems.
7. A good solder joint has just enough solder to adequately cover the entire connection and has a smooth bright appearance.
8. Test the solder joint by moving the wire lead to see if it is properly connected. It should not move within the solder joint.

© BREADBOARD EXPERIMENT

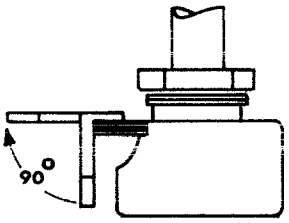
In the modern Electronic Industry, development normally begins as a concept or problem in the minds of Design and Development Engineers. At an early stage, experiments must begin with actual components working on an experimental layout called a breadboard.

Purpose

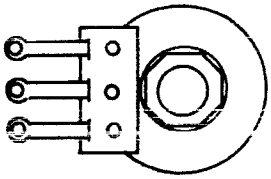
This experiment will illustrate the relationship between components and schematic symbols. It will effectively demonstrate the "how and why" of the 503 Oscillator circuit.

Procedure

1. Follow the instructions on page 15 under the title of "Oscillator Breadboard," in preparing the schematic diagram.
2. After the schematic diagram has been stapled onto a wood base, place tacks in the large X's on the diagram. Use the tacks provided. Hammer the tacks about halfway into the wood base.
3. Tin, coat with solder, the tops of all tacks. IMPORTANT: Use only ROSIN CORE SOLDER on this project or any other electronic project.
4. With the hookup wire provided, connect a wire between tacks 1 and 2. Connect another wire between tacks 3 and 4. See illustration on page 15.
5. Solder the 1800 ohm resistor (R-1) in place. Do not cut the leads on this or any other component, as these leads will be unsoldered at a later date. Then the rough soldered ends will be trimmed off, and the components mounted on the printed circuit board.
6. The potentiometer (R-2) has three terminals that must be bent upward 90°. See illustration. Solder one terminal to the tack on the schematic diagram.

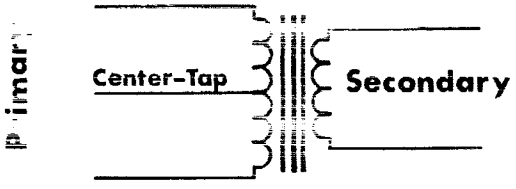


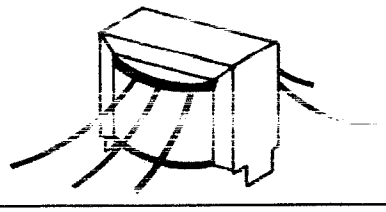
Side View



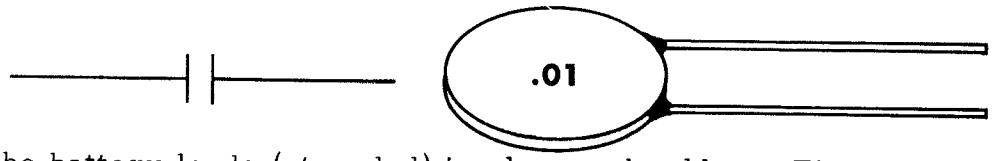
Top View

7. Mount transformer (T-1) by making small slits with a knife through the paper and into the wood. (Be careful!) Force the legs of the transformer through these slits.
8. Hook up the wires from the primary side of the transformer. The primary side of this transformer is the side that is center-tapped. See illustration.





_____ **9.** Position and solder capacitor (C-1) into the circuit. Capacitor (C-1) is a disc ceramic type. On this type of capacitor it is not necessary to observe polarity. Therefore, a disc ceramic capacitor may be connected into the circuit in either direction.

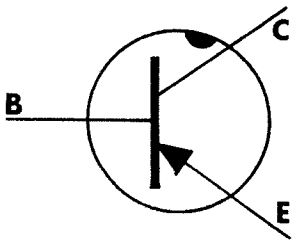


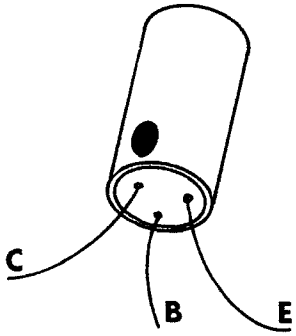
_____ **10.** Position the battery leads (stranded) in place and solder. The black lead on all battery connectors represents the negative polarity. Use extreme CAUTION in soldering the wire leads onto the battery holder. Avoid excessive heat.

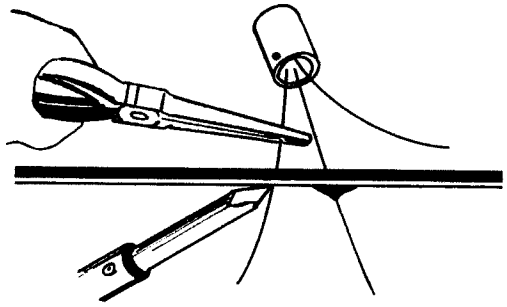
_____ **11.** Strip and tin the leads on both ends of the parallel cord. Solder the leads of one end of the cord to the tacks on the schematic that represents the symbol for key. Attach the other end of the cord to the knurled binding post on the key.

_____ **12.** Connect the secondary leads of the transformer to the speaker (S-1). CAUTION: Do not overheat the soldering terminals on the speaker.

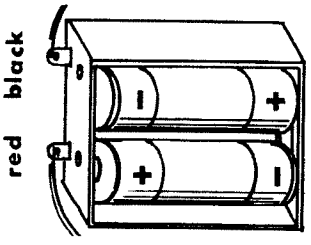
_____ **13.** You are now ready to connect the transistor (Q-1) into the circuit. Use extreme care in working with this component, as it is the heart of the 503 Oscillator. Turn the transistor upside down and connect the collector lead to the tack marked, "dot." See the illustration below for identification of the transistor leads and soldering techniques. IMPORTANT: Use a heat sink when soldering or unsoldering the transistor leads. This can be done by holding a pair of long-nose pliers on the lead between the body of the transistor and the connection being soldered.

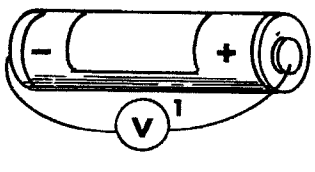


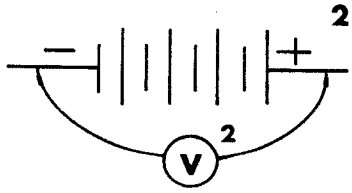




_____ **14.** Before connecting the batteries into the battery holder, have your instructor approve your breadboard wiring. Be sure the batteries are placed into the holder in the correct position. See illustration for the correct battery polarity. With a DC voltmeter, measure the voltage across each battery separately. Measure the voltage across both batteries in series. Record your answer in the space provided.







1 _____

2 _____

_____ **15.** When you have completed construction of the 503 Oscillator on the breadboard and it is in a working condition, have your instructor grade and initial your progress chart.

(D) OSCILLATOR EXPERIMENT

Purpose

This experiment will demonstrate the function of each component in the 503 Oscillator circuit.

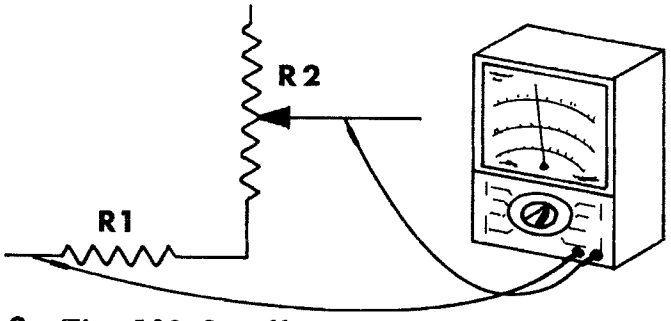
Procedure

_____ **1.** Close the key and listen to the quality of the tone. Now, unsolder one lead of capacitor C-1. Closing the key again, do you notice any change in the quality of the tone? The function of capacitor C-1 is to bypass some of the higher frequencies from reaching the transformer and speaker. This gives the oscillator a pleasant bass tone. You can experiment with different values of capacitance and observe the effect they have on the tone quality.

_____ **2.** Resistors R-1 and R-2 are connected in series. Their main function is to establish bias on the base of transistor Q-1. By adjusting the potentiometer R-2, you can change the bias resistance on the base. This change in base bias will change the frequency of the oscillator.

Unsolder the primary lead that connects to R-2 and solder it in series with resistor R-1. Now, close the key and listen to the tone. Adjust the potentiometer. What effect does it have on the tone of the oscillator?

The main function of resistor R-2 is to change the frequency of the oscillator by varying the forward bias resistance to the base of transistor Q-1.



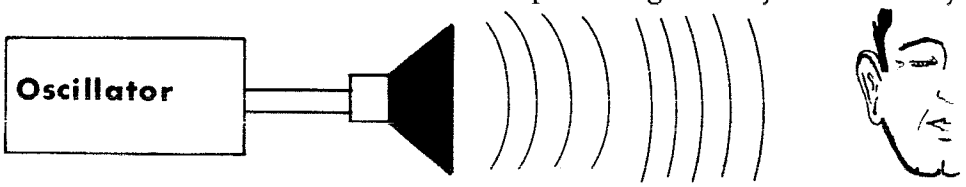
Resolder the primary lead of the transformer to R-2. With an ohm-meter, measure the resistance of R-1 and R-2 together. Record the highest and lowest value of resistance of this circuit.

Lowest _____

Highest _____

_____ **3.** The 503 Oscillator produces an electrical current that oscillates within the audio frequency. The function of the speaker is to convert this electrical energy into a mechanical motion. This mechanical motion produces air waves which your ears convert into sound.

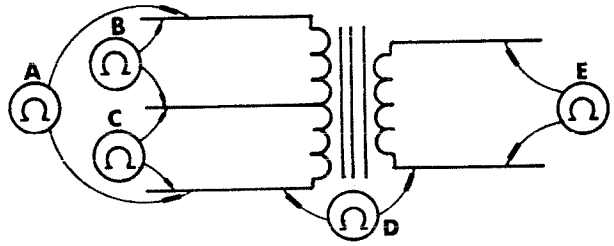
Unsolder one of the secondary leads of the transformer from the speaker. Close the key; the oscillator is now operating. Do you hear anything? Why?



_____ **4.** Transformer (T-1) performs two functions in the 503 oscillator circuit. First, it serves as an important part of the circuit by linking the emitter-base circuit with the emitter-collector circuit. At the same time, the induction of the primary coil plays an important part in the blocking circuit. Second, it matches the impedance of the oscillator to impedance of the speaker. When the impedance of the primary and secondary of the transformer are properly matched, a greater transfer of energy will occur.

Disconnect the speaker from the secondary side of the transformer and connect it to the primary side. Close the key. Does any sound come from the speaker? Why?

Temporarily unsolder all leads on the primary and secondary. With an ohmmeter check the continuity of the primary and secondary winding of the transformer. Measure and record the resistance (ohms) of the transformer as illustrated below. Record your readings in the space provided.



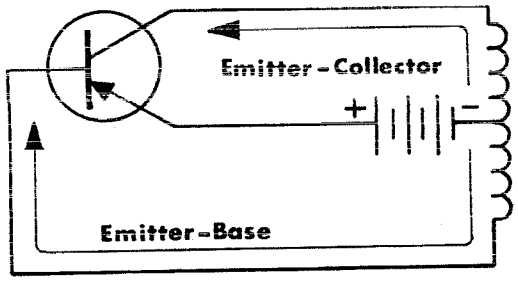
A = _____
B = _____
C = _____
D = _____
E = _____

_____ **5.** The transistor (Q-1) is the heart of the 503 Oscillator. A full explanation of how transistors operate is beyond the scope of this booklet. If you are interested in learning more about the function of transistors, check the reference books in your school or public library.

Transistor (Q-1) has two basic circuits, the emitter-collector and the emitter-base. A small flow of current in the emitter-base circuit will control a larger current flow in the emitter-collector circuit. This large current flow in the emitter-collector circuit induces an E. M. F. in the primary winding of the transformer. This E. M. F. increases to a point where it blocks the current flowing in the emitter-base circuit.

When current in the emitter-base circuit stops flowing, it acts like a switch and prevents current from flowing in the emitter-collector circuit. Thus, when current stops flowing in this circuit, the induced E. M. F. of the primary which caused a blocking action on the current flow in the emitter-base circuit, disappears. Current in the emitter-base circuit is now able to flow and the entire cycle starts over again.

The foregoing explanation is made in a slow motion manner. But in reality, the motion is made in extremely rapid cycles, maintaining a constant audio frequency. By means of the key, you are able to control the oscillating current by opening or closing the circuit.



Wave Form

_____ **6.** When you have completed the above experiments have your instructor grade and initial your progress chart.

Conclusion

The 503 Oscillator consists of a number of different components, each performing an important function in the operation of the total circuit.

(E) EXTERNAL SPEAKER EXPERIMENT

Purpose

To experiment and understand the function of the speaker in the 503 Oscillator circuit. Also, to learn the basic parts of a permanent magnet speaker.

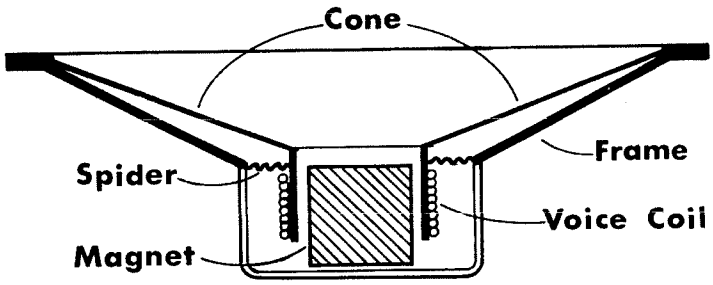
Procedure

_____ **1.** What is sound? Clap your hands together. What do you hear? Definition of sound: The vibration of a body at a rate which can be heard by human ears, the extreme limits of human hearing are about 20 to 20,000 cycles per second. Sound can travel through any medium which possesses the ability to vibrate; these vibrations are called sound waves.

_____ **2.** Place one finger lightly on the cone of the speaker and close the key. Do you feel a vibration? Use extreme care in performing this experiment so as not to damage the speaker cone.

_____ **3.** Listed below are the main parts that make up the 503 speaker. The 503 speaker is a miniature permanent magnet type.

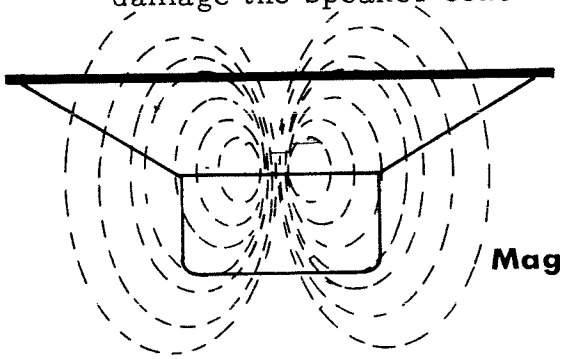
- Cone (paper)
- Permanent Magnet (P. M.)
- Voice Coil (8 ohms)
- Spider
- Frame (steel)

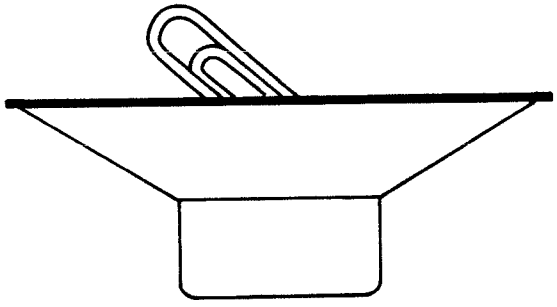


Using the illustration of a cut-away speaker, try to identify the parts of the 503 speaker.

_____ **4.** The main function of the cone is to move or vibrate the air in front of it. Therefore, if the cone could be made to vibrate at a certain rate (frequency), it would cause the air in front of it to vibrate at the same rate. Your ears then convert the vibrating air movements into sound.
With one finger, press lightly in the center of the cone. Notice that the cone moves in and out.

_____ **5.** The permanent magnet is another important part of the speaker. Its main function is to produce a nonfluctuating magnetic field. With a paper clip held lightly at one end, bring it near the center of the speaker. What does this experiment prove? Use caution in performing this experiment so as not to damage the speaker cone.



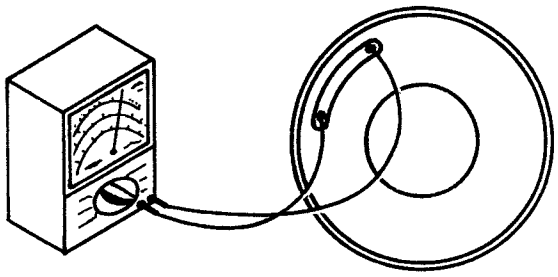


_____ **6.** The voice coil, along with the permanent magnet, are the two parts of the speaker that cause the cone to vibrate. Unsolder the two leads from the speaker. With clip leads, connect the battery (3 volts) across the speaker terminals. These terminals connect to the voice coil inside the speaker. Notice that the cone moves in only one direction. Now reverse the leads on the speaker. What direction does the cone move now? Why?

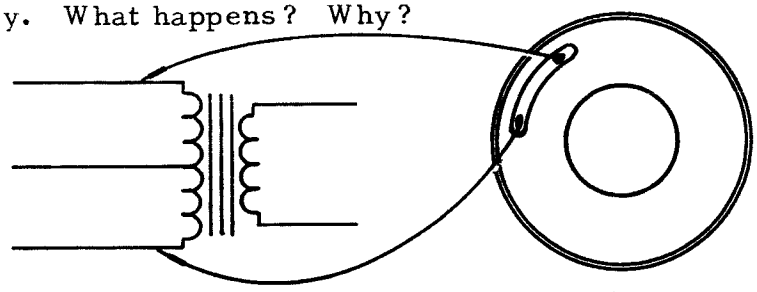
Explanation: One end of the coil form the voice coil is wound on is connected to the center of the cone. The other end fits over one end of the permanent magnet. When current passes through the voice coil, it sets up a magnetic field that has North and South poles. When the polarity of these two magnets, the permanent and electromagnet, are the same, they will repel one another. When the polarity is opposite, they will attract one another. It is this attracting and repelling that causes the cone to move. Take two magnets and experiment with like and unlike poles. What happens when the like poles of two magnets are brought near one another?

_____ **7.** With an Ohm meter check the continuity of the voice coil of the speaker. Also, measure the resistance of the coil and record your answer in the space provided.

_____



_____ **8.** The transformer serves two functions in the circuit. One, it is part of the Oscillator, and two, it matches the impedance of the oscillator and speaker. When the impedance (measured in ohms) of the voice coil matches the impedance of the oscillator, a more efficient transfer of energy takes place. With clip leads, connect the speaker across the primary of the transformer. Close the key. What happens? Why?



_____ **9.** The 503 speaker and cabinet can be used as an external or extension speaker for an intercom, radio, or amplifier. CAUTION: The wattage rating on this speaker is only .1 of a watt. Keep Vol. turned down!

_____ **10.** When you have completed the above experiments, have your instructor grade and initial your progress chart.

Conclusion

A loudspeaker is a device for converting electrical energy into mechanical energy. This mechanical energy causes the cone to vibrate and produce sound waves.

(F) SIGNAL GENERATOR EXPERIMENT

Purpose

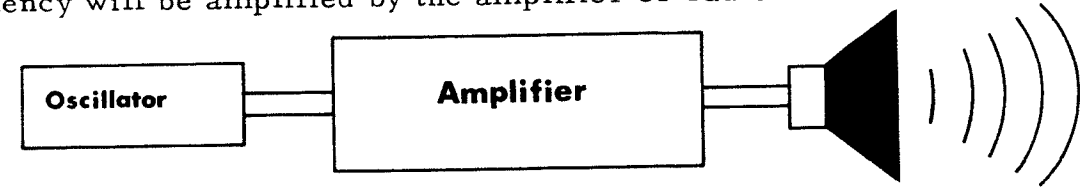
To use the 503 Oscillator as a signal generator. This experiment will allow you to gain useful knowledge about the use of signal generators in testing and servicing radios, amplifiers, speakers, etc. The 503 Oscillator produces a frequency that corresponds to an audio sound wave. The extreme limits of an audible frequency varies with the individual and is from about 20 cycles to about 20,000 cycles per second.

Procedure

_____ **1.** Unsolder one of the secondary leads of the transformer from the speaker.

_____ **2.** Connect clip leads from the secondary of the transformer to the input of an audio amplifier or the audio section of a radio.

_____ **3.** By closing the key, the oscillator produces an audio frequency. This frequency will be amplified by the amplifier or radio. See illustration below.



_____ **4.** If the amplifier or audio section of the radio fail to produce a tone from the speaker, use the 503 Oscillator as a servicing device to determine which section of the amplifier or radio is defective.

_____ **5.** Place the leads of the signal generator across the speaker terminals. If the speaker produces a tone, you know it is in operating condition. Next connect one lead to common ground and the other lead to the grid of the output tube. If the output tube is operating, a tone should be heard from the speaker.

_____ **6.** Continue to check each section of the amplifier or audio section of the radio until the defective stage is located.

_____ **7.** When you have completed this experiment be sure to have your instructor grade and initial your progress chart.

Conclusion

The signal generator feature of the 503 Oscillator can be used as a valuable test instrument in checking and servicing radios, amplifiers, speakers, etc.

(G) ELECTRONIC BURGLAR ALARM EXPERIMENT

Purpose

To illustrate the use of the 503 oscillator as a signaling device.

Procedure

_____ **1.** The alarm device described here is just one of several ways of using the 503 oscillator.

_____ **2.** Construct a switch similar to the one illustrated below. This switch is made from a piece of sheet metal bent 180°. There are two soldering terminals on the switch. Terminal number one must be insulated from the metal by using insulating washers. Connect two wires from the tacks marked "key" on the schematic to the terminals on the switch.

_____ **3.** Place the switch under a rug in front of a doorway. When someone enters and steps on the rug, it causes the switch to make contact and turns on the oscillator.

(H) CODE OSCILLATOR EXPERIMENT

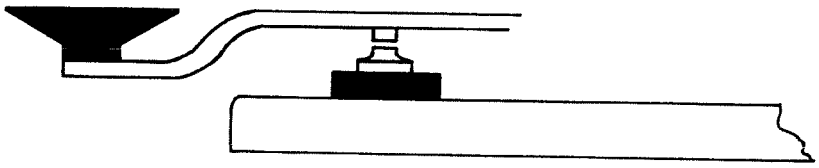
Purpose

To use the 503 Oscillator as a practice code oscillator for learning the Morse Code. Under Federal Communications Commission (FCC) regulations, an applicant for an Amateur Radio license must be able to send and receive code to be eligible for a license. The NOVICE license requires a speed of 5 words per minute and the GENERAL license requires thirteen words per minute.

Procedure

_____ **1.** Resolder the wires from the secondary of the transformer to the speaker terminals. Make sure all other wiring is complete according to the schematic.

_____ **2.** Adjust the spring tension on the key so that the spacing between the contacts is approximately 1/16".



_____ **3.** By pressing the key you will hear a long or short tone, depending upon the length of time the key is depressed. Thus, by long or short tones, you are able to send messages.

_____ **4.** A complete Morse Code table is located on page 13. Listed below are some helpful study hints.

_____ **5.** The long "dah" of the Morse Code should be 3 times as long as the short "dit." The interval between "dah" and "dit" is equal to the length of "dit." Combinations of "dahs" and "dits" make a letter. The interval between letters is the same length of time as one "dah."

_____ **6.** When you have completed the above experiment be sure to have your instructor grade and initial your progress chart.

Conclusion

Memorization of the International Morse Code and the use of the 503 Code Oscillator allows you to communicate with another individual through the use of a combination of long and short sounds. But more important, it is a stepping stone to the exciting field of Amateur Radio and a broader understanding of electronics.

NOTE → STUDY HINTS

1. Study only two or three characters at a time.
2. Memorize each character by sound so that you do not have to hesitate in recognizing it.
3. Do not think about speed at first, concentrate on memorization of the characters.
4. Many short code practice sessions are better than a smaller number of long sessions.
5. Whenever possible, study with a friend. Learn the code by listening to it.
6. There is no shortcut to learning the code. The exact time required varies with the individual's ability and how regular he practices.
7. For beginners, adjust the key contact spacing about 1/16 inch apart.
8. Maintain uniform spacing in each character.

INTERNATIONAL MORSE CODE

A	·−	U	··−
B	−···	V	···−
C	−·−·	W	·−−
D	−··	X	−··−
E	·	Y	−·−−
F	··−·	Z	−−··
G	−−·	1	·−−−−
H	····	2	··−−−
I	··	3	···−−
J	·−−−	4	····−
K	−·−	5	·····
L	·−··	6	−····
M	−−	7	−−···
N	−·	8	−−−··
O	−−−	9	−−−−·
P	·−−··	0	−−−−−
Q	−−·−	Period	·−·−·−
R	·−·	Comma	−−··−−
S	···	Question Mark	··−−··
T	−		

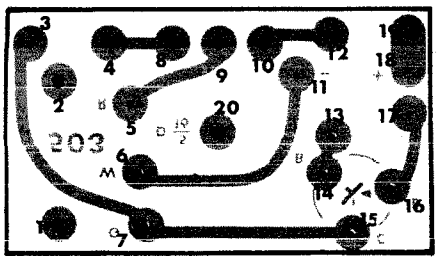
In learning the Continental International Code you should think of it in terms of a language of sounds. It is nothing more than another way of conveying information. The code consists of short sounds called dots and long sounds called dashes. The dash is three times as long as the short dot. When heard over the air the dots sound like "dit" and the dashes sound like "dah." For example, "A" (·−) sounds like didah and "B" (−···) sounds like dahdididit. (Notice that the "T" is dropped in combination.)

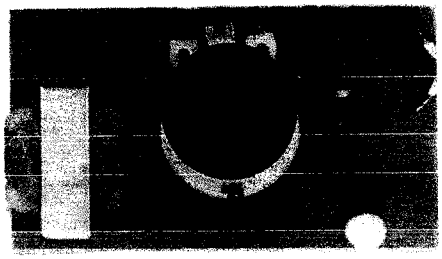
① CIRCUIT BOARD CONSTRUCTION

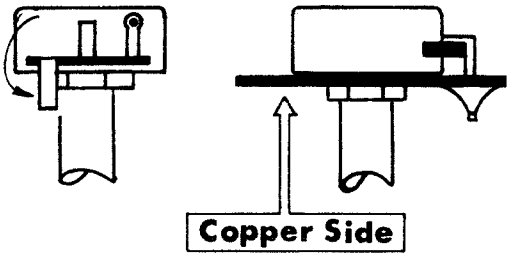
Drilling the printed circuit board must be accomplished with the drill press at the highest speed available. A hand drill may also be used. Examine the first several holes drilled to make sure that the board is not chipping on the under side. Drill with the COPPER SIDE UP. Chipping is a sign of too much pressure, too slow a drill speed or a broken drill.

PROCEDURE:

_____ **1.** Drill all the holes with a #56 drill.
_____ **2.** Re-drill holes: 1, 2, 8, 9 and 10 with a #32 drill.
_____ **3.** Drill hole #20 with a 5/16 inch drill.
_____ **4.** You are now ready to mount the components onto the circuit board. Unsolder one component at a time from the breadboard and place it on the







NON-COPPER side of the circuit board as indicated in the following instructions. Bend the leads to hold them firmly in place. Important: Clean the copper circuit lines to a bright shiny surface with steel wool. Be sure that all the steel wool strands are removed after cleaning the board. Sometimes these small and almost invisible strands of wire will short out the circuit.

_____ **5.** Mount the transformer (T-1) through holes 1 and 2. Position the transformer so that the secondary leads are at the end of the circuit board.

_____ **6.** Position the primary leads of the transformer through holes 5, 6 and 7. The red lead through hole number 5 and the green lead through hole number 7. The center tap lead goes through hole number 6.

_____ **7.** Mount the .5K ohm potentiometer (volume control) on the P. C. board. The potentiometer has three terminals which must be trimmed and bent downward 180° so that they, the terminals, point toward the end of the control shaft. (see illustrations) The trimmed terminals go through the holes marked 8, 9 and 10.

_____ **8.** Position the disc capacitor (C-1) through holes 3 and 4 and solder in place.

_____ **9.** Mount resistor (R-1) through holes 12 and 13 and solder in place.

_____ **10.** Position transistor (Q-1) through the correct holes on the circuit board. Review step number 13 on page 6 for correct lead identification and soldering procedure. Be sure to use a heat sink. The dot goes through hole number 15.

_____ **11.** Insert and solder the leads of one end of the parallel cord through holes number 17 and number 19.

_____ **12.** Connect and solder the battery leads in the correct holes on the board. Remember red is positive and black is negative.

_____ **13.** Mount and position speaker (S-1) inside the plastic case with the voice coil terminals at the top.

_____ **14.** Insert the shaft of the potentiometer through the hole in the case from the inside and secure with a washer and hex nut. Position the circuit board with the transformer at the top. Attach the knob to the shaft, secure with the set screw.

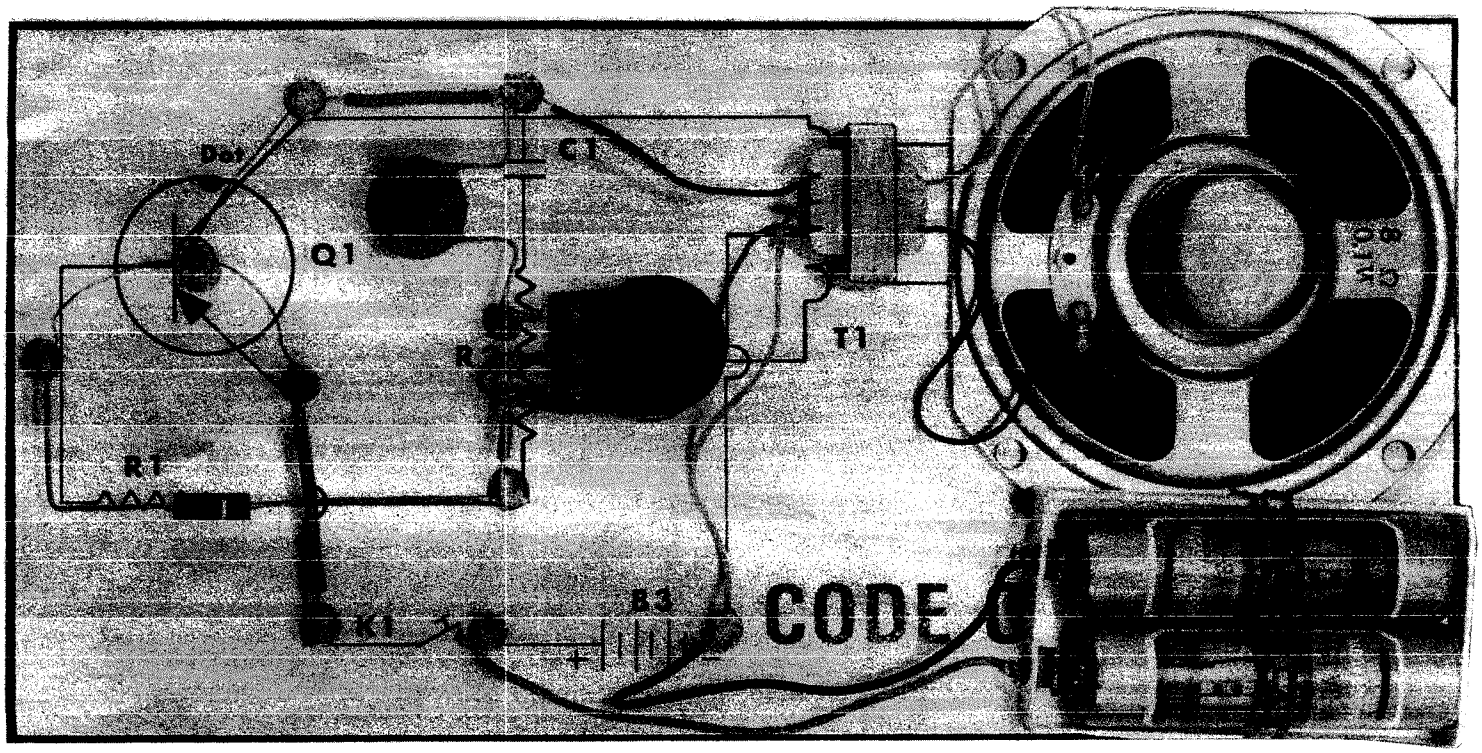
_____ **15.** Solder the wires from the secondary of the transformer to the speaker terminals.

_____ **16.** Position the battery holder and batteries at the bottom of the case.

_____ **17.** Insert the free end of the parallel cord through one of the large holes in the back panel. Position and secure the back panel to the case with the 4 screws provided.

_____ **18.** Connect the two spade lugs onto the free end of the parallel cord. Attach these lugs to the binding post on the key.

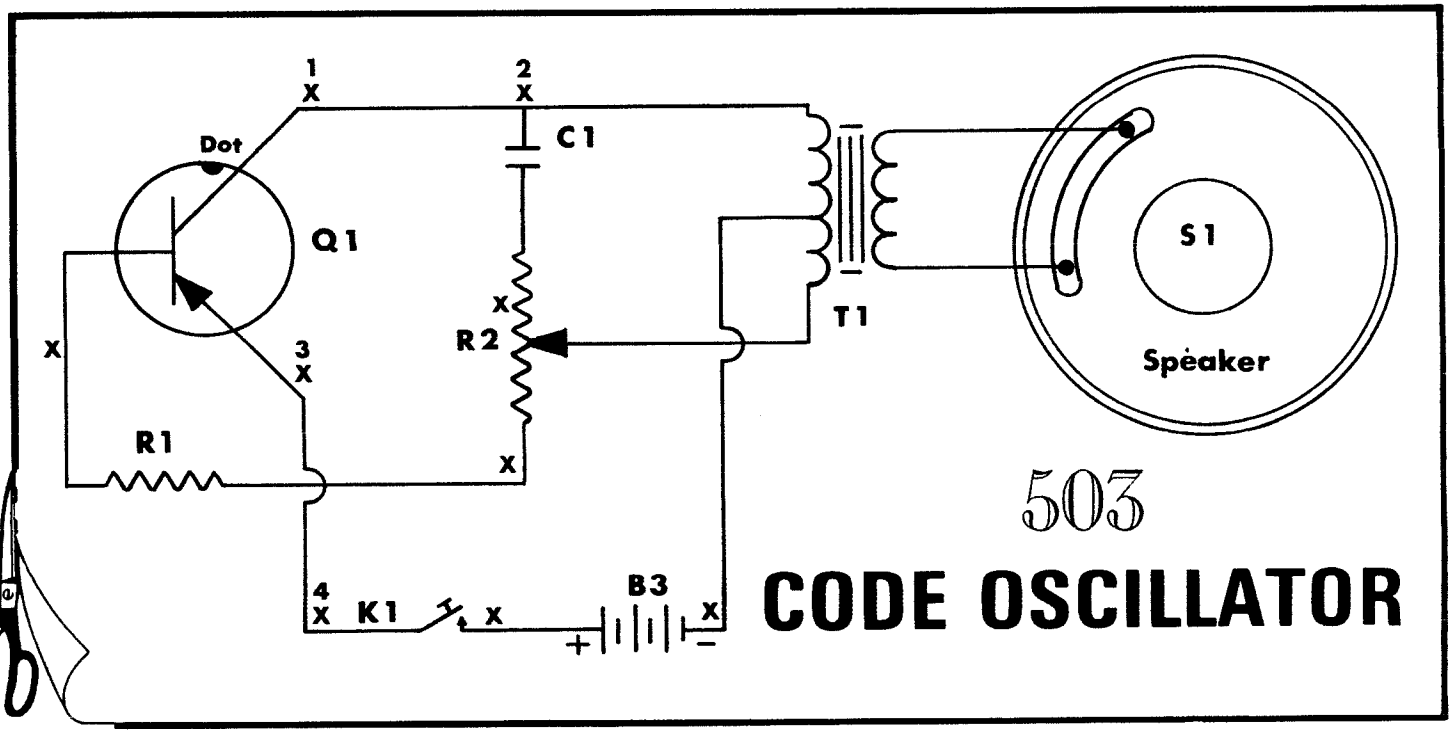
_____ **19.** You have now completed the construction of the printed circuit board and mounting of all parts in the plastic case. Have your instructor grade and initial your progress chart.



CODE OSCILLATOR BREADBOARD

You may use the breadboard schematic that appears below in one of two ways.

1. Cut the schematic diagram out and attach it to a wood base using either glue or staples.
2. Trace the schematic diagram onto another piece of paper and then attach the tracing onto the base. This method does not damage the booklet.



Graymark

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