CASSETTE PLAYER KIT

MODEL AK-200

Assembly and Instruction Manual

SECTION 1 - PARTS LIST

RESISTORS

Qty	Symbol	Value	Color Code	Part #
☐ 2	R1, R2	390Ω 5% 1/4W	orange-white-brown-gold	133900
☐ 1	R7	1kΩ 5% 1/4W	brown-black-red-gold	141000
☐ 1	R8	8.2kΩ 5% 1/4W	gray-red-red-gold	148200
☐ 2	R3, R6	12kΩ 5% 1/4W	brown-red-orange-gold	151200
☐ 2	R4, R5	180kΩ 5% 1/4W	brown-gray-yellow-gold	161800
☐ 1	VR2	1kΩ	Potentiometer	191411
☐ 1	VR1	50kΩ	Potentiometer	191533

CAPACITORS

Qty	Symbol	Value	Description	Part #
☐ 3	C5, C6, C16	0.001μF (102)	Discap	231035
☐ 2	C20, C21	0.005μF (502)	Discap	235016
☐ 4	C1, C2, C18, C19	0.02μF (203)	Discap	242010
☐ 1	C17	0.1μF (104)	Discap	251010
☐ 4	C3, C4, C10, C13	10μF	Electrolytic (Lytic)	271045
☐ 4	C9, C12, C14, C15	100μF	Electrolytic (Lytic)	281024
☐ 1	C11	220μF	Electrolytic (Lytic)	282223

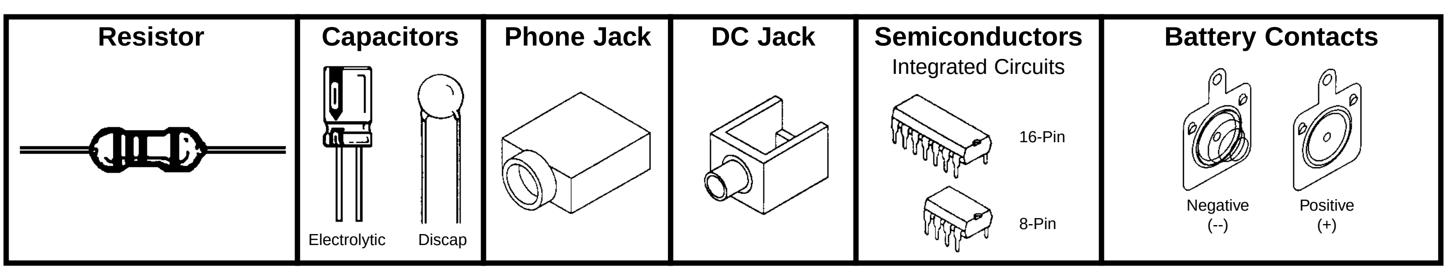
SEMICONDUCTORS

Qty	Symbol	Value	Description	Part #
☐ 1	IC2	AN6650	Integrated Circuit	336650
☐ 1	IC1	AN7108	Integrated Circuit	337108

MISCELLANEOUS

Qty	Description	Part #	Qty	Description	Part #
☐ 1	PC Board	517020	☐ 1	Stereo Headset	629202
☐ 1	Battery Contact +	610815	☐ 3	Screw 7/32”	643150
☐ 1	Battery Contact –	610816	☐ 1	Screw 3/32”	643155
☐ 1	DC Jack 2.5mm	621013	☐ 2	Screw 1” Black	643196
☐ 1	Phone Jack 3.5mm	621015	☐ 1	Socket IC 8-pin	664008
☐ 1	Top Plate	623106	☐ 1	Socket IC 16-pin	664016
☐ 1	Bottom Plate	623204	☐ 1	Manual	753260
☐ 1	Thumbwheel	626006	☐ 1	Wire 1.6” Red	825320
☐ 1	Tape Deck	626007	☐ 2	Wire 2.8” Black	834510
☐ 1	Lid	626008	☐ 4	Wire 2.8” Red	834522
☐ 1	Clip	626009	☐ 1	Wire 1.2” Bare	845400
☐ 1	Battery Cover	626011	☐ 1	Solder	9ST4

PARTS IDENTIFICATION



SECTION 2 - INTRODUCTION

It is the goal of this project to educate the builder in the principles of magnetic tape recording and to teach the skills necessary to build this kit. The AK-200 Stereo Cassette Player is divided into two parts - Motion Control and Audio. This manual contains:

1) Detailed assembly instructions for each part. For ease of assembly, both parts are built at the same time.

2) Specifications and a test procedure for each part coupled with a troubleshooting guide for each test.

3) An explanation for each part (Theory of Operation).

In addition, specifications and a schematic diagram are given. A Quiz (with answers) is included to demonstrate the overall knowledge gained by building this kit.

SECTION 3 - GENERAL OVERVIEW

The main features of the Model AK-200 Stereo Cassette Player are:

a) Plays 4 track 0.15” tape cassettes. Two tracks are played at the same time. When the cassette reaches the end of the tape, it can be turned over and reinserted to play the remaining two tracks.

b) Drives stereo headphones.

c) Runs on two “AA” size batteries or an external 3 volt power supply via an AC adapter (not included).

Figure 3-1 shows a block diagram of the cassette player. No mechanical assembly is required on the tape deck. It comes completely pre-assembled and pre-aligned. You need only to build the PC board, wire it to the tape deck, insert the batteries and the tape cassette and you are ready for your favorite kind of music.

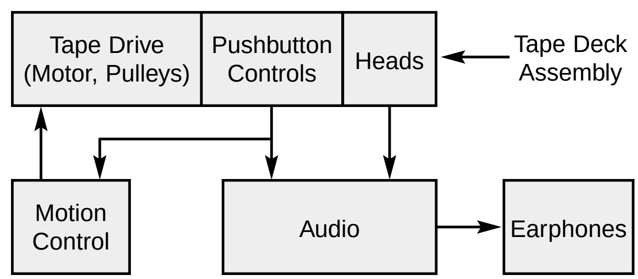


Figure 3-1

TAPE DECK ASSEMBLY

See Figures 5-3 and 5-5.

TapeDeck Assembly consists of three main parts:

1) **Tape Drive Train** - The Tape Drive Train contains a motor which turns at a constant speed. The motor is connected by a drive belt to a large pulley which turns the capstan. When the AK-200 is in Play Mode, that is, with the Play button pushed, the pinch roller clamps the tape against the capstan. This causes the tape to be pulled across the head at a constant speed.

   At the start of tape play, the tape is winding onto an empty take-up reel. As the tape builds up on the take-up reel, it takes more tape to go once around the reel. Since the tape is moving at a constant speed, the take-up reel must turn faster at the start of tape play than at the end. A belt from the capstan drives a small pulley to turn the take-up reel. This pulley, if it were rigidly connected to the take-up reel, would drive the reel much faster than required even at the start of tape play. A slip clutch is therefore inserted between the small pulley and the take-up reel to allow the reel to turn at the different speeds required to wind up the tape.

2) **Push-button Controls** - Three push-buttons control tape play. Pushing any button places the AK-200 in that mode until another button is pushed.

   Play - Pushing the PLAY button closes the ON switch which supplies power the motor, motion control and audio amplifier electronics. In addition, the head and tape guide are moved into contact with the tape and the pinch roller clamps the tape against the capstan. You may then listen to the tape through the stereo headphones.

Fast Forward - Pushing FAST FORWARD closes the ON switch which, as in PLAY mode, supplies power to the motor, motion control and audio amplifier electronics. The head, tape guide and pinch roller are not moved into contact with the tape. The tape is therefore driven solely by the take-up reel. Since there is little drag, there is little or no slippage in the slip clutch and the tape moves forward at high speed. FAST FORWARD is used to space forward to a particular section of tape or, after using the tape over, for rewinding.

Stop - Pushing STOP takes the AK-200 out of PLAY or FAST FORWARD mode and stops the tape. After opening the lid, STOP may be used again to pop up the tape cassette for easy removal.

3) **Heads** - The purpose of the heads is to convert the magnetization on the tape into an electrical signal. The AK-200 has two playback heads. Each head plays one of the four tape tracks when the cassette is inserted one way and another track when the tape is turned over.

MOTION CONTROL

When the two 1.5V batteries are new, they put out their full 3V rated voltage. In time, as the batteries are used, this voltage drops. If the battery voltage was applied directly to the motor, the motor would slow down as the battery voltage dropped. Tape speed would then decrease, causing music to be off key and voices to sound too low. The Motion Control Section is therefore used to keep a constant voltage on the motor and insure uniform tape speed.

AUDIO AMPLIFIERS

The audio amplifier section consists of two separate amplifiers, one for each head, each amplifier driving one of the stereo headphone speakers. The gain of both amplifiers is set by the thumbwheel on the side of the tape player. The amplitude on the low frequencies from the head is lower than that of the high frequencies. The frequency response of the amplifiers is therefore set to emphasize the lows and thus equalize the overall response.

CONSTRUCTION

Introduction

The most important factor in assembling your AK-200 Stereo Cassette Player Kit is good soldering techniques. Using the proper soldering iron is of prime importance. A small pencil type soldering iron of 25 - 40 watts is recommended. **The tip of the iron must be kept clean at all times and well tinned.**

Safety Procedures

- Wear eye protection when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it.
- **Do not hold solder in your mouth.** Solder contains lead and is a toxic substance. Wash your hands thoroughly after handling solder.
- Be sure that there is adequate ventilation present.

Assemble Components

In all of the following assembly steps, the components must be installed on the top side of the PC board unless otherwise indicated. The top legend shows where each component goes. The leads pass through the corresponding holes in the board and are soldered on the foil side.

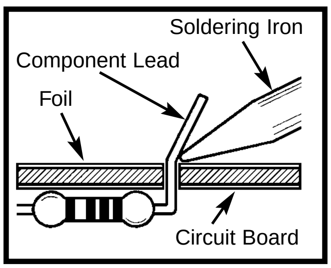
Use only rosin core solder of 63/37 alloy.

DO NOT USE ACID CORE SOLDER!

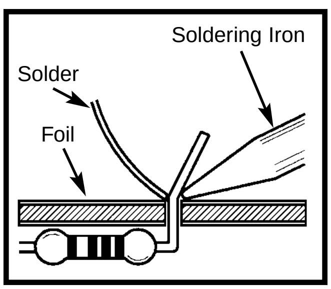
What Good Soldering Looks Like

A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

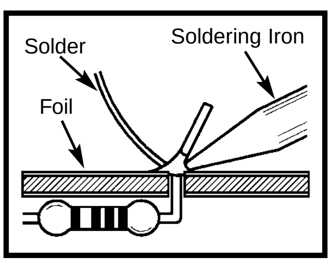
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



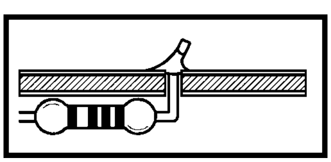
2. Apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.

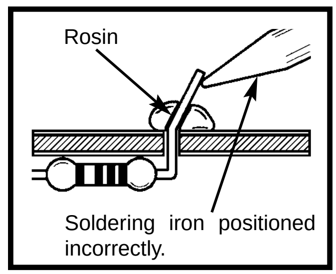


4. Here is what a good solder connection looks like.

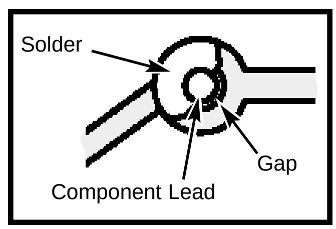


Types of Poor Soldering Connections

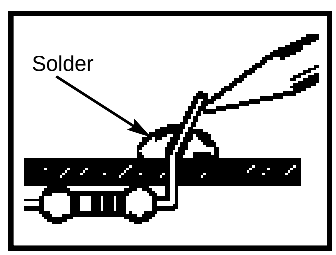
1. **Insufficient heat** - the solder will not flow onto the lead as shown.



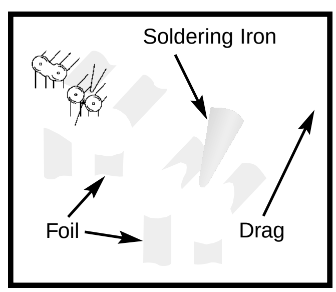
2. **Insufficient solder** - let the solder flow over the connection until it is covered. Use just enough solder to cover the connection.



3. **Excessive solder** - could make connections that you did not intend to between adjacent foil areas or terminals.



4. **Solder bridges** - occur when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder. To correct this, simply drag your soldering iron across the solder bridge as shown.



SECTION 5 - ASSEMBLY INSTRUCTIONS

TOOLS NEEDED: Small Blade Screwdriver, Phillips Screwdriver (small point size), Diagonal Cutters, Long Nose Pliers and a Soldering Iron (25 - 40 watts).

PC BOARD ASSEMBLY - Your kit may contain several extra capacitors and wires. Please disregard these parts.

Identify and install the following parts as shown in Figure 5-1. After soldering each part, place a check in the box provided.

Figure A

Use a discarded resistor lead for a jumper wire.

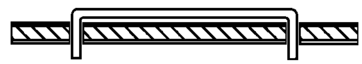
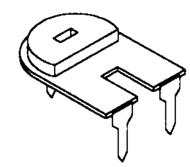


Figure B



- ☐ C6 - .001µF (102) Capacitor (Lay flat on board)
- ☐ C5 - .001µF (102) Capacitor (Lay flat on board)
- ☐ C3 - 10µF Lytic Capacitor (see Figure C)
- ☐ R1 - 390Ω 5% 1/4W Resistor (orange-white-brown-gold)
- ☐ C1 - .02µF (203) Capacitor
- ☐ R3 - 12kΩ 5% 1/4W Resistor (brown-red-orange-gold)
- ☐ R4 - 180kΩ 5% 1/4W Resistor (brown-gray-yellow-gold)
- ☐ C7 - Jumper Wire (see Figure A)
- ☐ C20 - .005µF (502) Capacitor (This location may not be marked on the PC board. Use the picture.)
- ☐ C8 - This is not used.
- ☐ VR2 - 1kΩ Potentiometer (see Figure B)
- ☐ R7 - 1kΩ 5% 1/4W Resistor (brown-black-red-gold)
- ☐ 8-pin IC Socket IC2 - AN6650 Integrated Circuit (see Figure D)
- ☐ C16 - .001µF (102) Capacitor
- ☐ C17 - .1µF (104) Capacitor
- ☐ R8 - 8.2kΩ 5% 1/4W Resistor (gray-red-red-gold)
- ☐ C11 - 220µF Lytic Capacitor (see Figure C)
- ☐ Jumper Wire (see Figure A)
- ☐ C12 - 100µF Lytic Capacitor (see Figure C)

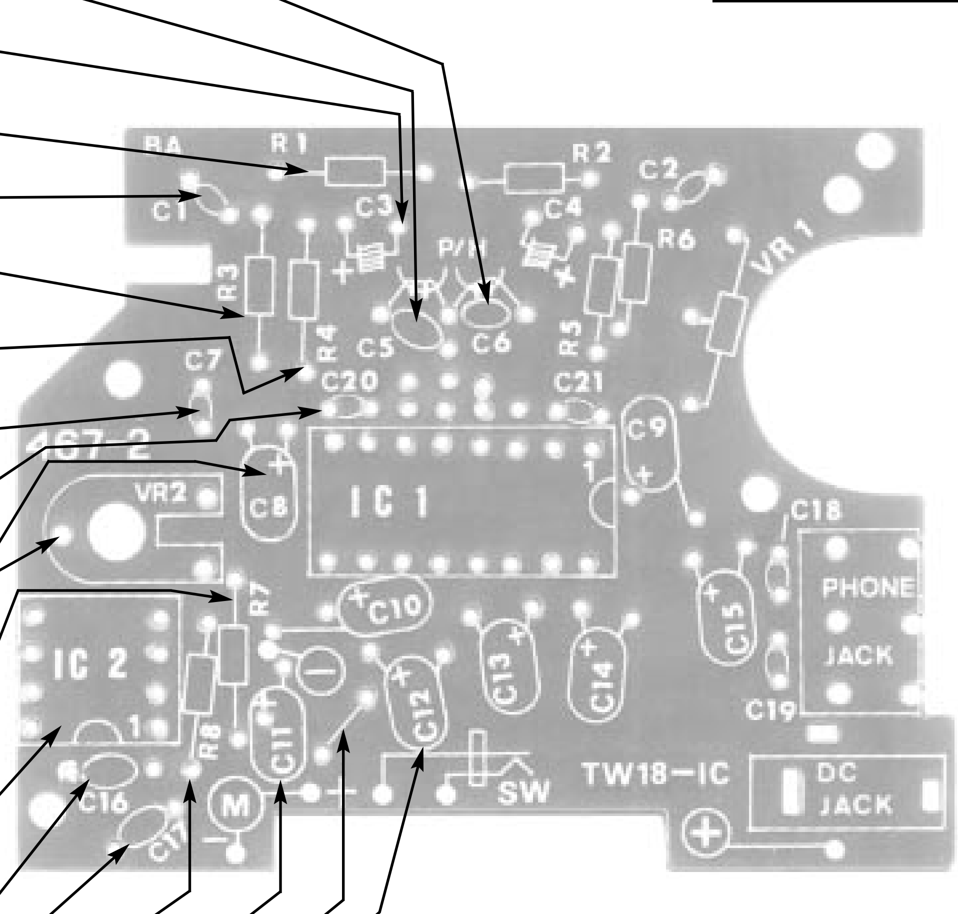
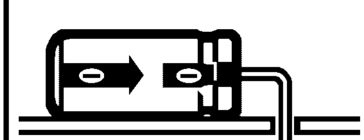
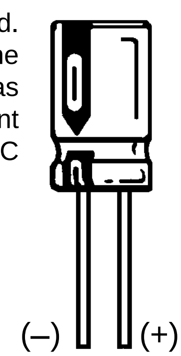


Figure C

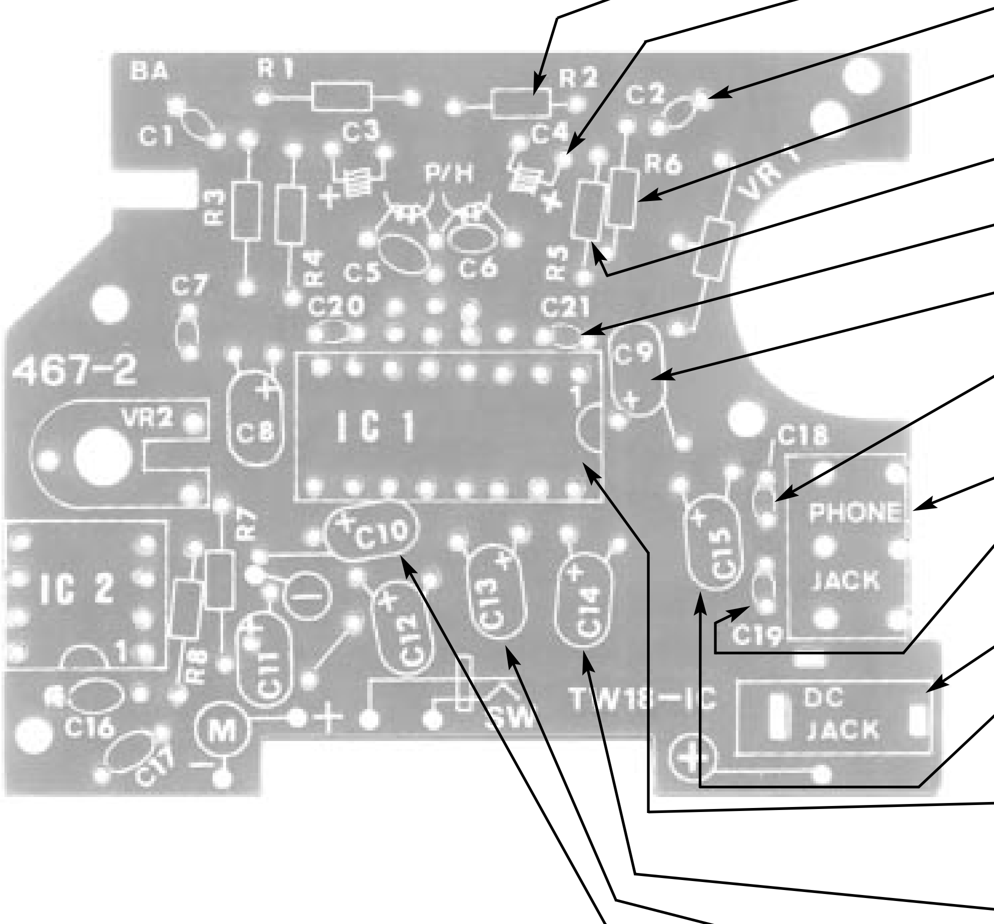
These capacitors are polarized. Be sure to mount them with the "+" lead in the correct hole as marked on the PC board. Mount the capacitor lying flat on the PC board as shown below.





ASSEMBLY CONTINUED

Identify and install the following parts as shown in Figure 5-2. After soldering each part, place a check in the box provided.



- ☐ R2 - 390Ω 5% 1/4W Resistor (orange-white-brown-gold)
- ☐ C4 - 10µF Lytic Capacitor (see Figure C)
- ☐ C2 - .02µF (203) Capacitor
- ☐ R6 - 12kΩ 5% 1/4W Resistor (brown-red-orange-gold)
- ☐ R5 - 180kΩ 5% 1/4W Resistor (brown-gray-yellow-gold)
- ☐ C21 - .005µF (502) Capacitor
- ☐ C9 - 100µF Lytic Capacitor (see Figure C)
- ☐ C18 - .02µF Capacitor (This location may not be marked on the PC board. Use the picture.)
- ☐ Phone Jack (see Figure E)
- ☐ C19 - .02µF Capacitor (This location may not be marked on the PC board. Use the picture.)
- ☐ DC Jack (see Figure F)
- ☐ C15 - 100µF Lytic Capacitor (see Figure C)
- ☐ 16-pin IC Socket
  IC1 - AN7108 Integrated Circuit (see Figure D)
- ☐ C14 - 100µF Lytic Capacitor (see Figure C)
- ☐ C13 - 10µF Lytic Capacitor (see Figure C)
- ☐ C10 - 10µF Lytic Capacitor (see Figure C)

Figure D

Insert the IC socket into the PC board with the notch in the direction shown on the top legend. Solder the IC socket into place. Insert the IC into the socket with the notch in the same direction as the notch on the socket.

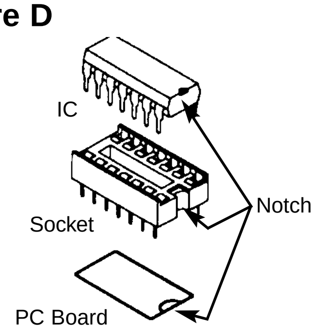


Figure E
Phone Jack

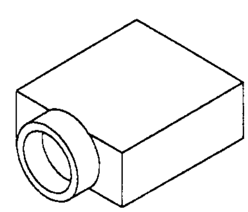
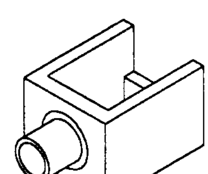


Figure F
DC Jack



TAPE DECK ASSEMBLY

☐ Solder two red 2.8” wires to the ON switch as shown in Figure 5-3.

☐ Mount the thumbwheel to pot VR1 as shown in Figure 5-4.

☐ See Figure 5-5. **PUSH THE POT TO THE RIGHT AGAINST THE PC BOARD** so that the thumbwheel will not hit the top or bottom plate when the unit is completely assembled. Then solder the pot in place as shown in Figure 5-5. It is helpful to Scotch® Tape VR1 in position leaving one or two terminals open to solder the remaining terminals.

☐ Solder two red 2.8” wires to the two head terminals and the PC board as shown in Figure 5-5. **NOTE:** The head may have only two terminals. If so, solder to those terminals.

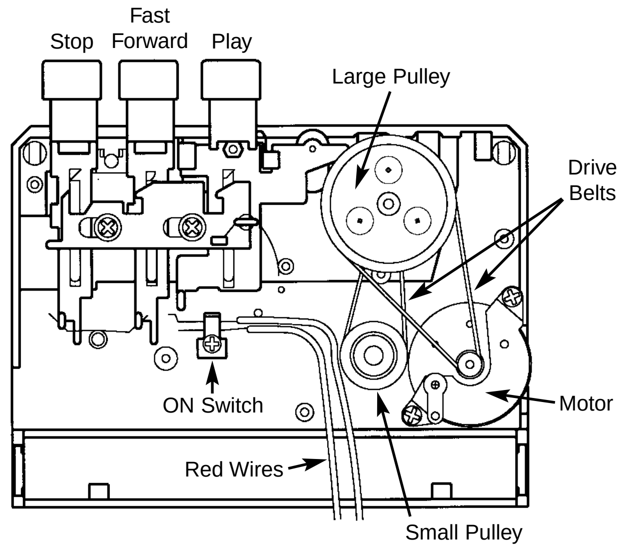


Figure 5-3

☐ Connect a 1.2” piece of bare wire to the two/four head terminals and the head common terminal as shown in Figure 5-5. Solder the wire to the two/four head terminals but not to the head common terminal.

☐ Solder one end of a 2.8” black wire, and the bare wire from the head, to the head common terminal. Solder the other end of the black wire to the PC board as shown in Figure 5-5.

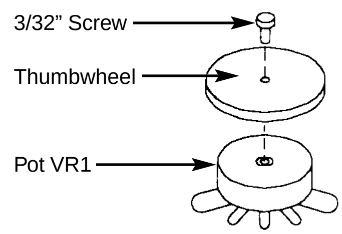


Figure 5-4

CONNECTING THE PC BOARD - See Figure 5-6. The wires connected to the PC board should be positioned so that they do not touch the pulleys or drive belts and do not interfere with the placement of the batteries.

☐ Fasten the PC board to the tape deck using three 7/32” screws as shown in Figure 5-6. Be sure the two wires from the ON switch are accessible at the right of the PC board.

☐ Insert the (+) and (--) battery terminals into their slots as shown in Figure 5-6.

☐ Solder the 1.6” red wire to the (+) battery terminal and the PC board as shown in Figure 5-6.

☐ If there are any wires already attached to the motor case terminal, remove them.

☐ Cut a black 2.8” piece of wire into two 1.4” pieces. Strip 1/8” of insulation off the new end of both wires. Solder one end of both 1.4” wires to the motor case terminal as shown in Figure 5-6.

☐ Solder the other end of one of the wires on the motor case terminal to the PC board as shown in Figure 5-6.

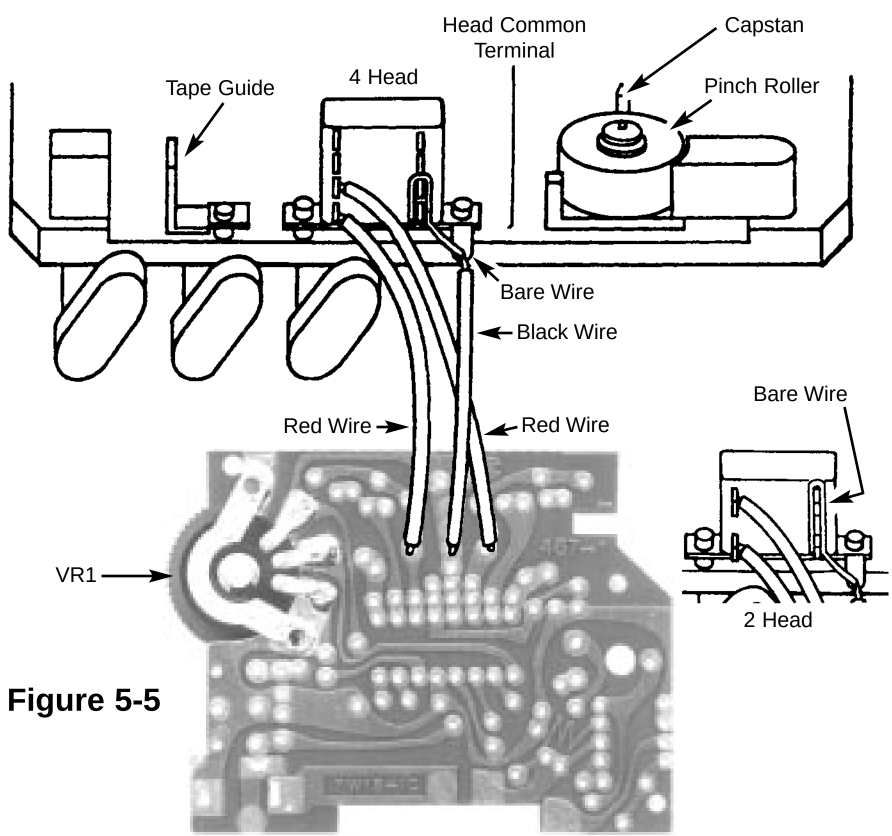


Figure 5-5

- ☐ Solder the other end of the remaining 1.4” wire on the motor case terminal to the (–) battery terminal as shown in Figure 5-6.
- ☐ Solder one end of the red 2.8” wires from the ON switch to point A on the PC board as shown in Figure 5-6.
- ☐ Solder the other red 2.8” wire from the ON switch and the red wire from the motor to point B on the PC board as shown in Figure 5-6.
- ☐ Solder the black wire from the motor to point C on the PC board as shown in Figure 5-6.

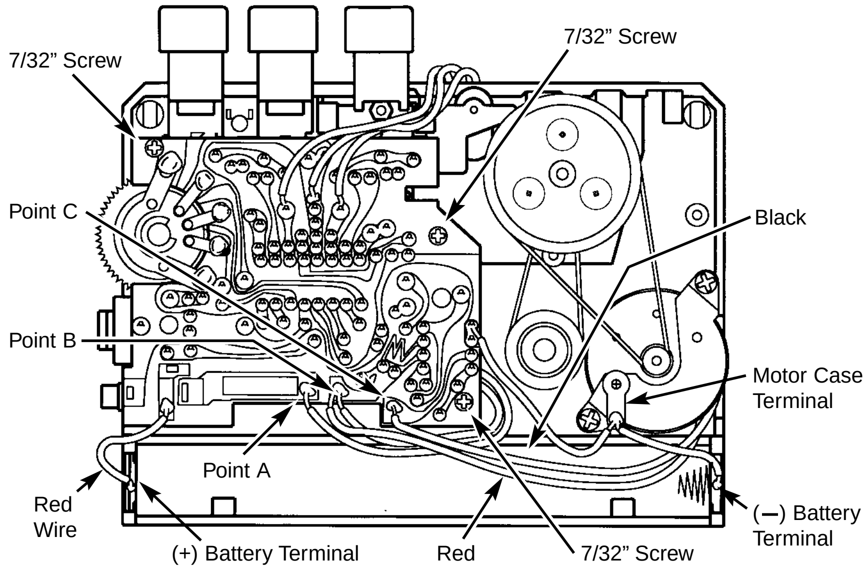
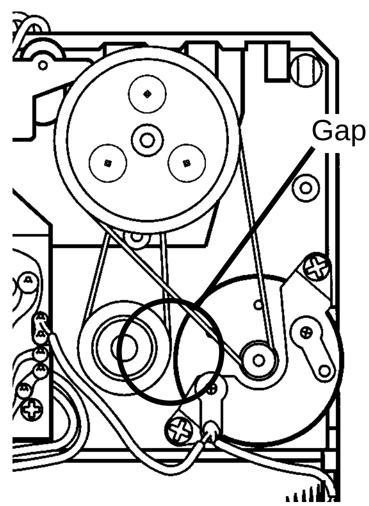


Figure 5-6

SECTION 6 - TEST PROCEDURE - MOTION CONTROL

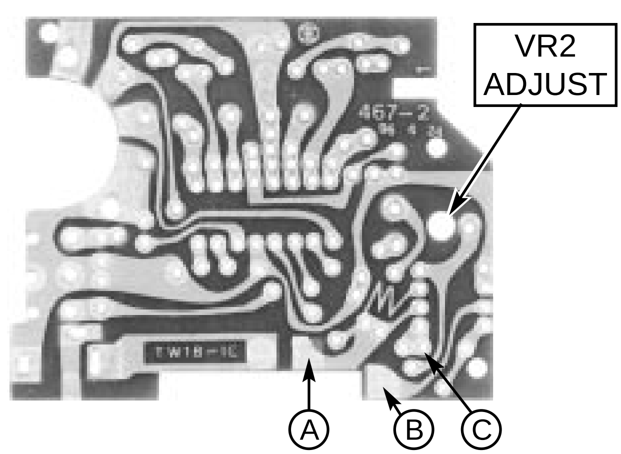
MOTOR SPEED TEST

1. Insert two “AA” size batteries into the battery compartment. See Figure 5-6 for polarity.
2. Set VR2 to midway between its two extremes.
3. Insert a tape cassette and push the PLAY button. If the tape runs out during testing, turn it over and play the other side. Do not perform the tests with the tape reels not moving.
4. Observe that the motor turns and that the tape moves across the head. If it does not:
   a) Check that the batteries are good.
   b) Check that both drive belts are seated correctly on their pulleys.
   c) Check that the wires to the PC board are wired as shown in Figures 5-3 and 5-6.
   d) Check that the ON switch closes when the PLAY button is pushed. See Figure 5-3.
   e) Check that IC2 is mounted with the notch as shown in Figure 5-1.
   f) Check the soldering at IC2. Be sure that there are no solder shorts between the pins.
   g) Check for a gap between the pulley and motor. If there is no gap, then loosen the screws mounting the motor and move it to the right (see Figure to the right).



5. Turn VR2 fully counter-clockwise. Observe that the motor turns faster. Turn VR2 fully clockwise. Observe that the motor turns slower. If either of these tests fail:
   a) Check the value of R7 and R8 as shown in Figure 5-1.
   b) Check the soldering around R7, R8, VR2 and IC2.
6. Reset VR2 to midway between its two extremes.
7. Tests 7 and 8 require a voltmeter. If you do not have a voltmeter, go on to test 9. Connect the voltmeter between point A (+ lead) and C (– lead) to measure the reference voltage (see Figure 6-1). It should be close to 1.3V. If it is not 1.3 + or –.05V:
   a) Check the values of R7 and R8.
   b) Check the soldering around R7, R8, VR2 and IC2.

Figure 6-1



8. Connect the voltmeter between points A (+ lead) and B (-- lead) to measure the motor voltage (see Figure 6-1). It should be approximately 1.8V. If it is not:

    a) Check the values of R7 and R8.

    b) Check the soldering around R7, R8, VR2 and IC2.

    c) Check that the motor is wired to the PC board as shown in Figure 5-6.

9. Push the FAST FORWARD button. Observe that the tape moves forward faster than when in PLAY mode. If it does not:

    a) Check the wiring to the ON switch.

    b) Check that the PC board does not interfere with the STOP button.

IMPORTANT: When using the PLAY, F.FWD, and STOP controls, be sure to push the button straight down. Pushing the button sideways can cause it to jam.

To repair a loose button on the cassette player, apply some glue on the sides of the button and slide it back over the control arm.

SECTION 7 - TEST PROCEDURE - AUDIO

Tests 3 through 7 require a voltmeter. If you do not have a voltmeter, skip these tests to go on to test 8.

AUDIO TESTS

See Figure 7-1 for test point connections.

1. Insert two “AA” size batteries into the battery compartment. See Figure 5-6 for polarity.

2. Insert a tape cassette and push the PLAY button. If the tape runs out during testing, turn it over and play the other side. Do not perform the tests with the tape reels not moving.

3. Connect a voltmeter between point A (+ lead) and point G (-- lead) to measure the input voltage. It should be around 3 volts. Record the input voltage: ________V.

4. Connect the voltmeter between point B (+ lead) and point G (-- lead) to measure the reference voltage. It should be 1/2 of the input voltage + or --0.2V. If it is not:

    a) Check the wiring between the ON switch and the PC board.

    b) Check that IC1 is mounted with the notch as shown in Figure 5-1.

    c) Check the soldering around IC1, R2, R3, VR1 & C9.

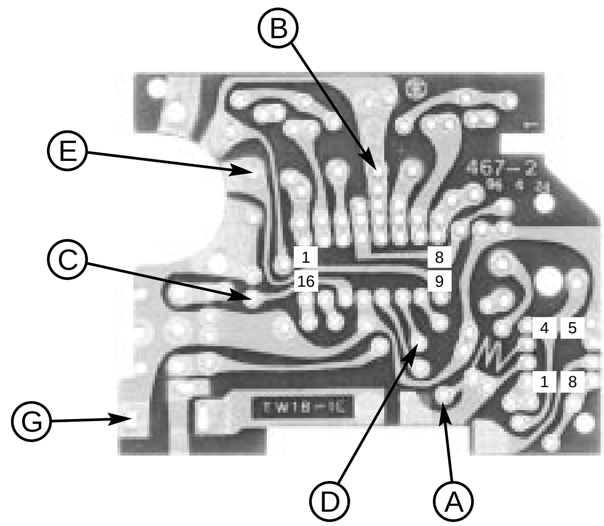


Figure 7-1

5. Connect the voltmeter between point C (+ lead) and point G (-- lead) to measure the driver DC output voltage (amplifier A, pin 14). It should be 1/2 the input voltage + or --.3V. If it is not:

    a) Check the soldering around IC1 and C15.

6. Connect the voltmeter between point D (+ lead) and point G (-- lead) to measure the driver DC output voltage (amplifier A, pin 14). It should be 1/2 the input voltage + or --3V. If it is not:

    a) Check the soldering around IC1 and IC2.

7. Connect the voltmeter between point E (+ lead) and point G (-- lead) to measure to volume control voltage to pin 9. Rotate the thumbwheel fully clockwise. The volume control voltage should be within 0.1V of the reference voltage measured in Step 4 on the previous page. Rotate the thumbwheel fully counter-clockwise. The volume control voltage should be less than 0.1V. If either of these tests fail:
   a) Check that the thumbwheel will turn about 240 degrees.
   b) Check the soldering around IC1, VR1, and C9.
   c) Check the value and soldering of R1 and R2.

8. Plug the stereo headset into the phone jack and listen to your tape. Check that the thumbwheel adjusts the playback volume. If it does not:
   a) Check that the head is wired to the PC board as shown in Figure 5-5.
   b) Check that all other wires are wired to the PC board as shown in Figure 5-6.
   c) Check that both drive belts are seated correctly on their pulleys.
   d) Check that the thumbwheel will turn about 240 degrees.
   e) Check the soldering around IC1, VR1 and C9.
   f) Check the value and soldering of R1 and R2.

9. Adjust VR2 so that the pitch and tempo of the music sound right. If it cannot be adjusted properly:
   a) Check that both drive belts are seated correctly on their pulleys.
   b) Check the soldering around IC2 and VR2.
   c) Check the value and soldering around R7 and R8.

SECTION 8 - FINAL ASSEMBLY

☐ Place the tape deck on the bottom plate. Be sure that the wires to the PC board do not touch the pulleys or drive belts and will not interfere with the batteries. Snap on the top plate and fasten with two 1” screws as shown in Figure 8-1.

☐ Place the clip over the three mounting holes in the top plate as shown in Figure 8-1. Press down to snap the clip onto the top plate.

☐ If not already in place, snap the lid onto the bottom plate as shown in Figure 8-2.

☐ Put two “AA” size batteries (alkaline works best) into the AK-200. The polarity is shown on the case. Then, slide the battery cover in place as shown in Figure 8-3.

Figure 8-1

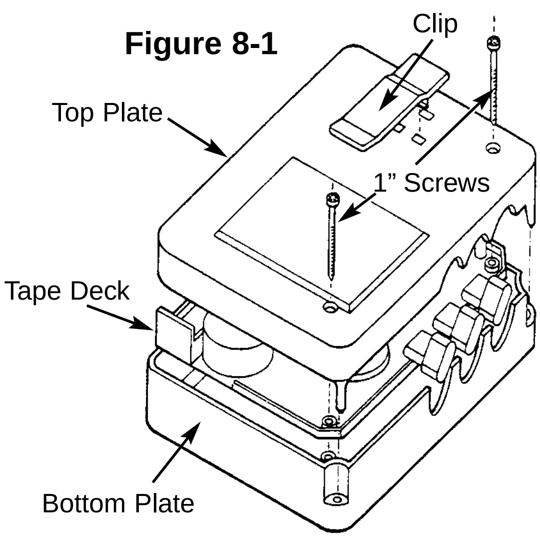


Figure 8-2

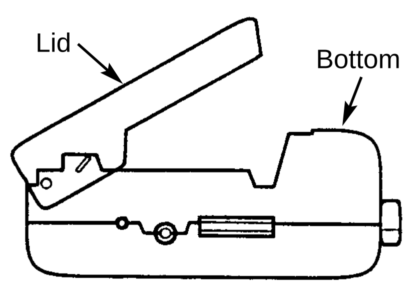
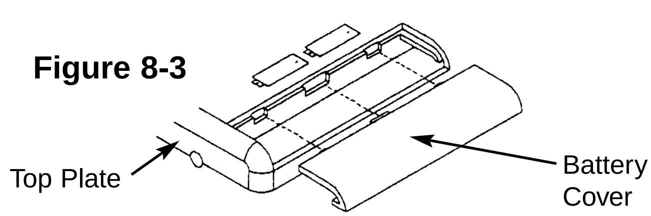


Figure 8-3



SECTION 9 - SPECIFICATIONS

Tests 3 through 7 require a voltmeter. If you do not have a voltmeter, skip these tests and go on to test 8.

INPUT VOLTAGE RANGE: 2.2V - 3.5V

TAPE SPEED: 1 7/8 IPS

AMPLIFIER IC SPECIFICATIONS: (Ta = 25C, Vcc = 3V, fo = 1kHz, volume = 100% unless noted otherwise.

CHARACTERISTIC CONDITIONS	**TEST TYPICAL**	**VALUE**
Gain	Input = -75 dBm Volume = 50%	54dB
Distortion	Input = -70 dBm	0.7%
Distortion	Input = -60 dBm Volume = 50%	0.5%
Maximum Output	Load = 32Ω THD = 10%	30mW

SECTION 10 - THEORY OF OPERATION - MOTION CONTROL

The tape speed is determined by the voltage across the motor. The purpose of the Motion Control Section is **a)** to set the tape speed by adjusting the motor voltage, and **b)** to keep the motor voltage constant as the battery voltage drops. To do this, the Motion Control Section contains a voltage divider (R7, R8 and VR2) and a motor control IC (AN6650). See the schematic diagram, Section 13. The IC contains the following major parts:

1. *Reference Voltage* - This circuit together with the current source feeding it maintains a constant 1.3V between pins 2 and 1 (and thus across the voltage divider) until the supply voltage to the IC drops to approximately 1.6V.

2. *Op-amp* - The op-amp amplifies the voltage difference between the (+) and (--) inputs. If the difference is positive (+ input more positive than -- input) the output goes positive. If the difference is negative (+ input more negative than -- input) the output goes negative. The gain of the op-amp is high. A small difference at the inputs produces a large change in the output.

   The op-amp circuit consisting of the op-amp, the transistor and resistors RA and RB (see schematic diagram, Section 13) employs negative feedback. This means that the op-amp output changes so as to reduce any voltage difference at the inputs. For example, if the (--) input goes negative, creating a positive difference at the inputs, the output goes positive. The transistor then turns on harder and the collector voltage drops. This voltage drop is fed back via RA to the (+) input which tends to remove the original difference between the inputs. Since the gain of the op-amp is very high, the two inputs are kept at virtually the same voltage.

   The motor voltage is adjusted by VR2. Turning the wiper of VR2 toward R8 lowers the voltage at the (--) input of the op-amp. This, as in the example above, lowers the transistor collector voltage and increases the voltage on the motor.

   Once the motor voltage is set, the motion control section keeps the voltage constant as the battery voltage drops. If, for example, the battery voltage drops by 0.5V, point A will drop by 0.5V. Due to the constant 1.3V across the voltage divider, point C, and the (--) op-amp input also drop by 0.5V. As explained above, this drops the transistor collector voltage (point B). In our example, the collector voltage must drop 0.5V to make the (+) op-amp input equal to the (--) input. Since points A and B both drop 0.5V, the motor voltage remains constant.

SECTION 11 - THEORY OF OPERATION - AUDIO

MAGNETISM

BAR MAGNETS - Figure 11-1a shows a bar magnet. The magnet is similar to a compass needle. It has a North seeking end and a South seeking end and thus its ends are labeled N and S. The magnetic field consists of lines of force (magnetic flux) which form closed paths through the magnet. By convention, the lines are thought of as flowing out of the North end (pole) back around to the South end and then through the magnet back to the North end. The lines shown indicate the direction of the magnetic field, that is, at every point they are tangent to the direction, a compass needle would point if placed at that point. The strength of the magnetic field is indicated by the density of the lines, that is, the number of lines per unit area. For example, a field strength of 1 gauss has 1 line square centimeter.

If we apply a voltage to a coil of wire, shown in Figure 11-1b, a current will flow in the wire and a magnetic field will be produced. The magnetic field produced by the current is the same as that of the bar magnet. It can, however, be easily varied by changing the current in the coil. If the current in the coil is reversed, the field is proportional to the current. Doubling the current will double the strength of the field.

INDUCING VOLTAGE - Above we used a voltage to produce a magnetic field. We may also use a magnetic field to produce a voltage. This can be done by inserting the magnet of Figure 11-1a into the coil of Figure 11-1b. The magnetic lines of force of the bar magnet cutting the wires of the coil induce a voltage in the coil. The voltage is proportional to the rate of change of magnetic lines (magnetic flux) linking the coil. Thus, the faster the magnet is inserted, the higher the voltage. Once inside the coil and stationary, the number of lines linking the coil is high, but the rate of change of the lines is zero and there is no induced voltage. When the magnet is withdrawn, a voltage of opposite polarity is induced.

FERROMAGNETISM - An electron spinning around the nucleus of its atom is an electric current just like the current in the coil mentioned above. It therefore generates a small magnetic field. The electron spinning on its own axis also contributes to the field. In a piece of ordinary matter, the small magnetic fields generated by the individual electrons are randomly oriented. They therefore cancel each other out, leaving the material as a whole unmagnetized. When certain materials known as ferromagnetic materials are subjected to an external magnetic field, some of the small magnetic fields align themselves with the external field and the material field itself becomes magnetized. Thus, if a cylinder of ferromagnetic material were inserted into the coil of Figure 11-1b, the cylinder would become magnetized and the field around the coil would greatly increase. A cylinder of a non-ferromagnetic material would have no effect on the field.

The main ferromagnetic materials are iron, cobalt, nickel, and some of the oxides and alloys of these metals. Some compounds of manganese and chromium dioxide are also ferromagnetic.

A hard ferromagnetic material is one that retains a large portion of its magnetization after the external field is removed. Hard magnetic materials are used in permanent magnets and in the coating of magnetic recording tape. Soft ferromagnetic materials retain very little of their magnetization after the external field is removed. Soft magnetic materials are used in relays, transformers and magnetic recording heads.

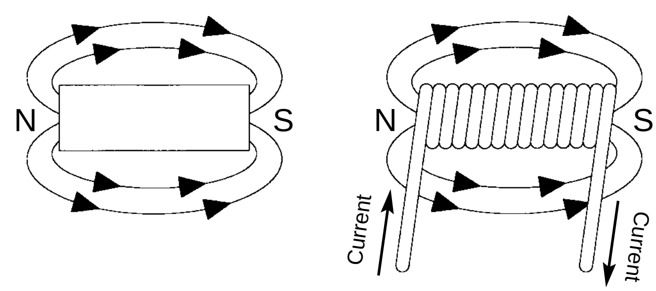


Figure 11-1a **Figure 11-1b**

HYSTERESIS LOOPS - Figure 11-2a shows a hysteresis loop for a hard magnetic material. If we start with an unmagnetized sample with no magnetizing force, the sample is at the origin (O). As we increase the magnetizing force, the field strength increases to point A. At this point, most of the small magnetic fields due to the orbiting electrons are in line and further increases in the magnetizing force produce very little increase in the field of strength. The material is then said to be saturated. When the magnetizing force is removed, the field strength falls back to the remnant magnetization B. If the magnetizing force is reversed, the field strength falls to zero at C. The magnetizing force required to do this is called the coercive force. As the magnetizing goes further negative, the sample again saturates at D. When the magnetizing force is brought positive again, the field strength follows the path D-E-F back to A. Figure 11-1b shows the hysteresis loop for a soft magnetic material. Note that the remnant magnetization and the coercive force are much less than for hard magnetic materials.

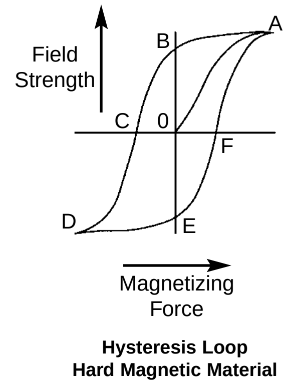


Figure 11-2a

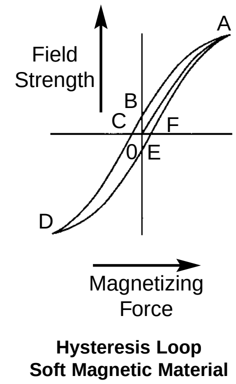


Figure 11-2b

MAGNETIC RECORDING - The four main parts of a magnetic recording system are the tape, the record head, the playback head and the erase head.

TAPE - The tape consists of a plastic backing, usually mylar, about 1 mil thick. On the backing is a thin coating of hard magnetic material, usually iron oxide, typically .2 mil thick.

RECORD HEAD - The recording head is made up of thin laminations of soft magnetic material such as mu metal formed into a ring with a small gap. A wire is wrapped around a ring, see Figure 11-3. When a current is passed through this winding, the head becomes a magnet with an N and S pole at the gap. Magnetic flux passing from the N to the S pole magnetizes the iron oxide under the gap. The iron oxide is a hard magnetic material and retains this magnetization as the tape leaves the gap area. Reversing the direction of the head current reverses the direction of magnetization of the tape. In Figure 11-3, the head current was periodically reversed. The tape is thus a series of small bar magnets facing in opposite directions.

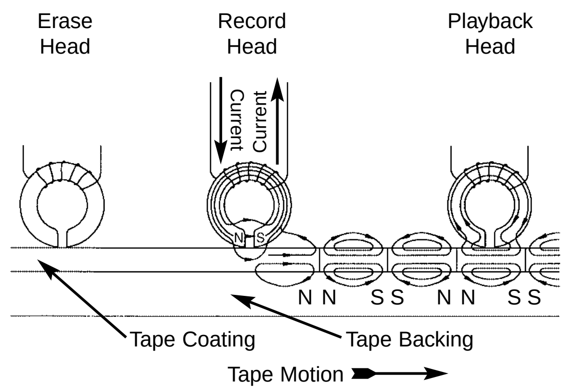


Figure 11-3

If, for example, an audio signal of 1kHz is fed to the record head, there will be 2000 bar magnets recorded each second. At a tape speed of 1 7/8 inches per second, each bar magnet will be 1.875"/2000 = .9375 mils or approximately one thousandth of an inch.

PLAYBACK HEAD - The playback head, like the record head, consists of a wire wound around a ring of soft magnetic material. The record and playback heads are so much alike that in some inexpensive tape recorders the same head is used for both record and playback.

Figure 11-3 shows the playback head positioned over a bar magnet with an N pole on the left and an S pole on the right. The flux from the magnet goes clockwise around the head. As the tape moves to the next magnet, the position of the poles and the direction of flux reverses. The changing flux induces a voltage in the head. As each magnet passes under the head, a voltage of alternating polarity is induced. If as in the example above there are 2000 magnets passing the head each second, a 1kHz signal is induced in the head. This duplicates the 1kHz record head signal that recorded the tape.

ERASE HEAD - The erase head is similar to the record and playback heads except that it is wider, extending across the entire width of the tape, and has a wider gap. A high frequency current of 50 to 100kHz is passed through the head. The amplitude is enough to saturate the tape under the gap. Thus, as an area of tape passes the gap, its direction of magnetization is reversed many times. As the tape leaves the gap area, the reversals slowly decrease in amplitude, leaving the tape unmagnetized. This gets rid of anything previously recorded on the tape and improves the signal to noise ratio of the recording.

AC BIAS - Ideally the remnant magnetization in the tape should correspond to the record head current. If the current should double or triple, the remnant magnetization should double or triple. That is, there should be a linear relationship between the magnetizing force and the remnant magnetization. As can be seen from the shape of the hysteresis loop for a hard magnetic material (Figure 11-2), this relationship is very non-linear.

This means that if the record head current corresponds to an audio signal, the remnant flux on the tape and hence the playback signal will be very distorted. To avoid this distortion, the head is driven by a composite signal made up of an audio signal and an AC bias (see Figure 11-4). The AC bias is a high frequency current well above the audible range, usually the same frequency as the erase head current. The amplitude is several times that of the audio current. When the amplitude of the AC bias current is set to the correct value, the remnant flux and the playback signal become linear. This greatly improves the quality of the recording.

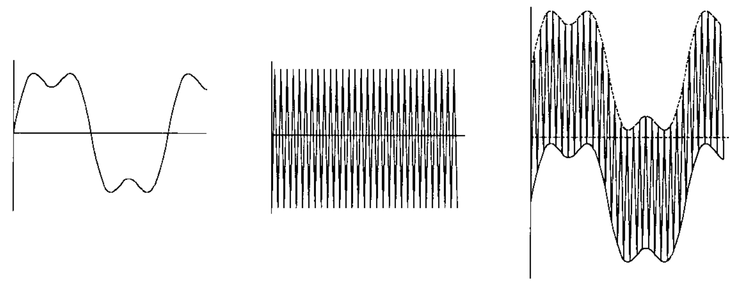


Figure 11-4

EQUALIZATION - If we use a constant amplitude record head signal and record different frequencies on tape, we find that the amplitude of the playback signal depends on the frequency of the input signal. At the low frequency end, about 100 or 200Hz, the playback amplitude increases at 6dB per octave. This means that if we double the frequency, the output amplitude will double. This is because the induced voltage depends on the rate of change of magnetic flux. At a constant amplitude, a 200Hz signal is changing twice as fast as a 100Hz signal. As we continue to increase the frequency, the output will continue to increase until about 2 or 3kHz. The output will then roll off due to head losses.

To maintain a flat frequency response over the full audible range, both the high and low frequencies must be given a boost. Music and the human voice have less power at high frequencies than at lower frequencies. It is therefore possible to boost the high frequencies during the recording process without saturating the tape. This is called pre-equalization.

It is not practical to fully boost the low frequencies during the recording process. It is therefore done by boosting the low frequency response of the playback amplifier. This called post-equalization. The National Association of Broadcasters (NAB) has set a standard response curve for playback amplifiers. In general, pre-recorded tapes are recorded so that the response is flat over the audible range when played back through an amplifier having this response.

CIRCUIT DESCRIPTION - The Audio Section of the AK-200 Cassette Player consists of the AN7108 integrated circuit, its associated resistors and capacitors, and the phone jack. The AN7108 is a dual channel audio amplifier with a common volume control. Since the two amplifiers are identical, it is only necessary to describe one.

As shown on the schematic diagram (Section 13), each amplifier consists of a pre-amplifier and driver with a volume control circuit between them. The playback signal from head A is input to the pre-amp on pin 3. The pre-amp has a gain of 30dB (about 32 times) at 1kHz. Resistors R2, R5 and R6 and capacitors C2 and C4 are placed in the feedback circuit of the pre-amp to provide the NAB standard frequency response. The driver provides 30dB of gain and sufficient driving power to drive the headphones. Potentiometer VR1 provides a means of varying the volume control voltage to pin 9. This voltage is converted to a current and fed to the volume control circuit to control the gain of the amplifiers. Figure 11-5 shows the approximate frequency response of the amplifier. The voltage reference circuit generates a voltage of approximately 1/2 the input voltage (pin 12). This is used to provide the IC with a wide operating range (1.8 to 6.5V).

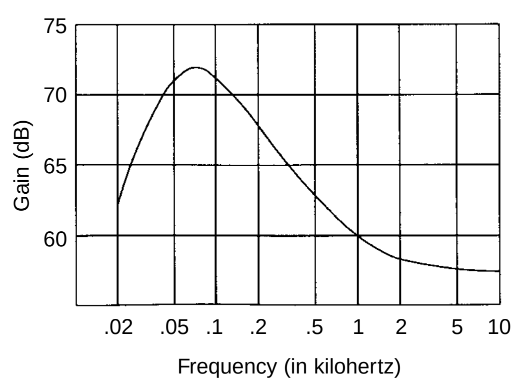


Figure 11-5

SECTION 12 - QUIZ

INSTRUCTIONS: Complete the following examination, check your answers carefully.

1. The AK-200 motor . . .
   - □ A) turns at a constant speed.
   - □ B) runs on 120VAC, 60Hz only.
   - □ C) changes speed with battery voltage.
   - □ D) is directly coupled to the supply reel.

2. The slip clutch . . .
   - □ A) causes the tape to slip past the head.
   - □ B) allows the drive belts to slip on their pulleys.
   - □ C) allows the supply reel to turn at different speeds.
   - □ D) allows the take-up reel to turn at different speeds.

3. The Motion Control Section of the AK-200 . . .
   - □ A) causes the tape to move forward and reverse.
   - □ B) keeps a constant voltage on the motor.
   - □ C) reverses the tape motion.
   - □ D) powers the audio amplifier only when the tape is in motion.

4. The op-amp in the Motion Control Section . . .
   - □ A) amplifies the voltage difference between its (+) and (--) inputs.
   - □ B) has a very high gain.
   - □ C) goes positive when its (+) input is more positive than its (--) input.
   - □ D) all of the above.

5. The magnetic lines of force in a bar magnet . . .
   - □ A) form closed paths.
   - □ B) flow from the S to the N pole.
   - □ C) indicate the voltage between the N and S pole.
   - □ D) all of the above.

6. If a bar magnet is inserted into a coil of wire . . .
   - □ A) nothing happens.
   - □ B) the bar magnet loses its magnesium.
   - □ C) a voltage is induced in the coil of wire.
   - □ D) the N and S poles are reversed.

7. A ferromagnetic material . . .
   - □ A) is always made of iron.
   - □ B) may be magnetized by an external magnetic field.
   - □ C) never retains it magnetization when an external field is removed.
   - □ D) none of the above.

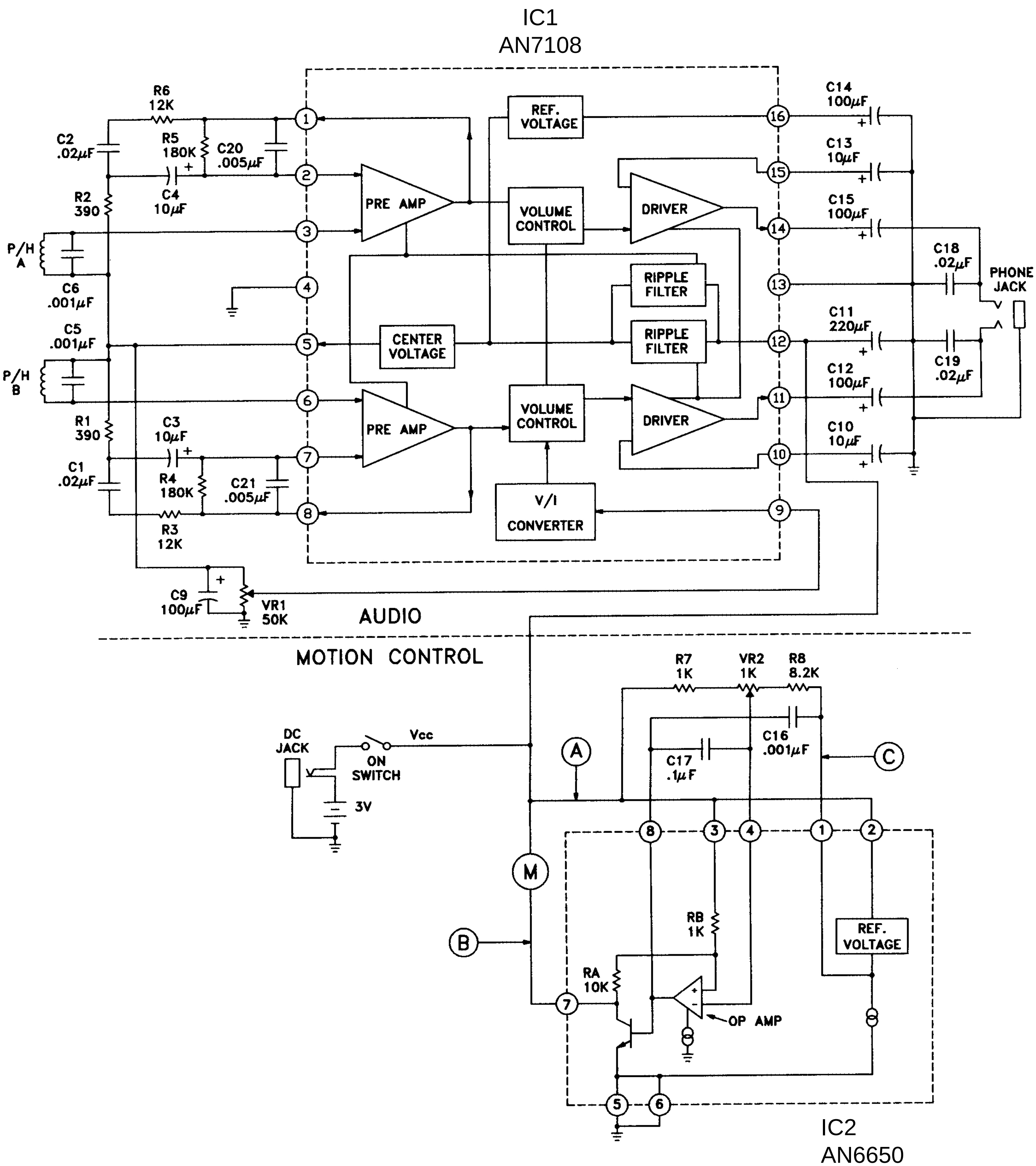
8. The magnetizing force required to reduce the field strength or a magnetic material to zero is called . . .
   - □ A) remnant magnetization.
   - □ B) coercive force.
   - □ C) hyteresis force.
   - □ D) soft force.

9. The AC bias frequency is . . .
   - □ A) 60Hz.
   - □ B) well below the audible range.
   - □ C) well above the audible range.
   - □ D) 100 to 200Hz.

10. The Audio Section of the AK-200 Stereo Cassette Player consists of . . .
    - □ A) a dual channel audio amplifier IC with a common volume control.
    - □ B) a dual channel audio amplifier IC with individual controls.
    - □ C) a transistor amplifier with an AGC circuit.
    - □ D) a single channel audio amplifier with an AGC circuit.

Answers: 1. A, 2. D, 3. B, 4. D, 5. A, 6. C, 7. B, 8. B, 9. C, 10. A

SCHEMATIC DIAGRAM



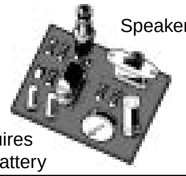
REV-A

EDUCATION KITS

Complete with PC Board and Instruction Book

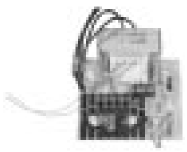
Space War Gun
K-10
Rapid fire or single shot with 2 flashing LEDs.

Speaker Incl.

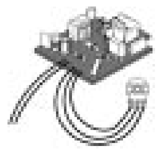


Requires 9V Battery

0-15V Power Supply
K-11
A low-cost way to supply voltage to electronic games, etc.
0-15VDC @ 300mA.



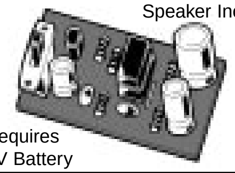
Strobe Light
K-12A
Produces a bright flash via xenon flash tube. The flashing rate is adjustable.



Requires 2 "C" Batteries

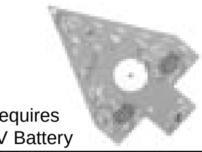
Automatic Siren
K-13
Can be used with a burglar alarm or as an attention getter.

Speaker Incl.



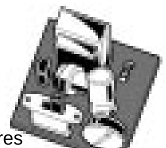
Requires 9V Battery

Christmas Tree
K-14
Produces flashing colored LEDs and three popular Christmas melodies.



Requires 9V Battery

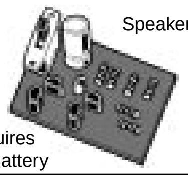
Fish Caller
K-15
Makes a sound that should attract hungry fish.



Requires 9V Battery

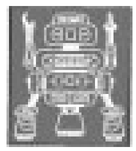
Electronic Cricket
K-16
Your friends will go crazy trying to find it.

Speaker Incl.



Requires 9V Battery

LED Robot Blinker
AK-400/K-17
You'll have fun displaying the PC board robot. Learn about free running oscillators.

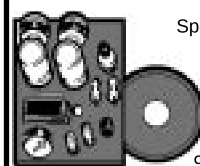


Requires 9V Battery

Telephone Hold Button
K-18
Put all incoming and outgoing calls on hold at the press of a button.

Digital Bird
K-19
You probably have never heard a bird sing this way before.

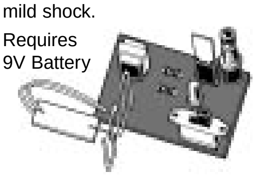
Speaker Incl.



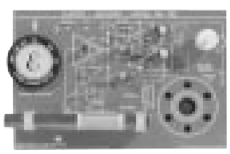
Requires 9V Battery

Nerve Tester
K-20
Test your ability to remain calm. Indicates failure by lit LED or mild shock.

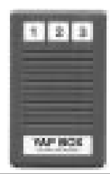
Requires 9V Battery



2 IC AM Radio Kit
AM-780
New Design - Easy-to-Build complete radio on a single PC board. Requires 9V Battery

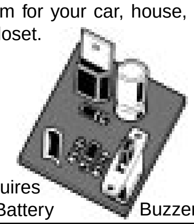


Yap Box
K-22A
This kit is a hit at parties. Makes 6 exciting sounds.



Requires 9V Battery

Burglar Alarm
K-23
Alarm for your car, house, room or closet.



Requires 9V Battery

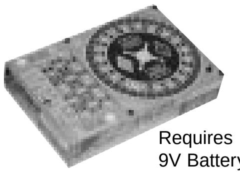
Buzzer Incl.

Whooper Alarm
K-24
Can be used as a sounder or siren.

Speaker Incl.

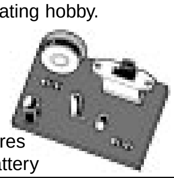
Requires 9V Battery

Digital Roulette
AK-300/K-25
Sure winner with your friends. 32 LEDs as arranged in a 5" circle.



Requires 9V Battery

Metal Detector
K-26
Find new money and old treasure. Get started in this fascinating hobby.

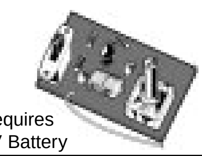


Requires 9V Battery

Pocket Dice
K-28
To be used with any game of chance.

Requires 9V Battery

TV / FM Oscillator
K-29
Learn about oscillators and FM transmitters.
Use as FM transmitter.

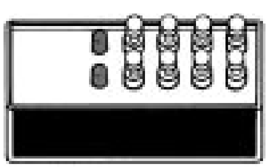


Requires 9V Battery

FM Mic
AK-710/K-30
Learn about microphones, audio amplifiers, and RF oscillators. Training course incl.

Requires 2 "AA" Batteries

Digital Lock
K-31
Program your combination from thousands of different choices.



One Button Bandit
K-34
Press the button and away she goes, if 3 LEDs light, you win. Our version of Vegas one arm bandit.

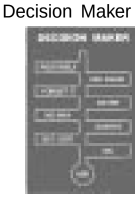
Requires 9V Battery

Telephone Bug
K-35
Size of a dime yet transmits both sides of a phone conversation to any FM radio. No battery needed.

Sound Activated Switch
K-36
Clap and the light comes on, clap again and it goes off.

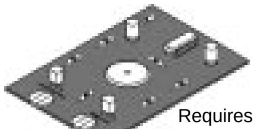
Requires 9V Battery

Decision Maker
K-43
Need help in making up your mind? The Decision Maker will do it for you!



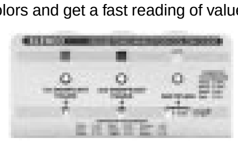
Requires 9V Battery

Lie Detector
K-44
The sound will tell if you are lying. The sound gets louder the more you lie. Fun at parties!



Requires 9V Battery

Color Code Calculator
for resistors, capacitors, & inductors
CC-100
Pocket-sized calculator is easy-to-use in determining values of resistors, capacitors, and inductors. Match colors and get a fast reading of values.



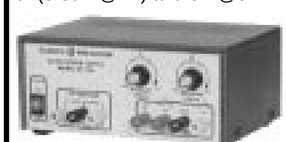
Motion Detector Kit
SS-50K
Use as a sentry, message minder, burglar alarm, or a room detector.

Requires 9V Battery

Transistor Tester Kit
DT-100K
Test in-circuit transistors and diodes.

Requires 9V Battery

Variable Power Supply
XP-720K
Three fully regulated supplies: 1.5-15V @1A, -1.5 to -15V @1A or (3-30V @1A) and 5V @3A.



EDUCATION KITS

Complete with PC Board and Instruction Book

LEARN SURFACE MOUNTING TECHNIQUES FUNCTION GENERATOR KIT Model FG-600K

These versatile function generators include surface mount components such as IC's, resistors and capacitors. When completed, they provide Sine, Square and Sawtooth waveforms, continuously variable to 1MHz. Amplitude adjustable. Complete with all parts and PC board. Both include case and extensive training manual.

SPECIFICATIONS

OUTPUT:
Waveforms: Sine, Square, Triangle
Frequency: 1Hz-1MHz
Impedance: 600Ω ±10%
Amplitude: Sine/Triangle 0-3V at 12V DC input Squarewave .5-12V (no load)
Frequency Variable Range: 100:1 or more
Frequency Multiplier: x1, x10, x100

SINE WAVE
Distortion: Less than 1%
Flatness: ±0.5 dB 1Hz-100kHz
Temperature Stability: ±20ppm/^{o}C Typical

SQUARE WAVE
Symmetry: Less than 5% (at 1kHz)
Rise & fall time: Less than 300ns (at 1kHz)

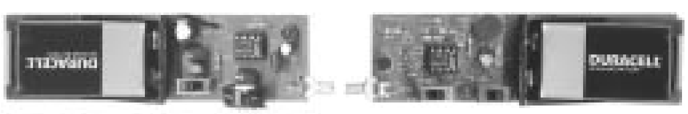
TRIANGLE WAVE
Linearity: Less than 1% (up to 100kHz)
Power Requirements: 9 to 18V DC at input

Requires 9 volt battery

TELEPHONE KIT Model PT-323K

Build this high-tech, see-through clear plastic telephone. Learn theory on how telephones work and then proudly show off your work with the transparent phone case. Complete with all parts and manual. Neon lamps flash when the phone rings.

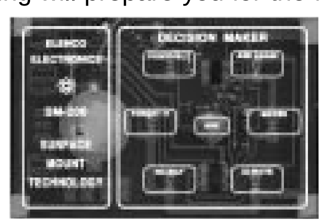
Fiber Optics Kit Model FO-30K



Learn the basics of fiber optics data communications while you build this exciting kit. Comes complete with all of the necessary components, including the PC board, fiber optic cable and separate transmitter and receiver.

Surface Mount Technology Model SM-200K

The future of electronics is headed for miniaturization through Surface Mount Technology (SMT). Taking our course of training will prepare you for the future.



Requires 9V battery

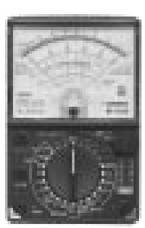
Includes all parts and instructions to give you experience on working with surface mount components. The finished project has 6 flashing LEDs to help you make vital decisions.

Digital Multimeter M-1005K Kit

- 3 1/2 Digit LCD
- 18 Ranges
- Diode Test
- Overload Protection
- Pocket Size
- Low Cost
- Transistor Test

Analog Multimeter M-1250K Kit

- 20,000Ω/V
- 19 Ranges
- 3 1/2" Meter
- Mirrored Scale
- 3% Accuracy
- Checks Transistors
- 10A DC Current
- Dial Scale Reading Kit Included.



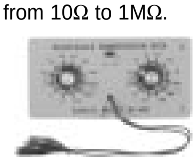
Power Supply Kit Model XP-15K

Fully regulated, great for TTL and other circuits.

Output:
1.25 - 15V
0.5A - 8V
0.3A - 12V
0.2A - 15V

Resistor Substitution Box Kit K-37

Contains 24 resistors from 10Ω to 1MΩ.



Capacitor Substitution Box Kit K-38

Contains 24 capacitors from 100pF to .1µF.