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SECTION 1

SAFETY GUIDELINES

When working with electricity and electronics there can be many hazards. Because of this, you must learn to respect electricity and follow basic guidelines when handling equipment. Listed in this section are some of the things that you can do to avoid these hazards. Please keep in mind that all possible situations cannot be covered in this manual; therefore, you must always conduct yourself in a safe manner by using common sense when working with equipment.

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1-1 ELECTRICAL OUTLETS AND POWER CORDS

1. Observe the power cord when moving games away from the wall; do not let it be pulled from the socket.

2. Pull from the plug when unplugging power cords. Never pull on the cord itself.

3. When plugging power cords into outlets, make sure that there is adequate lighting so that you can see what you are doing.

4. Never use a power outlet or power cord that is damaged.

5. When replacing power outlets, turn the breaker off that controls that outlet. Use only **INDUSTRIAL GRADE, 3 THREE PRONG OUTLETS** and observe the same wiring configuration that was used on the broken outlet. Use **HOSPITAL GRADE** outlets for floor sockets.

6. Use 3 prong (grounded) power plugs on all games. Never use grounding adapters. It is important that all games be properly grounded. Failure to properly ground electrical equipment presents shock hazards and will sometimes cause the game to operate improperly.

7. Observe the proper wiring configuration when replacing power cords. Replace the entire line cord, not just the plug. Our parts department stocks three prong replacement cords. **NEVER SPLICE A NEW CORD INTO AN EXISTING ONE.** Proper strain relief **MUST** be provided for the power cord.

8. If a plug must be replaced instead of the entire cord, use a UL approved three prong replacement power plug. Wire the plug in the following manner:

- * The Green wire must connect to the middle (round) pin.
- * The White wire (sometimes Blue) must connect to the pin that plugs into the right (small) slot of the outlet.
- * The Black wire (sometimes Brown) connects to the pin that plugs into the left (larger) slot of the outlet.

Make sure there are no stray strands of wire. Failure to wire the plug in this manner can result in a lethal shock hazard!

9. Do not push games flat against the wall; this can damage the power plug or the outlet. It also obstructs the ventilation of the game.

1-2 BOARD HANDLING

1. Many boards are easily damaged by static electricity. When handling a board you must properly ground yourself. Do this by touching the grounding braid that runs through the game, or touch the metal cage that the boards are mounted in, or touch the metal plate that some boards are mounted on.

2. Make sure that the power to the game is turned off while removing boards.

3. When removing boards, mark the connectors or draw a picture that shows the position and the direction of each connector. Some connectors are 'keyed' so that they will only fit in one location or in only one direction -- but many are not. If a connector is plugged in the wrong way, severe damage will be done to the board.

4. Pull from the connector housing when unplugging connectors. Never pull the wires. Doing so can damage the wires or pull them out of their sockets.

5. Never attempt any repair to a board without specific permission from your service center.

6. When mailing a board; place it inside a plastic bag. This will help keep static charges from contacting the board. Most styrofoam packing materials store large amounts of static electricity. The bag will also keep the packing material from getting between the boards and causing the service center personnel to loose time removing the packing material. Use a box that is at least three inches larger in all directions than the item being shipped. Use plenty of packing material to fill the box and protect the board. Never let two items directly touch each other in the box. Use bubble pack, cardboard, or plastic to insulate them from each other. After sealing the box, test it to make sure that it will not easily crush under hard pressure. Do not use newspaper for packing material.

7. Never allow tools or a probes near a board while the power is turned on.

8. Do not place boards on metal surfaces. Many boards have voltage present even when they are removed from the game. Allowing the solder connections to touch a metal surface can damage the components, or delete portions of the programming.

9. When replacing a board, compare your connections with the drawing that you made when you removed the item from the game. Replace all the screws that were used to mount the board. Many of these screws are used for an electrical connection and are necessary for proper game operation.

10. Treat all boards with great care. Replacement cost often exceeds one thousand dollars.

1-3 MONITORS

1. Never touch a monitor with the power turned on. Most monitors have voltages present that exceed 19,000 volts.

2. When removing a board from a monitor you must first use a flat tip screwdriver and a jumper wire to discharge the high voltage that is stored in the picture tube (CRT). Here is how:

- * Connect one end of the wire to the monitor's metal frame (chassis). Connect the other end to the blade of the screwdriver.
- * Without letting your fingers touch the metal portion of the screwdriver, and with the power turned off, carefully slip the blade of the screwdriver under the High Voltage Anode's rubber insulating cup (this is located on the back surface of the picture tube and resembles a suction cup with a thick red or black wire extending from it).
- * Usually, when the screwdriver touches the metal contact under the rubber cup, a large spark will be seen and a loud pop will be heard. Hold the screwdriver in place for about five seconds -- then use it to gently unhook the contact clips that secure the anode to the hole in the picture tube.

3. Make a drawing of all the connectors before removing them from the monitor. Some monitors have a single black wire leading from the back of the picture tube to the neck board. This wire sometimes has a plug connecting it to the neck board. Sometimes it does not have a plug and must be cut in the middle and connected again when the board is reinstalled. If you must cut the wire, make sure that you resolder it when you put the board back in. You may also use a plastic "wire-nut" to tie the ends together and insulate them. This wire is very important.

4. Removal of the Neck Board must be done very carefully. This board cracks easily and the glass picture tube can be broken if it is not handled with caution.

5. All picture tubes (CRTs) must be handled with care. If the tube is broken, it will implode and sometimes explode; **THIS CAN CAUSE SERIOUS INJURY**. The most fragile part of the CRT is the neck. Care should be taken when removing or replacing back doors to avoid breaking the neck.

6. Replace all screws and hardware when working on a monitor. Some screws are used for electrical connections. Monitors are very heavy; failure to replace all the mounting hardware may cause the monitor to be damaged when the cabinet is moved.

1-4 CABINETS

1. Watch out for sharp edges on games that could injure people or tear their clothing.

2. When moving games, do not drop them or bang them into walls and other games. Rough treatment of the cabinet will degrade the game's appearance, and may damage its internal components.

3. Do not strain yourself or make unwise movements when using a two wheeled hand-truck. Learn to use leverage by finding the center of gravity. Always follow general safety habits when doing this type of work, and use common sense.

4. Do not damage the adjustable levelers on the bottom of game cabinets and pinball machines. You may have to screw them in before moving the game.

5. Make sure that all control panels are securely latched or bolted down with the proper hardware.

6. Back door locks should be tight on all games. Keys are to be hanging on a hook fastened to the coin door. Do not let the keys or the hook near the lamp sockets or other electrical connections.

7. Use caution when working with control panels. Do not let the panel hang by its wires. If you must walk away from a game while the control panel is open, make sure that it is secure and cannot fall.

8. Use caution when unloading a game from a truck. Generally, the driver is very helpful and knows how to safely unload large items. Find the center of gravity while sliding the game off the edge of the truck on its back. One person (usually the driver) will guide the carton from the top and you will steady it from the bottom. If you are doing it correctly, you will never experience and strain from the weight of the game.

1-5 MERCHANDISE GAMES

1. All merchandise games must be properly grounded with a three prong power plug. See section 1-1 for more information about power plugs and outlets.

2. Replace cracked or broken glass immediately. Always use glass with polished edges. This will protect you and your customers from injury.

1-6 LASER DISC GAMES

1. When moving laser disc games, remove the disc and lock the slider using the locking screw. You must also protect the lens with the lens cap supplied with the player. Refer to section 3-8 for instructions.

2. Wait one minute after turning off a laser disc game before you move it. This will give the disc inside the player time to stop spinning.

3. Never move a laser disc game without first locking the slider as described in section 3-7.

4. Never open a laser disc player while the disc is still spinning.

1-7 GENERAL SAFETY

1. Do not leave games open and unattended with the power on.
2. Never let persons who are not employed by Nickels and Dimes Inc. work on games.
3. Do not leave tools where they are accessible to customers -- especially power tools and sharp objects.
4. If you do not completely understand a testing or repair procedure, contact your supervisor or service center.
5. Never try to extinguish a fire with water or any chemical other than an approved fire extinguisher.
6. Be careful with soldering tools. Do not place them where customers may touch them or where you might accidentally burn yourself or other objects.
7. Wear safety goggles while using power tools and soldering guns.
8. Be careful when working inside game cabinets. Many devices have dangerous voltages present, with or without the power turned on.
9. Do not work on equipment with wet hands, or on a wet floor.
10. When operating power tools, persons with long hair should take precautions to keep their hair from getting caught in the tool.
11. When removing joysticks, switches, logic boards, etc., take the time to draw a picture of the wires and the wire colors that go to each connection. Many mistakes have been made by careless employees who did not do so. Masking tape works very well for marking wires and connectors. If a logic board or monitor is sent to a service center, keep in mind that you may not be the one who installs it when it is returned to the store. For this reason you should always make your markings very easy to read.
12. To avoid injury, do not use your back when lifting objects; use your knees and legs instead.

16. Never operate a shredder with the cover removed! Keep ties, hair, jewelry, or other narrow, long and/or dangling items clear of the throat opening of the shredder!
17. Never stand on the top, or second from the top, ladder step. Make sure ladder legs are locked and firmly seated on the ground. Read and follow all safety instructions printed on your ladder's safety label. Do not use a ladder that is too short, weak, shaky, or damaged.

SECTION 2

PRINCIPLES OF GAME OPERATION

This section of the manual covers some very basic principles of electricity and electronics, and some of the common devices that are found in games. Also covered in this section is the basic architecture and operation of video and pinball games.

Please realize that this information is entry level and will not enable you to repair games at a component level (i.e. I.C.s, transistors, etc.). However, learning everything in this section will certainly increase your ability to troubleshoot and repair most games.

2-1 Understanding Electricity

2-2 Common Devices Used In Games

2-3 Game Architecture

2-1 UNDERSTANDING ELECTRICITY

WHAT IS VOLTAGE?

Voltage can be defined as electron pressure in an electrical wire or circuit. It is usually expressed in volts (V).

Voltage can be easily understood by comparing it to water pressure (not water flow). When a water faucet is turned off, it has behind it a certain amount of water pressure. This pressure is usually measured in PSI (pounds per square inch). The water has the potential of flowing out of the faucet and doing work.

A battery contains "electrical pressure" (or potential for work). This pressure is measured in Volts rather than pounds per square inch, as in our water example. A wall outlet has electrical pressure (voltage) just waiting to flow out. A battery may have 9 volts, 1.5 volts or perhaps 12 volts of electrical pressure just waiting to be put to work.

WHAT IS CURRENT?

Current can be defined as the flow of electrons. Usually expressed in amperes (amps or A), milliamperes, (mA) or microamperes (uA).

When electrons are pushed out of a voltage source, such as a battery or a wall outlet, the flow of these electrons is called "Current." Returning to our water example, we would say that the water flowing through a hose would be our current. The water is being pushed by pressure (voltage) and flows through the hose at a rate measured in gallons per minute (current). This measurement of gallons per minute shows the flow, or the speed -- not the pressure.

The flow of electrons through wires and circuits (current) is measured in Amperes (amps). This current flowing through wires and electronic components creates heat. This heat can sometimes cause problems. If a connector, for example, is not able to handle the amount of current flowing through it, it may become too hot and burn. If this happens, the current cannot properly flow through the connection.

WHAT IS RESISTANCE?

Resistance can be defined as difficulty in moving electrical current through a wire or component.

All components have a certain amount of resistance to current. This resistance is usually measured in units called "Ohms."

All electronic or electrical systems must have voltage and current in order to do work. A flashlight for example, must have a voltage source (battery) to push electrons through wires and the lamp. This flow of electrons (current) through the lamp causes the filament inside of it to glow.

Games are filled with components that must have a voltage source in order to operate. Instead of batteries, they use the voltage that is available from wall outlets. This voltage however, is not suitable for the operation of all the game's components. Remember that there are different types of batteries, but not all radios and appliances can operate from the same voltage battery. Some require 9 volts, while others may use 5 volts.

Some devices can operate directly from the voltage that is present at a wall outlet (usually found to be between 110 and 120 volts AC). The voltage from a wall outlet alternately pushes and pulls electrons in and out. This is known as AC, or alternating current. Some components are designed to operate with AC current. Others can only operate with electrons flowing in one direction (DC, or Direct Current).

The computer in a game must have +5 volts DC to operate correctly. Notice the + sign in front of the number 5. This shows the "polarity" of the voltage, like the + and - on the ends of a battery. This tells us which way the current will flow. When working with electronics it is very important that proper polarity always be observed.

The 110 to 120 volts AC from the wall must be changed into a voltage that the computer can use and will not be damaged by. To do this, the voltage is stepped down and changed to +5 volts by the "power supply." This power supply is often made up of a large transformer and a printed circuit board with electronic components mounted on it, or it may just appear to be a rectangular metal box. In either case, the results are the same.

The computer may also require additional voltages for other operations; like sound or lamp control. A -5 volt source may even be needed to operate some of the components. All these voltages are provided by the power supply after they have been changed from the voltage coming from the wall outlet.

Other parts of the game may be designed to operate directly from the AC voltage supplied by the wall outlet. An example of this would be the fluorescent light used to illuminate the marquee. Other devices, such as the monitor, operate from 110 to 120 volts AC but cannot be directly connected to the wall outlet. In these cases, the game uses an "Isolation Transformer." This device provides the necessary protection that the monitor needs by isolating it from direct contact with the wall voltage while maintaining the voltage at 110 to 120 volts AC. The isolation transformer will be covered in more detail later in this text.

By now, you should have a clear understanding of electricity. If you do not understand the definitions of voltage and current, please go back and read this section again.

2-2 COMMON DEVICES USED IN GAMES

SWITCH

A switch is a very simple device that is used to make an electrical connection between two points. There are many different types of switches found in games. Some are made from two long pieces of flexible metal with contact points at the ends. When these contact points touch each other (make contact), current is allowed to flow through them. Some switches are enclosed in a plastic case. An example of this would be a typical coin switch.

The contact points of switches get dirty from time to time. Thin cardboard or paper may be used to clean them. Squeeze the paper or cardboard between the points while you slide it back and forth until the points are clean. Never use sandpaper or a file to clean contact points. Most switches that are used in games have gold plated contacts which conduct current easily. Rubbing the contacts with a rough surface will scratch them and reduce the switches' ability to conduct high speed digital signals. The exception to this is a flipper End Of Stroke switch, or a flipper button switch -- these have very large contact points which are usually badly burned. Refer to section 3-10 for more information about flipper switches. Also read section 3-17 for switch adjustment and cleaning information.

STEP DOWN TRANSFORMER (Power Transformer)

This device steps the AC voltage from the wall outlet (110 to 120 V) down to smaller AC voltages used throughout the game.

ISOLATION TRANSFORMER

An isolation transformer 'isolates' a device from the wall outlet while keeping the output voltage at the same level as its input (115 volts in, 115 volts out). An isolation transformer must always be used with a monitor.

LINE FILTER

A line filter removes some of the 'noise' and small voltage fluctuations from the AC line that are present when air conditioning units, motors, power tools, and other devices are being used. It also helps keep noise being generated by the game off of the AC line. The line filter usually goes between the power cord and transformers.

POWER SUPPLY (Regulator)

The power supply can be compared to the water pump in our earlier example. It pushes (pumps) electrons through the electronic circuits in the game. The power supply changes the voltage from the wall outlet into voltages that can be used by the components in the game. The most common voltages produced by a power supply are:

+5v. This is the single most important voltage in the game. All logic boards must have this voltage in order to operate.

+12v. Often used in sound circuits and is sometimes used for video display and lamps.

-5v. Not often used, but sometimes necessary for computer operation, sound, or lamps.

-12v. Not often used, but sometimes necessary for sound circuits.

There are sometimes other voltages produced by the power supply. These voltages will vary from game to game. Pinball machines, merchandise games, and games with motors almost always have their own unique voltages to operate their various components.

The +5 volts generated by the power supply is vitally important. It is essential that it be exactly +5v -- it must not fluctuate at all. If it does fluctuate, the system will not operate correctly. The power supply continually monitors its output voltage and adjusts (regulates) itself to maintain a constant +5 volts.

Some power supply boards include a circuit that produces a "reset" signal. This signal is not at all like the other voltages supplied by the unit. The reset signal is used by the computer (logic board) when the game is first turned on. It pulses very quickly from +5 volts down to 0 volts and then back up again to +5 volts. This action causes the computer to start from the beginning of its program. Without this reset signal, the computer will not operate correctly.

Most logic boards create their own reset signal and do not receive it from the power supply.

FUSE

Fuses are protective devices used to prevent circuit damage and fires that can be caused during certain failure modes of electronic equipment. Fuses are rated at specific amperage amounts and blowing speeds.

A fuse acts like a pressure relief valve does in an air or

water system; if the pressure gets too high, the valve will open, thus protecting the system from further damage. Likewise, in an electrical system when the current exceeds the amperage rating of the fuse, it will burn open the filament, not letting current pass through the circuit.

Fuses must always be replaced with the proper type.

Refer to section 3-1 for more information about fuses and how to test them.

CIRCUIT BREAKER

Most games do not use circuit breakers; however, some games using motors to move the seat or other heavy mechanisms may sometimes use them. Change machines also have circuit breakers. A circuit breaker works in the same way that a fuse does; however, a circuit breaker can be reset by pushing its button, or by toggling its lever. Circuit breakers do not normally need to be replaced when they pop open (trip).

POWER CHASSIS

Some games have a primary power supply called a "power chassis." This is usually a large, heavy, metal unit located in the bottom of the game. This power chassis usually contains the power transformer, fuses, the line filter, a filter capacitor, and sometimes other components.

The power chassis does not produce the +5 volts. Instead, the power chassis usually produces 'raw' voltages (unregulated) that are sent to the Power Supply (regulator) where they are then 'refined' and regulated. Not all games have a power chassis.

LOGIC BOARDS

The logic boards are the heart of the system -- and the most delicate. The logic board is a computer that makes decisions, creates the picture, and responds to the player's input. There are many different types and configurations of logic boards that differ from game to game. Sometimes there are several logic boards in a game -- each one interfaces with the other to produce a desired outcome. Some boards produce video, some produce sound, others have different operations assigned to them.

The logic boards that are used in games are known as "dedicated computers." A dedicated computer is pre-programmed to perform unique (dedicated) operations. Dedicated computers do not have disc drives or cassettes for loading and saving programs, as do most personal computers. Instead, it has its program already stored in its I.C.s.

METER

The meter is a device used to count coins.

Meters are never to be tampered with by an employee. If a problem exists with a game's meter, the supervisor must be notified at once. It is up to the supervisor to decide what action to take.

Tampering with meters will always result in immediate termination!

MONITOR

The monitor is the part of the game that displays the picture being created by the computer. The monitor does not create the picture or make decisions about game play. Monitors operate much like television sets.

There are several different brands of monitors used in games. Most of them can be interchanged from game to game. Some games use "X/Y" type monitors. These X/Y monitors operate differently than the more common Raster monitors. They use odd voltages and display the picture in a unique way. Newer games do not use this type of monitor because it is both an unreliable and undesirable method of display. Because of this, X/Y monitors will not be covered in this manual.

The raster monitor consists of the following parts: the *picture tube* (or *CRT*), the *yoke* (the copper wire and plastic device located on the neck of the CRT), the *neck board* (plugged onto the end of the CRT neck), the *main board* (usually mounted on the metal chassis), and the *chassis frame* (metal frame and mounting brackets). The main board and the neck board can be easily removed by following the guidelines given in Section 3-15.

The monitor produces several dangerous voltages. The highest one is usually between 13,000 and 30,000 volts. This "high voltage" is present at the Anode (the thick red or black wire attached to the back of the CRT with a rubber cup). The neck board also has several very dangerous voltages on it.

There are several adjustments on the monitor. These adjustments change the size, brightness, and color of the picture. They also affect the vertical and horizontal timing of the monitor. Never adjust the color controls on the neck board. If you must make brightness, vertical, or horizontal adjustments, first contact your supervisor and refer to the monitor's instruction manual. An improperly adjusted monitor can severely affect a game's earnings.

picture. They also affect the vertical and horizontal timing of the monitor. Never adjust the color controls on the neck board. If you must make brightness, vertical, or horizontal adjustments, first contact your supervisor and refer to the monitor's instruction manual. An improperly adjusted monitor can decrease a game's earnings.

CONTROL PANEL

The control panel is made up of switches, potentiometers (pots), optic sensors, and various other types of controls that are used by game manufacturers. These devices tell the computer what the player's responses are. It is very important that all these switches and controls work perfectly at all times. If the control panel has loose parts, dirty contacts, or other problems, the game will not earn properly.

The control panel switches and controls are usually connected directly to the computer by way of the wiring harness. Because of this, it is important that great care be taken when working on the control panel. Touching wires and switches to each other can cause damage to the logic board.

All control panels have a wire called "Switch Common" or "Switch Ground." This wire (Switch Common) is connected to one terminal of each switch on the panel. The wire is usually black and loops from switch to switch. If this wire breaks, none, or only some of the switches will work.

Always take the time to make sure all the connections on the switches and other devices are good and tight. Also make sure that the control panel is latched or bolted down properly after it has been open.

COIN DOOR

The coin door is a very important part of the game. If the coin mechanisms or other parts do not function properly, the game will decrease in earnings. Most games have at least two coin mechanisms. It is the policy of this company that ALL coin mechanisms work correctly at all times. It is not acceptable to have only one coin slot working. If a customer inserts a coin and it is returned to them, they will usually leave that game thinking that it is completely broken.

A malfunctioning coin slot can be just as harmful to earnings as a broken logic board or a poorly adjusted picture.

When a coin is inserted, it will slide down the slot and enter the coin mechanism. The coin mechanism tests the coin to see if it is the proper size, shape, weight and non-magnetic material. If the coin passes all these tests, it then drops over

the trip wire which closes the coin switch. The coin switch sends a signal to the logic board to give the player a credit. The coin then drops into the cash box. If the coin does not pass any of the tests, it will be rejected to the coin return slot where the player may retrieve it.

Most coin switches have three terminals. They are the "common," the "normally open," and the "normally closed" terminals (C, NO, & NC). Some switches only have two terminals (C & NO). Although the switch has three terminals, only two of them are usually used.

The shape of the trip wire is very important. If it is not properly shaped, it might cause the coin to stick, or allow the coin to pass without fully closing the switch. Sometimes, the speed at which the switch is made is important. On some games, if the coin passes too slowly, the computer may ignore the signal and not give the player a credit.

Adjustment of the trip wire should not have to be done. However, if an employee uses their finger to trip the game instead of dropping a coin through the slot, the wire will probably bend out of shape and have to be adjusted. Doing so requires a 'light touch'. Use needle nose pliers or a contact point adjusting tool to lightly bend the wire along its length. Do not sharply bend the wire or put a kink in it. As with most procedures, this is to be done with the power turned off. Read section 3-17 for adjustment and cleaning instructions.

For information about testing switches, see Section 3-4.

Coin entry lamps are usually a part of the coin door. These lamps are sometimes powered from the transformer's 6.3 volt AC output. Some games use the + or the - 5 volts for the lamps. Some games use other voltages to power the lamps. Always use the correct type of lamp for replacement. Using the wrong lamp can cause problems with the game, such as; blown fuses, burned connectors, or intermittent reset.

The wiring harness usually bends around the coin door hinge. This can sometimes cause problems. Constant opening and closing of the door may cause the wires to rub against the metal and eventually wear through the insulation causing the bare wire to short to the metal. When this happens, the game may give no credits, or it may give credits without inserting a coin. If the damaged wire belongs to the lamps, it could cause a problem with the lights. Sometimes the wires will get pinched in the hinge when the door is closed.

Often times, the coin door will have a "Self Test" switch or button mounted on or near it. When this switch is used, it puts the computer (logic board) into a mode where various tests can be done and certain bookkeeping functions may be viewed on the screen.

Another switch sometimes found on the coin door is the "Slam Switch" (tilt switch). This switch is used to prevent the coin switches from bouncing and giving credits when the door is kicked or hit. Some slam switches are normally open and others are normally closed.

OTHER CONTROLS

Accelerators, brakes, rotary controls, etc. are all devices used to send the player's response to the computer. These vary from game to game and will most assuredly change as technology progresses and game designs change.

Most accelerators and brakes use a potentiometer or an encoder to tell the exact position of the pedal. Some use an optic device that senses the control's position. Adjustment of these devices is often quite simple and is usually covered in the game's manual.

LASER DISC PLAYER

There are several games that use a device called a Laser Disc Player. Most of the video displayed on the screen is much like that in a movie or a cartoon. Certain drawbacks exist with these games. First: the disc players are very fragile and are very expensive to repair. Second: the game play is very limited in choices so the game will quickly become boring to the player.

Laser Disc Players play a "laser disc." This laser disc resembles an audio recording but has a mirrored surface. The video that is recorded on the disc is sent to the monitor and displayed there. Sometimes the computer (logic board) generates its own picture that is mixed with the laser disc video.

Because of their fragile nature, great care must be taken when handling the player and the disc. Read sections 3-7 and 3-8 for more information about laser disc players and their proper care.

2-3 GAME ARCHITECTURE

THE VIDEO GAME

Now that you have had a basic education in electricity and the components that make up most games, we can begin to piece these items together. In doing so, we will break the game into blocks, or "black boxes." We will not be covering the inner-workings of these blocks, but will instead be looking at their connections and general functions.

Looking at the block diagrams of our video game (fig 3A through 3F), you see that the power cord comes from the wall to deliver the 110 to 120 volts AC to the game (henceforth we will refer to this voltage as 115 VAC). One of the wires from this line goes through a fuse, to the On/Off switch. The other wire goes to one of the input terminals on the line filter. The output terminal of the On/Off switch (power switch) goes to the other input terminal of the line filter. The ground wire (green) from the line cord connects to the middle terminal of the line filter. This ground connection (safety ground) continues to the metal frame of the transformers, the control panel, and various other metal assemblies throughout the game. Some games use a power switch that has two poles. This is known as a DPST switch (double pole, single throw). When this type of switch is used, both of the 115 VAC wires will go through the switch.

The other side of the line filter sends the 115 VAC wires to several places. One set goes to the fluorescent light that illuminates the marquee. Another set of 115 VAC wires go to the input side of the isolation transformer. The input side of the transformer is called the "primary" side.

Sometimes the 115 VAC will go other places, such as fans, or laser disc player power cords. But in our example it does not.

The transformer shown in the video game block diagram is an "isolation transformer." This means that the same amount of voltage on the primary side (input) will be present at the secondary side (output). The isolation transformer has its output (secondary) connected to the power input lines of the Monitor. An isolation transformer MUST ALWAYS be used with a monitor!

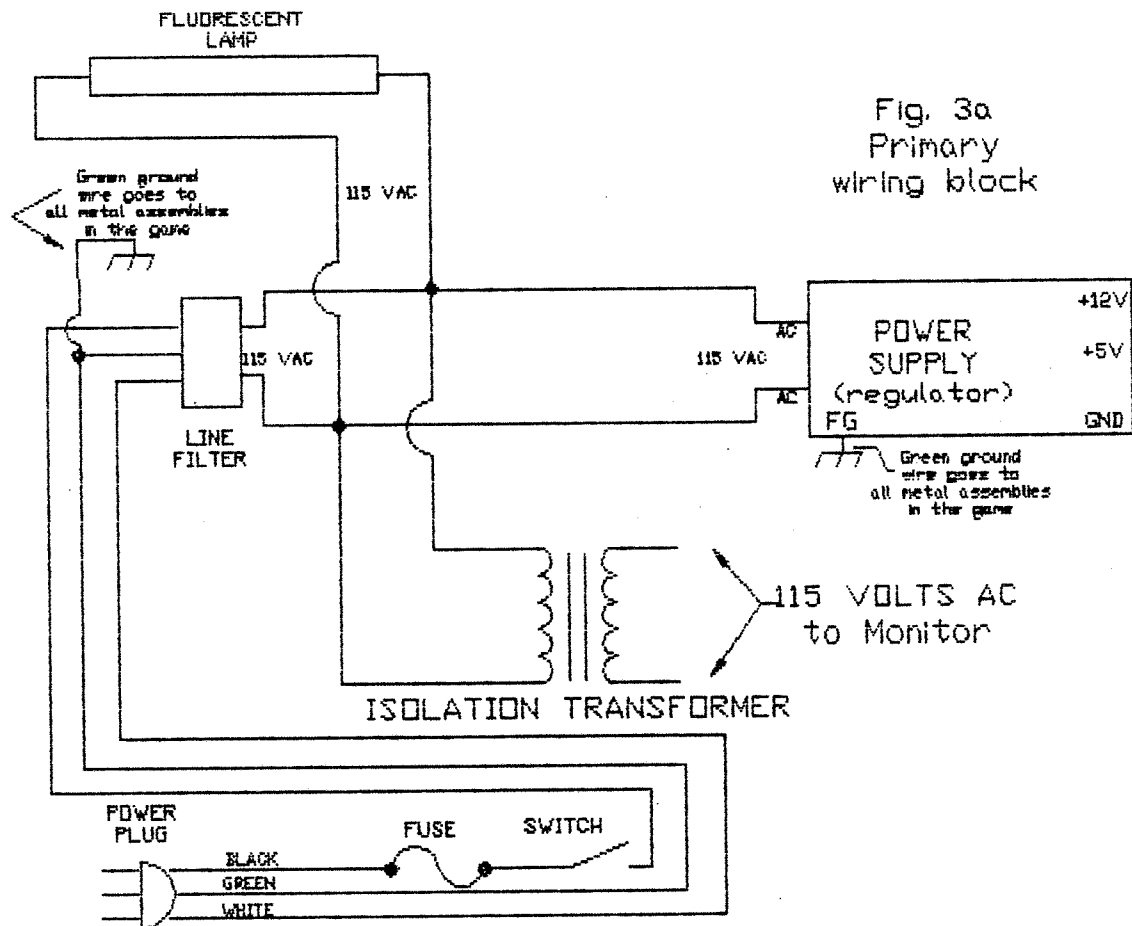


Fig. 3a
Primary
wiring block

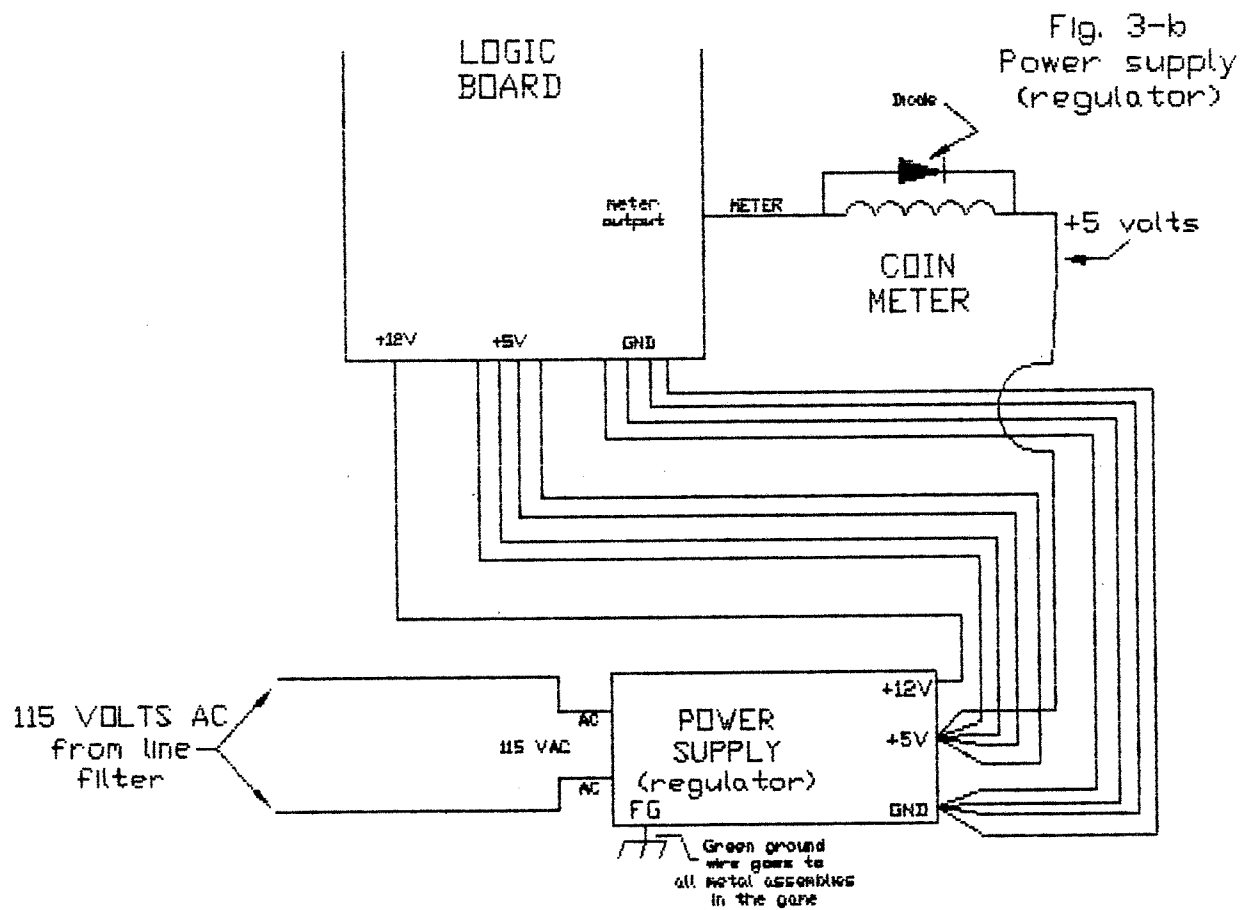


Fig. 3c
Monitor connections

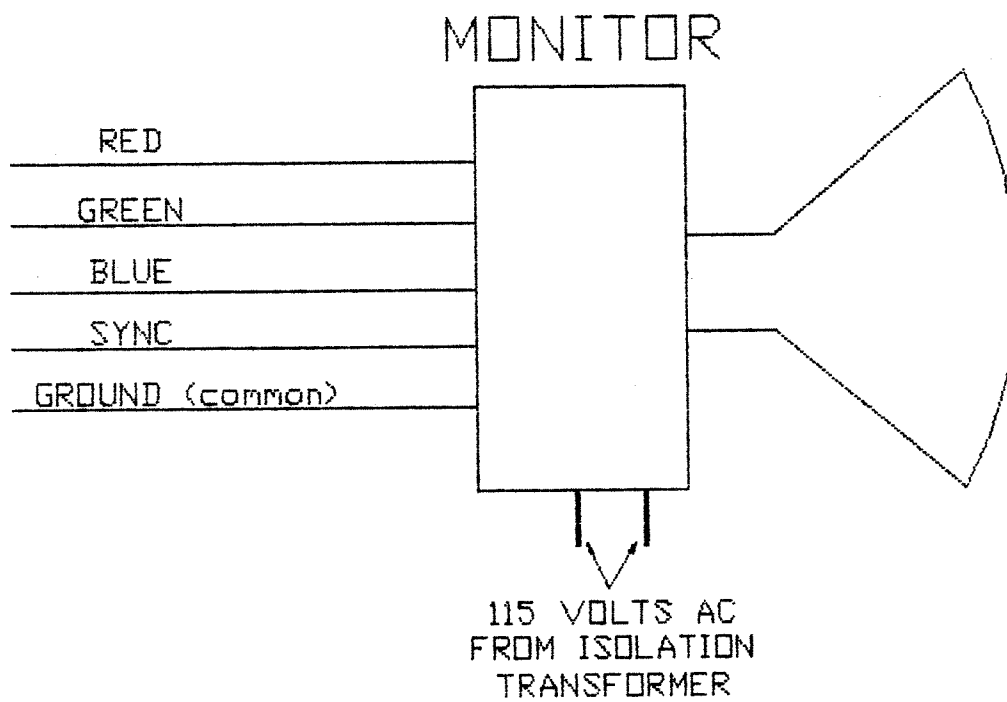


Fig. 3d
Coin door
connections

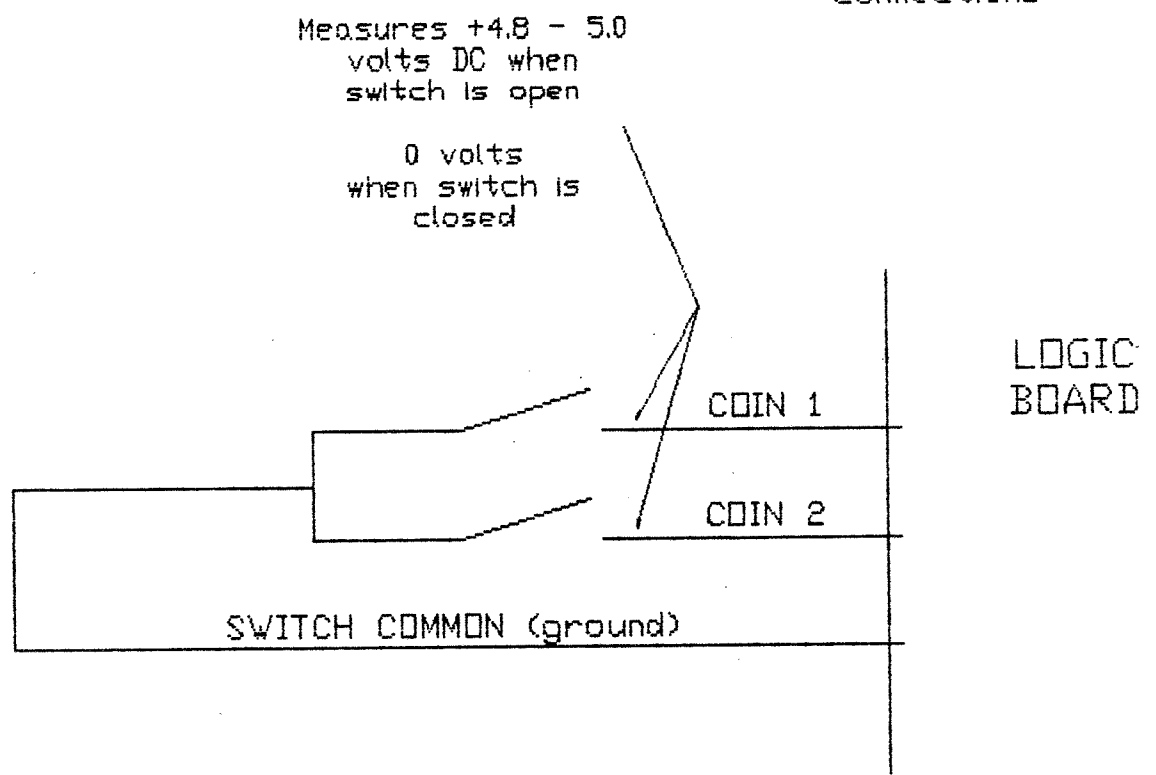
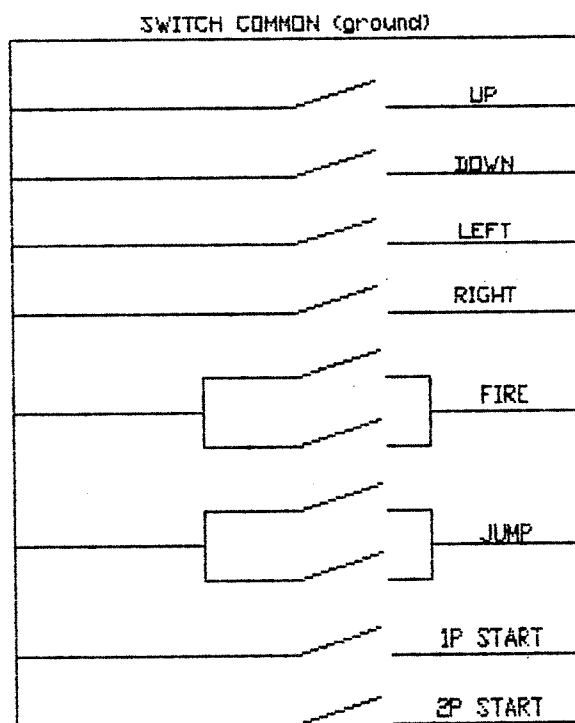


Fig. 3e
Control panel
connections



All switch input
wires measure
between 4.8 and
+5 volts DC when
NOT closed.

They measure
0 volts when
closed.

Video game block diag.

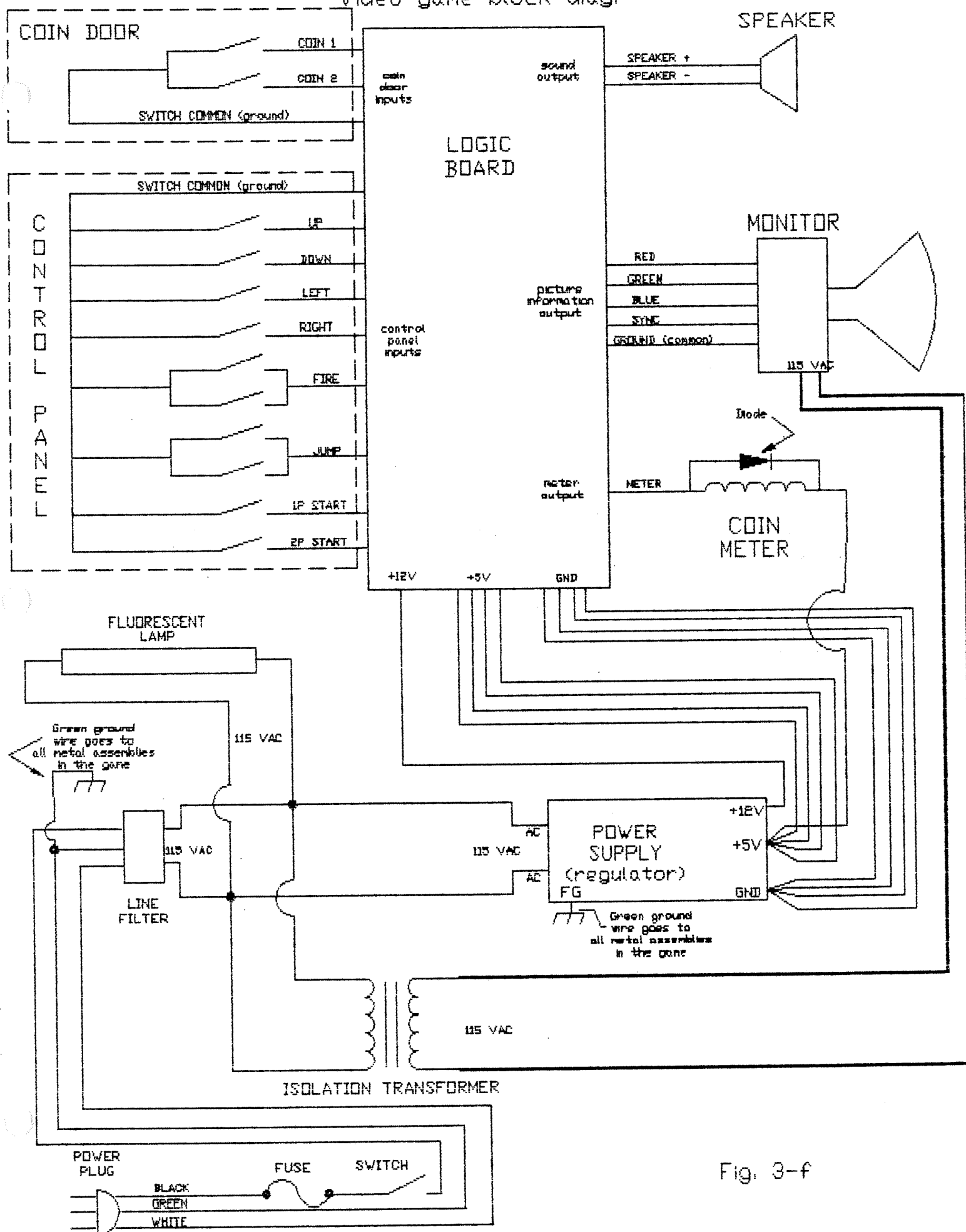


Fig. 3-f

Looking at the power supply regulator, we see that its AC input terminals are connected to the 115 volts AC coming from the line filter. There are two output voltages: +5 VDC, and +12 VDC. Remember that some games use additional voltages in their design.

The +5 volts goes two places; one wire goes to the meter (banded, or cathode side of the diode), the other +5 volt connections go to the logic board. Notice that there are four wires shown going from the +5 volt terminal of the power supply to the logic board. The purpose for this (although not always connected this way) is to divide the amount of current between the wires and keep them from getting too hot and burning at the connectors. Instead of having, for example, 6 amps of current flowing through one wire, we divide it so that there will only be 1 1/2 amps flowing through each wire. The +5 volts could also have been connected to the coin door lamps; however, in this example there are no lamps.

The +12 VDC goes to the logic board. This voltage is normally used in the sound (audio) circuits of the board.

The ground terminal (common) of the power supply is also connected to the logic board. There is more than one wire used here to divide the current between the wires, thus reducing the amount of current each wire must carry. The ground may also be directly connected to other items in the game; however, it usually runs through the logic board before going anywhere else.

This would be a good time to note that there is usually a loss of voltage level across a length of wire. If you were to measure the +5 volts on the terminals of the power supply, and then compare it the +5 volt connections on the logic board, you would find that the voltage on the logic board is slightly lower than at the power supply. This is why adjustment of the voltages should always be done while measuring at the board rather than at the power supply. This happens because the wire acts like a resistor, thus causing a loss of voltage level at the ends away from the power supply.

The last terminal on the power supply is the FG (frame ground) terminal. This is connected to the ground wire from the line cord and also to the other metal assemblies of the game.

The picture generated by the logic boards is displayed on the monitor. There are four different output signals from the logic board that connect to the monitor; Red, Green, Blue and Sync. These four signals are connected to the monitor by individual wires; one for the red information, one for the green, and one for the blue. The monitor mixes the RGB (red, green, and blue) to make any color on the CRT. The Sync signal is used to synchronize the timing of the monitor with the timing of the computer. Without this signal, the picture will roll vertically and horizontally. Some games have two sync wires instead of one; the Horizontal and the Vertical sync wires. Most games have only the one wire; composite (comp or C) sync. A ground wire is also

connected from the logic board to the monitor. Without this ground wire, the picture will not be displayed properly.

The computer's audio circuits generate an output to the speakers. Some games have mono sound. Others have stereo sound. If the game has mono sound, there will be only one output to the speakers. The + side of this output can be connected to more than one speaker. The other side of the speakers will be connected to ground. If the game generates stereo sound, two audio outputs will be used. Each output will go to a different speaker (or pair of speakers). All the speakers will have their second terminals connected to ground.

Some video games turn lamps off and on. Our example does not. If it did, there would be an output wire for each lamp. The other side of the lamps would probably be connected to +5 volts, +12 volts, or ground. Some games use motors or other devices to move seats and other assemblies. These devices are considered output devices and are usually wired in a unique way. This of course will depend on the design of the board.

The meter is the last output of the logic board on our example. This output wire is connected to the meter's anode side. This is the side of the meter that has the end of the diode without the stripe or band. All meters must have a component across them known as a "diode." Without this diode, the meter will produce a dangerous voltage 'spike' when it operates that will damage the logic board. The other end of the diode (the banded, or striped) end, is connected to a + voltage. Usually +5 VDC or +12VDC. The voltage that is used will depend on the type of meter it is. The banded end of the diode is also called the "cathode."

The next connections to cover are the inputs. The first inputs we will look at are the coin switches. Each coin switch must have a ground wire (common). This wire is the same as the ground from the power supply, but is almost always taken from the logic board (remember that the power supply ground connects to the logic board).

Each coin switch has an input wire labeled either "coin 1" or "coin 2." These wires go to the logic board. When coin switch #1 or #2 is pressed (or closed), it connects that logic board input directly to ground. When the logic board sees this, it will give the player credit.

Sometimes the two coin switches have separate wires going to the board, as does our example. In some cases, the two coin switches are wired "parallel" with each other and are connected to only one coin input wire leading to the board (see fig 3-D). If this is the case, the common terminal of both switches are connected to the switch ground wire, and both of the normally open terminals are connected to the coin #1 wire. With the switches wired in parallel, closing either switch will connect the coin wire to switch ground and give the player credit.

If you were to use your volt meter to measure the voltage on the coin switches, you would find that the coin #1 and #2 wires have approximately +5 volts when the switch IS NOT being pressed. When you Press (close) the coin switch, the voltage will drop to 0 volts. The reason for this is that when the switch is closed, the coin wire is connected directly to ground, which is 0 volts. The +5 volts that you read on the coin wire IS NOT the same voltage that is produced at the power supply. This +5 volts (actually a little lower than +5v) is a signal input to an I.C. - not a power supply voltage.

The switching systems of pinball machines are designed in a different way. Measuring the switches of a pinball machine will not give you the same results as in our video game example.

The control panel portion of the game has many switches. These switches function in the same manner as the coin switches you just learned about. The joystick has four switches: up, down, left, and right. There are two start switches: one player and two player start, two jump buttons, and two fire buttons. All the switches have one wire in common with each other: Switch Common (also called Switch Ground). Switch common is usually black and loops from switch to switch over the entire control panel. This switch common is just like the coin switch common for the coin switches.

The other side of each switch has a wire going to the logic board. When a switch is pressed (closed), it connects that wire to switch ground. If you were to measure the voltage on the switch wire (not the switch ground), you would find approximately +5 volts with the switch open. When you close the switch, the voltage would drop to 0 volts.

Notice that both of the jump buttons are wired parallel with each other and are connected to the same switch input wire. This is because one of the jump buttons is located on the left side of the joystick and the other is located on the right side of the joystick. This gives the player the choice of which hand to use for operating the joystick. The fire buttons are wired in the same way as the jump button.

Many games have more switches than in our example. You can have as many switches as the computer has switch inputs -- but they will all be wired in the same manner. Each having one side connected to switch common, and the other side connected to an input wire leading to the logic board.

Some games use an adjustable control called a "potentiometer" (pot) as one of the player inputs. A pot is an adjustable resistor. When a pot is used, the most common method of wiring is to connect one of the outside terminals to ground, and the other outside terminal to +5 volts. The third terminal (usually the middle one) is connected to the input wire of the logic board. When the player turns the pot's shaft, the voltage on the middle terminal changes -- it will go between 0 volts and

+5 volts. A volt meter can be used to measure the voltage on the middle terminal. The meter will show an increase and decrease in voltage as you turn the shaft of the pot back and forth.

There are many types of controls that are used on games. Some may involve optic devices, or magnetic sensors. Often, you will find a control device that has its own printed circuit board with its own I.C.s. These boards almost always need a +5 volt wire to provide the components with their supply voltage.

You must always exercise caution when working with switches and other input devices. Touching two input wires together can cause damage to the I.C.s on the logic board. Some controls use higher voltages than switches do. One may find +15 volts or -15 volts connected to a pot or printed circuit board. Always keep this in mind and use caution as you work on the game.

THE PINBALL MACHINE

In our discussion of pinball machines we will again be using a block diagram. Pinball machines are unique in design; a pinball game does not usually produce a video picture (although some pinball machines do). A pinball machine must control devices that manipulate the ball(s), respond to the action taking place on the playfield; produce sounds, and display numbers and/or words. All these functions are either inputs or outputs. Since Williams' games are the most common brand, we will be using their design as our example.

Begin by looking at the power supply. The line cord enters the game and goes through a line filter and the power switch (just like our video game example). The 115 VAC is then stepped down to several smaller AC voltages that are connected to many places. One voltage is for "general illumination." General illumination lamps are those lamps that are on most of the time. An example would be the coin door lamps. These lamps are not to be confused with the 'controlled lamps'. Controlled lamps are those that light only at certain times, such as bonus lamps. The general illumination voltage is usually about 6.3 volts AC. The two wires for general illumination go to every one of the general illumination lamps in the game. All these lamps are wired in parallel and are protected by one or more fuses. If you look at the underside of a playfield you will see a pair of non-insulated (bare) silver wires connecting to numerous lamps; these are the general illumination wires.

Another one of the transformer's output voltages goes to the power supply where it is changed to DC and regulated to become the +5 volts that is distributed to the logic board, the sound board, and the display board. Remember that all boards which have I.C.s must have +5 volts to operate. The power supply also has a +12 volt and a -12 volt output. These go to the logic and sound boards where they are used for the sound and reset circuits.

The next voltage we see is the 13.5 volts AC leaving the transformer and going through a device called a "bridge rectifier." The bridge rectifier changes the AC into DC which then becomes 18 volts DC. The 18 VDC goes through the power supply board where it is protected by a fuse. Next, it is sent to the logic board where it is used for the "Controlled" lamps. The computer turns these lamps off and on during the attract mode and while the player is playing the game. Examples of controlled lamps are: bonus lamps, special lamps, and extra ball lamps.

The 26 VAC from the transformer goes through a bridge rectifier where it becomes 34 volts DC. It also has a device called a "capacitor" attached to the output side of the bridge rectifier. The capacitor filters (smoothes out) the voltage to a more steady level. The 34 VDC then goes through the power supply board, where it is protected by a fuse and is then distributed to most of the coils (solenoids) throughout the game.

The transformer's 88.5 volts AC goes to the power supply board where it is changed into +100 and -100 volts DC. These voltages go to the display board and to each of the display tubes.

The last transformer output voltage is 48 volts AC. This voltage is sent to the flipper power supply board where it is changed to 65 volts DC and protected by a fuse. This voltage (the flipper voltage) is distributed to each of the flipper coils and sometimes to other coils that need a higher voltage than the normal solenoid voltage.

All the switches in the game are wired in a "matrix" pattern. This matrix pattern is not at all like the control panel in the video game example. In this pattern (matrix), there is not a common ground. Instead, there are eight columns and eight rows of switches that are connected at intersections. Looking at the chart in figure 3-H, we see that switch #1 (Plumb bob tilt) is connected to the intersection of column #1 and row # 1. Switch # 29 (visor target 2) is connected to column #4 and row #5. Look at the wire color for row #4. The chart tells us that it is a grn-yell wire. Now look at row #5's wire color; it is wht-grn. Therefore, all the switches located on the column #4 have the same wire (grn-yell). Likewise, all the row #5 switches use the wht-grn wire.

The computer looks at each of the rows and columns to see if the switch at each intersection is closed or open. If the device on the logic board that controls a column fails, then ALL the switches that are on that column will be affected and will not work properly. If there is a board failure on a row controlling device, the entire row of switches will not work correctly.

If you were to use a meter to measure the voltage on one of these rows or columns, it would not be +5 volts dropping down to 0 volts as it does in a video game. The reason is that each of the rows and columns have high speed computer generated pulses on them; most video game switches do not operate this way. Each of the switches in the matrix also has a small component called a diode mounted on it. This diode is essential to the operation of the switch.

Almost every coil in the game is connected to the solenoid voltage that comes from the power supply. This voltage is +34 volts DC (games made by manufacturers other than Williams use different voltages) and it is connected to the terminal of the coils that have the banded side of the diode. The wire carrying this voltage starts at the power supply and runs to the first coil and then continues to the next coil, and the next, until all the coils have been reached. This is why most coils have two wires connected to the terminal with the banded side of the diode. If this continuing wire (known as the solenoid bus) were to break somewhere along its path, every coil after that break would cease to function.

The second terminal of each coil is connected directly to the logic board, each coil has its own wire leading to the board. The board then uses devices called "transistors" to connect this side of the coil to ground when it is time to turn the coil on. When the transistor turns off, the coil turns off. When the transistor turns on, the coil turns on. Each coil MUST have a diode across its terminals. Without a diode, the coil will produce a voltage "spike" each time it is turned on and off. This spike will destroy the transistors and other components on the board.

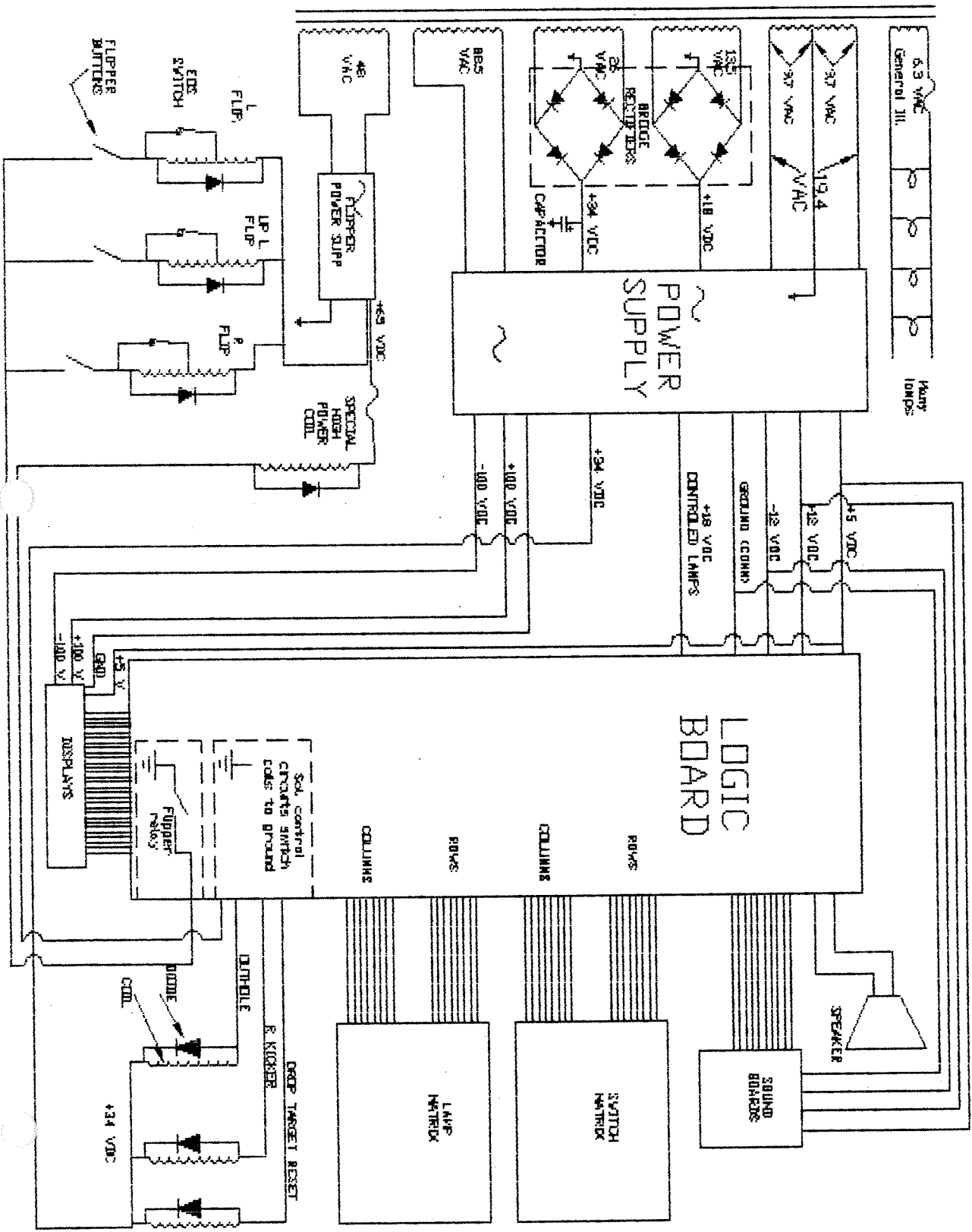
If you were using a volt meter to measure the voltage on one of the coils, you would find +34 VDC on both terminals when the coil is not turned on. When the board turns the coil on, the voltage on the cathode terminal (the terminal with the non-banded end of the diode) will drop to 0 volts for as long as the coil is turned on.

Some of the coils may be connected to the 65 VDC that comes from the flipper power supply. The reason is that some coils must have more power than others, and the type of coil being used may need a higher voltage than the regular solenoids.

The flippers are the most important part of the game. Without strong, and fast flippers, the game is not enjoyable. The flipper voltage goes from the flipper power supply to the outside terminal of each flipper coil with the banded end of a diode (some flipper coils have two diodes instead of one). The other outside terminal of the coil goes to the button that the player presses, then up to the board where it passes through a device called a relay. This relay keeps the flippers from being turned on when the game is over. From there it goes to ground. The middle terminal of the coil goes to the E.O.S. switch (see section 3-10 for an explanation of E.O.S. and other facts about flippers). The other side of the E.O.S. switch usually goes to the outside terminal of the coil that does not have the banded end of a diode.

The display board is connected to the logic board. The logic board tells the display board what numbers or letters to display. There are also connections between the logic board and the sound board. The logic board tells the sound board what sounds to make. These sounds are sent back through the logic board where they are amplified and sent to the speakers.

The controlled lamps are connected in a matrix pattern similar the switches' matrix design. Looking at the lamp matrix chart in figure 3-H, you see columns and rows. These columns and rows are controlled by transistors on the logic board.



2 Double Lamp

PIN-BOT Lamp-Matrix Table

Δ = #555 Bulb, p/n 24-8767
Remaining Lamps = #44 Bulb, p/n 24-6549

COLUMN	1 Q66 YEL-BRN 1J7-1	2 Q64 YEL-RED 1J7-2	3 Q62 YEL-ORN 1J7-3	4 Q60 YEL-BLK 1J7-4	5 Q58 YEL-GRN 1J7-6	6 Q56 YEL-BLU 1J7-7	7 Q54 YEL-VIO 1J7-8	8 Q52 YEL-GRY 1J7-9
ROW								
Q80 RED-BRN 1J6-1	Game Over (Backbox) 1	2X 9	Drop Targets' Single Timer Lamp 17	Earth 25	Shoot Again (Playfield) 33	Drop Targets' Top Lamp 41	Left Outlane Extra Ball 49	Right Outlane Extra Ball 57
Q81 RED-BLK 1J6-2	Match (Backbox) 2	3X 10	Advance Planet 18	Venus 26	Score ENERGY 34	Drop Targets' Middle Lamp 42	Left Return Extra Ball 50	Right Return Extra Ball 58
Q82 RED-ORN 1J6-3	Ball In Play (Backbox) 3	4X 11	Pluto 19	Mercury 27	Solar Energy Value 35	Drop Targets' Bottom Lamp 43	Special 51	Not Used 59
Q83 RED-YEL 1J6-5	Mouth 1 (Backbox Left) 4	5X 12	Neptune 20	Yellow 1 (Top) 28	Blue 1 (Top) 36	Amber 1 (Top) 44	Green 1 (Top) 52	Red 1 (Top) 60
Q84 RED-GRN 1J6-6	Mouth 2 (Backbox) 5	Single Eject's 25K 13	Uranus 21	Yellow 2 (Top) 29	Blue 2 (Top) 37	Amber 2 (Top) 45	Green 2 (Top) 53	Red 2 (Top) 61
Q85 RED-BLU 1J6-7	Mouth 3 (Backbox) 6	Single Eject's 50K 14	Saturn 22	Yellow 3 (Top) 30	Blue 3 (Top) 38	Amber 3 (Top) 46	Green 3 (Top) 54	Red 3 (Top) 62
Q86 RED-VIO 1J6-8	Mouth 4 (Backbox) 7	Single Eject's 75K 15	Jupiter 23	Yellow 4 (Top) 31	Blue 4 (Top) 39	Amber 4 (Top) 47	Green 4 (Top) 55	Red 4 (Top) 63
Q87 RED-GRY 1J6-9	Mouth 5 (Backbox Right) 8	Single Eject's Light Extra Ball 16	Mars 24	Yellow 5 (Bottom) 32	Blue 5 (Bottom) 40	Amber 5 (Bottom) 48	Green 5 (Bottom) 56	Red 5 (Bottom) 64

PIN-BOT Switch-Matrix Table

COLUMN	1 Q45 GRN-BRN 1J8-1	2 Q49 GRN-RED 1J8-2	3 Q44 GRN-ORN 1J8-3	4 Q48 GRN-YEL 1J8-4	5 Q43 GRN-BLK 1J8-5	6 Q47 GRN-BLU 1J8-7	7 Q42 GRN-VIO 1J8-8	8 Q46 GRN-GRY 1J8-9
ROW								
1 WHT-BRN 1J10-9	Plumb Bob Tilt 1	Playfield Tilt 9	Ball Trough #1 (Lower Right) 17	Left Eject 25	Right 5-Bank (Top) 33	Not Used 41	Left Drop Target (Upper) 49	Not Used 57
2 WHT-RED 1J10-8	Ball Roll Tilt 2	Left Lane Change 10	Ball Trough #2 (Center) 18	Right Eject 26	Right 5-Bank 34	Not Used 42	Left Drop Target (Mid) 50	Not Used 58
3 WHT-ORN 1J10-7	Credit Button 3	Right Lane Change 11	Advance Planet 19	Not Used 27	Right 5-Bank (Center) 35	Not Used 43	Left Drop Target (Lower) 51	10 Point 59
4 WHT-YEL 1J10-6	Right Coin Chute 4	Left Outlane 12	Shooter Lane 20	Visor Target 1 (Left) 28	Right 5-Bank 36	Ramp Down 44	Top Jet Bumper 52	10 Point 60
5 WHT-GRN 1J10-5	Center Coin Chute 5	Left Return Lane 13	Not Used 21	Visor Target 2 29	Right 5-Bank (Bottom) 37	Score Energy 45	Bottom Jet Bumper 53	Not Used 61
6 WHT-BLU 1J10-3	Left Coin Chute 6	Right Return Lane 14	Vortex 20K 22	Visor Target 3 (Center) 30	Single Eject 38	Visor Closed 46	Left Sling 54	Not Used 62
7 WHT-VIO 1J10-2	Slam Tilt 7	Right Outlane 15	Vortex 100K 23	Visor Target 4 31	Exit Ramp 39	Visor Open 47	Right Sling 55	Not Used 63
8 WHT-GRY 1J10-1	High-Score Reset 8	Outhole 16	Vortex 5K (Exit) 24	Visor Target 5 (Right) 32	Enter Ramp 40	Left Jet Bumper 48	10 Point 56	Not Used 64

CONCLUSION

What you have learned in this section is very basic, yet essential to understand the operation of games. Remember that there are numerous designs and configurations of game electronics. Not all games are as simple as our examples. Many have complicated wiring systems and circuit boards that have not been covered in this manual. Use the knowledge you have gained in this section as a base from which to begin, and as a tool to reference.

One of the most valuable skills that you can learn is reading wiring diagrams (wiring schematics). Being able to understand the symbols and reference designators used in these diagrams will improve your troubleshooting and repair skills tremendously. A trip to the public library, or to the literature department of a Radio Shack can be well worth your time.

SECTION 3

BASIC TECHNICAL PROCEDURES

Detailed in this section are many of the very basic testing and repair procedures that are used in the day-to-day operation of your store. Follow the directions step-by-step and do not be careless as you do them. If you have not read Section 1 of this manual, do so now. Section 1 covers many safety guidelines that you must follow.

- | | |
|------|---|
| 3-1 | Fuses |
| 3-2 | Re-seating I.C.s |
| 3-3 | Removing and Cleaning Connector Pins |
| 3-4 | Testing Switches With a DMM |
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3-1 FUSES

The two types of fuses most commonly found in games are the AGC and the MDL. The AGC type is a FAST blowing fuse. It will blow (the filament will break) when the current reaches the specified value printed on the fuse's metal cap; i.e. an AGC 3 will quickly blow at 3 amps of current.

The MDL (sometimes MSL) type is a SLOW blowing fuse - it will not blow quite as fast as an AGC fuse. Both AGC and MDL fuses are 1 1/4" long and 1/4" in diameter. Occasionally you will encounter smaller fuses. These are usually 5mm in diameter, and 20mm long (5mm x 20mm). There are several other types of fuses sometimes found in games; however, they will not be covered in this section. For more information about fuses not listed in this section, contact your service center.

When reading a fuse's value, always look for a decimal point before the number or between two numbers. Numbers like .25 (1/4) can easily be mistaken for 2.5 or 25. A mistake like this could result in fire, component damage, or electrical shock.

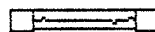
For additional information about fuses and their function, refer to Section 2 page 6 of this manual.



AGC



MDL



DO'S and DON'TS

- * DO check fuses with a meter when they are not visibly blown.
- * DO refer to the game's documentation to find the proper fuse value.
- * DO NOT check fuses while they are still in the fuse clip. Doing so may give an inaccurate reading or damage your meter. Always lift one end of the fuse out of its holder, or completely remove it from the game.
- * DO NOT assume that the value printed on the cap of the fuse that you removed from the game is the correct value. Someone before you may have installed the wrong value fuse.
- * DO NOT install a new fuse without first reading its value on the cap. Never assume that just because you found it in a labeled drawer or box that it is the correct value. Fuses can be (and often are) easily mixed up in parts drawers.

DO NOT install a new fuse without first reading its value on the cap. Never assume that just because you found it in a labeled drawer or box that it is the correct value. Fuses can be (and often are) easily mixed up in parts drawers.

DO NOT replace an AGC fuse with an MDL or MSL.

DO NOT increase the value of a fuse.

DO NOT replace all of a game's fuses as a method of troubleshooting. This is costly and often results in wrong fuse values and loose fuse clips. Instead, check the fuses one by one with a DMM.

VISUAL INSPECTION

If a fuse does not look blown **YOU STILL MUST TEST IT WITH A DMM**. Sometimes the filament is broken inside the metal cap where you cannot see it. Checking the fuse with a DMM will tell you if this has happened.

Always unplug the game when checking fuses! Remove the fuses one at a time and look at the filament (the wire inside the fuse) to see if it is broken. If the filament does not appear to be burned or broken, you must check it with your DMM. Never check the fuse with the meter while the fuse is still in the game. Doing so may render an inaccurate reading and may damage the meter.

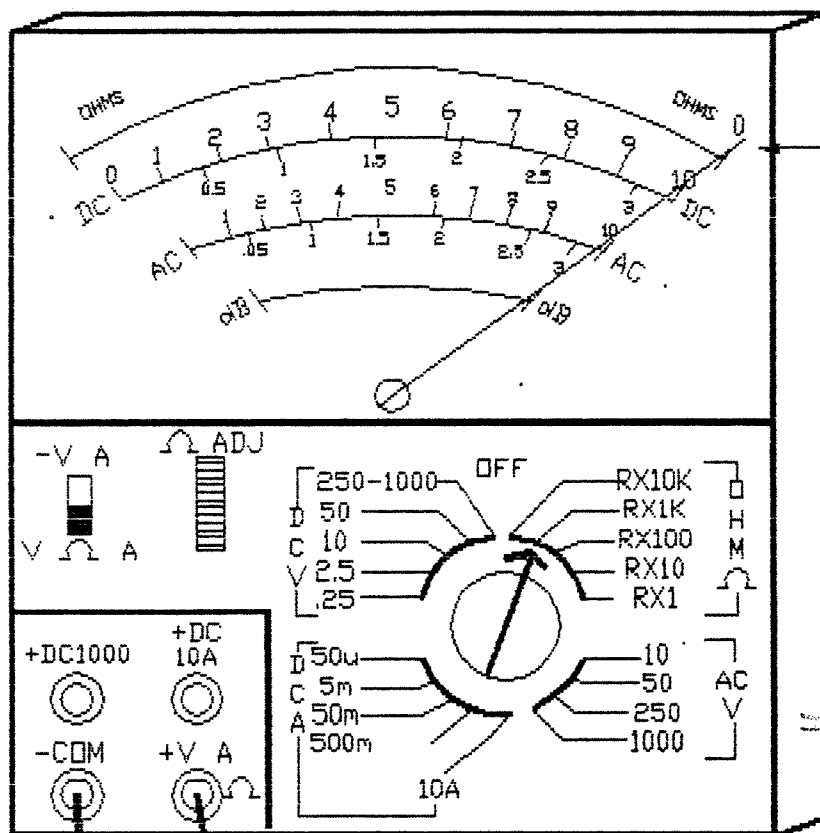
CHECKING A FUSE USING A DIGITAL MULTIMETER (DMM)

First, determine which type of DMM your store has. Do this by comparing your DMM with the diagrams in this section.

Once you have found the correct diagram:

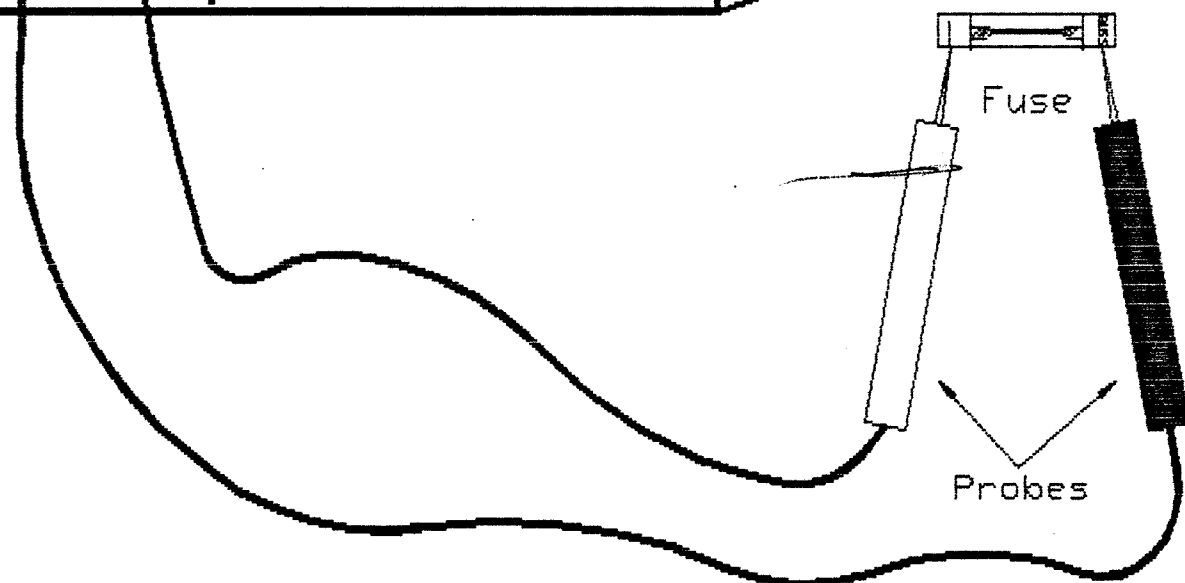
1. Turn game's power off!
2. Set the DMM's switches and controls exactly as shown in the diagram.
3. Test the meter by touching the probes together. The display should drop from 1.000 (or 1000) to almost 0.00. If you are using the CONTINUITY (CONT) function (if your meter has one) you should hear a 'beep' from the meter.
4. With the fuse removed from the game (or with one end completely lifted out of the fuse holder) place a test probe at each end of the fuse (as shown in the diagram). Do not let your fingers touch the probe tips or the metal fuse caps.

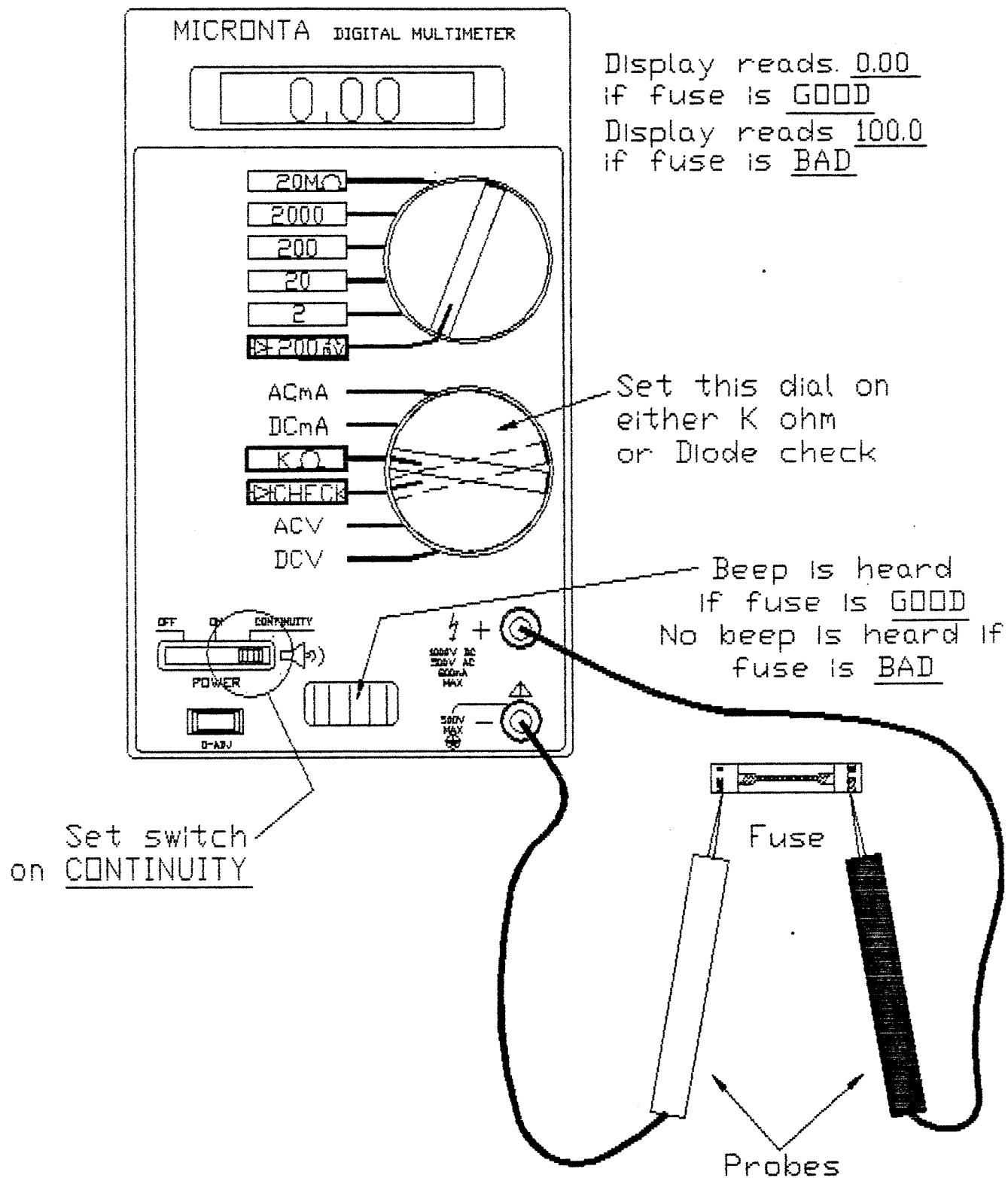
5. If the fuse is good, the display's reading should drop from 1.000 (or 1000) to almost 0.00 (the same as when you touched the probes together). If you are using the CONTINUITY (CONT) checking function (if your meter has one), a good fuse will cause the meter to 'beep'. A bad fuse will give a reading of 1.000 (or 1000) and no beep will be heard.



If the fuse is good, the needle will swing to the right end of the scale.

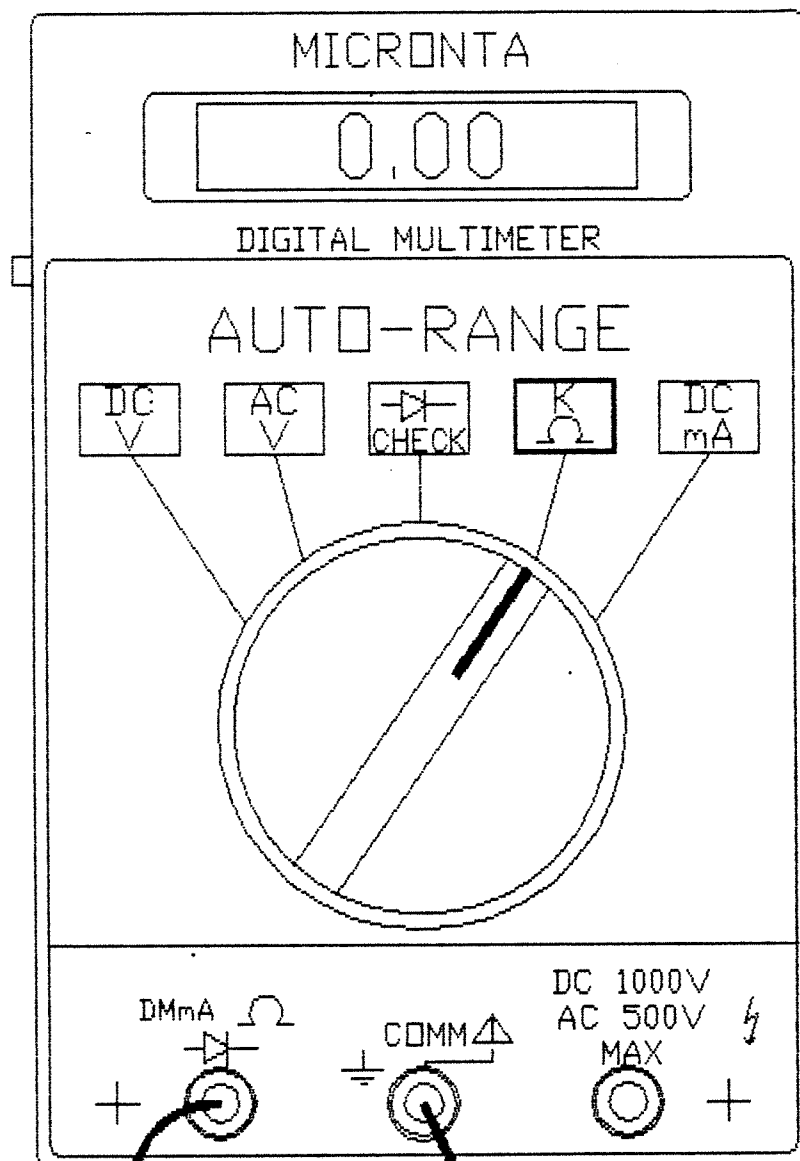
Fig 1-A



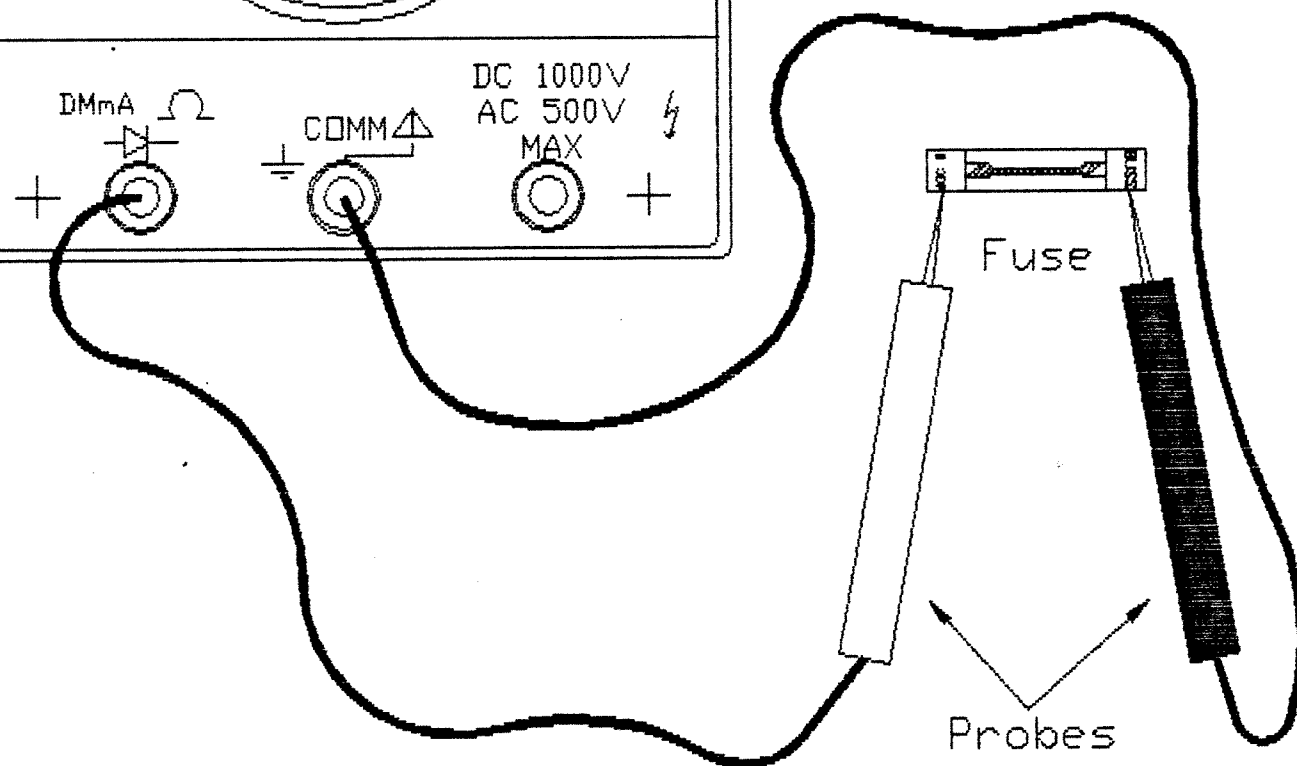


CHECKING A FUSE WITH A NON AUTO-RANGING DIGITAL METER

Fig 1-B

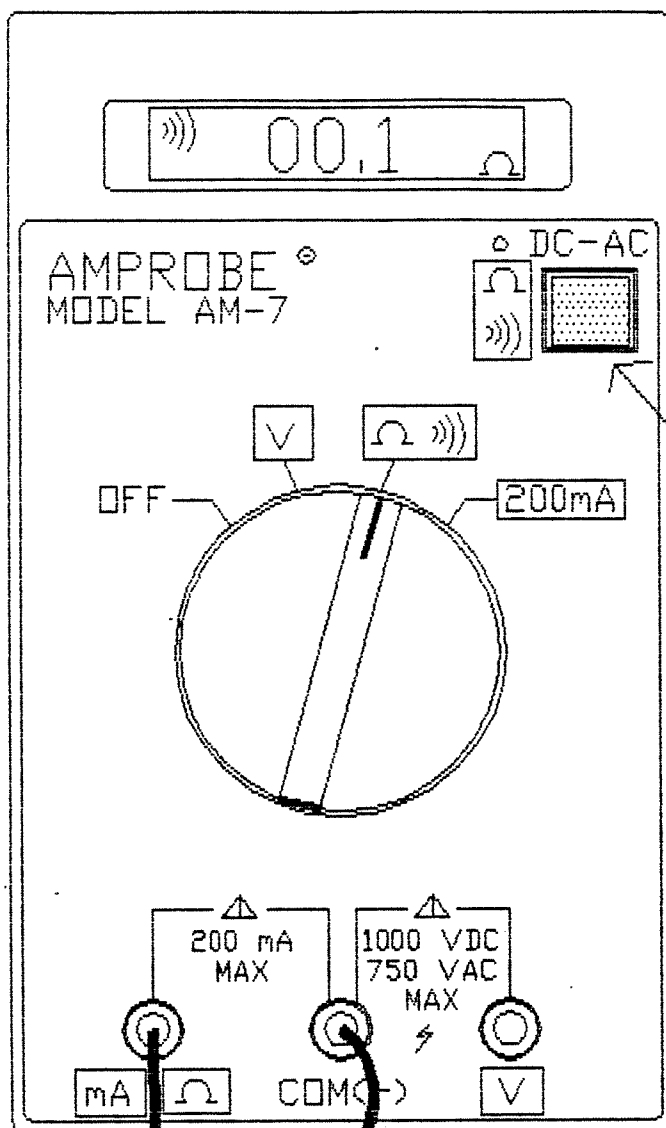


Display reads 0.00
if fuse is GOOD
Display reads 100.0
if fuse is BAD



CHECKING A FUSE
WITH AN AUTO-RANGING
DIGITAL METER

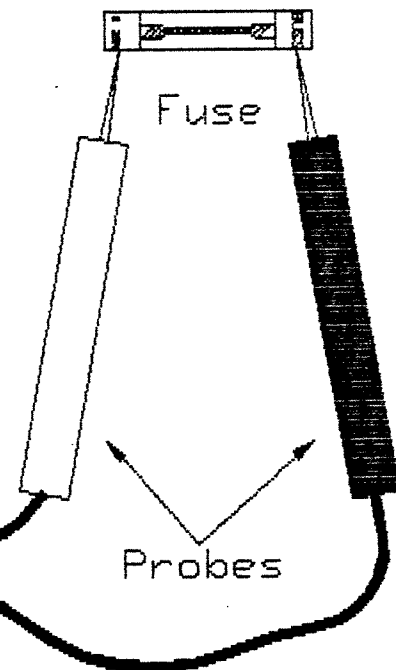
Fig 1-C



A good fuse will read 00.0 (or 00.1) and a Beep will be heard (if the "BEEP" function is turned on).

A bad fuse will read 1 and no beep will be heard.

Press the DC-AC button to turn the "BEEP" function ON. This is indicated by the))) symbol in the upper left corner of the display.



CHECKING A FUSE
WITH AN AUTO-RANGING
DIGITAL METER

Fig 1-D

3-2 RE-SEATING I.C.s

I.C.s, or *chips*, are the components on logic boards that look like black caterpillars with silver legs. Some of these I.C.s are soldered into the boards. However, some of them are plugged into sockets on the board so that they can be easily removed and replaced when necessary. Because they are in sockets the connection sometimes becomes poor due to vibration, heat, dust, etc. To improve this connection it becomes necessary to re-seat the I.C. by doing the following:

1. Turn game's power off!
2. Place your hand behind the board (solder side) to keep from bending the board.
3. Use thumb of other hand to gently but firmly push the I.C. down.

Sometimes a game has two or three boards mounted together in a stack. You will have to very carefully separate them so that you can reach the socketed I.C.s in the middle of the stack. When you do this, use extreme caution so as not to scratch the board with a tool. Remember, do not bend the board.

Occasionally, just pushing on the I.C.s is not effective. In this case you must go a little further (if your supervisor instructs you to do so). With a small knife, *very gently* pry the I.C. up on one end, but **not enough to lift any of the pins completely out of the socket** (see Figure 2-A). Place the small knife blade (or flat tip screwdriver) between the bottom of the I.C. and the top of the socket - not between the socket and the board!

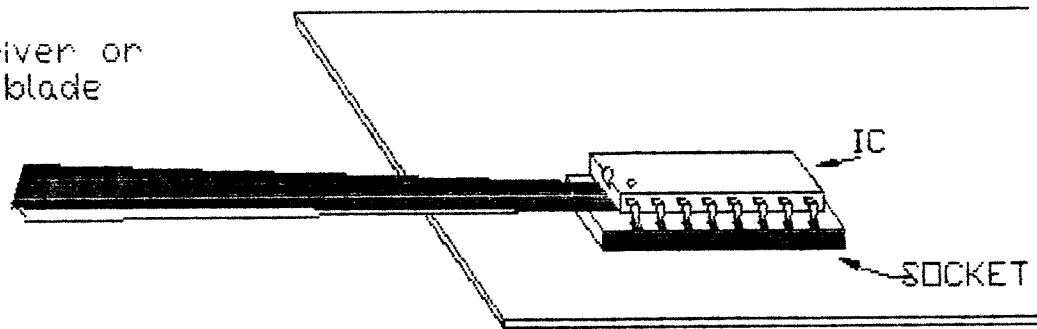
This will cause the pins of the I.C. to wipe against the pins in the socket, thus cleaning them. At this point you may re-seat the I.C. by pushing down on it as described in the above steps.

Make sure all of the pins are properly seated in their sockets and are not bent. If you do bend one, very carefully pry the I.C. up again, straighten the pin, and carefully re-seat it once more. Inspect all of the pins one last time. Bending pins and scratching the surface of the board are two of the most common mistakes that are made during this procedure, so be careful and **DO NOT REMOVE THE I.C. COMPLETELY FROM THE SOCKET.**

<p style="text-align: center;">CAUTION</p> <p>DO NOT LET THE TIP OF THE SCREWDRIVER BLADE TOUCH THE PC BOARD BENEATH THE I.C. SOCKET!!!</p>

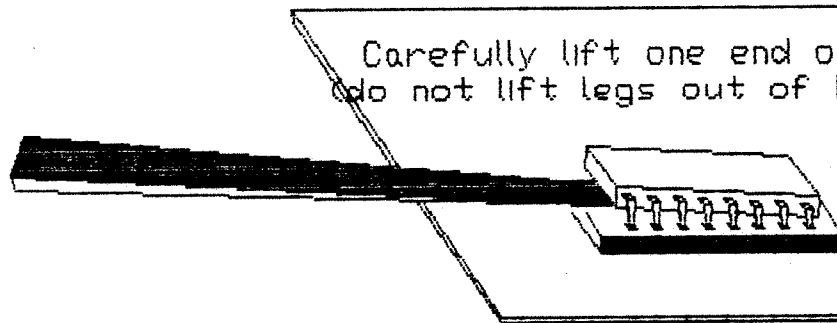
See Section 3-23 for Information about replacing socketed I.C.s.

Screwdriver or
knife blade
Fig. 2-A

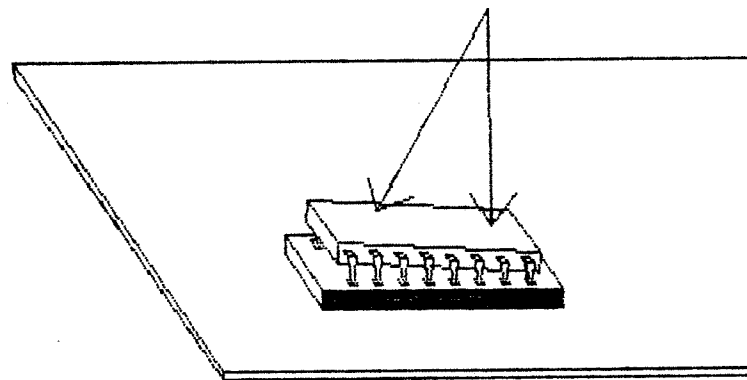


Place blade between
IC and Socket

Carefully lift one end of IC
(do not lift legs out of holes)



PUSH BOTH ENDS DOWN



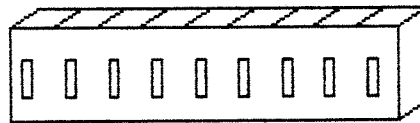
3-3 REMOVING AND CLEANING CONNECTOR PINS

Quite often, connectors will become burned due to too much current passing through them which heats the metal. When this happens its like putting a kink in a water hose; the current simply can't get through to where it is supposed to go. This is usually very easy to find, just look for dark discoloration in the plastic connector (usually on the power supply of logic board). If you find a burn, do the following:

1. Unplug the game and mark which direction the connector plugs fit on the board.
2. Unplug the burned connector.
3. Mark where the wire goes in the connector. The type of connectors that usually burn look like this:

Fig. 3-A

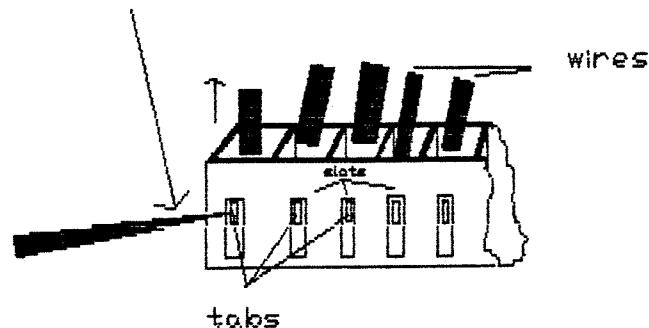
Molex connector housing



4. To repair the burn, you must remove the pin inside the connector. Place a knife blade against the tab on the metal pin in the slot (see figure 3B)

Fig. 3-B

Use pointed tool
to press on tab while
gently pulling up on wire.



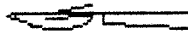
5. Gently push on the tab with the knife blade.
6. Gently pull up on the wire while maintaining pressure on the tab.
7. Continue pulling on the wire until the pin is completely removed from the plastic connector.

CAUTION: Do not damage the tab by inverting it into the pin or by pulling the pin out while the tab is still caught on the plastic connector.

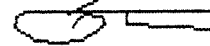
The next step is to replace the pin, or the re-shape and clean the old one. If you do have replacement pins you should by all means replace the burned one. If you do not have replacements, do the following:

1. With the knife blade, re-shape the pin to the proper size and shape.

Fig. 3-C



BAD SHAPE



GOOD SHAPE

2. Use a fine contact burnishing tool or sand paper to file the surface back to a shiny silver color.
3. Slide the pin and wire back into the plastic connector until the tab pops into the slot.
4. Gently tug on the wire to see if the pin comes back out. If it does, you bent the tab out of shape and it is not locking into place in the slot.

You may find that the plastic connector is melted and must also be replaced.

If you do have replacement pins, do the following:

1. Cut the old pin off at the wire.
2. Strip the wire back about 1/8 inch. (Not too much!)
3. Place the bare portion of the wire in section A of the pin. Put the insulated portion in section B. (see Fig. 3D)

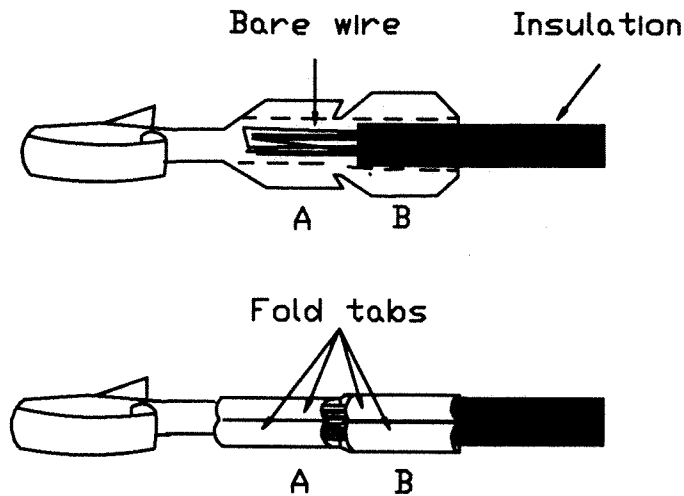


Figure 3-D Crimping the Connector Pin Onto the Wire

4. If you have a Crimping Tool, use it to crimp section A and B. If you don't have the tool, use needle nose pliers to bend section A flaps around the bare wire. Do the same with section B flaps around the insulation on the wire. Make the bends as smooth and tight as you can without damaging the pin.
5. If you did not use a Crimping Tool, you should now apply a very small amount of solder to section A with a soldering pencil, not a solder gun.
6. Insert the pin into the connector housing.

After you have repaired the pin in the connector housing you must also repair the pin that it makes contact with it (*see Figure 3-E*). This pin will also be burned and must be cleaned with a burnishing tool or very fine sandpaper until it is shiny on all sides. Failure to clean the pin properly will make your efforts of pin replacement almost futile. Many times the pin is badly burned and must be replaced. Replacement should only be done by a qualified individual.

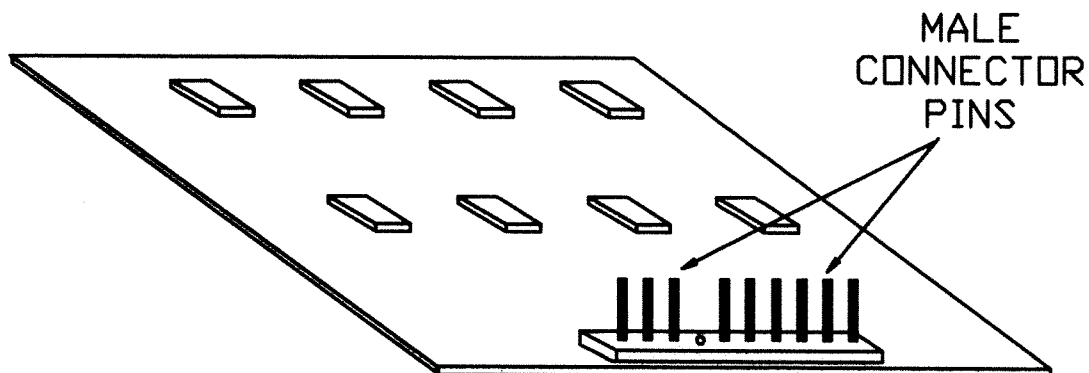


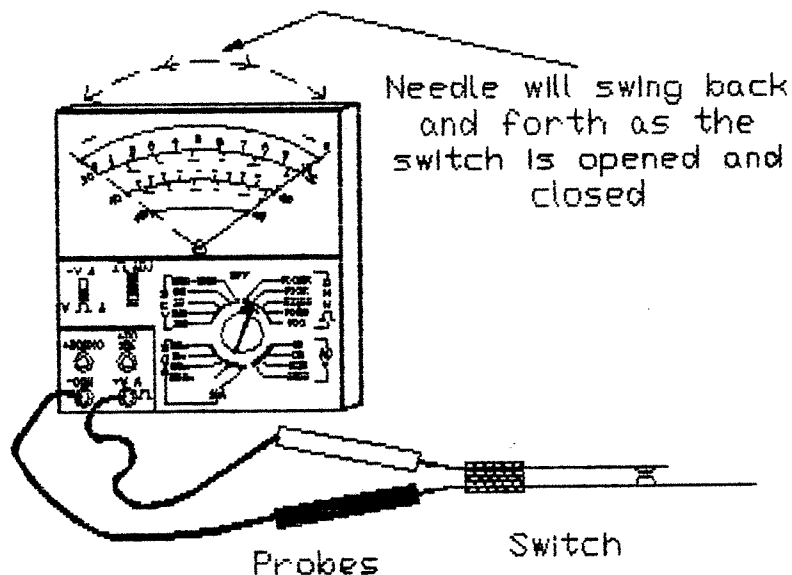
Figure 3-E Male Connector Pins on PC Board

3-4 USING THE VOLT OHM METER TO CHECK SWITCHES

If you are in question about whether or not a coin switch, shifter switch, joystick switch, etc. is working, you should check it with your meter by doing the following:

1. Remove the wires from the switch in question. Make a drawing of where the wires go.
2. Insert the black probe of your meter in the common jack. Insert the red probe wire into the volt/ohm jack. Set the meter select switch to one of the Ohm RX settings (RX1, RX10, RX100, RX1k)
3. Touch the probe tips together. The needle should swing to the right. If it does, adjust the Ohm () adjustment knob until the needle rests on the 0 at the right of the meter scale.
4. If your switch has 2 terminals, (Fig. 4A), place the black probe on one terminal and the red probe on the other terminal.
5. Now operate the switch (open and close). If the needle swings back and forth, your switch is good. If it stays to the left, your switch is bad or not making contact. If it stays to the right all the time, your switch is stuck closed.

Fig. 4-A



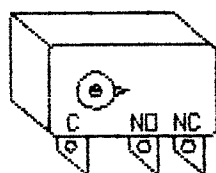
USING A METER TO TEST A SWITCH

If the switch has three terminals, as shown in Fig. 4B, do the following:

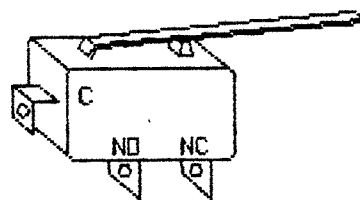
1. Put the black probe on the terminal that is marked "C" or "Com" on the side of the switch.
2. Put the red probe on the terminal marked N.O. (normally open).
3. Operate the switch. If the needle swings to the right when you hold the switch closed, the switch is good. If not, your switch is bad.
4. Keep the black probe on the "Com" terminal. Move the red probe to the terminal marked N.C. (normally closed).
5. Operate the switch. Does the needle move back and forth as you operate it? When you are not operating the switch does the needle stay at the far right on the meter? If so, your switch is probably good.

Fig. 4-B

TYPICAL SWITCHES



COIN SWITCH



LEVER SWITCH

3-5 INTERCHANGING PARTS

It is sometimes possible to interchange boards and monitors with other games for testing purposes.

Logic boards are generally not interchangeable between games (except for instance from a Pole Position to another Pole Position). There are some cases where logic boards do interchange, but you must find this out from your service center.

Power Supplies do sometimes interchange, especially in the case of Switching Power Supplies. Check with your service center first.

Quite often monitors are interchangeable. Check with your service center and read section 3-15 for more information.

3-6 TESTING +5 VOLTS DC WITH A DIGITAL MULTIMETER (DMM)

Extreme caution must be observed when doing this test so the meter's probe tips do not slip and accidentally short a component's pins together.

CAUTION...ADJUSTING A GAME'S POWER SUPPLY ABOVE 5.2 VOLTS AT THE LOGIC BOARD CAN CAUSE SEVERE DAMAGE TO THE COMPONENTS!!!

ABOUT "VOLTAGE DROP"

The voltage measured at the +5 volt and Common terminals of the power supply will always be slightly higher than what is measured at the logic board. There is always a drop in voltage across the wires that connect the logic board to the power supply. This is why it is important that you adjust the power supply while measuring at the logic board, not the power supply. The difference in voltage between the power supply and logic board varies depending on the game design. The usual difference is approximately .2 volts (2/10 of a volt).

Excessive voltage drops (.3 volts or more) usually indicate a problem with the game's wiring or connectors, such as burned or loose connector pins, loose wires at power supply terminals, loose fuse clips, or overheated wires that have hardened or burned inside the insulation. These types of problems must be found and corrected. It is unsafe to adjust a power supply higher to compensate for excessive voltage drops. If this is done, the voltage on the logic board will be too high when the problem is finally corrected, and damage will occur to the logic board.

Example: If the voltage at the power supply measures +5.6 volts, and the voltage measured at the logic board is 5.02, this is too much of a voltage drop (.58 volts).

WHERE TO MEASURE +5 VOLTS DC

There are four places where you can measure +5 volts. They are:

- At the JAMMA edge connector (if the game has a JAMMA logic board)
- At the board's +5V and Ground Test Points (most boards do not have these test points)
- Across an I.C. (*chip*) on the logic board
- At the Power Supply terminals (Note: this **DOES NOT** give an accurate reading of what the voltage actually is at the logic board and is therefore **NOT** to be considered the board's +5 volt reading. See the above explanation of "Voltage Drop")

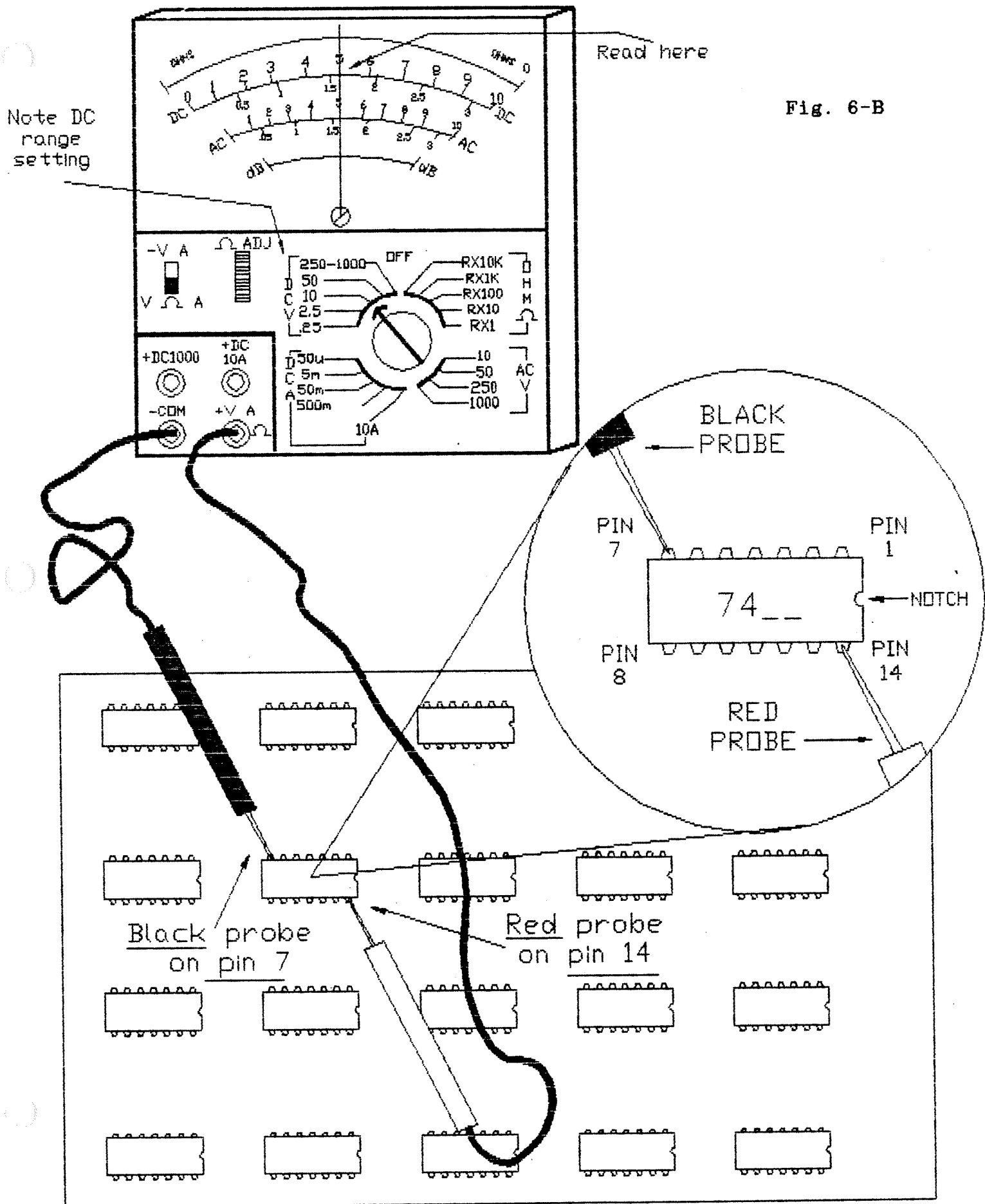
4. Place the voltmeter's probe tips on the appropriate Test Points, or on the correct IC pins, as shown in the diagram you selected as matching your voltmeter.
5. Have someone else turn the game's power switch on so that you don't have to move your hands.
6. Read the numbers on the meter's digital display - this is the voltage. If the reading is less than 5.00 or more than 5.2, contact your service center for further instructions.

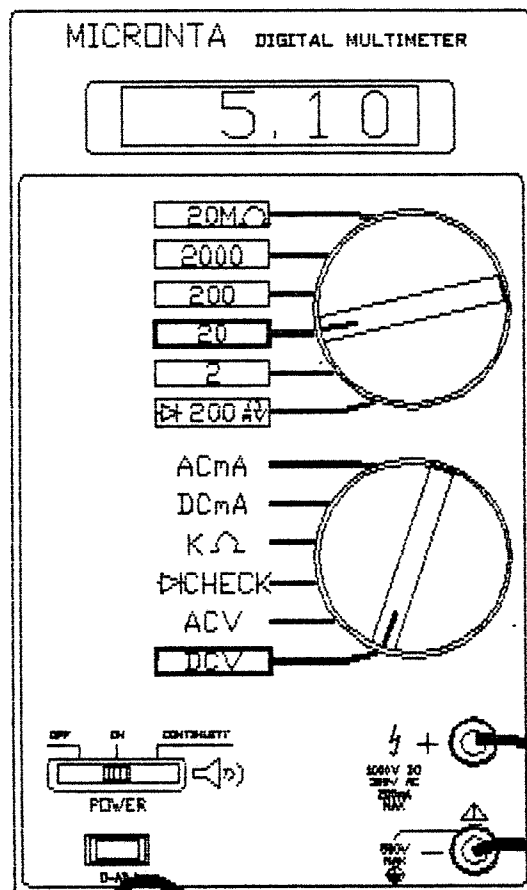
USING AN ANALOG METER (one with a needle type display)

Note: Most analog meters found in our stores are not very accurate; therefore, any voltage that you measure with an analog meter must not be considered appropriate for adjusting purposes. If you do not have a Digital meter in your store, contact your supervisor to make arrangements to acquire one.

1. Plug the black test probe into the hole marked "Common" on your meter.
2. Plug the red test probe into the hole marked DCV or +V or VDC on your meter.
3. Set the selector switch on the DC 10 or 15 volt setting. (Never less than this).
4. Set the polarity switch (if it has one) to +DC.
5. Turn the game off.
6. Place the voltmeter's probes on the appropriate Test Points, or on the correct IC pins as described earlier.
7. Have someone else turn the game on so that you don't have to move your hands.
8. Look at the meter. Did the needle swing to the right? If it did then look at the number that the needle is resting on. If you set your range switch on the DC 10 setting you should read the scale on the meter that is black and ends in the number 10. If you set your range switch on 15 or 30 you read the black scale that ends 15 or 3 or 30.
9. If the meter reads 5 on the scale then you probably have +5 volts. If it is less than five on the scale you either did it wrong, or there is no +5 volts.

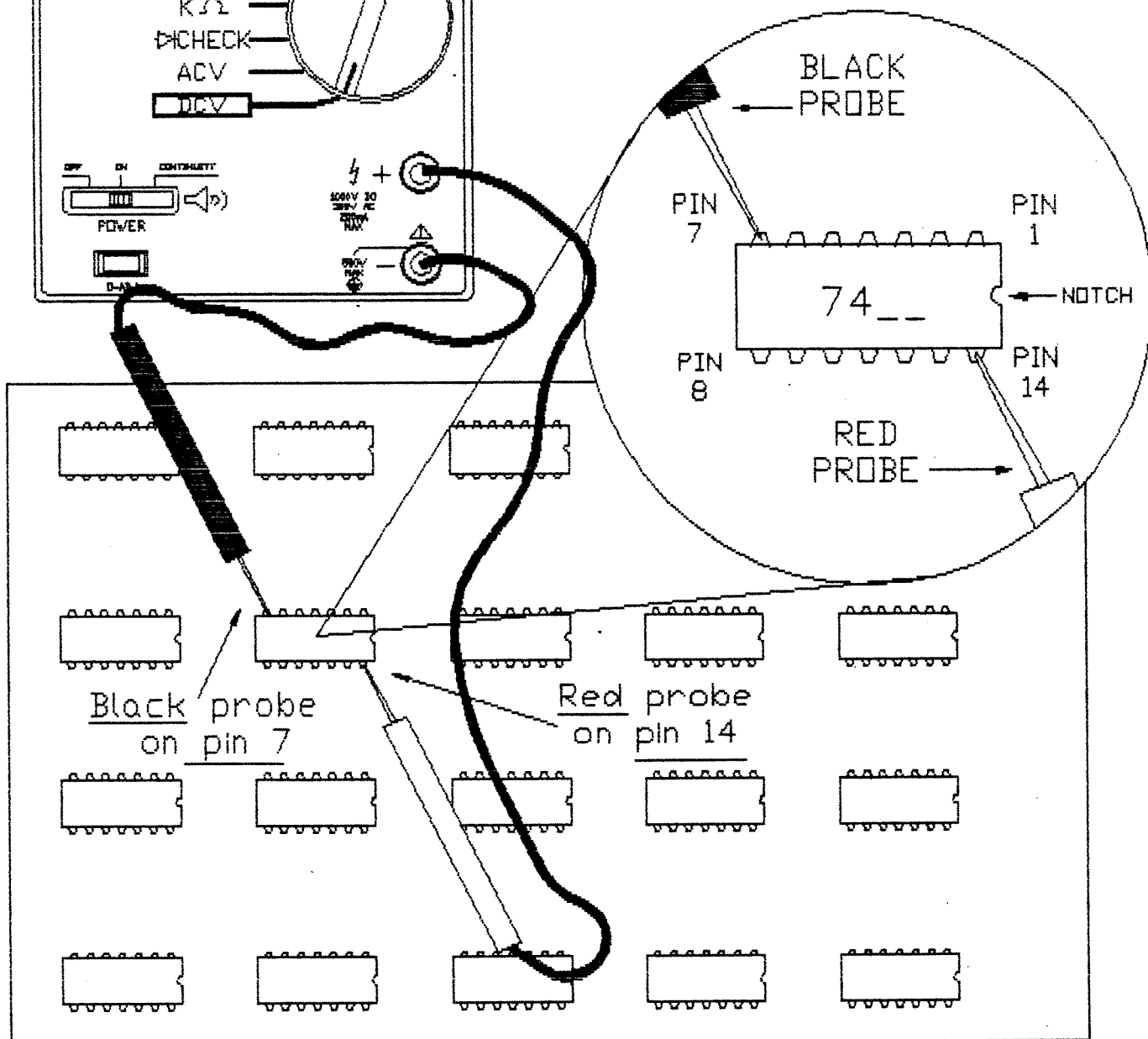
If the needle swings to the left, **IMMEDIATELY** remove the probes from the board and go back to step 1.

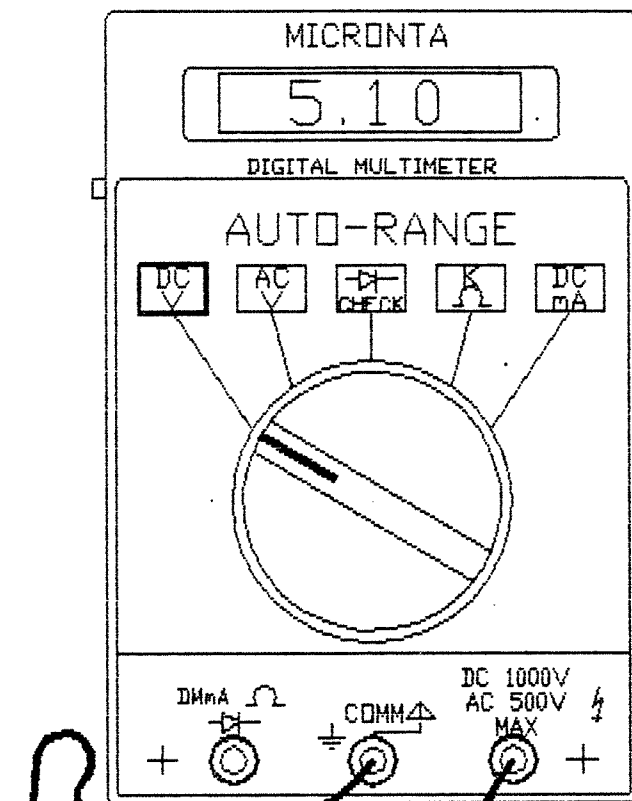




CHECKING +5 VOLTS
WITH AN NON-AUTORANGING
DIGITAL METER

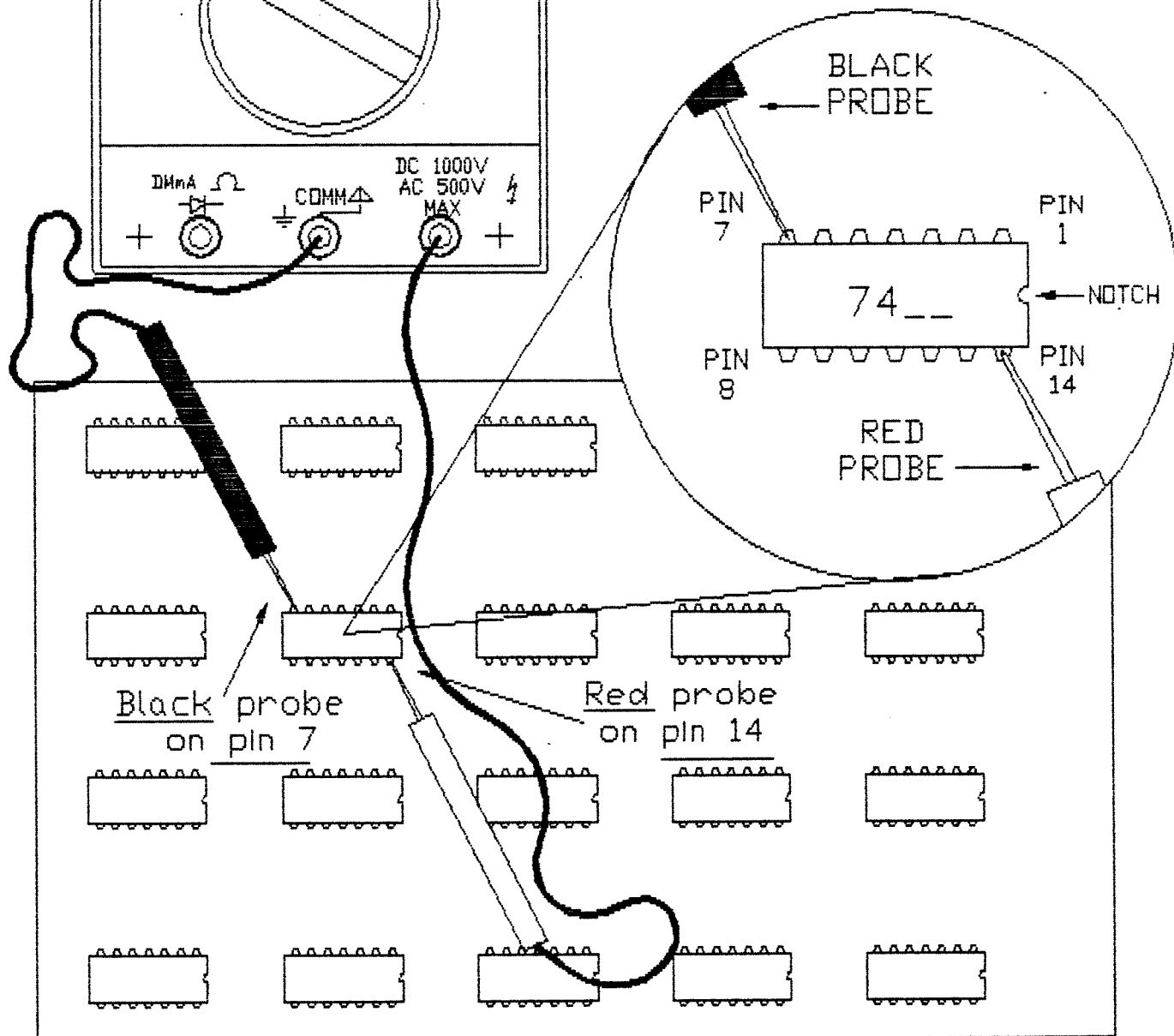
Fig 6-B2

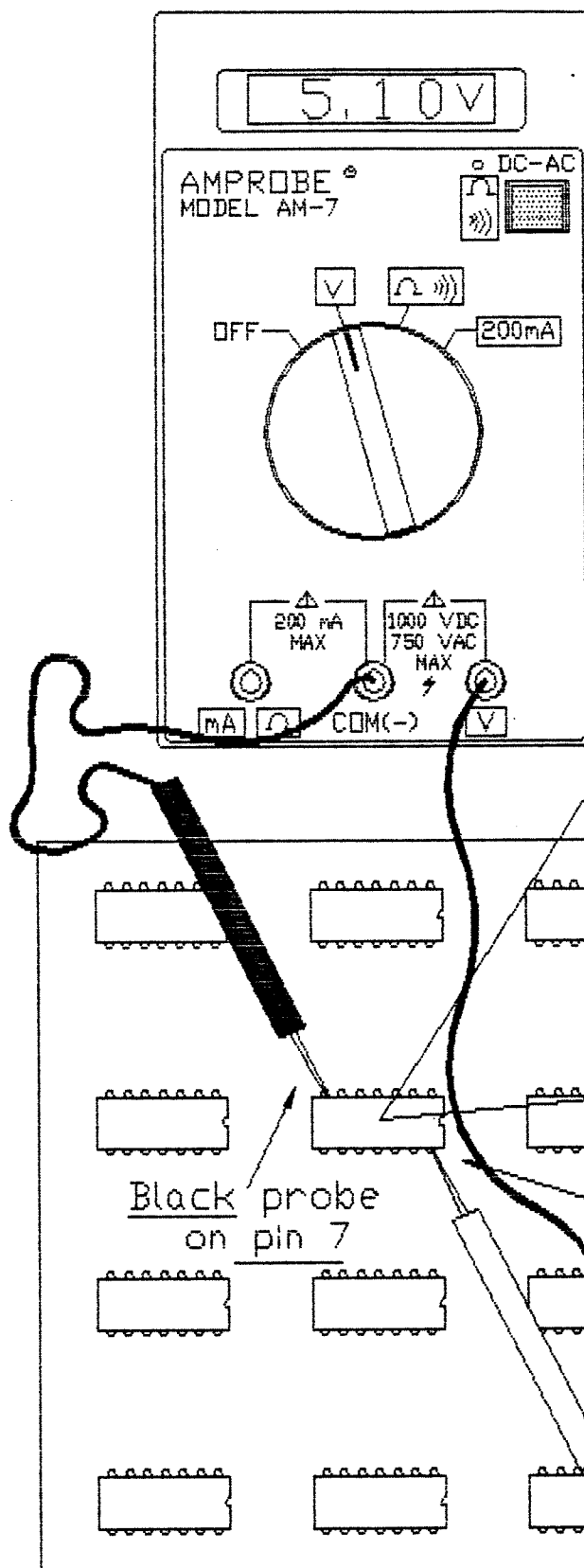




CHECKING +5 VOLTS
WITH AN AUTO-RANGING
DIGITAL METER

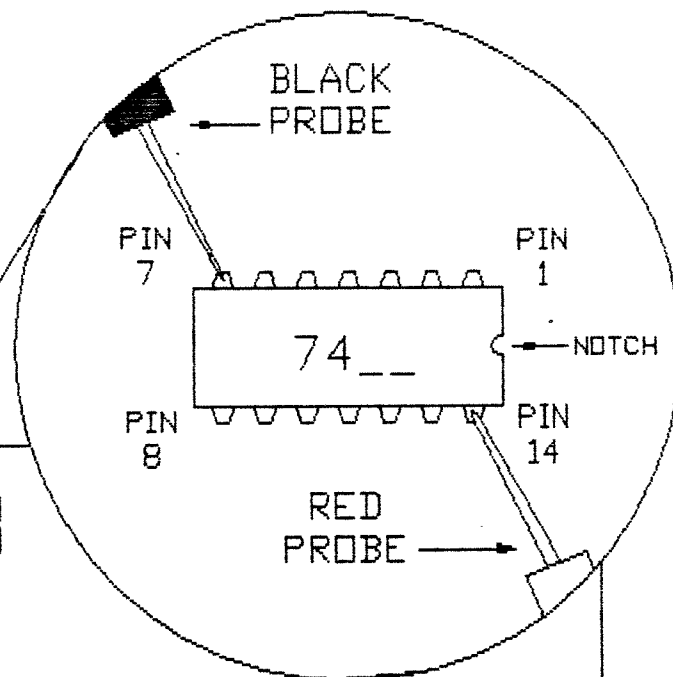
Fig 6-B3





CHECKING +5 VOLTS
WITH AN AUTO-RANGING
DIGITAL METER

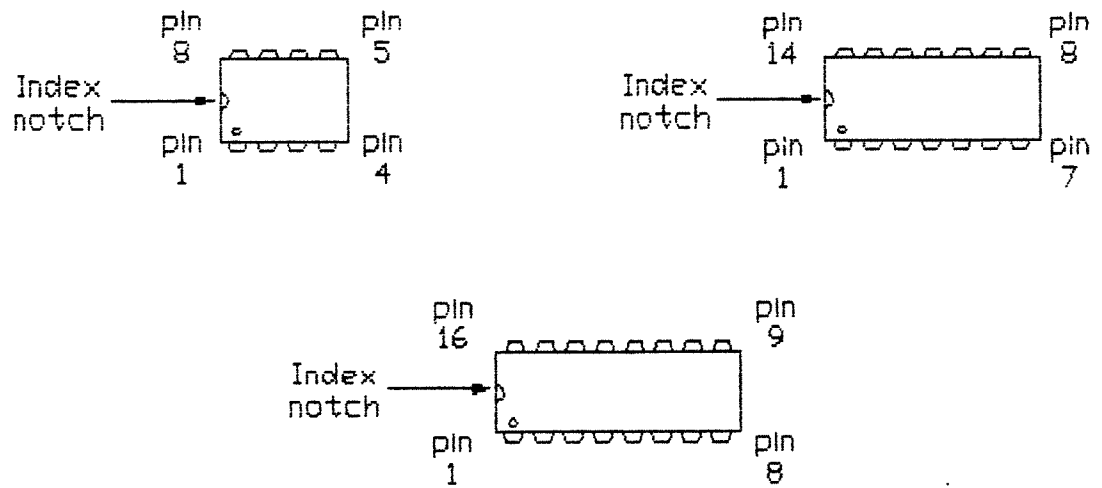
Fig 6B-4



Black probe
on pin 7

Red probe
on pin 14

Fig. 6-C



IC PIN CONFIGURATIONS

3-7 CLEANING A LASER DISC AND PLAYER

The number one enemy of a laser disc player is **DUST**. Video games collect dust daily, especially if the game has a fan to cool the electronic components. This dust gets inside the disc player, some enters the compartment where the disc actually is, and some dust enters the player through the bottom. Inside the disc player is a very delicate and expensive laser optic assembly. This laser optic assembly is the most expensive part in the entire player, and also the most frequent part to fail. The most common cause of this part failing is dust.

Never open a player while the disc is still spinning. Never tip a disc player (especially while it is still spinning).

Store personnel can do nothing to clean the dust that enters the bottom of the player or the dust which enters the laser optic unit. However, they can extend the life of the player several-fold by doing the two following things on a regular basis.

1. VACUUM THE INSIDE OF THE GAME ONCE EVERY TWO WEEKS.
2. CLEAN THE DISC AND DISC COMPARTMENT WITH GLASS CLEANER AND A SOFT CLOTH ONCE EACH WEEK.

The only things in the player you can clean are the disc and the disc compartment. To do so, first you must open the lid to the player. Turn the game on and immediately press the reject, eject, or lid open button. You only have a few seconds to do this before the computer in the game takes over and makes the disc player ignore you. After the lid opens, turn the game off and look inside at the disc to see which side is facing up and which side is facing down. This is very important. Usually the shiny side faces down. Remove the disc and clean it with glass cleaner and a soft lint free cloth.

Before replacing the disc, look for dust in the area where the disc goes. Place the lens cap over the glass lens to keep dust particles from settling on the lens. Then wipe out all of the dust in the compartment and underside of the lid with a soft lint free cloth and glass cleaner. Wait a minute for all of the dust particles to settle and then remove the lens cap. **NEVER TOUCH THE LENS WITH ANYTHING! NOT WITH YOUR FINGER, A Q-TIP, A PAPER TOWEL OR EVEN A TISSUE.**

Lens cleaning must be done with special papers and solutions by a qualified individual. Keep in mind that a microscopic smoke particle on the lens in just the wrong place can cause your player to malfunction. The only thing that you may do with the lens is blow gently across the it, as long as you do not spit when you do so. Replace the disc (in the proper direction), close the lid and turn the game on.

3-8 MOVING AND PACKING A LASER DISC PLAYER

Laser disc players contain a very delicate and very expensive laser optic unit. To protect this unit, on some older disc players, you must lock it into place with a special screw and spring plate provided with each game. You must also install the rubber lens cap. Most newer model disc players do not require lens caps or locking screws.

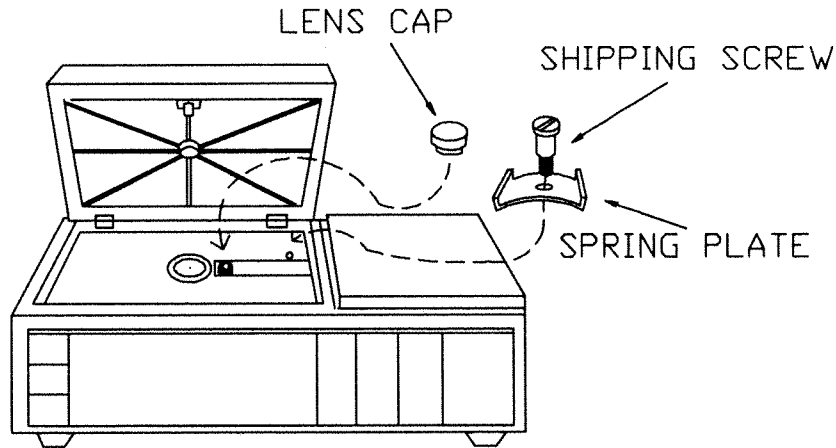


Figure 8-A Older Model Laser Disc Player Locking Screw and Lens Cap

You must lock the laser unit with this screw whenever you:

- Move the game (even across the room)
- Tip the game
- Tip the player
- Remove the player
- Ship the player

Do not put the disc inside the player while this screw is in place, it will badly scratch the disc. Don't forget to remove the locking screw and lens cap when you reinstall the player in the game.

When shipping a laser disc player:

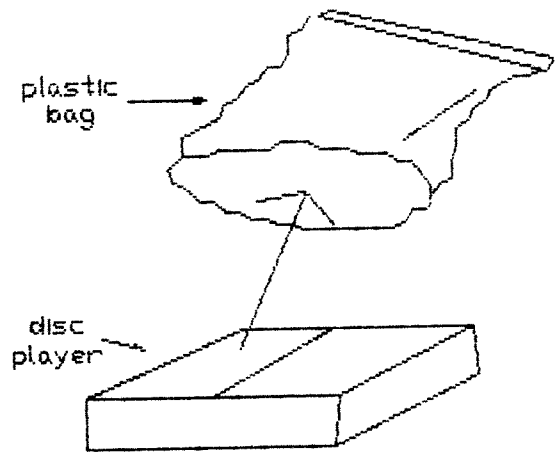
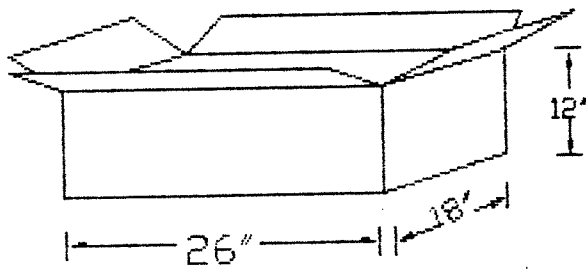
1. Install the locking screw and lens cap (where applicable).
2. Place the player inside a plastic trash bag. This will keep particles from the packing material from entering and damaging the optic unit.
3. Place the player in a strong new box that is at least 26" x 18" x 12" in size.
4. Use plenty of packing peanuts and bubble pack to cushion the player.
5. Reinforce the four corners of the box with bubble pack and extra cardboard. Most shipping damage is in the corners.

Keep in mind that this is an expensive device that is easily damaged by rough handling.

A Pioneer disc player packaged in this manner usually weighs between 30 and 34 pounds.

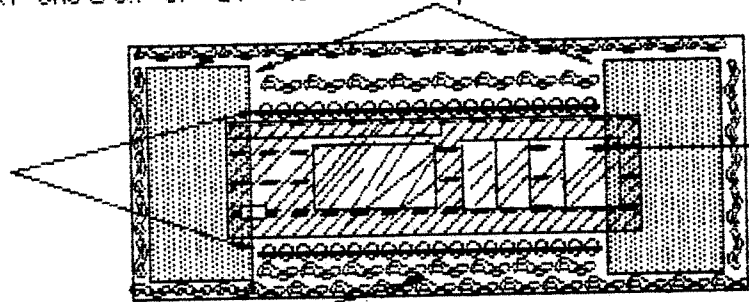
A Sony player packaged in this manner usually weighs between 25 and 27 pounds.

Fig. 8-B



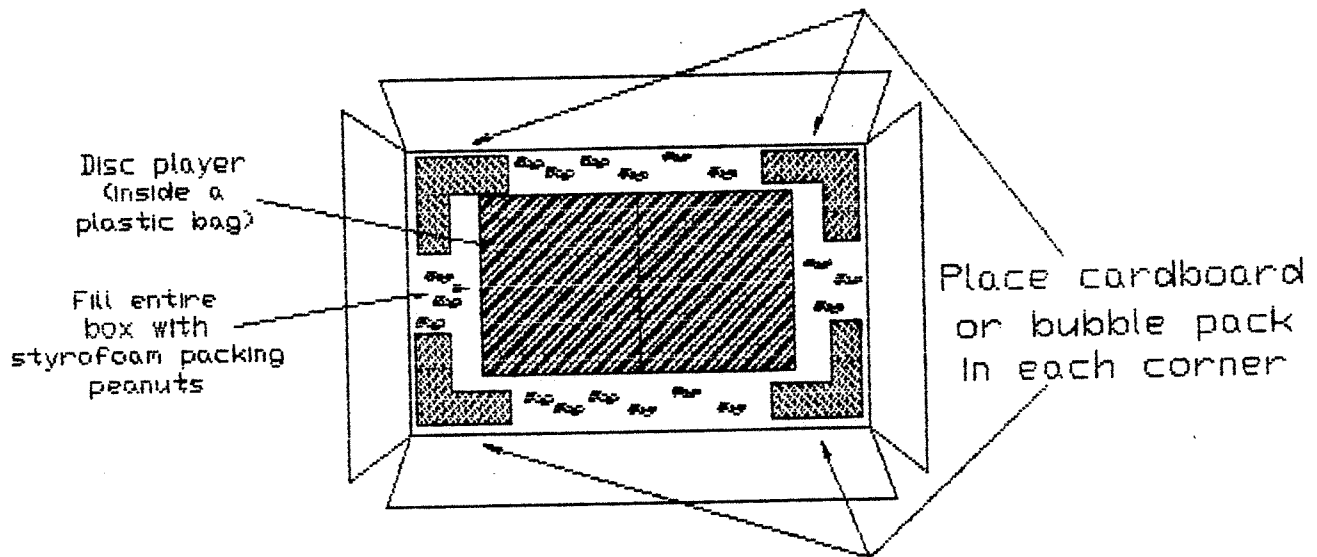
Cardboard or bubble pack in each corner

Layers of bubble pack



Disc player
(inside a
plastic bag)

Fill entire box with
styrofoam packing peanuts



3-9 TESTING A LASER DISC PLAYER

Read sections 3-7 and 3-8 before proceeding.

The most reliable method of testing a disc player is to check it in a known good game. Locate the model number on the player and try to find a game that has the same model disc player. Here is a list of some of the possibilities:

LDV1000

Dragons Lair, Space Ace, and Thayer's Quest will all interchange.

PR8210 (without ribbon cable jack on back panel, i.e. Mach 3)
Will test in a Cobra Command, Cliff Hanger, Goal to Go, Mach 3.

PR8210A (with ribbon cable jack on back panel, i.e. Star Rider).
Will test in Cobra Command, Cliff Hanger, Goal to Go, but NOT Mach 3.

LD1100

Cobra Command, Cliff Hanger, and Goal to Goal will all interchange.

An alternate method of testing is to completely remove the questionable player from the bad game and plug its Video output directly into the video cable of a Dragons Lair, Space Ace, or Thayer's Quest (you may need a cable adapter from Radio Shack to match the connectors). This will allow you to view the picture from the questionable player on the monitor. Turn on the power to the game whose monitor you are using and plug the disc player's power cord into a wall outlet. Press the play button on the player and wait 15 or 20 seconds for the player to spin up to speed. If it does not spin the disc or if the picture does not appear on the screen, the player is probably bad.

This is not a completely reliable method of testing because there are several failures that will only surface when the player is being controlled by the game's computer by way of its remote control. Testing the player in a known good game is the most reliable method of troubleshooting.

3-10 FLIPPER COILS

Flippers use an electromagnet called a *coil* (or *solenoid*) to pull a plunger inside the coil which moves a lever, which moves the flipper. There are two types of flipper systems: solid state, and earlier, non-solid-state systems. In the non-solid-state system, the flipper coil is made up of two parts: the super strong winding, and the weak winding. When the player first presses the flipper button it causes electricity to go to the strong part of the coil so that it can really "whack" the ball. If the strong part (winding) of the coil stays on for more than a few seconds, it will become very hot and burn the wires inside the coil causing the plastic to melt. That's why they put an "End of Stroke" switch (*E.O.S.*) on the flipper unit right next to the coil (*see Figure 10-A*). The *E.O.S.* switch turns off the strong winding of the coil and leaves only the weak winding turned on so that the player can hold down the flipper button and hold the flipper up for a very long time without burning up the coil. The weak winding is not strong enough to hit the ball hard, but it is strong enough to hold the flipper up for long periods of time without getting hot and melting the wires inside the coil.

The end of stroke switch **MUST OPEN** when the flipper coil gets about 3/4 of the way up. If the *E.O.S.* does not open, the flipper coil will get hot and burn up! In fact, **THE ONLY THING THAT WILL CAUSE A FLIPPER COIL WITH AN END OF STROKE SWITCH TO BURN IS A FAILURE OF THE END OF STROKE SWITCH TO OPEN PROPERLY.**

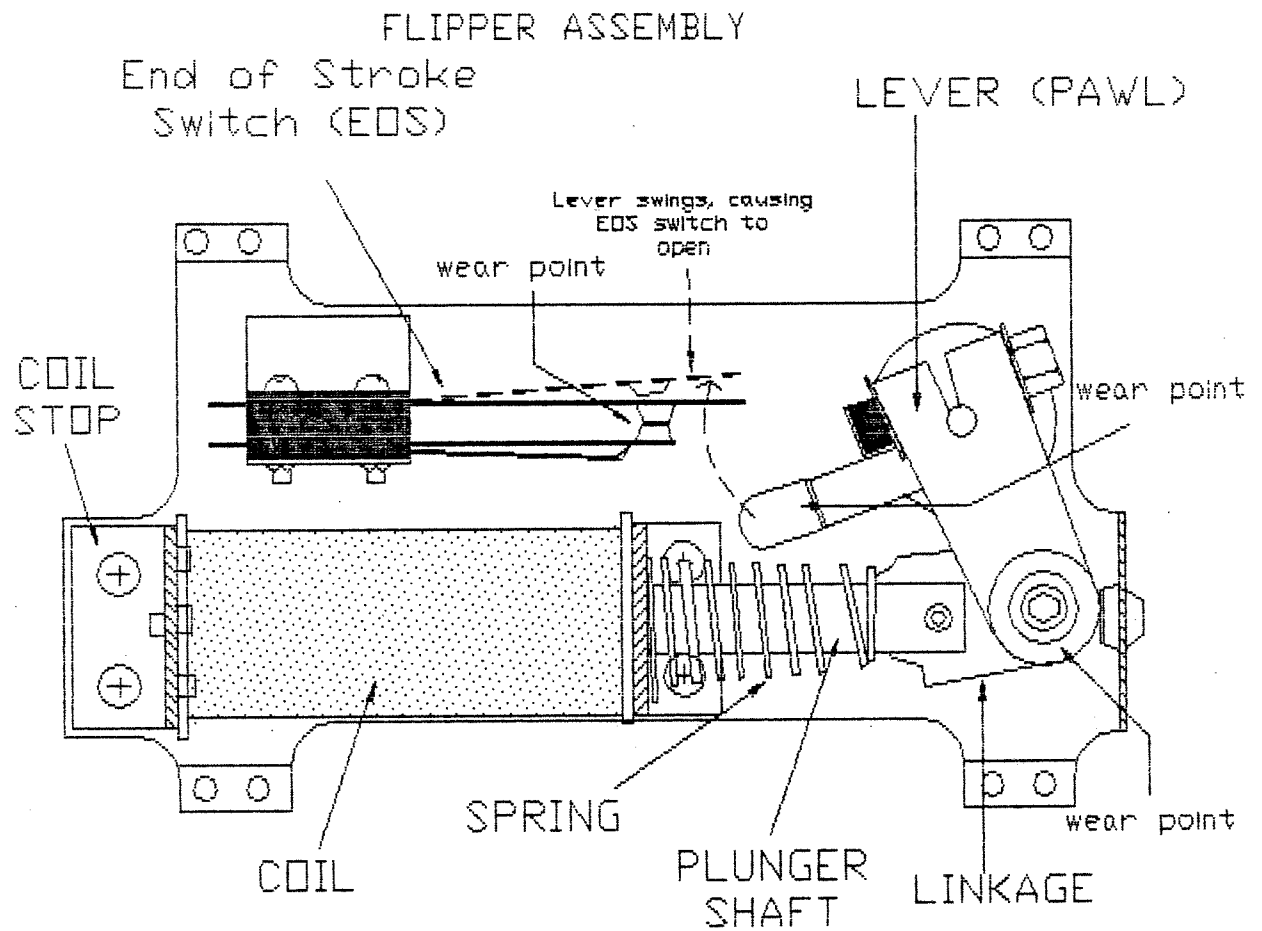
Here is a list of things which can prevent an *E.O.S.* switch from opening properly when the flipper gets 3/4 of the way up:

- The end of the *E.O.S.* switch blade may be broken or bent.
- The screws holding the *E.O.S.* may be loose, missing, or even the wrong size. Missing, loose, and incorrect hardware is responsible for most recurring flipper problems.
- The lever that turns and pushes the switch open may be broken or loose.
- The linkage that connects the plunger to the lever (pawl) may be loose or broken. This item should have no play in it when you wiggle it.
- The brackets that hold the coil in place may have come loose (check for proper hardware).

Never replace a flipper coil without first checking all of the above items. If you do not find out why the *E.O.S.* switch failed to open, you will continue destroying coils until you finally correct the problem.

Games with Solid-State Flipper Systems have only one winding in the coil and do not have an End Of Stroke switch (*see Figure 10-B*).

Fig. 10-A



3-11 CHANGING A COIL

When changing a bad or burned coil on a pinball machine follow these guidelines:

IMPORTANT NOTE: If you are replacing a Williams flipper coil, you must first discharge the flipper voltage. To do this, turn the power off and attach a jumper wire that has "alligator" clips at both ends to the metal frame on the coin door. Connect the other end of the jumper wire to each of the three terminals on the flipper coil (one at a time). Remove the jumper wire BEFORE turning the game back on. This must be done each time after the power has been turned on and off. Failure to do this may result in damage to the logic board.

1. If you are changing a flipper coil, check all of the items listed in Section 3-10.
2. Draw a picture showing the direction the coil is mounted.
3. Draw a picture showing which wire goes to each terminal on the coil.
(Wipe off the wires with a paper towel to see the actual wire colors.)
Some terminals have two wires on them.

NOTE: Coils have a small component called a Diode connected to the terminals. This diode is a very important part. If you look at the diode you will see a stripe, or a band. This band (*cathode*) indicates which end has the + voltage wire. Make sure that the wire on the banded end of the bad coil goes to the banded end of the new coil. Sometimes the diode is reversed when the coil is manufactured.

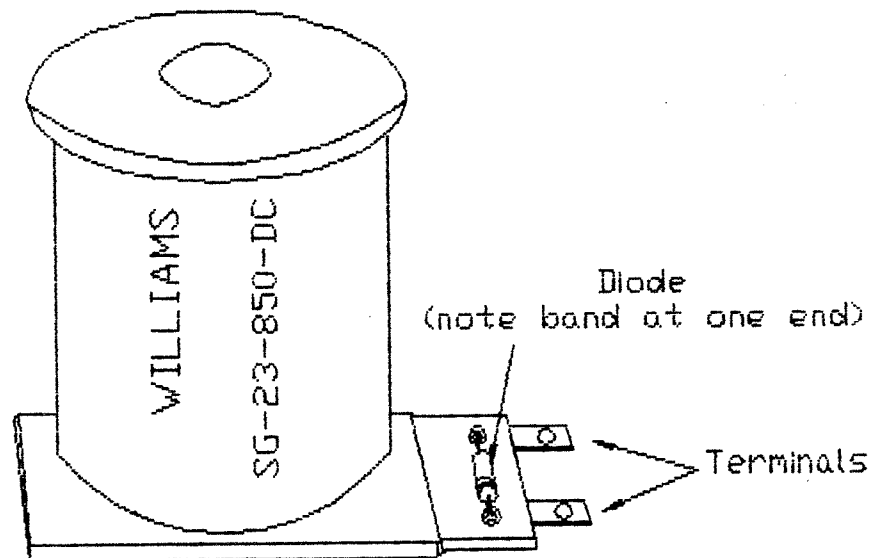
4. Remove the screws from the bracket (coil stop) and PLACE THEM ALONG WITH ALL OTHER HARDWARE IN A SPRAY PAINT CAN LID so as not to lose them.
5. Slide the coil off of the plunger and out of the assembly. This may be difficult if the coil has melted on the inside, but it is possible.
6. Do not lose the spring or the flexible washer that goes between the coil and the bracket.
7. Mount the new coil (the numbers on the new coil must match those on the old coil) using the proper hardware. Make sure that you insert the sleeve in the same direction as the one that was in the old coil.
8. Unsolder one wire at a time from the old coil and re-solder it to the new coil on the proper terminal. Make sure you run the wire through the hole in the terminal and twist it to make it tight. Look for stray strands of wire before soldering.
9. After you have soldered all of the terminals, recheck your work. Is all hardware the right size, in the right place, and tightened properly?

9. After you have soldered all of the terminals, recheck your work. Is all hardware the right size, in the right place, and tightened properly?
10. If you are replacing a flipper coil, before you turn the game on, you must check the E.O.S. switch to make sure that it opens when the flipper gets $\frac{3}{4}$ of the way up.

If you are changing a coil other than a flipper i.e. a slingshot, or a thumper bumper, your logic board will have damage to some of the components, so make sure you talk to your supervisor before turning the game on.

THROW THE OLD COIL AWAY, DO NOT KEEP IT.

Fig. 11-A

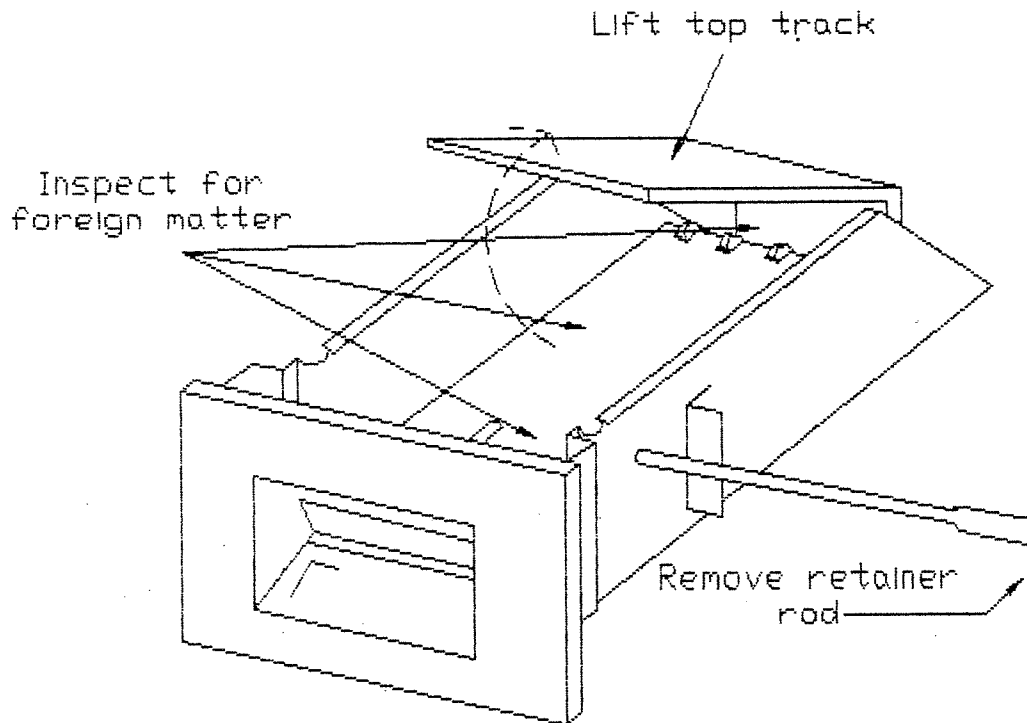


COIL
(solenoid)

3-12 REMOVING A JAMMED BILL FROM BILL ACCEPTOR

If when servicing the changer a jammed bill is discovered, removal is easily accomplished in the following manner:

Fig. 12-A



1. Unlock and open door.
2. Unplug bill acceptor harness and pull acceptor out to stop.
3. Pull out retainer rod.
4. Carefully lift up top track.
5. Remove jammed item from tracks.
6. Carefully place track down, and re-insert retainer rod and harnesses.
7. If jam cannot be removed by this procedure, turn off power, unplug and remove bill acceptor by lifting up latch lever tab and pulling out acceptor.
8. Remove retainer rod.

10. Remove jammed item from tracks.

11. Reassemble in reverse order, and reinstall acceptor in changer.

If frequent bill jamming occurs, perform the following checks and corrective procedures:

1. Make sure that all drive pulleys on both sides of bill transport are tight on their respective shafts.
2. Both drive belts must be snug - NOT TOO LOOSE OR TOO TIGHT.
3. Rubber drive rollers must not be loose or worn.
4. P6 flipper must work freely.
5. All nylon idler rollers in the top track assembly must rotate freely and move up and down freely in their respective slots. The retaining springs must also slide without binding in the guide slots and exert adequate force on the idler roller.
6. Bill pressure roller solenoid¹ must operate when the P1 photocell² is covered and when unit goes into reverse.
7. Top track must be properly seated into bill transport with retaining bushings snapped into place and the retaining rod in place.
8. Both top and bottom track bill surfaces must be free of dirt, moisture, burrs, projections, rough spots, etc., which might drag or hang up on the surface of bill.

¹ See Glossary for definition of Bill Pressure Roller.

² See Glossary for definition of P1 Photocell.

3-13 COIN HOPPER CLEANING PROCEDURE

The coin tracks are teflon coated to minimize dirt build-up. It is necessary to clean them at regular intervals (see section 4-1 for schedule). This will help prevent dirt accumulation in the coin path.

Failure to keep the coin path clean will result in coins sliding out of the track, indicating an empty condition even though the hopper contains sufficient coins. Clean the hoppers as follows:

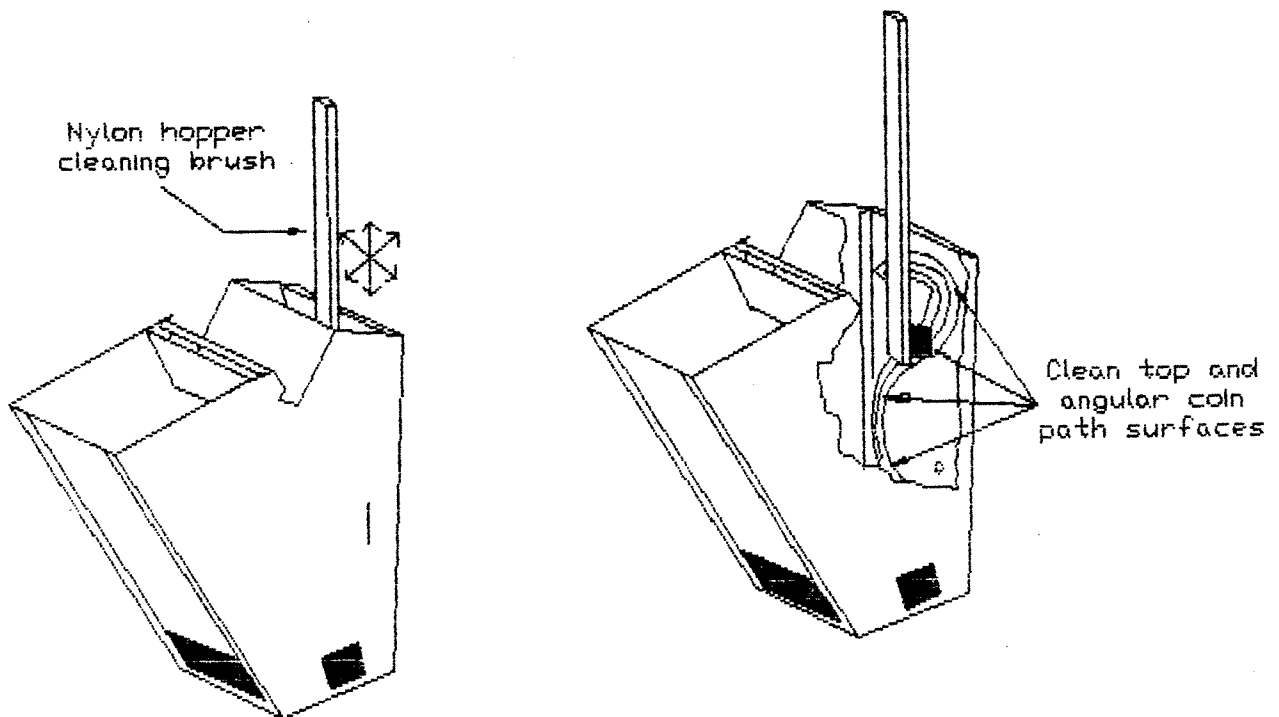
1. Remove hopper from bill changer and place on a working surface.
2. Using nylon hopper cleaning brush, remove dirt from the angular sides and flat surfaces of the serpentine coin path as shown in figure 13A.

CAUTION

DO NOT USE DETERGENTS TO CLEAN HOPPER. HOPPER HAS BEEN FACTORY LUBRICATED AND DETERGENT CLEANERS DESTROY THIS LUBRICATION.

Fig. 13-A

HOPPER CLEANING



3-14 TESTING 115 VOLTS AC WITH A DIGITAL MULTIMETER (DMM)

CAUTION

This procedure can be very hazardous. Do not attempt to perform the following steps unless you have read Section 1 of this manual.



WHERE TO TEST

There are three locations illustrated in this section where you can check for 115 volts AC. They are:

- The line filter
- The monitor's power connector
- The AC terminals on the switching power supply

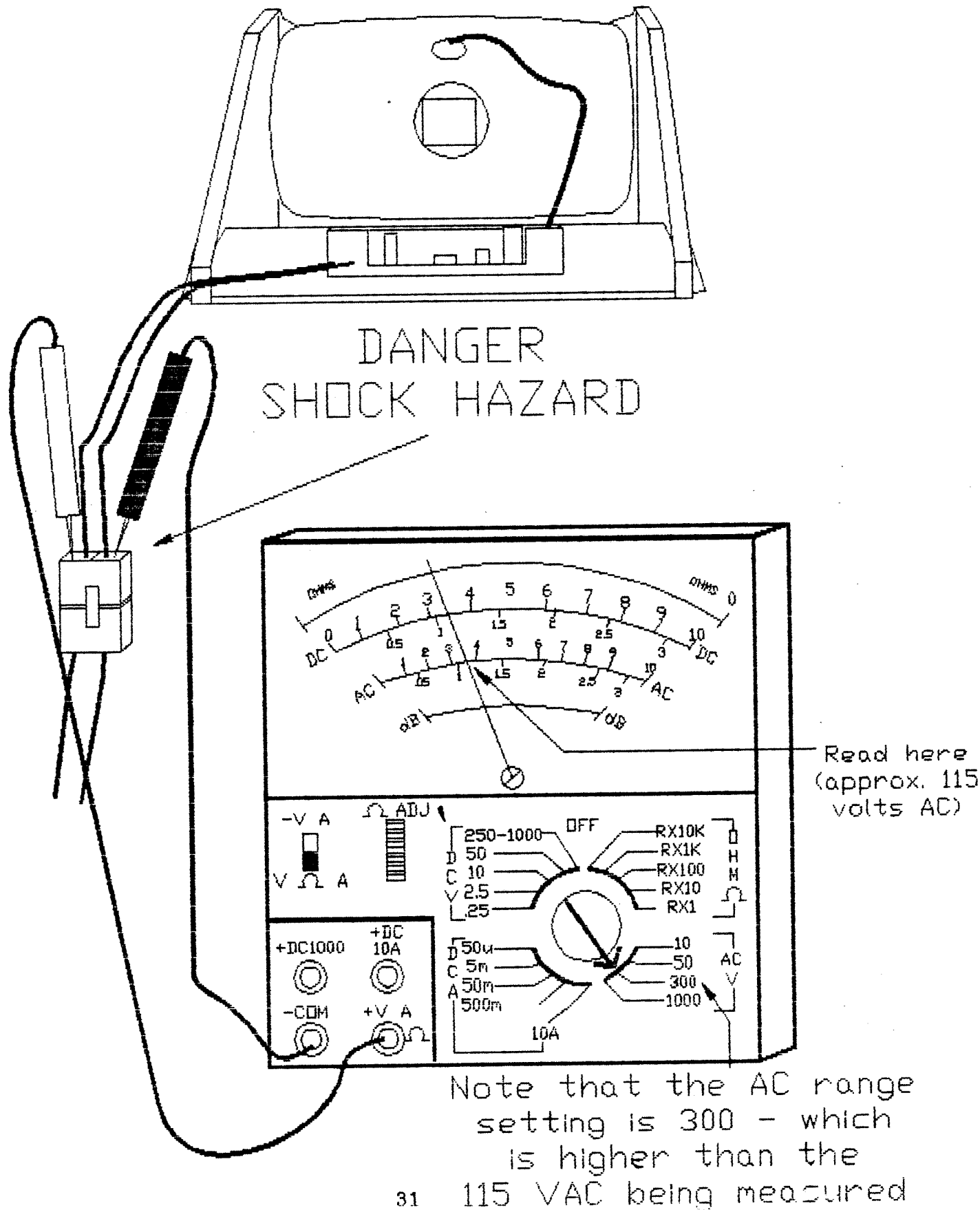
Consult with your supervisor or service center to determine at which location you should test.

PERFORMING THE TEST

1. Refer to the diagrams on the following pages to identify which type of DMM your store has. Once you have found the correct diagram, set the meter's switches and insert the test probes exactly as shown in the diagram which closely resembles your meter.
2. Turn the game OFF and UNPLUG the power cord.
3. Place the test probes as shown in the diagram illustrating the location at which you are testing (Line Filter, Monitor Power Connector, or Switching Power Supply). It does not matter which color probe goes to which connection.
4. Make sure both probes are securely in place and are not touching you, each other, or any other object. **REMEMBER - THIS IS A VERY DANGEROUS VOLTAGE!**
5. Have someone else plug the game in and turn the power on. Read the numbers directly from the digital display. The reading should be approximately 115 VAC. Unplug the game from the wall before removing the test probes from their test points.

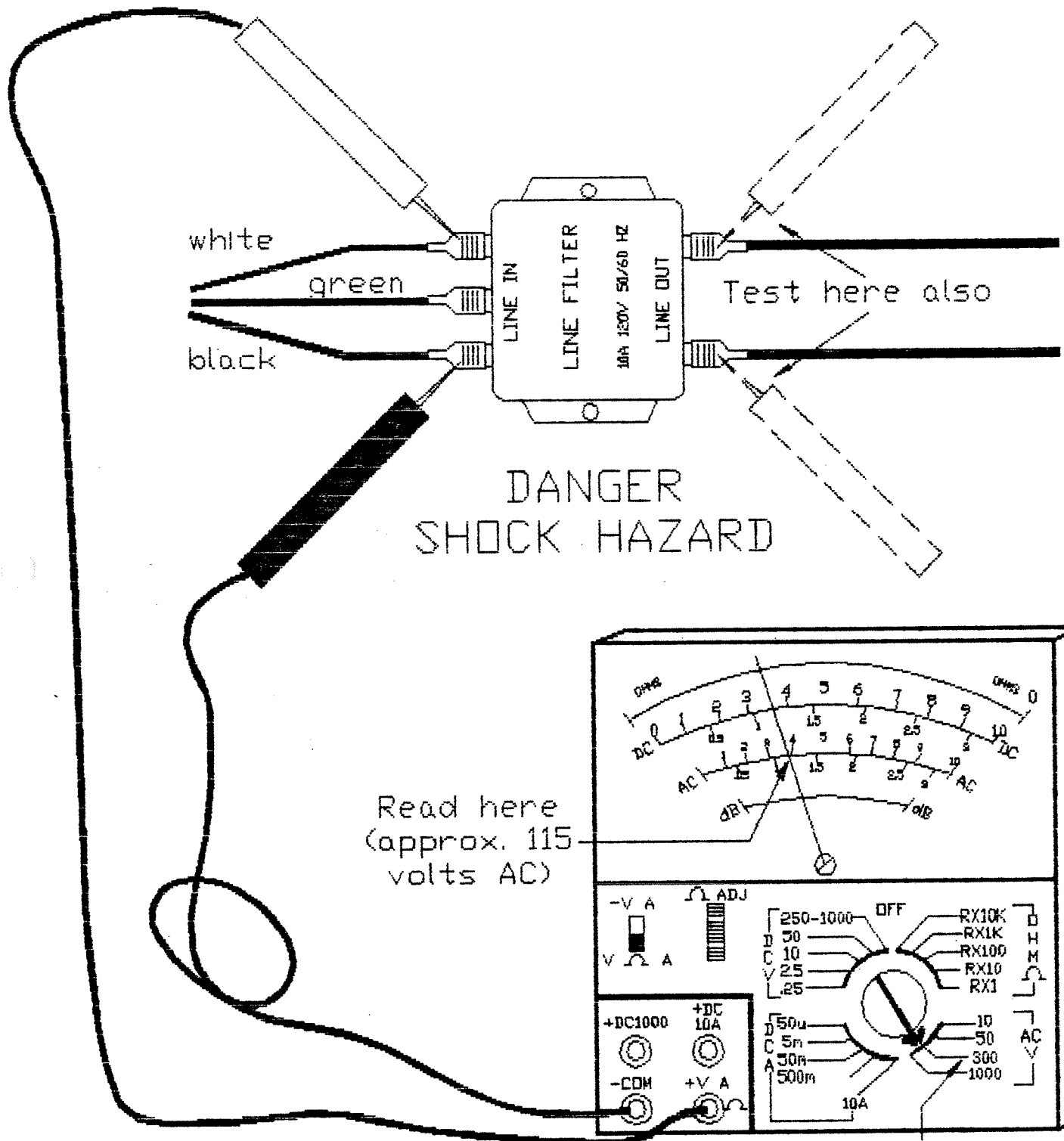
TESTING 115VOLTS AC AT MONITOR POWER CONNECTOR

Fig. 14-A



TESTING 115 VOLTS AC AT LINE FILTER

Fig. 14-B



Note that the AC range setting is 300 - which is higher than the 115 VAC being measured

TESTING 115VOLTS AC
AT MONITOR POWER CONNECTOR
WITH A NON AUTO-RANGING DIGITAL METER

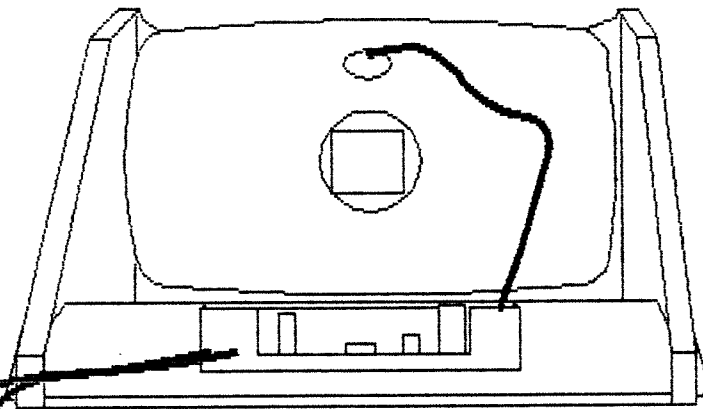
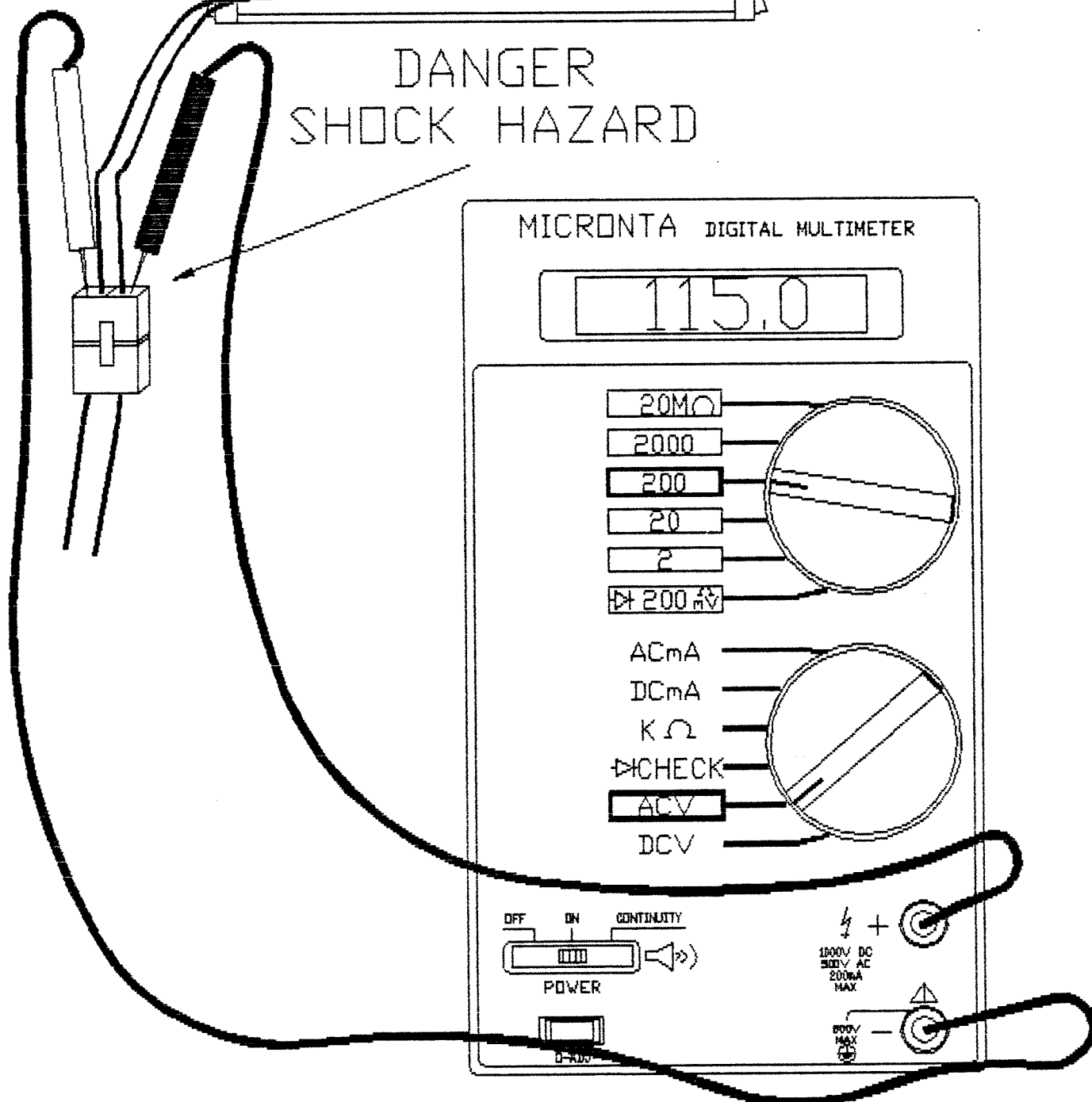


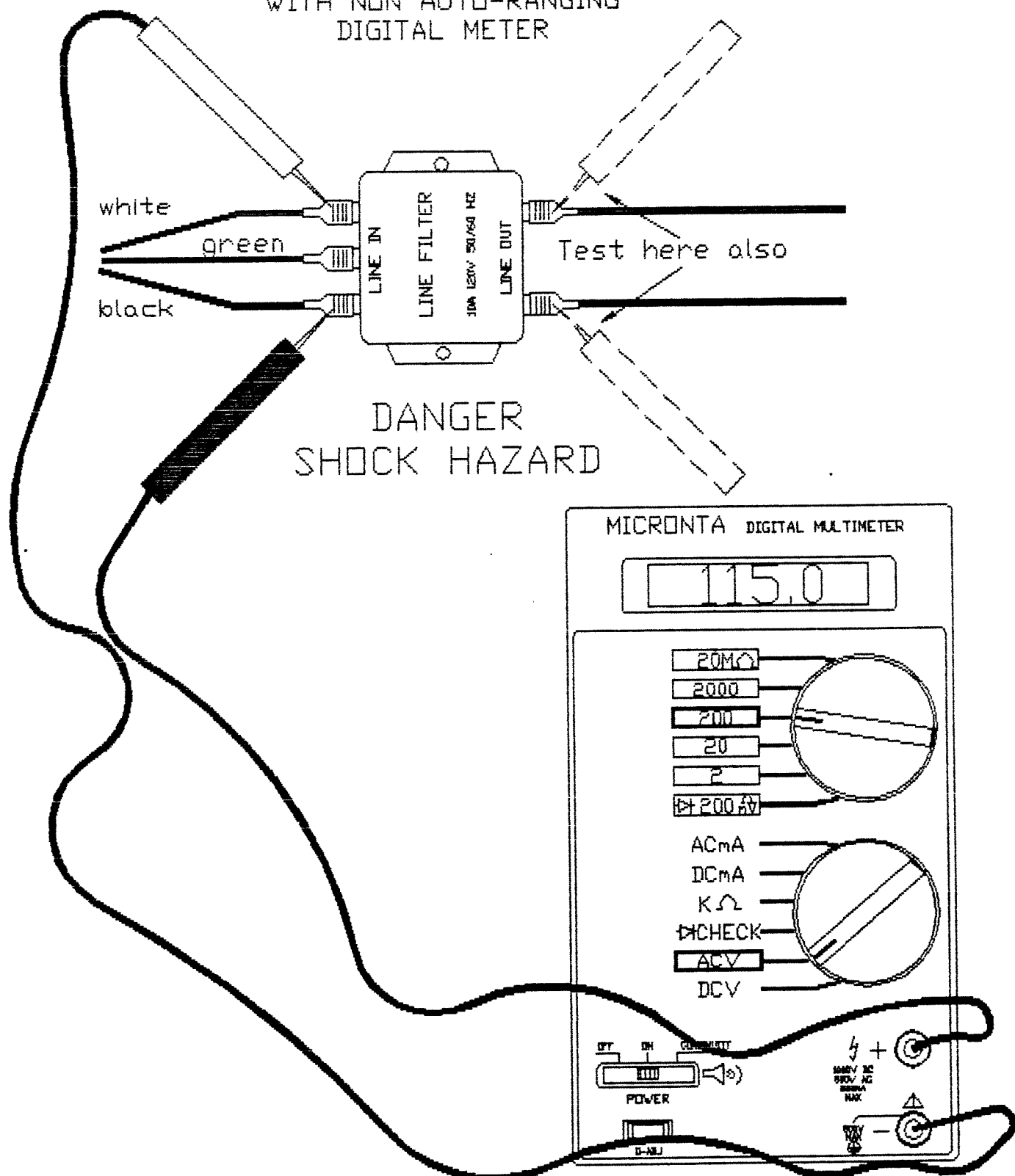
Fig 14-C

DANGER
SHOCK HAZARD



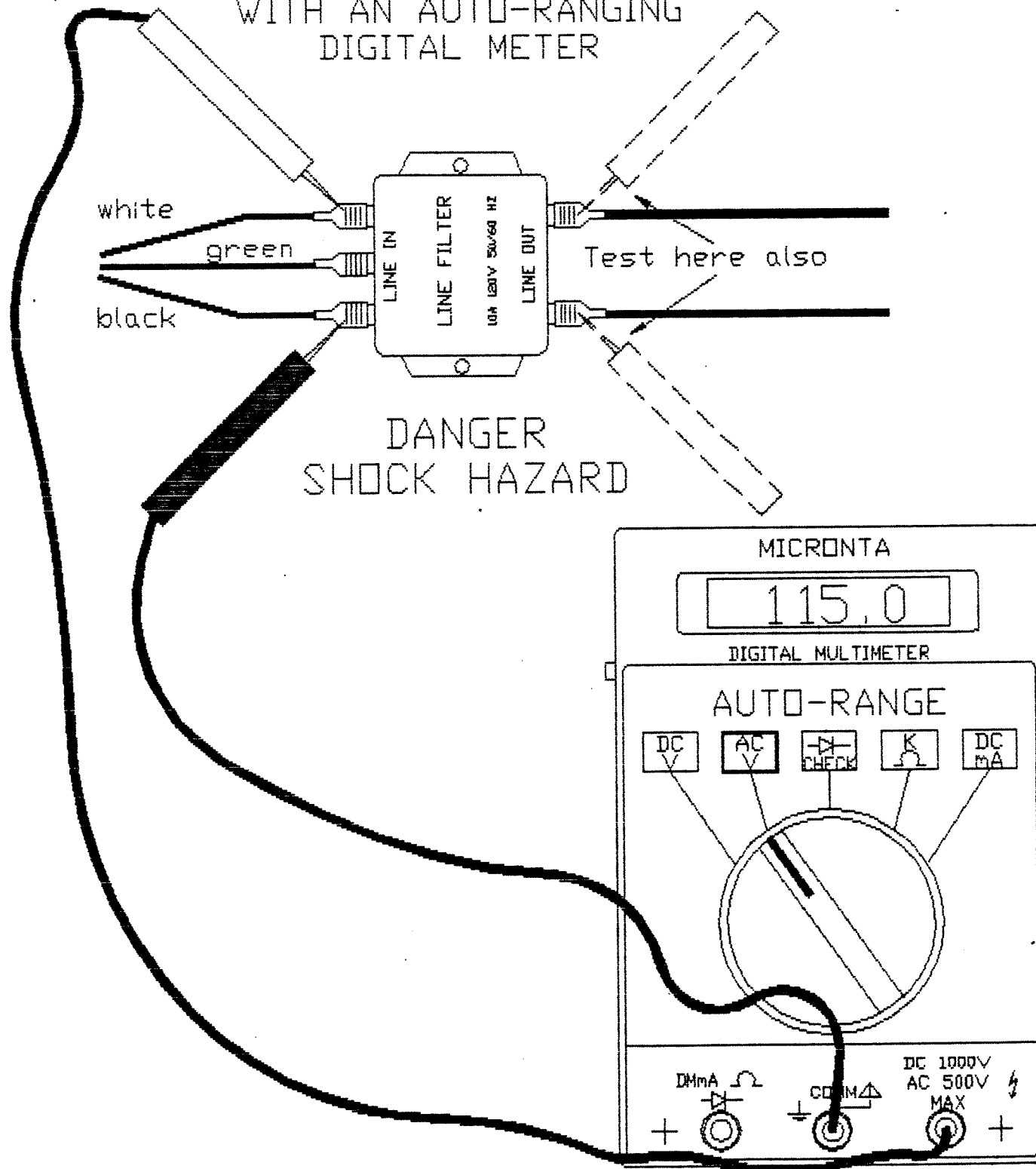
TESTING 115 VOLTS AC
AT LINE FILTER
WITH NON AUTO-RANGING
DIGITAL METER

Fig 14-D

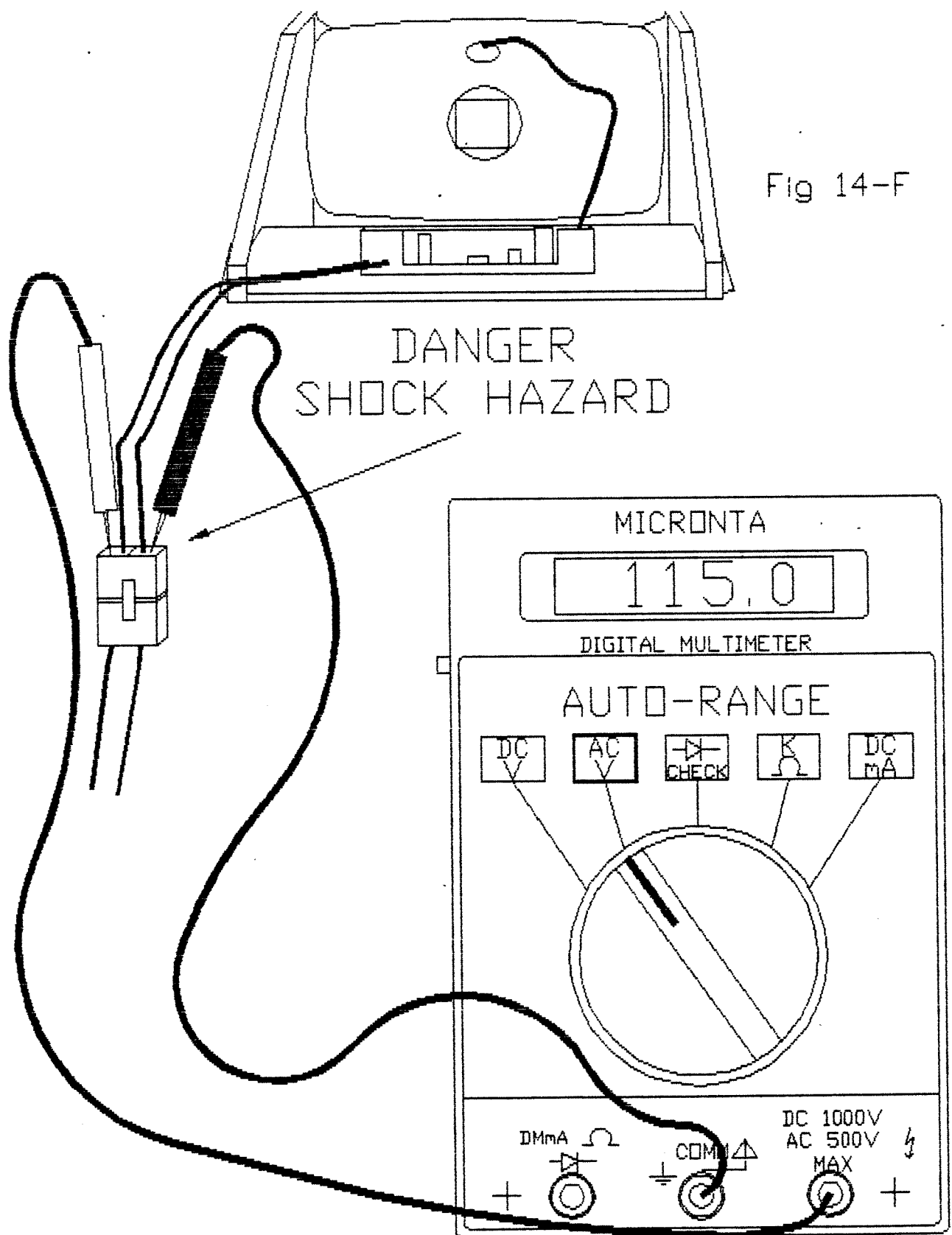


TESTING 115 VOLTS AC
AT LINE FILTER
WITH AN AUTO-RANGING
DIGITAL METER

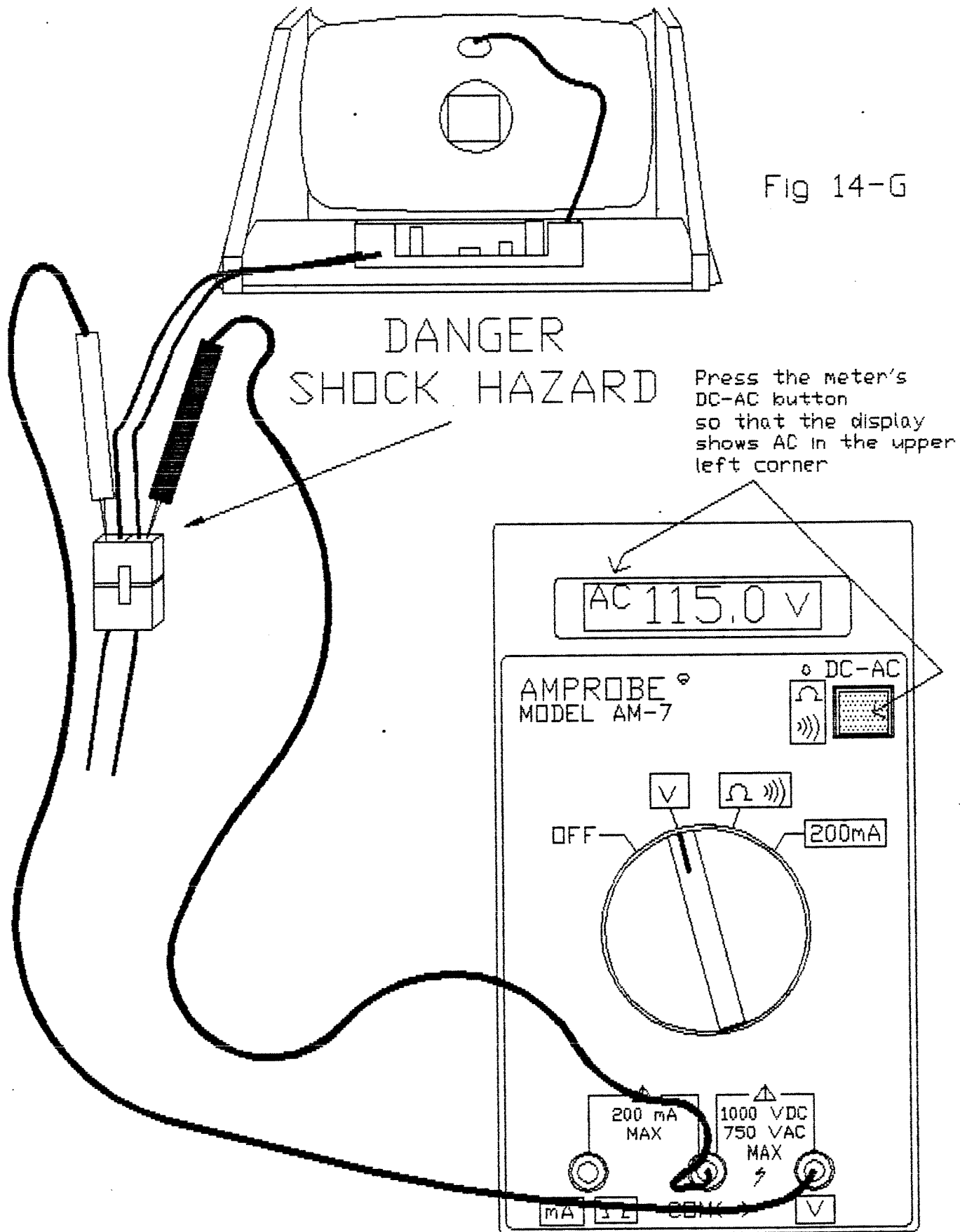
Fig 14-E



TESTING 115 VOLTS AC
AT MONITOR POWER CONNECTOR
WITH AN AUTO-RANGING DIGITAL METER

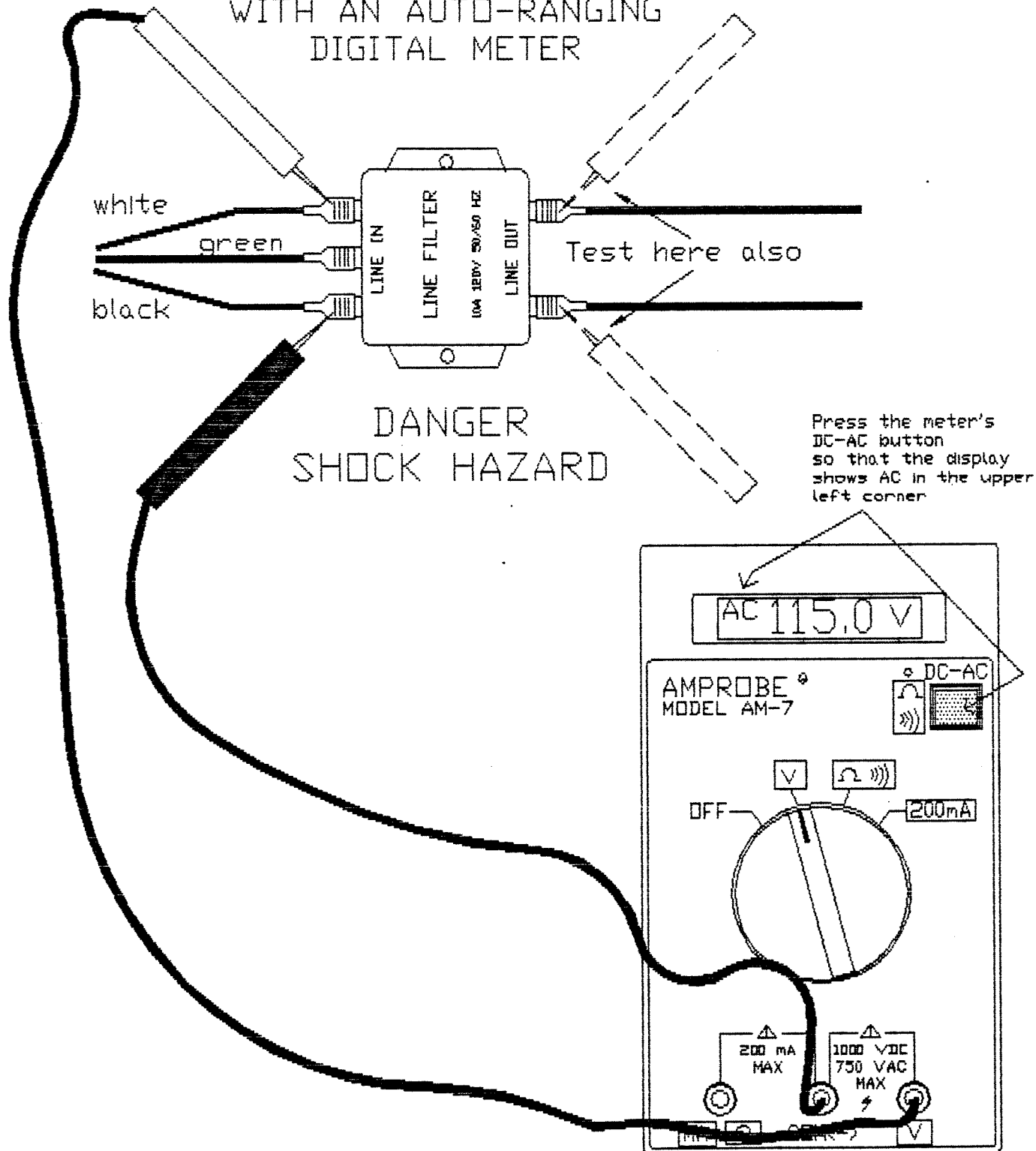


TESTING 115 VOLTS AC
AT MONITOR POWER CONNECTOR
WITH AN AUTO-RANGING DIGITAL METER



TESTING 115 VOLTS AC
AT LINE FILTER
WITH AN AUTO-RANGING
DIGITAL METER

Fig 14-h



3-15 MONITOR TESTING AND REMOVAL

Read Section 1-3 before proceeding!
--

CABINET-TO-CABINET TESTING

In many cases it is possible to connect the monitor from one game to another game without removing either monitor from its cabinet. To do so, follow these steps:

1. Locate a known good game that has the same type of monitor as the suspected bad one. Many times a different model will work. This is true with most *Raster* type monitors. Contact your service center to be sure.
2. Remove the back doors of both games and move them back to back.
3. Unplug both the power plug and the RGB signal plug from each monitor.
4. Stretch both of the plugs from the known good game over to the bad game and plug them both into the suspected bad monitor. You may have to unscrew some of the cable fasteners that attach the harness to the cabinet.
5. Check your connections carefully.
6. Turn the power on and look for the good game's picture on the suspected bad monitor. If the suspected bad monitor has no picture, it is bad. If the good game's picture does display on the suspected bad monitor, the monitor is good.

The above procedure can be reversed to test the known good monitor in the suspected bad game simply by plugging the two plugs from the bad game into the good monitor of the good game.

TESTING BY BOARD EXCHANGE

The monitor board of a suspected bad game may sometimes be removed and placed into a known working monitor, and vice-versa. **NEVER DO THIS WITHOUT FIRST CONSULTING YOUR SERVICE CENTER** - some monitor failures can cause damage to the good monitor or board.

1. Locate a monitor that is **IDENTICAL** to the one being tested. It must be the same brand (i.e. Electrohome, Wells-Gardner, Sampo, Sharp Image, etc.). It must be the same model number (there are some exceptions to this, contact your service center to be sure).

2. Remove the monitor's main board and neck board by following the instructions given in MONITOR BOARD REMOVAL. Be sure you discharge the high voltage anode!
3. Install the board into the other monitor. Replace all the screws and hardware. Some screws are used for electrical connections.
4. Check your connections carefully.
5. Apply power and look for a good picture. The brightness, height, and width may be a little different than it was before.

If you get a good picture, you know that the item you were testing is good. If you get the same symptom as you had before, the item being tested is probably bad. If you get something completely different, you probably connected something incorrectly.

MONITOR BOARD REMOVAL

To remove the monitor board, follow these steps. Remember that you are removing both the main monitor board AND the neck board. Do not leave the neck board on the CRT.

1. **Discharge the High Voltage that is stored in the picture tube (CRT) by the following method:**

- Unplug the game from the wall.
- Connect one end of a jumper wire (*wire with an alligator type clip at each end*) to the metal blade of a flat-tip screwdriver that has a plastic handle. Connect the other end of the jumper wire to the monitor's metal frame (*chassis*).
- Without letting your fingers touch the metal portion of the screwdriver, and with the game's power turned off, carefully slip the blade of the screwdriver under the *High Voltage Anode's* rubber insulating cup (this is located on the back surface of the picture tube and resembles a suction cup with a thick red, pink, or black wire extending from it).

Usually, when the screwdriver touches the metal contact under the rubber cup, a large spark will be seen and a loud pop will be heard. Hold the screwdriver in place against the metal contact for about five seconds- then use it to gently unhook the contact clips that secure the anode to the hole in the picture tube.



3-16 CHECKING CONTINUITY

Wires may be tested from one point to another by using the Ohm function of a volt-ohm meter.

This procedure is the same as checking a fuse (section 3-1), but instead of placing the probes on the two ends of a fuse, you place one probe on one end of the wire being tested, and the other probe on the other end of the wire under test.

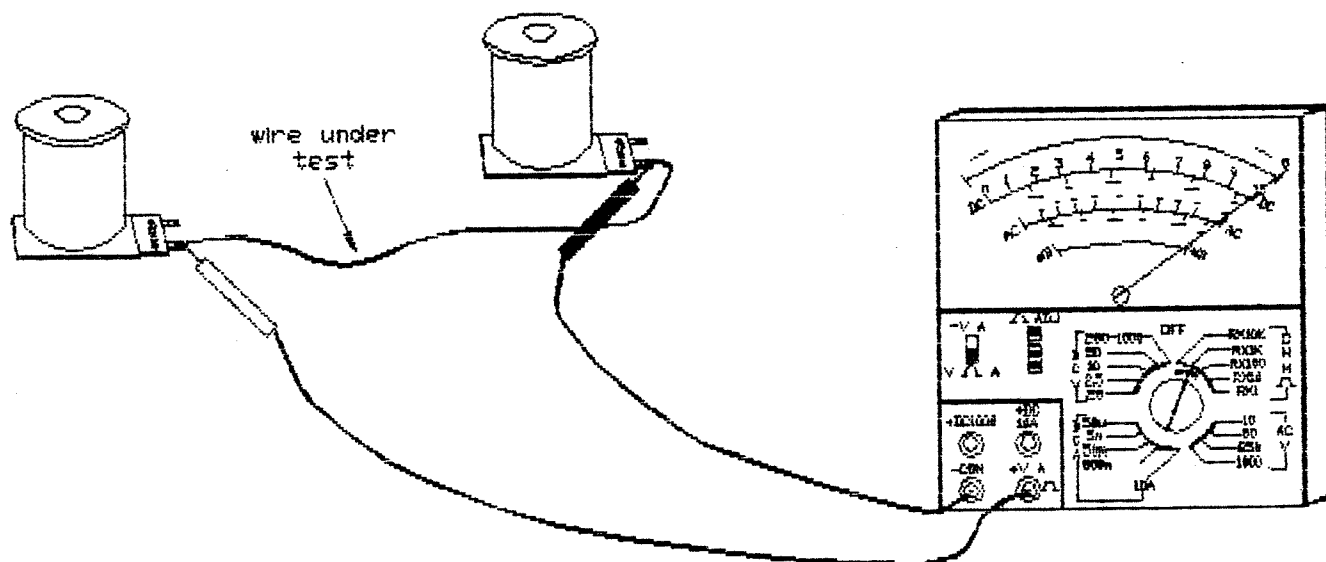
This test is also reliable for testing most connectors.

THIS TEST MUST BE DONE WITH POWER CORD TO THE GAME UNPLUGGED

1. Install meter probes and set range setting as per section 3-1 steps 1 through 5. Make sure you adjust the zero ohm adjustment knob.
2. Locate the two ends of the wire being tested and touch one probe to one end of the wire. Touch the other probe to the other end of the wire.

If the wire has a good connection between the two points, the needle will swing to the right side of the meter scale. If there is no connection, or a faulty one, the needle will swing only part way, or not at all.

CHECKING CONTINUITY



3-17 CLEANING AND ADJUSTING SWITCHES

Switches must always be adjusted with the power turned OFF. If you are adjusting a switch on a pinball machine, you must first discharge the flipper voltage as described in section 3-11. Failure to discharge the flipper voltage may damage the logic board.

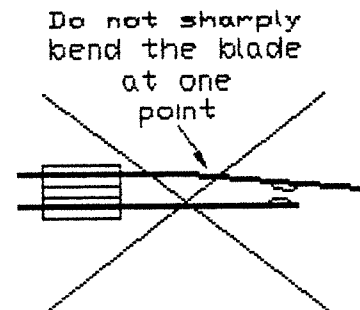
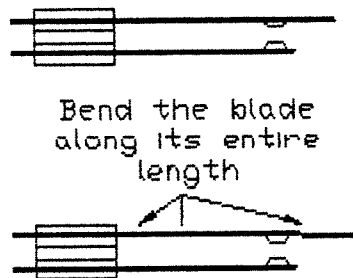
Using a blade adjusting tool or a small pair of needle nose pliers, carefully bend the blade starting at one end and work your way to the other end. DO NOT BEND THE BLADE IN JUST ONE PLACE. DOING SO WILL PUT A SHARP "KINK" IN THE METAL, WHICH WILL WEAKEN THE METAL.

Make sure the contact points make a good solid connection when the switch is activated. The switch may also need to be cleaned. If cleaning is necessary, use a small piece of cardboard or paper to wipe the contact points clean while you hold the switch closed.

DO NOT USE A FILE OR SANDPAPER TO CLEAN A SWITCH UNLESS IT IS A FLIPPER BUTTON SWITCH OR A FLIPPER E.O.S. SWITCH WITH LARGE CONTACT POINTS THAT ARE BADLY BURNED.

Files and sandpaper will scratch the surface of the contact point. Most switches have a gold plating on them -- scratching them will result in destruction of the switch.

Adjustment of coin switch trip wires should be done with the wire and switch removed from the coin door. It is very difficult to adjust a coin trip wire while it is still on the door.



3-18 SOLDERING AND WIRE SPLICING

Use a soldering pencil (25 watts) for most soldering work. Soldering guns are to be used only on large metal terminals, such as those found on coils.

DO NOT SOLDER ON BOARDS WITHOUT SPECIAL TRAINING AND EQUIPMENT

To solder:

Firmly apply the tip of the hot soldering pencil to both of the items being bonded together (i.e. the wire and terminal). All of the metal you are soldering must be evenly heated or the connection will not be good.

After the metal is hot enough to melt the solder, apply the solder to both the surfaces to be bonded. Apply an ample amount of solder but do not be excessive. Be careful not to cause solder 'blobs' and do not let the solder drip off of the connection. Try not to melt the insulation on the wires.

When you are finished, the connection should be shiny and silver. Make sure there are no stray strands of wire, then insulate the connection.

NEVER USE ACID CORE SOLDER. ALWAYS USE ROSIN CORE SOLDER

Keep the tip of your soldering pencil and gun tight and clean at all times. A loose tip will result in very little heat.

PROTECTIVE GOGGLES ARE RECOMMENDED WHEN SOLDERING AND DE-SOLDERING

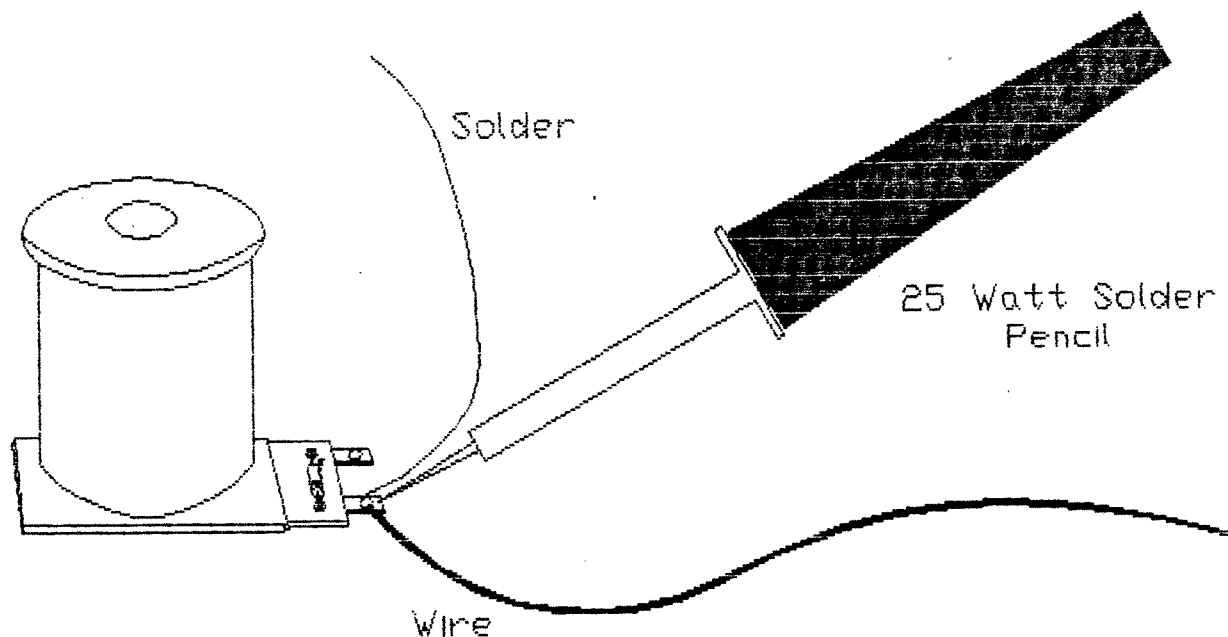
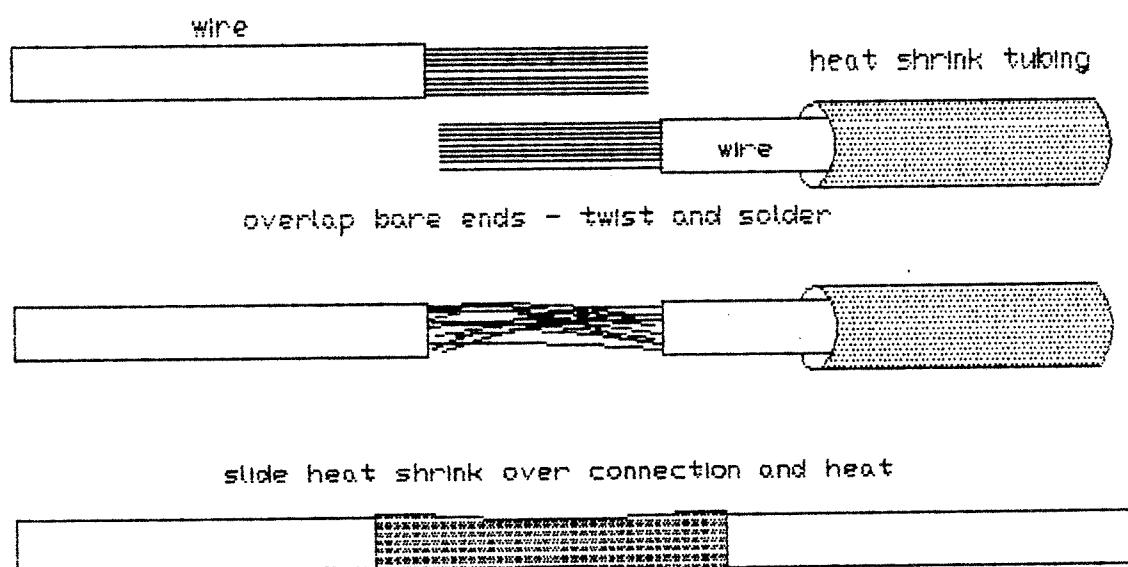


Fig. 18a

WIRE SPLICING



3-19 COIN ACCEPTOR REPAIR AND ADJUSTMENT

{Standard Type Acceptor}

IMPORTANT

Proper coin acceptor operation is critical! Poorly working coin acceptors (mechanisms) will severely reduce game income. If a player's coin is rejected, he or she might leave the game and not try again. They may even leave the arcade after enough failures. It is Nickels and Dimes Inc. policy that ALL COIN ACCEPTORS FUNCTION 100% CORRECTLY AT ALL TIMES. Do not adjust coin mechanisms without first understanding how the mechanism works. Arbitrarily turning screws, bending cradles, and moving levers without knowledge is 'bad medicine' which can lead to more trouble than you started with.

Problems with frequent coin jams, or games not operating because "good" coins are rejected are sure signs that the acceptor needs to be adjusted. The following is a list of possible adjustments for trouble signs. Keep in mind that the adjustments listed are only possible solutions. If there is a coin jam in the acceptor, adjusting for larger diameter may solve the problem. But the trouble could just as easily lie in the cradle, the magnet, etc.

TROUBLESHOOTING COIN ACCEPTOR PROBLEMS {Standard type acceptor}

(Refer to Adjustment Procedures and Figure 19-A before making any adjustments.)

Problem	Check Points
Rejects good coins	Adjust the magnet. Move the separator left or right. Move the kicker left or right.
Coins jam in the acceptor	Remove foreign particles from the magnet. Adjust for larger diameter. Adjust cradle in or out. Adjust the magnet out slightly. Move the separator slightly towards the "accept" path. Clean the acceptor.
Bad coins are found in the cash box	Adjust for smaller diameter. Adjust the cradle inwards if the bad coins are larger than a quarter, or outwards if the bad coins are smaller than a quarter.
Pennies in cash box	Install an anti-penny flipping device. Order this part from your supervisor.

Table 19-A Troubleshooting Standard Coin Acceptor

ADJUSTMENT PROCEDURES {Standard type acceptor}

(Refer to Figure 19-A)

Note: some coin mechanisms are not adjustable.

Diameter adjustment:

Insert a screwdriver into the slot on the diameter stop and turn clockwise for a larger diameter, counter-clockwise for a smaller diameter.

Kicker and Separator adjustment:

1. Set the coin mechanism with the back of the unit facing you in the test position.

2. Loosen the screws holding the Kicker and Separator and move both as far to the right as they will go. Lightly tighten the screws.
3. Insert several coins (both old and new) and note that some are returned by striking the separator.
4. Loosen the separator screw and move the separator a slight amount to the left. Tighten the screw.
5. Insert the coins again, if some of them are still returned. Repeat Step 4 until all the coins are accepted.
6. Loosen the Kicker screw and move the kicker as far to the left as it will go. Tighten the screw.
7. Insert several coins and note that some of them are returned.
8. Loosen the kicker screw and move the kicker a slight amount to the right. Tighten the screw.
9. Insert the coins again, if some of them are still returned. Repeat Step 8 until all the coins are accepted.

Cradle adjustment:

Bend the legs in for a smaller coin or out for a larger coin. About one third of the coin diameter should drop into the cradle. If more than one-third of the coin drops in, the cradle will not tip. If less than one-third of the coin drops in, the coin will sit too high and get stuck on the diameter stop.

Magnet adjustment:

Loosen the lock nut and turn the hex screw clockwise for thicker coins or counter-clockwise for thinner coins. The coin should just clear the magnet. Give the slotted hex screw a further one-half turn clockwise for optimum clearance and tighten the lock nut. Do not remove the magnet, as it is used to alter the speed of the coin during the run-down by the induction of eddy currents within the coin and to stop the acceptance of ferrous coins such as tokens, slugs, and Canadian quarters. *Note: some coin acceptors do not have a hex screw and lock nut for this adjustment; instead, they have a slotted head screw.*

Serration Detector (only on some mechanisms):

Only certain coin mechanisms have a Serration Detector spring (usually Coin Mechanisms Inc. mechs). As the coins pass the detector spring it senses the serration on the coin edge, therefore directing the coin to the accept side of the mechanism.

To adjust: a slight pressure downward on the serration spring will enable a greater variety including smooth edge coins to be accepted. Should a coin become wedged between the spring and rail, a slight

upward pressure on the spring is advised. Caution and care must be taken to avoid damage or distortion to spring.

ADJUSTMENT TIPS

- When adjusting the acceptor, use new coins to set the adjustments. Bear in mind that use of new coins will ensure acceptance of most coins and rejection of fraudulent coins. Using worn coins may cause acceptance of "bad" coins.
- When adjusting the magnet, try to use a bicentennial quarter (1976) to set the adjustments, since they are slightly wider than regular quarters. Failing to use these quarters to set the magnet could cause coin jams later.
- Adjust the acceptor for maximum performance, but be careful not to go too far. Mechanical coin acceptors are carefully designed to maximize game revenue and prevent fraud.
- Grease and oil are not recommended for lubricating coin mechanisms. Dirt may cling to the lubricant and hinder proper operation.

ADJUSTMENT PROCEDURES [Roll-down type acceptor]

The Roll-Down type mechanism can be adjusted both for diameter and thickness. The thickness adjustment is done first, as this affects the diameter setting. It is often impossible to do this adjustment while the mechanism is still within the machine. It is therefore advisable that a spare fixed half be used so that the swinging half can be removed from the machine (by removing the curved bull-dog clip on top), and temporarily attached to the spare. This will allow the swinging half to be adjusted outside the machine.

(Refer to Figures 20-A and 20-B)

Thickness adjustment:

To adjust the thickness setting, first release the setting screws' locknuts. Place a good coin on the coin track and adjust the thickness setting to a point where the coin just starts to fall through the track at both ends of the track. Before tightening the locknuts, the screws should be withdrawn just enough to allow the good coin to ride on the edge of the track at the fixed side.

Diameter adjustment:

The track is adjustable for all coins, quarters and tokens. The diameter setting is adjustable by moving the slider. Release the slider fixing screws, and with a good coin, adjust the slider so that it is parallel to the base of the coin track, and adjustment stops the coin from falling out of the side of the run down. Check this at both ends of the track, and if corrected, re-tighten the fixing screws.

ADJUSTMENT TIPS

- When adjusting the acceptor, use new coins.
- If possible, check the acceptor with a bicentennial quarter (1976). They are slightly wider than regular quarters.
- Grease and oil are not recommended for lubrication of coin mechanisms. Dirt may cling to the lubricant and hinder proper operation.

OPERATIONAL DESCRIPTION

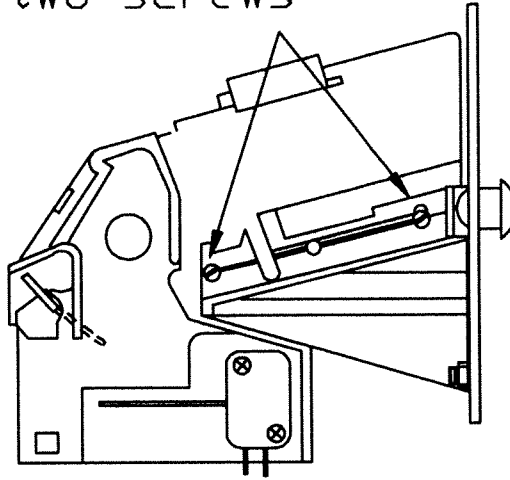
The Roll-Down acceptor tests for diameter and thickness, ferrous content, roundness, underweight, washers, tilting, coin-on-string, wire and matchstick frauds.

The front plate is the first check. This prevents entry of oversize, bent or badly distorted coins. The coin passes onto the run-down test track. This is inclined 14 degrees from the horizontal to permit the coins to run down due to gravity, and 5 degrees from the vertical, so as to check for diameter. As the coin enters the track it passes the washer catcher. This has a tooth which engages in the hole in a washer preventing further travel of the washer. At this point, the coin passes an over-diameter stop on the adjustable slider, which stops the passage of slightly

Adjust Thickness with these
two screws

Roll-Down
Acceptor
Adjustment

Make sure you firmly
tighten the locking
nuts on both screws
after adjustment



Adjust Slide Bar Up or Down
to set coin diameter

Make sure you tighten
the screws down
firmly after
adjustment

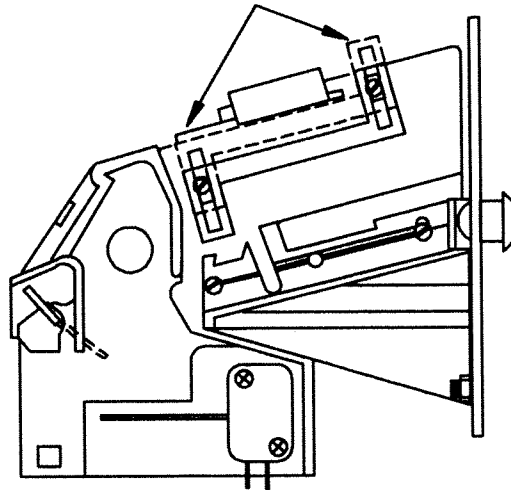


Figure 20-A Roll-Down Acceptor Adjustment

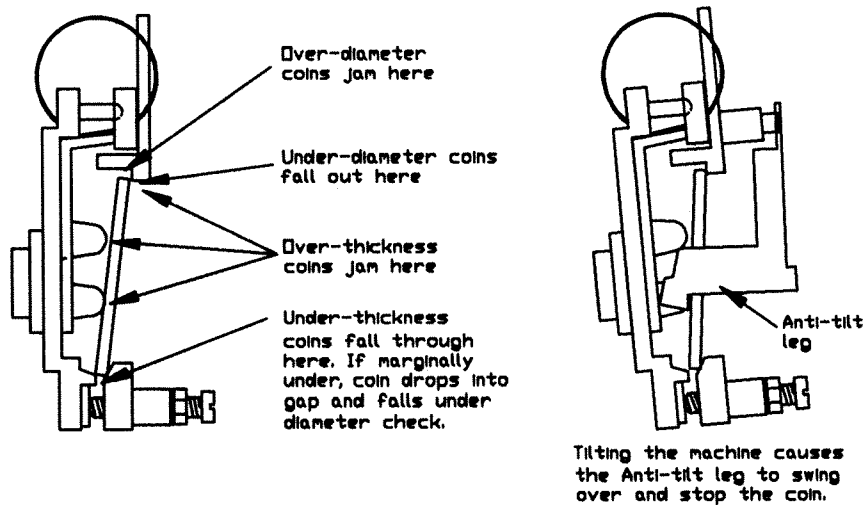
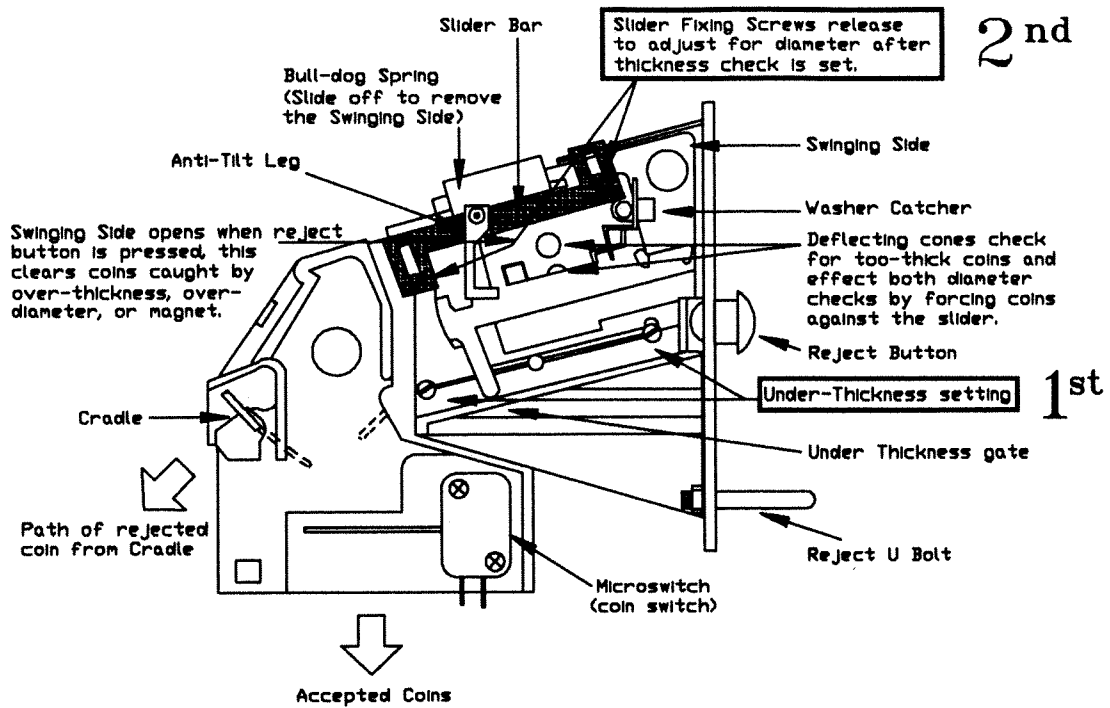


Figure 20-B Roll-Down Acceptor Overview

3-21 CRANE STRING REPLACEMENT

WHEN TO REPLACE A STRING

Crane strings should be replaced if:

- The string is excessively worn
- The string is too short
- The knot or knot stopper is missing

The most common string failure results in the string winding up backwards on the string spool (pulley). There are generally 4 reasons why this happens (number 1 and 2 are the most common).

1. The knot stopper is missing.
2. There isn't a knot tied 15" from the top of the string.
3. The rocker armature is sticking.
4. The rocker (slack detection) switch is incorrectly adjusted.

IT IS ESSENTIAL THAT THERE BE A KNOT STOPPER ON THE STRING, AND THAT A KNOT IS TIED 15" FROM THE TOP END OF THE STRING. WITHOUT THE KNOT AND THE KNOT STOPPER, THE STRING WILL REVERSE ITSELF IF THE PLAYER LOWERS THE CLAW OVER THE OPENING WHERE THE PLUSH IS DROPPED, OR IF THE STRING IS TOO SHORT.

The purpose of the knot and the knot stopper is to prevent the string from being reeled out too far. If this happens, the string will reach its end and will begin winding up backwards on the spool, thus resulting in the game being out-of-order. However, if the knot stopper is in place, and there is a knot tied 15" from the top end of the string, the knot will hit the knot stopper before the string reaches its end. When this happens, the rocker (slack detector) is allowed to momentarily lower, thus sending the proper signal to the board. When the board sees that the rocker has lowered, it can reverse the string spool and bring the claw up with the string wound in the proper direction.

HOW TO REPLACE A STRING

Refer to the diagrams on the following pages to identify what type of crane your store has, and in which direction your string should wind onto the spool. Once you have found the correct diagram, cut the string to the proper length and follow the directions on that diagram's page.

COMMON MISTAKES

- String is cut too short
- Failure to tie a knot 15" from the top end of the string

- Knot Stopper is missing from the string
- Knot at the spool is too small
- Knot at the claw cap is too small (make this knot at least 5 layers to keep it from slipping through the hole)
- String is threaded through the path incorrectly
- The claw casing is assembled incorrectly. The metal coil cover that has a flat edge must be in place, and must have electrical tape covering the bottom, edge, and top of the flat edge. This tape prevents the coil's solder connections from touching the metal.
- The coil's solder connections are sloppy (too large, stray strands of wire, etc.).
- Both screws are not placed back in the claw cap or the screws are the wrong size.

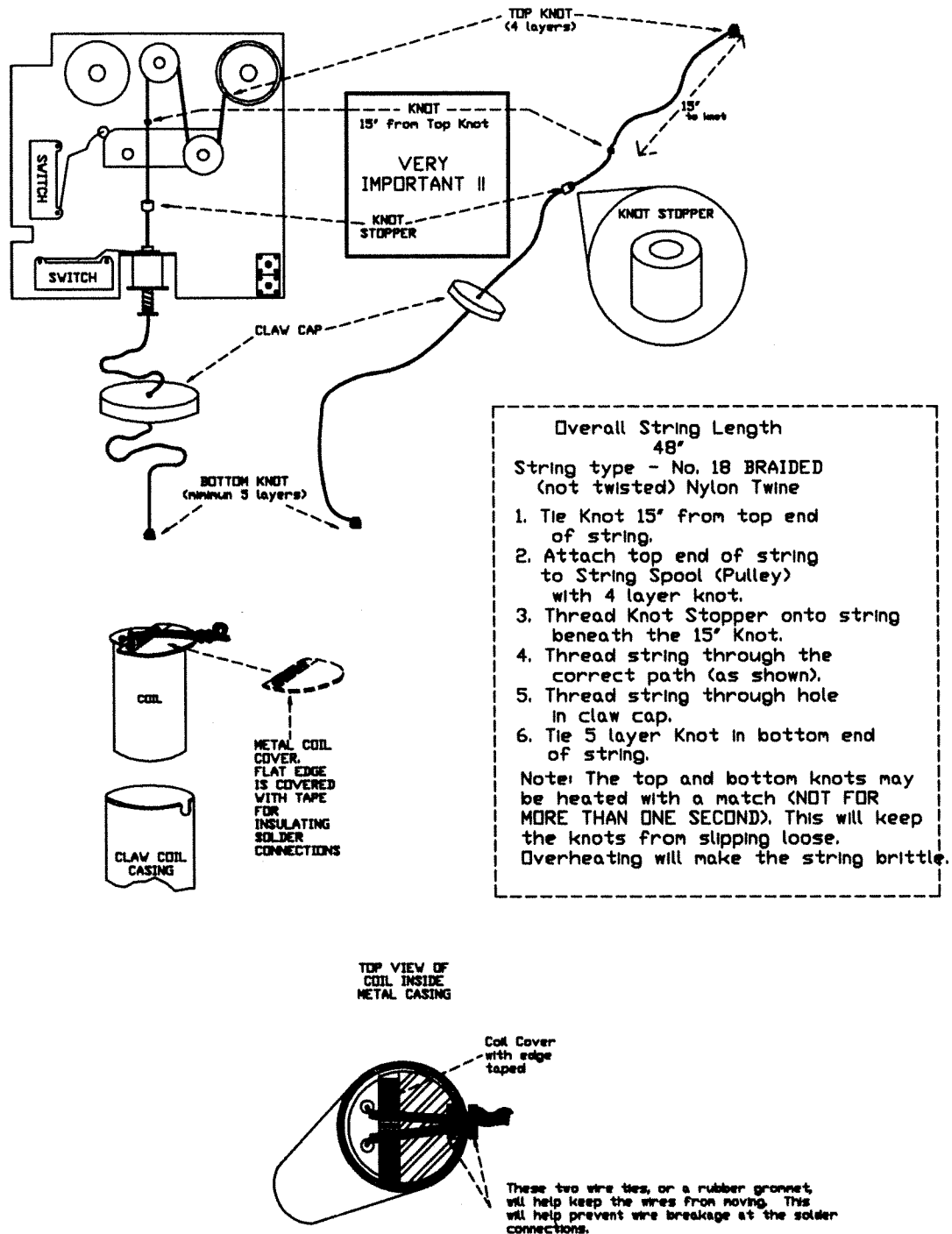


Figure 21-A String Replacement For Cranes With String Wound Counter-Clockwise (CCW) On Pulley

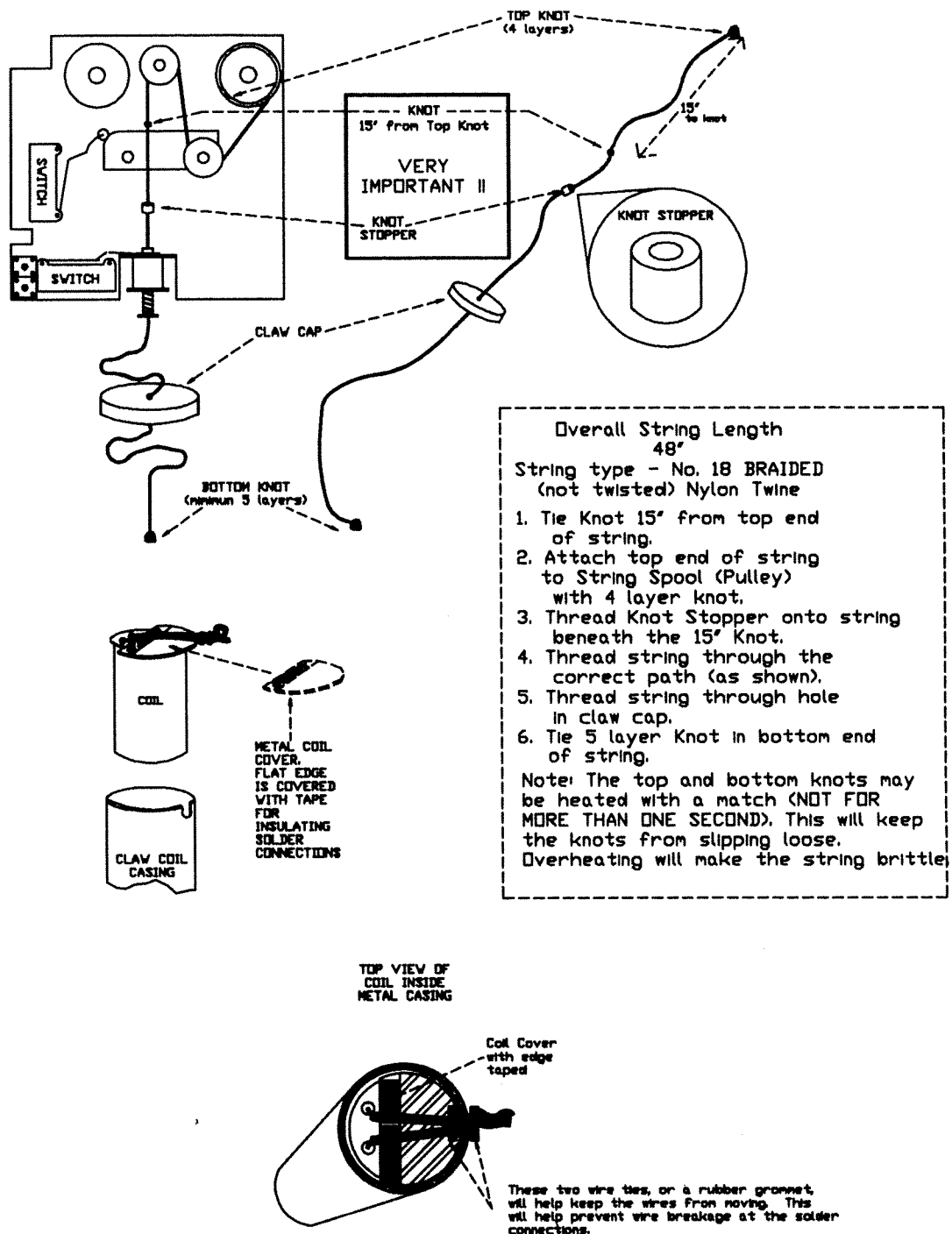


Figure 21-B String Replacement For Cranes With String Wound Clockwise (CW) On Pulley

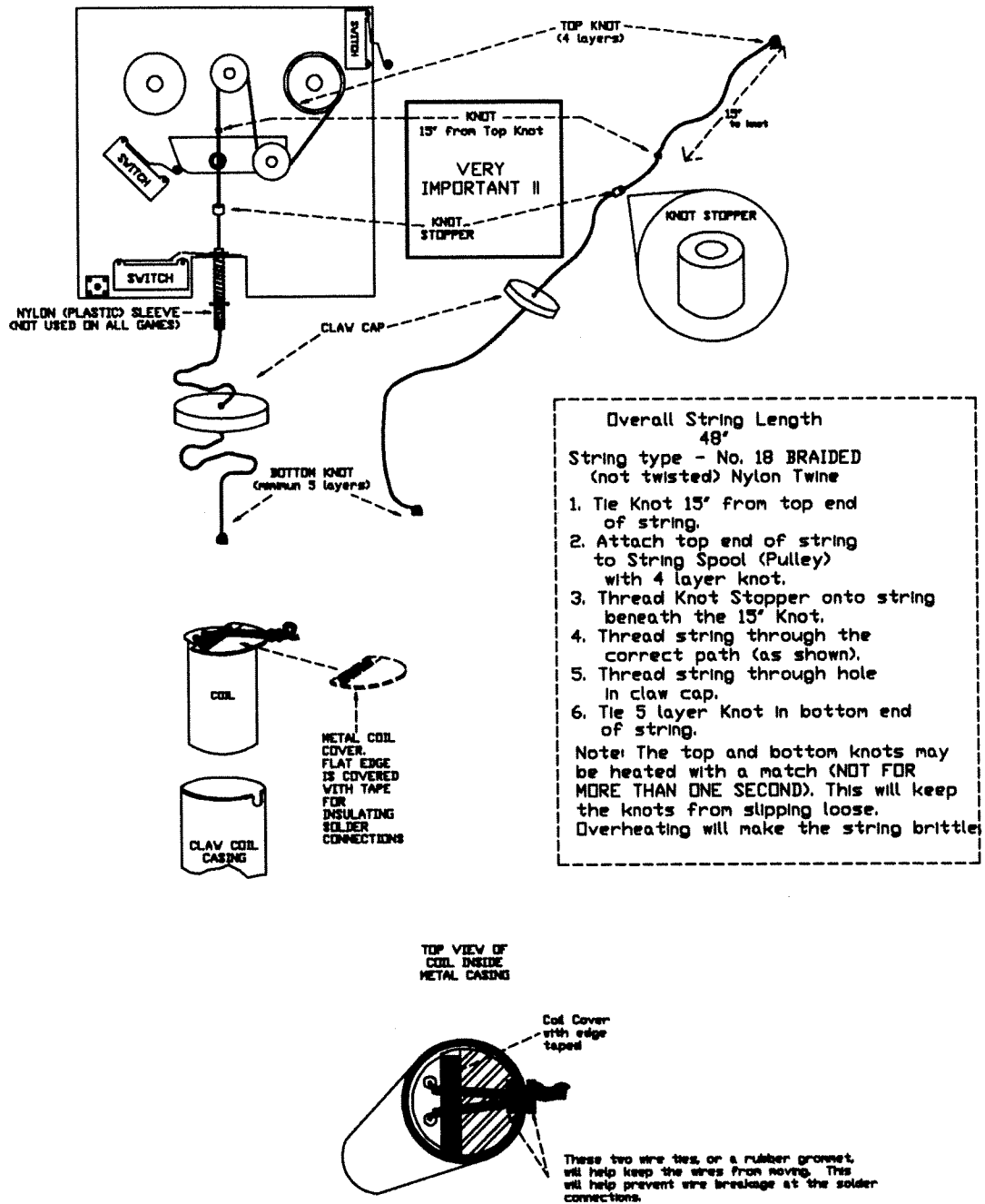


Figure 21-C String Replacement For Triple Way and Triple Skill Cranes

3-22 DISK DRIVE CARE

Certain games use disk drives in conjunction with their logic boards. These disk drives are very much like the ones found in most home and office computers. It is unusual for a game to have a disk drive; however, since some games do, it is necessary for store personnel to know how to care for them. To date, 3.5 inch double sided/high density disk drives and disks are used in some Sega games. Among those are: Gain Ground, Crackdown, Hot Rod 3, and Hot Rod 4. Do not mistake computer disk drive games for Laser Disc games; they are not the same thing.

BACKING UP A DISK

A *Back-Up* copy of the original disk must be made immediately upon receiving the game. This back-up disk should be the one used to operate the game. The original disk should be kept inside the game in a plastic envelope and used only as a source for back- ups. **DO NOT RUN THE GAME USING THE ORIGINAL DISK - EXCEPT IN EMERGENCIES.** The reason for this is that if the original disk fails, making a back-up copy from a back-up copy disk will not work. Always label disks with the game name, part number, revision number, and the date made. Blank disks are available from service centers and the parts department.

CARING FOR A DISK DRIVE

Dust and vibration are the worst enemies of the disk drive. Most disk drives have a dust cover that must be screwed onto the face of the drive. To protect the drive from dust, **KEEP THE DRIVE'S DUST COVER IN PLACE AT ALL TIMES.** Service records show that drives without dust covers fail frequently, while drives with dust covers will usually operate trouble free for extended periods of time.

Moving the game with the power on, and excessive banging to the cabinet can damage the drive and therefore should be avoided.

Drives can be cleaned using a disk drive cleaning kit that is available at most Radio Shack stores. This should be done every six months.

<p>Never use a Degaussing Coil to demagnetize the picture tube on a game with a disk drive. Doing so could permanently damage the disk drive and erase the disks in the game.</p>

3-24 SPEAKER TESTING

To determine if a game's speaker is good or bad, do the following:

Method #1

1. Turn the game off.
2. Disconnect the two wires going to the two speaker terminals.
3. Using a DMM, check the speaker in the same way that you check a fuse (see Section 3-1 of this manual). A good speaker will check like a good fuse, but a bad speaker will test like a bad fuse.

Method #2

1. Turn the game off.
2. Disconnect the two wires going to the two speaker terminals.
3. Using a 9 volt battery, connect one of the battery's terminals to one of the speaker's terminals, and the other battery terminal to the other speaker terminal. If the you hear a click from the speaker, assume that the speaker is good.

Mistakes are common when diagnosing sound problems, you should consider all the possibilities. There are four basic areas that often cause the loss of sound:

- Power Supply failure (loss of +12 volts)
- Logic Board failure
- Wiring failure (including off-board volume controls)
- Speaker failure

Power supply failures can be checked by measuring the voltages with a DMM. Logic board failure can often be determined by testing the logic board(s) in a known working game - contact your supervisor before attempting to do this. Wiring failures can be isolated by using a DMM to check continuity of the wires (*see Section 3-16 of this manual for continuity testing instructions*).

3-25 POWER SUPPLY REPLACEMENT

This section is divided into five parts:

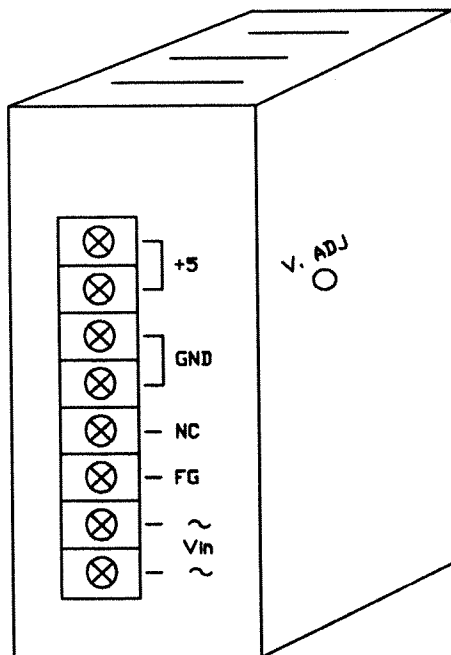
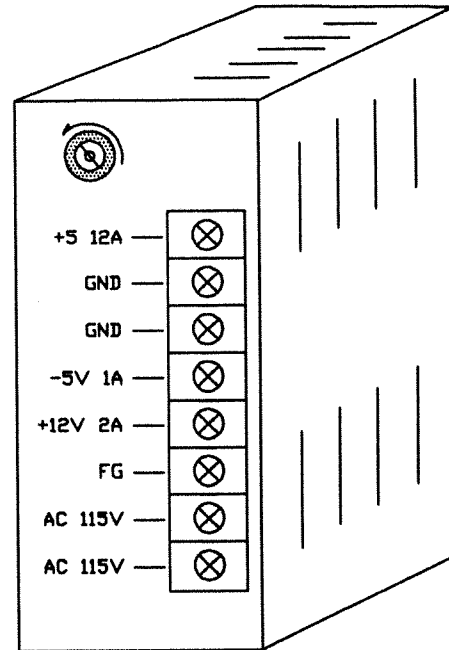
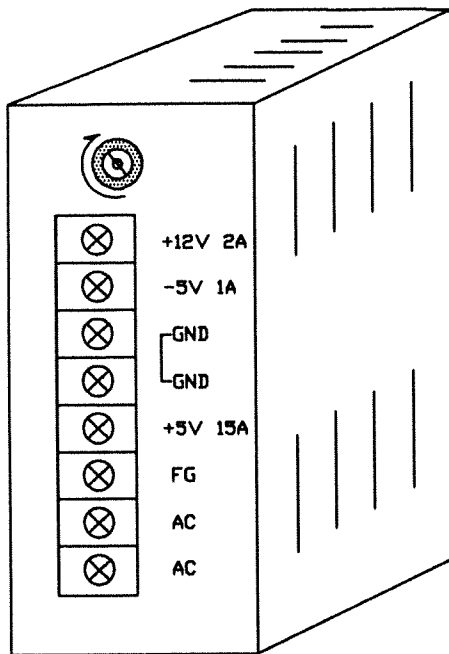
- TERMINAL DEFINITIONS
- IMPORTANT FACTS ABOUT POWER SUPPLY REPLACEMENT
- REPLACING THE STANDARD SWITCHING POWER SUPPLY
- REPLACING THE IBM STYLE POWER SUPPLY
- MISTAKES OFTEN MADE WHEN REPLACING POWER SUPPLIES

The first portion of this section covers important general information about power supply terminals and connections, current and voltage ratings, and an explanation of voltage drop. The second portion of this section covers replacement of *Standard Switching Power Supplies* which have individual terminals (usually screw type terminals) for wire connection. Most Switching Power Supplies are similar in appearance to the ones illustrated in this section. They are usually rectangular metal boxes with air vent holes or slots, and screws for connecting the wires. The third portion of this section covers replacement of *IBM Style Power Supplies* which do not have individual terminals for wire connection. Instead, they have a wiring harness with in-line connector(s). Some older games do not use switching power supplies. Instead they may use a *Linear Power Supply*. Linear power supplies usually have large heavy components and dissipate large amounts of heat. Linear power supplies are not covered in this section.

CAUTION

Read this entire section about power supply replacement before proceeding. It is essential that you know how to determine if the current and voltage ratings of your replacement power supply are correct!

Refer to the diagrams in this section for clarification.




Note that the order of the connections is different on each of these power supplies. Also note that the location of the +5 volt adjustment is different, and the direction that you turn the adjustment pot is different.

Not all power supplies have +12 volt and -5 volt terminals. The power supply shown to the left does not. Also note the NC terminal. This stands for No Connection. The Vin terminals are for the two 115 volt AC input wires.

The FG terminal is for Frame Ground. This connects to the Green wire from the power cord and to all metal that the player contacts.

Figure 25-A Some Common Standard Switching Power Supplies

TERMINAL DEFINITIONS

Terminal Name	Number of Terminals	Other Names and Symbols Used	Definition and Connections
AC IN  High voltage. Turn off power before servicing.	Two terminals	AC Vin AC 115V Line In ~ (sine wave symbols)	The two AC terminals connect to the two 115 volt AC wires. These wires are usually one Black and one White. DO NOT CONFUSE THIS BLACK WIRE WITH THE BLACK WIRES THAT MAY BE USED FOR THE DC COMMON! Some games use different colors such as Gray and Orange, or Pink and Blue. The Black wire is the AC Hot wire, the White wire is the AC Neutral wire. Do not let these two wires touch each other!
FRAME GROUND	One terminal	FG GND (In cases where the DC ground is labeled something other than Grd)	Frame Ground connects to the game's safety ground, which is usually the Green wire that comes from the middle prong of the AC power cord. This wire is connected to several places in the game, such as the coin door, monitor's metal frame, control panel, isolation transformer, and all metal that is exposed to the player. This wire provides protection against accidental electrocution from the 115 volt AC line during certain types of failures. Therefore, the FG connection is EXTREMELY IMPORTANT . This connection is also used to reduce electrical noise interference.
DC GROUND	Usually two terminals	Gnd Com DC Com DC Gnd -V G	This connection is for the DC voltage ground and is sometimes called logic ground. The wires connected to these terminals are usually thick Black wires, but not always. Some manufacturers use White, Brown or Green wires. DO NOT CONFUSE THE BLACK DC COMMON WIRES WITH THE BLACK AC HOT WIRE - THEY ARE NOT THE SAME!
+ 5 VOLTS	Usually one or two terminals	+5V +V (In cases where no other DC voltages are present on the power supply)	Wires connected to +5 volts are often Red, but not always. Some manufacturers use Yellow, Orange, Red/White, or some other color. This connection provides the main DC voltage to the game's logic board. This voltage must be adjusted correctly in order for the logic board to function properly.
-5 VOLTS (Not to be confused with the +5 volt terminal THEY ARE NOT THE SAME!)	Usually one terminal	-5V	This terminal often has no wire connected to it. This is because some game designs do not require -5 volts. When there is a wire connected to the -5 volt terminal it is often Violet, White, Red, Blue, or Gray, but it may be some other color. Various manufacturers use different wire colors for their games.
+12 VOLTS	Usually one terminal	+12V	Wires connected to this terminal are often Orange, Blue, Red, or Yellow, but can be any color that the manufacturer decides to use. Most games use the +12 volt DC terminal; however, not all do.
+ and - SENSE	One of each terminal	+S and -S +Sense and -Sense	These two terminals are not found on all power supplies. Most Atari games use power supplies with these terminals. The +Sense terminal usually has a Red wire and the -Sense a Brown wire. If you are replacing this type of power supply with one that does not have + and - Sense terminals, connect the wire that was on the +Sense to the +5 volt terminal, and connect the wire that was on the -Sense terminal to the DC Ground (Com).

IMPORTANT FACTS ABOUT POWER SUPPLY REPLACEMENT

VOLTAGES - Your power supply must have all the appropriate voltages. If the old power supply has terminals that are not used, the new power supply does not need to have those.

For example, suppose your old power supply has wires connected to the following terminals:

+5
+12

but has no wire connected to the -5 (minus 5) volt terminal. In this case, your new power supply must have +5, and +12 volt terminals, but it does not need a terminal for -5. You could use a power supply with a -5 volt terminal, you would just not connect any wires to the -5 volt terminal.

Some games use a power supply with only +5 volts, Com, FG, and AC terminals. This means that if you install a power supply that has +12 and -5 volt terminals, you will not need to connect them to any wires. They will be unused.

CURRENT RATING (amperage) - Your new power supply must be able to provide enough current to your game (see Section 2 of this manual for an explanation of Voltage and Current). Each voltage on the power supply has a maximum current rating. You must replace the old power supply with one that has at least the same current ratings.

For example, if your old power supply has the following ratings:

+5V 11A (11 amps)
+12V 2A (2 amps)

and both the +5 and the +12 volt terminals have wires connected to them, your replacement power supply must be rated at +5 volts minimum 11 amps, and +12 volts minimum 2 amps. **YOU COULD NOT INSTALL A POWER SUPPLY WITH LOWER AMPERAGE RATINGS** (i.e. +5V 7A, +12V 1A would not be adequate).

What this means is that the power supply is capable of delivering up to 11 amps to the circuits requiring +5 volts, and can deliver up to 2 amps of current to the game's +12 volt circuits. Replacing a power supply with one having amperage ratings lower than what are called for will result in damage to the power supply, and possibly other game components.

It is acceptable to use a power supply with **HIGHER** amperage ratings. For example, if the old power supply was rated at:

+5V 12A
+12V 1A

you could replace it with a power supply rated at:

+5V 15A
+12V 2A

Voltage Drop - The voltage measured at the +5 volt and Common terminals of the power supply will always be slightly higher than what is measured at the logic board. There is always a drop in voltage across the wires that connect the logic board to the power supply (see diagram). This is why it is important that you adjust the power supply while measuring at the logic board, not the power supply. The difference in voltage between the power supply and logic board varies depending on the game design. The usual difference is approximately .2 volts (2/10 of a volt).

Excessive voltage drops (.3 volts or more) usually indicate a problem with the game's wiring or connectors; such as burned or loose connector pins, loose wires at power supply terminals, loose fuse clips, or overheated wires that have hardened or burned inside the insulation. These types of problems must be found and corrected. It is unsafe to adjust a power supply higher to compensate for excessive voltages drops. If this is done, the voltage on the logic board will be too high when the problem is finally corrected, and damage will occur to the logic board.

Example: If the voltage at the power supply is +5.6 volts, and the voltage measured at the logic board is 5.02, this is too much of a voltage drop (.58 volts).

REPLACING THE STANDARD SWITCHING POWER SUPPLY

CAUTION
LETHAL SHOCK HAZARD, UNPLUG GAME BEFORE
SERVICING!!!



Once you have determined that your replacement power supply is the correct type, you can proceed with the task. Follow these steps to insure that the power supply is successfully replaced:

1. UNPLUG THE GAME FROM THE WALL!
2. Remove the screws that fasten the power supply to the cabinet.
3. Hold the new power supply beside the old one and compare the order of the terminals between the two units. The order of the terminal screws is often different from power supply to power supply. Re-read this section, or contact your supervisor or service center if you are unsure about any of the terminals.
4. ONE TERMINAL AT A TIME, carefully transfer the wires from the old power supply to the new one. Tighten the screw terminals firmly, but do not over tighten them and break the plastic.
5. Mount the new power supply to the cabinet. Use at least one screw at each end of the power supply to insure a safe and stable installation.
6. Refer to Section 3-6 of this manual for instructions on measuring the +5 volt level at the logic board. Adjust the power supply's adjustment control to set the +5 volt level between +5.00 and +5.15 volts at the logic board.

CAUTION
DO NOT LET THE VOLTAGE GO HIGHER THAN 5.2
VOLTS. THIS COULD SEVERELY DAMAGE THE LOGIC
BOARD!!!

7. Label the old power supply as "BAD" and contact your supervisor concerning what to do with it.

MISTAKES OFTEN MADE WHEN REPLACING STANDARD SWITCHING POWER SUPPLIES

- Adjusting the +5 volts while measuring at the power supply instead of at the logic board (*see Section 3-6*).
- Setting the +5 volts either too low or too high.

- Failing to check and adjust the +5 volts.
- Installing a power supply with current ratings that are too low.
- Disconnecting all of the wires at the same time instead of transferring them one at a time to the new power supply. This mistake often results in the wires being connected to the wrong terminals.
- Under tightening or over tightening the terminal screws.
- Failing to attach the power supply to the cabinet correctly.
- Installing a defective power supply that was left in the store without being marked as "bad".

REPLACING THE IBM STYLE POWER SUPPLY

Once you have determined that your replacement power supply is the correct type, you can proceed with the task. Follow these steps to insure that the power supply is successfully replaced:

Note: some IBM style power supplies require a minimum load in order to run correctly. In some cases it may be necessary to install a load resistor to remedy a problem. If you encounter a problem, contact your service center for assistance.

1. UNPLUG THE GAME FROM THE WALL!
2. Remove the screws that fasten the power supply to the cabinet.
3. Hold the new power supply beside the old one and compare the plug connectors and the order of the wires between the two units.
4. One plug at a time, carefully transfer the plugs from the old power supply to the new one. Make sure you plug the connectors together tightly.
5. Mount the new power supply to the cabinet using the hardware from the old unit.
6. Refer to Section 3-6 of this manual for instructions on measuring the +5 volt level at the logic board. Adjust the power supply's adjustment control to set the +5 volt level between +5.00 and +5.15 volts at the logic board.

<p style="text-align: center;">CAUTION DO NOT LET THE VOLTAGE GO HIGHER THAN 5.2 VOLTS. THIS COULD SEVERELY DAMAGE THE LOGIC BOARD!!!</p>

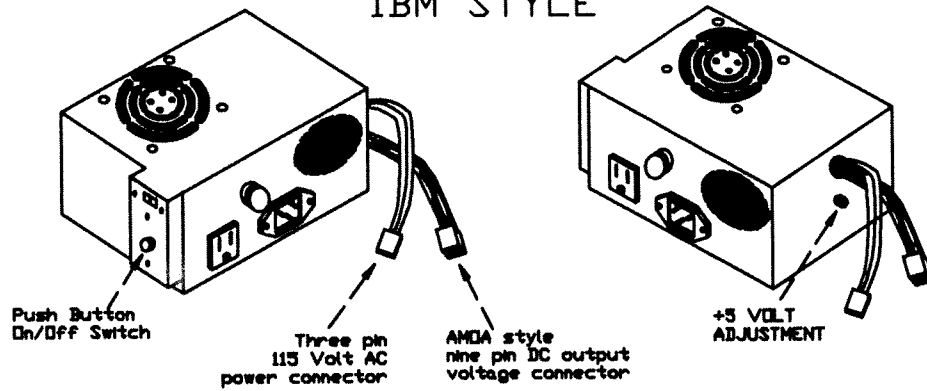
7. Label the old power supply as "BAD" and contact your supervisor concerning what to do with it.

MISTAKES OFTEN MADE WHEN REPLACING IBM STYLE POWER SUPPLIES

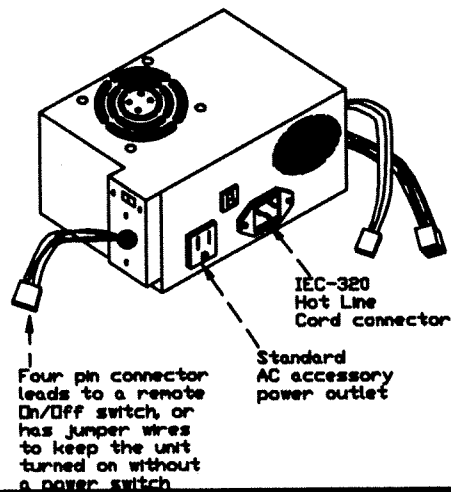
- Adjusting the +5 volts while measuring at the power supply instead of at the logic board (*see Section 3-6*).
- Setting the +5 volts either too low or too high.
- Failing to check and adjust the +5 volts.
- Installing a power supply with current ratings that are too low.

- Disconnecting all of the wires at the same time instead of transferring them one at a time to the new power supply. This mistake often results in the wires being connected to the wrong plug or terminal.
- Failing to attach the power supply to the cabinet correctly.
- Installing a defective power supply that was left in the store without being marked as "bad".

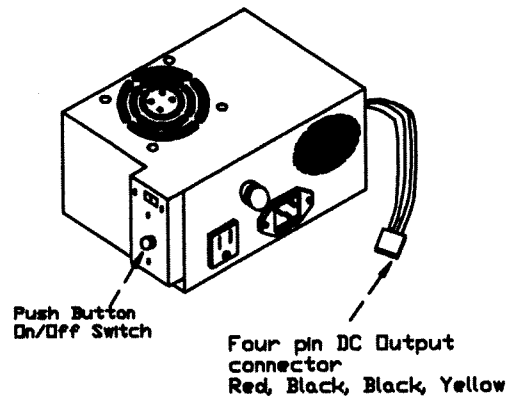
TYPE "A" IBM STYLE



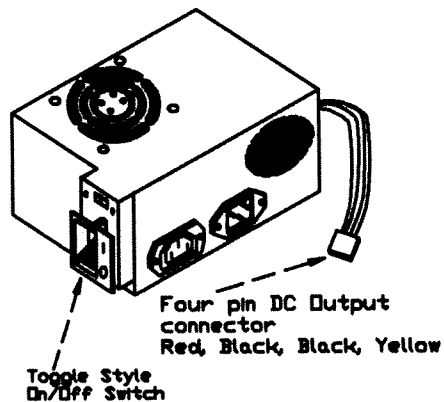
TYPE "B" IBM STYLE



TYPE "C" IBM STYLE



TYPE "D" IBM STYLE



TYPE "E" IBM STYLE

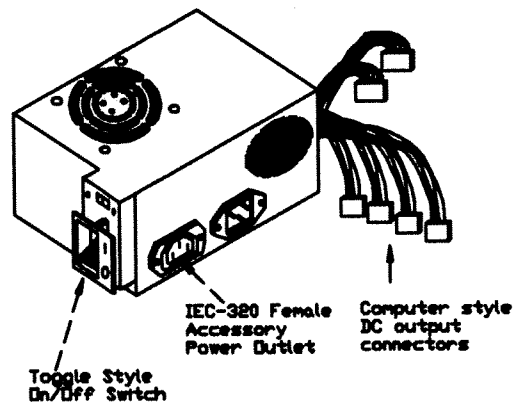
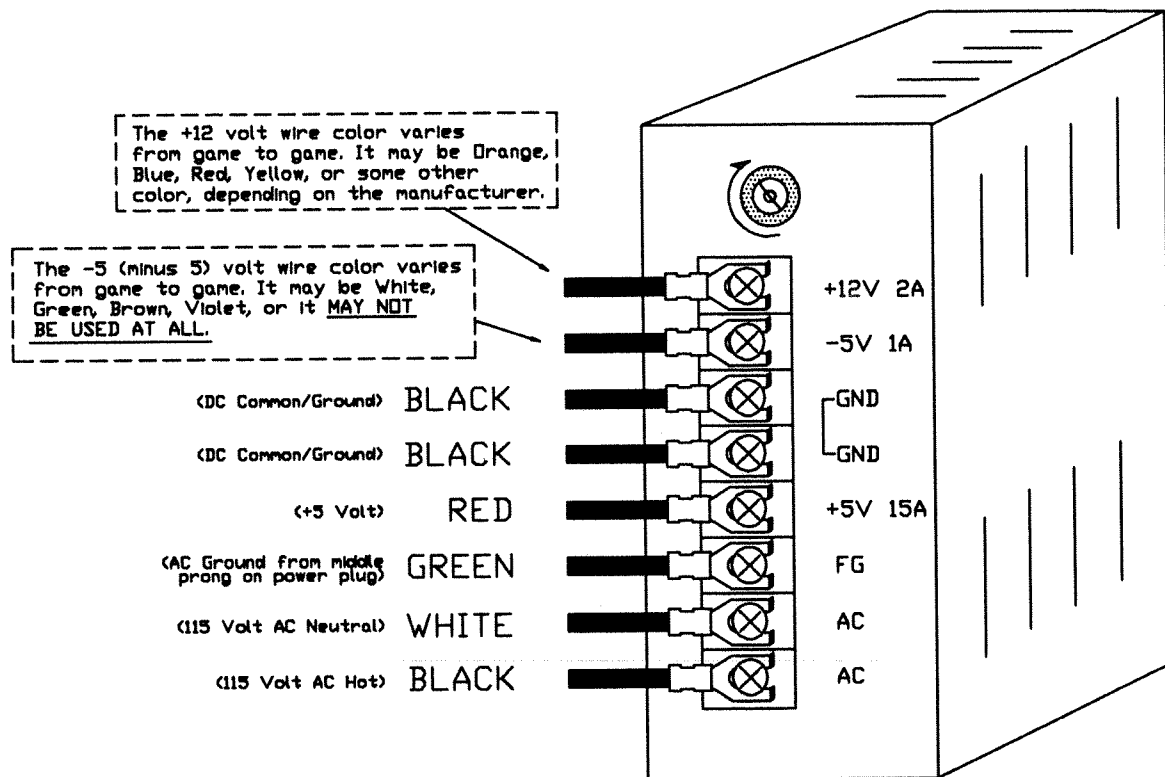


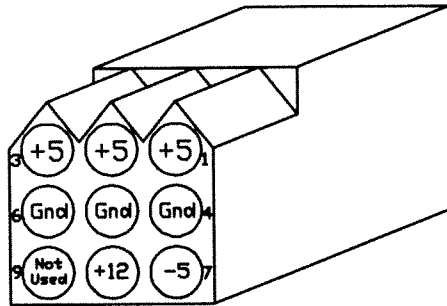
Figure 25-B Some Common
IBM Style
Power Supplies

A Typical Switching Power Supply Wiring Configuration

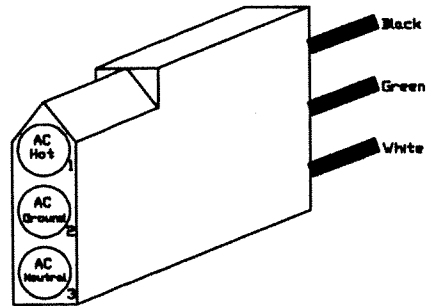


CAUTION... Wire colors may be different from game to game! Always move **ONE WIRE AT A TIME** when replacing a power supply. Follow the labeling next to the power supplies' terminals to determine the function of each wire. The order of the screw terminals on the replacement power supply is often different from the order on the power supply you are replacing.

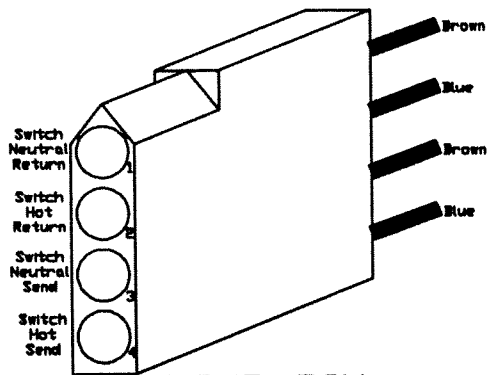
**Figure 25-C Power Supply Connections
On a Typical Switching Power Supply**



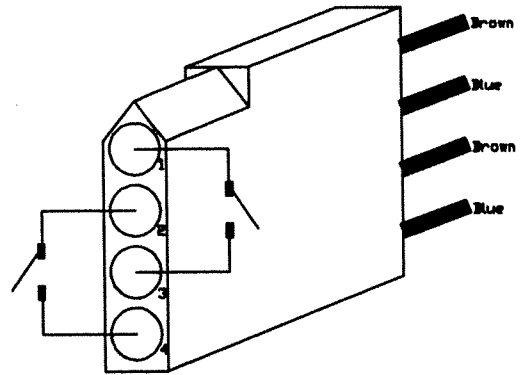
NINE PIN
DC OUTPUT
CONNECTOR



THREE PIN
AC OUTPUT
CONNECTOR

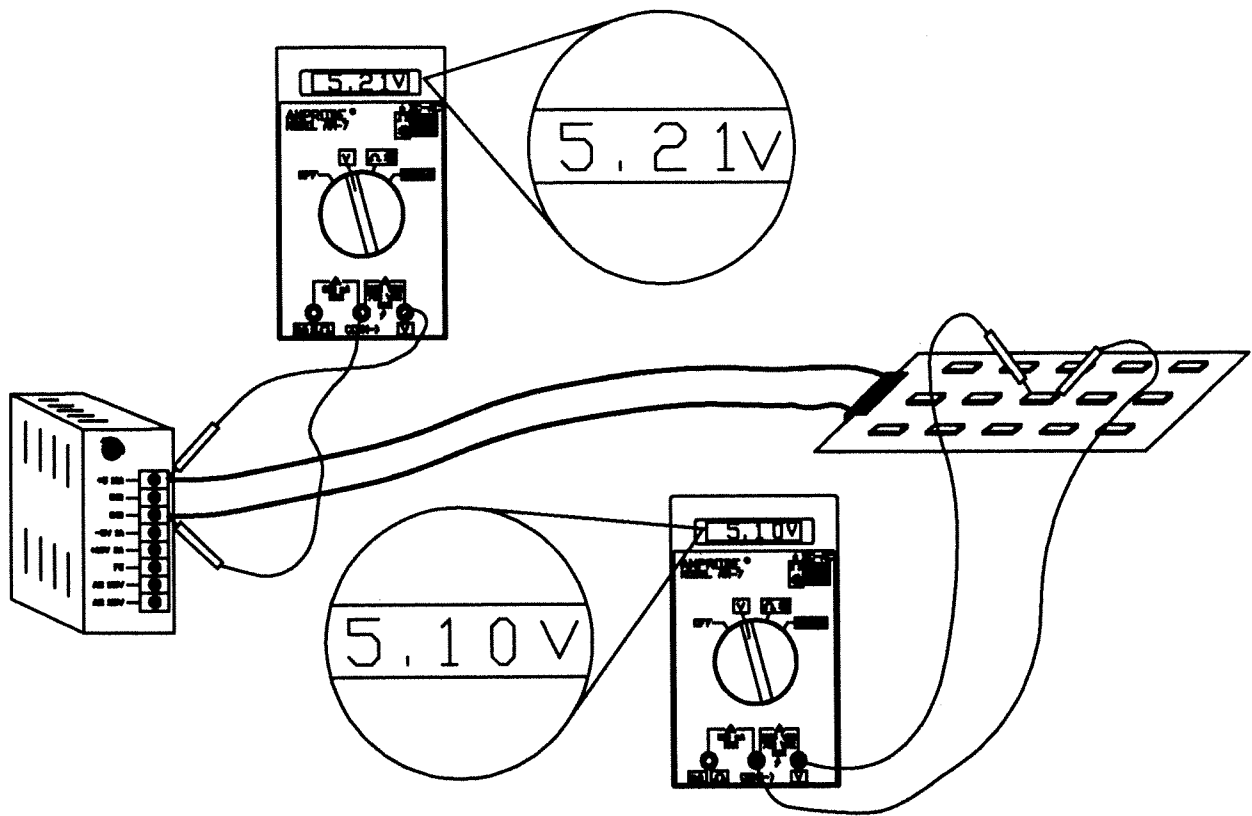


FOUR PIN
AC POWER
SWITCH CONNECTOR



SWITCH
(or Jumper)
WIRING

**Figure 25-D AMOA Standard
Connector Configurations
For IBM Style Power Supplies**



The voltage measured at the logic board will be less than the voltage measured at the power supplies' terminals. There is always a loss of voltage (voltage drop) across the wires between the power supply and the logic board. This is normal. Therefore, always measure the voltage on the logic board (see section 3-6 of this manual for instructions) when adjusting the power supply.

Figure 25-E Voltage Drop

AC POWER PLUG REPLACEMENT

Power Plug replacement should be avoided whenever possible. Instead, the entire Power Cord should be replaced. If this is not possible, contact your supervisor or service center to obtain permission to replace the Power Plug and follow the instructions given in this section.

Use only UL Approved three prong replacement plugs.



1. Unplug the game from the wall outlet.
2. Carefully examine the power cord for cracks, cuts, or nicks. If the power cord is damaged, you must replace it.
3. Use wire cutters to cut the old plug off the power cord.
4. Strip approximately 1/2" of insulation from the end of the three wires to be connected to the new plug.
5. Refer to Figure 26-A and connect the wires to the new plug's screw terminals in the positions shown. Wrap each bare wire around the correct screw's threads in a clockwise direction and tighten them firmly.

Make sure there are no stray strands of wire - this could cause sparks and molten metal debris to shoot from the plug and severely injure you.

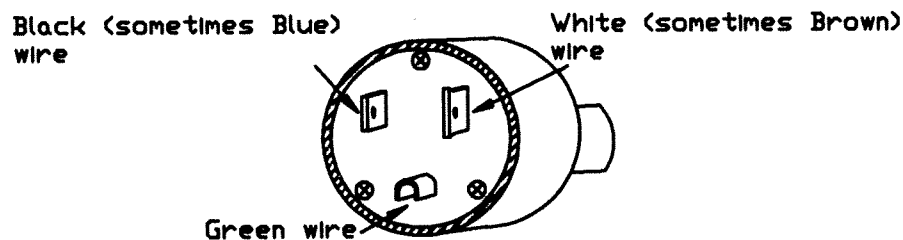


Figure 26-A Power Plug Wiring

3-27 TICKET DISPENSER REPAIR AND TESTING

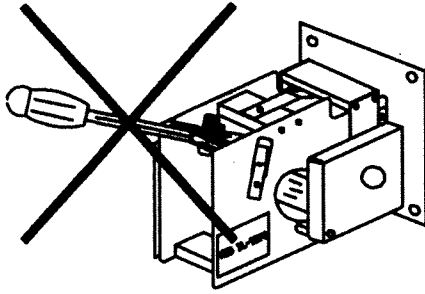
(Deltronic Brand)

This section covers the following:

- Most common Deltronic brand ticket dispenser problems
- Un-jamming a ticket dispenser
- Disassembly of a ticket dispenser
- Testing +12 Volts DC at a ticket dispenser with a DMM
- Testing the ticket dispenser's *Notch* signal with a DMM

MOST COMMON PROBLEMS

1. Tickets jam because of broken mounting tabs on plastic ticket support plate.
2. The Optical Notch Sensor is dirty and cannot correctly see the notches between the tickets (*see Section 4-8 for cleaning instructions*).
3. The PC board on the side plate is misaligned so that the Optical Notch Sensor on it cannot correctly see the notches.
4. The flat Ticket Spring on the side plate is misadjusted so that the tickets are not pressed towards the Optical Notch Sensor. Without constant, gentle pressure, the Optical Notch sensor can't see the notches. With too much pressure, the tickets may jam or break apart.
5. Loose or missing hardware.
6. Roller Tension Spring not correctly adjusted. This can allow tickets to be pulled out from the front of the dispenser.
7. Drive Roller set screw loose or not correctly tightened against the flat surface of the motor's drive shaft. This can allow tickets to be pulled out from the front of the dispenser.
8. PC board damaged by plugging or unplugging the dispenser with the game's power turned on.

DO'S AND DO NOT'S

Do not insert screwdriver blades between the ticket support plates to clear jammed tickets. This will break the tabs on plastic support plates, resulting in worse ticket jams.

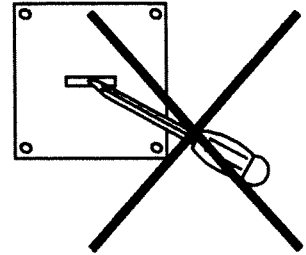


Figure 27-A

- DO NOT attempt to un-jam a ticket dispenser by inserting screwdrivers or other tools into the front slot or between the ticket support plates. This will most certainly break the tabs on the sides of the plastic support plate, causing increased ticket jams.
- DO NOT plug or unplug a ticket dispenser while the game is turned on. This can damage the game's circuitry and/or the ticket dispenser.
- DO NOT reassemble a ticket dispenser using a plastic support plate that has a broken tab(s).
- DO replace plastic TOP ticket support plates with the removable METAL type (older model dispensers used plastic top plates which have tabs along the sides that break and cause ticket jams).
- DO NOT replace BOTTOM ticket support plates with metal TOP plates; they cannot support the tickets from underneath.
- DO make sure all hardware is tight and that none is missing.

UN-JAMMING A TICKET DISPENSER

IMPORTANT

**MOST RECURRING TICKET JAMS ARE CAUSED BY BROKEN
TABS ON PLASTIC TICKET SUPPORT PLATES.**

**INSERTING SCREWDRIVERS OR OTHER TOOLS INTO THE
FRONT SLOT, OR BETWEEN THE SUPPORT PLATES, WILL
BREAK THESE TABS.**

First, determine if your ticket dispenser has a METAL top ticket support plate (guide) or a plastic one. If it is METAL, you can easily remove it from the dispenser without disassembly by the method described below.

If the top ticket support plate is made of black plastic (identical to the bottom ticket support plate), you will have to disassemble the unit to clear most ticket jams. Occasionally, tickets can be cleared by using a bent paper clip, tweezers, a pair of needle-nose pliers, or a pair of forceps. However, this can damage the plastic ticket support plate's tabs if you are forceful or careless. If your ticket dispenser has a plastic top support plate, replace it with a removable metal one (available from the Nickels and Dimes Inc. parts department).

To un-jam a dispenser with a removable METAL top ticket support plate (*refer to Figure 27-B*):

1. Spread the ticket dispenser's frame sides apart slightly and twist the metal top metal ticket support plate clockwise.
2. Carefully pull the support plate out through the rear of the dispenser, making sure it does not bump or scratch the Notch Sensor on the PC board.
3. Remove all jammed ticket material from the drive rollers and ticket path. Tweezers, forceps, or needle-nose pliers may aid in clearing the hard to reach places.
4. Inspect the bottom (black plastic) support plate to make sure NONE of the mounting tabs along its sides are broken, missing, misaligned, or damaged. Replace the plate if there are any damaged.
5. Reinsert the top METAL ticket support plate by sliding it into place and twisting slightly clockwise to allow one of the tabs to slide into its slot on the side plate. Spread the frame side slightly and fit the other tab into its slot. **BE CAREFUL NOT TO EXERT PRESSURE ON THE LOWER PLASTIC SUPPORT PLATE.**
6. Clean the notch sensor as described in Section 4-8.

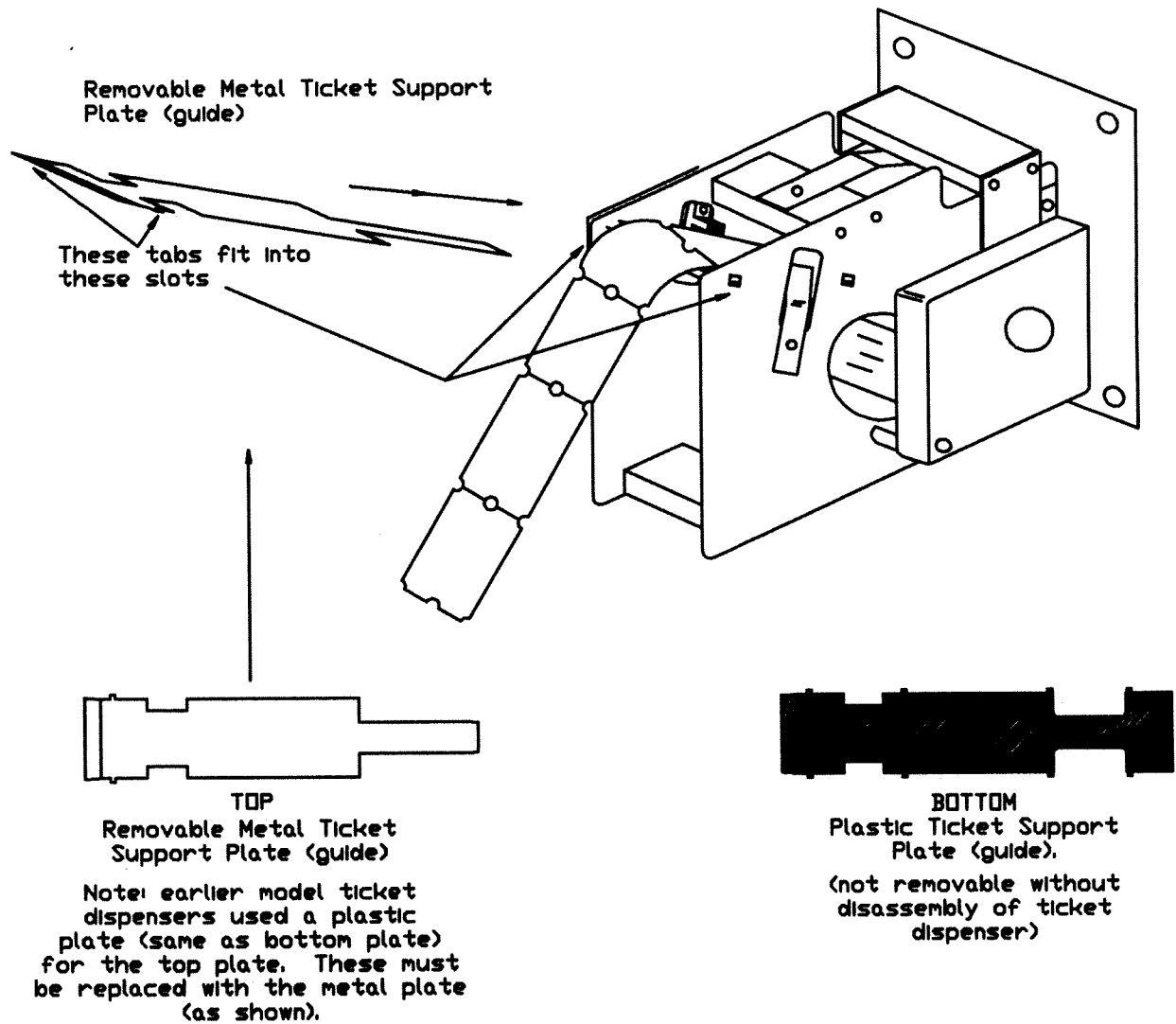
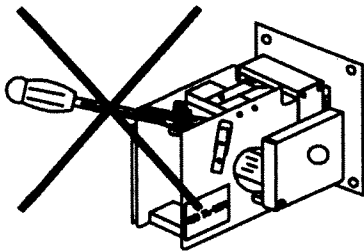


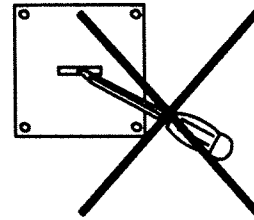
Figure 27-B Clearing a Ticket Jam on a Dispenser With a METAL Top Ticket Support Plate

DISASSEMBLY OF A TICKET DISPENSER

1. Refer to Figure 27-C and disassemble the unit by removing the side plate that has the PC board mounted on it, not the motor side. Follow, in order, the steps given in the diagram and place all screws, washers, and other loose parts in a paint can lid as you remove them. This will help you not lose them.
2. Inspect all of the unit's parts and replace the BOTTOM ticket support plate if any of the tabs along its sides are broken, missing, or damaged. If the TOP ticket support plate is black plastic instead of metal, replace it with a removable metal top plate.
3. Tighten the Drive Roller set screw.
4. Reassemble in reverse order, making sure the white Nylon (plastic) washers are installed correctly, that all hardware is tight, and that no screws are missing.
5. Make sure the Optical Notch Sensor is aligned correctly and that the tickets do not rub the surface of the sensor.

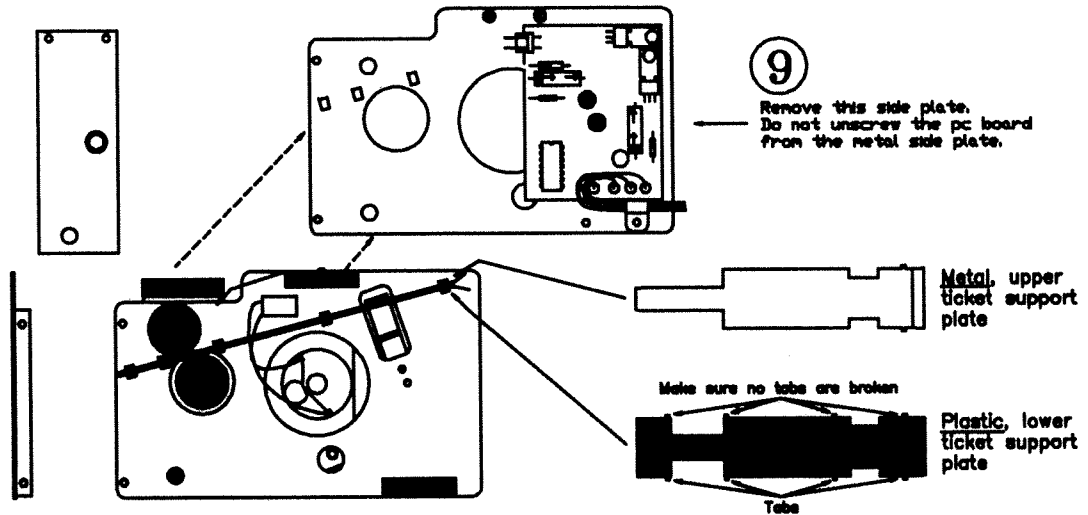


Do not insert screwdriver blades between the ticket support plates to clear jammed tickets. This will break the tabs on plastic support plates, resulting in worse ticket jams.



Disassemble the pc board side of dispenser

- ① Remove the four (4) screws (two on each side plate) holding the front plate, and remove the front plate
- ② Remove these four (4) screws
- ③ Remove these two (2) screws
- ④ Remove this E-Clip
- ⑤ Remove this pivot bracket
- ⑥ Unplug this two wire connector
- ⑦ Remove this E-Clip
- ⑧ Remove these three white nylon washers (two thin and one thick)



⑪ Reassemble in reverse order, making sure all tabs on the support plates are correctly aligned into their respective slots in both side plates.

Clear any jammed tickets from the mechanism.

If the lower (plastic) ticket support plate has ANY broken tabs along either side, replace it. Do not try to re-use a damaged one.

If the top ticket support plate was plastic, replace it with a removable metal one.

Figure 27-C Disassembly Of a Deltronic Ticket Dispenser

TESTING +12 VOLTS DC ON A TICKET DISPENSER WITH A DMM

Extreme caution must be observed when doing this test so the meter's probe tips do not slip and accidentally short a component's pins together.

Deltronic brand ticket dispensers require +12 volts DC to operate. This is the supply voltage for the dispenser. A digital multimeter (DMM) can be used to test for the presence of this voltage at the dispenser's connector (plug), or on the dispenser's PC board.

When discussing this +12 volt measurement with your supervisor or service center, it is important that you indicate where your measurement was taken - at the connector, or on the PC board.

PERFORMING THE TEST

First, determine which type of DMM your store has. Do this by comparing your meter with the diagrams in this section.

Second, determine the model number of the ticket dispenser by reading the sticker on the side plate of the dispenser and/or by comparing the appearance of the PC board to the diagrams.

- For model number DL-1275 (this is the most common type), and DL-1005-BSR, refer to Figure 27-E
- For model numbers DL-4-P-S and DL-4-S-S, refer to Figure 27-F

Once you have found the correct diagram:

1. Set the meter's switches and insert the test probes exactly as shown in the diagram which closely resembles your type of DMM.
2. Turn the game's power OFF.
3. Place the meter's probe tips on the points (connector pins, or across the capacitor on the ticket dispenser's PC board) shown in the appropriate illustration. Be extremely careful so as not to let the test probe tips touch anything but the connector pins or capacitor leads that are shown. If you are measuring at the connector, make sure the probes are firmly touching the metal connector pins inside the connector housing - it can sometimes be quite difficult to get a good connection.
4. Have someone else turn the game's power switch on so that you don't have to move your hands.
5. Read the numbers on the meter's digital display - this is the voltage. The reading should be approximately +12.00 volts (between 11.00 and 13.00). If the reading is lower or higher than this, contact your service center or supervisor for assistance.

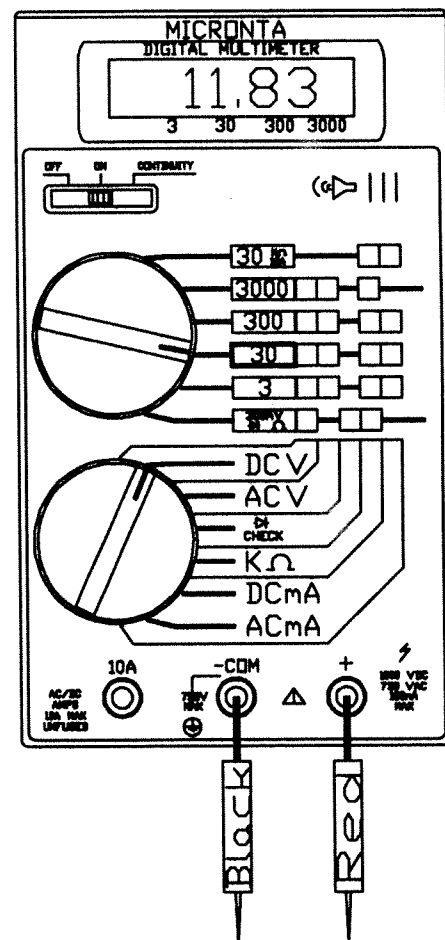
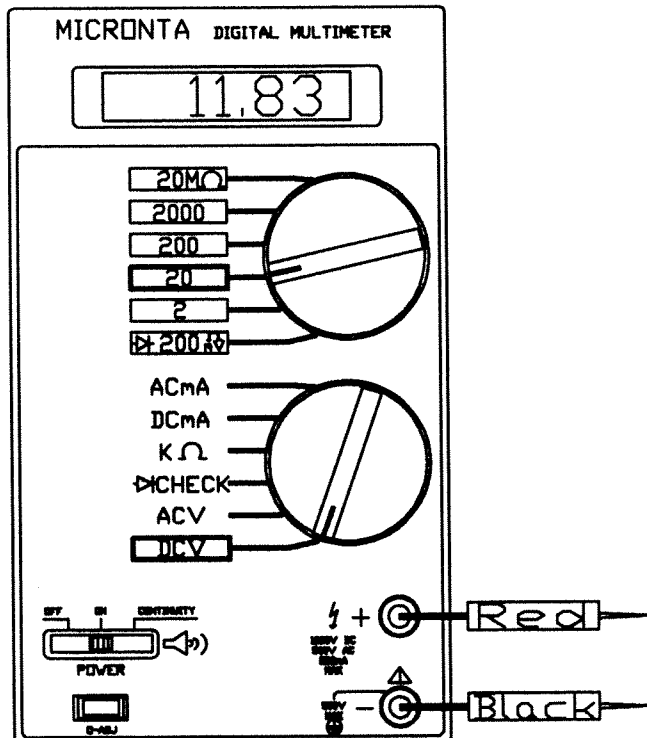
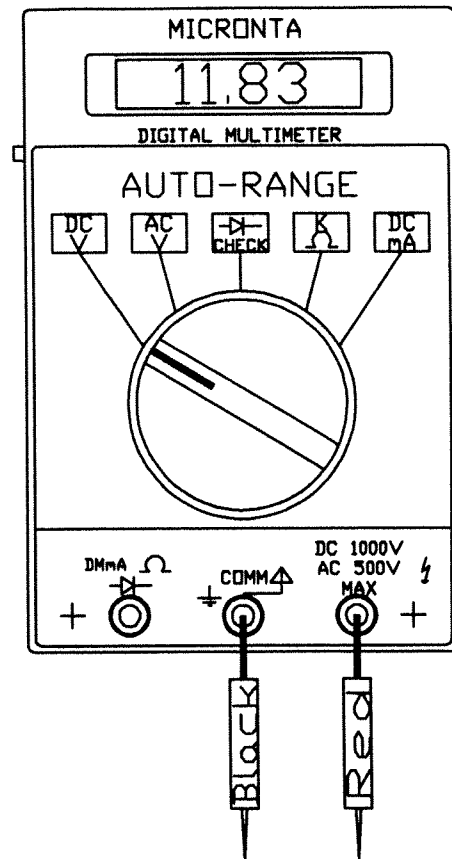
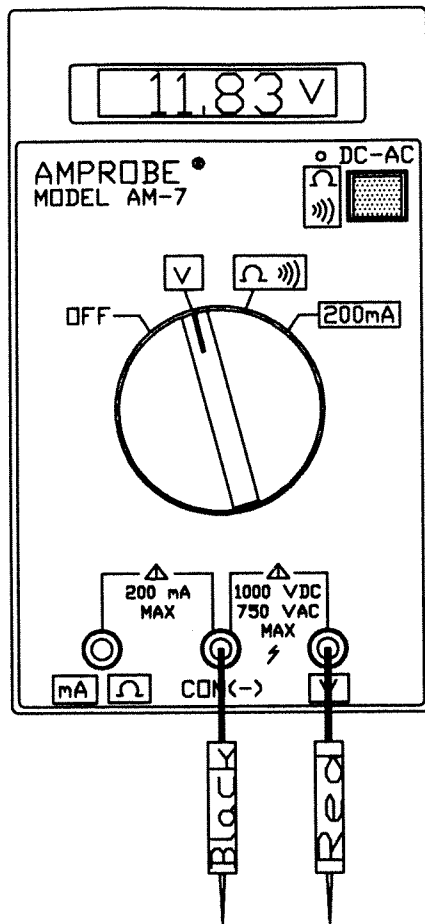


Figure 27-D Meter Identification and Setup For Ticket Dispenser Testing

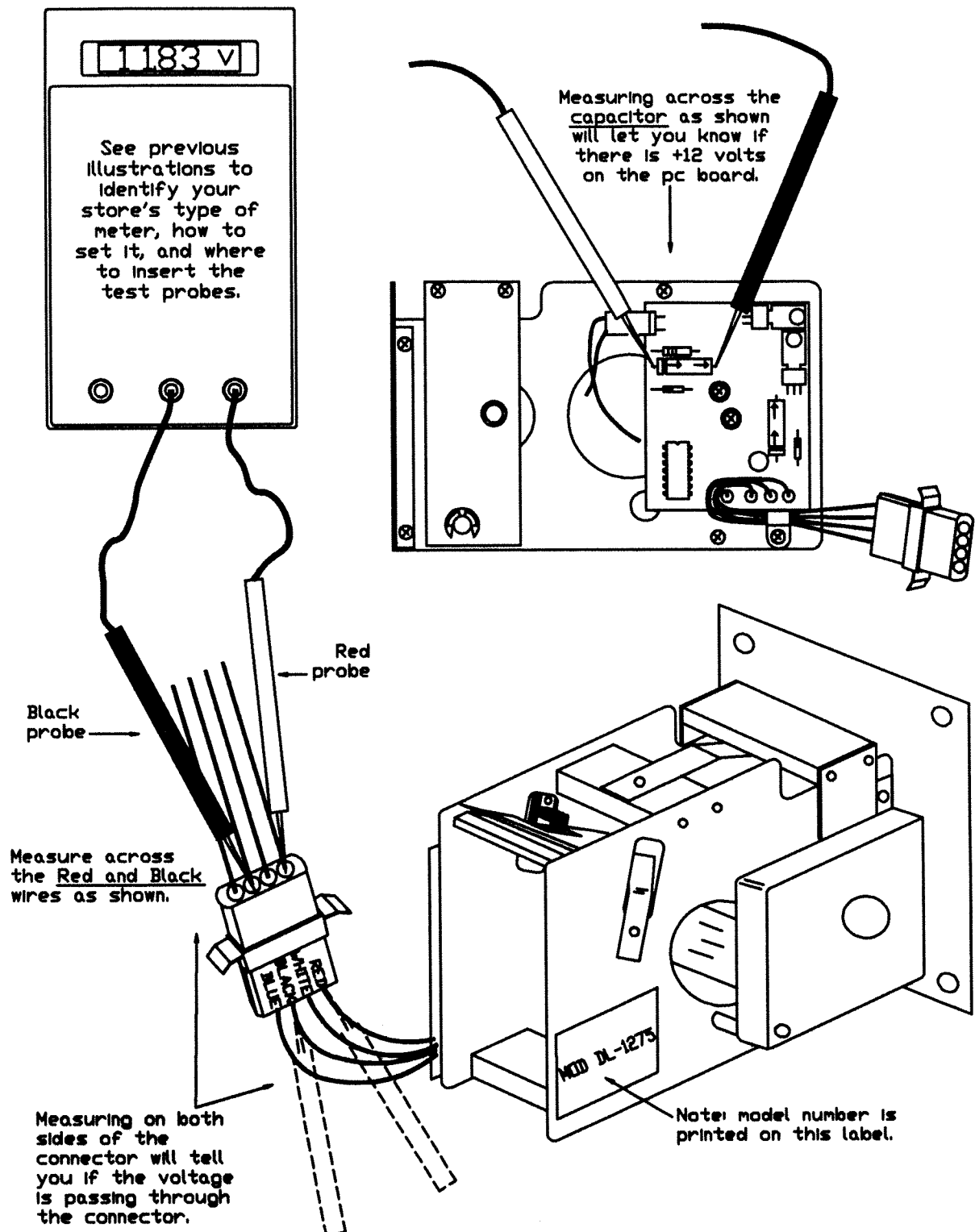
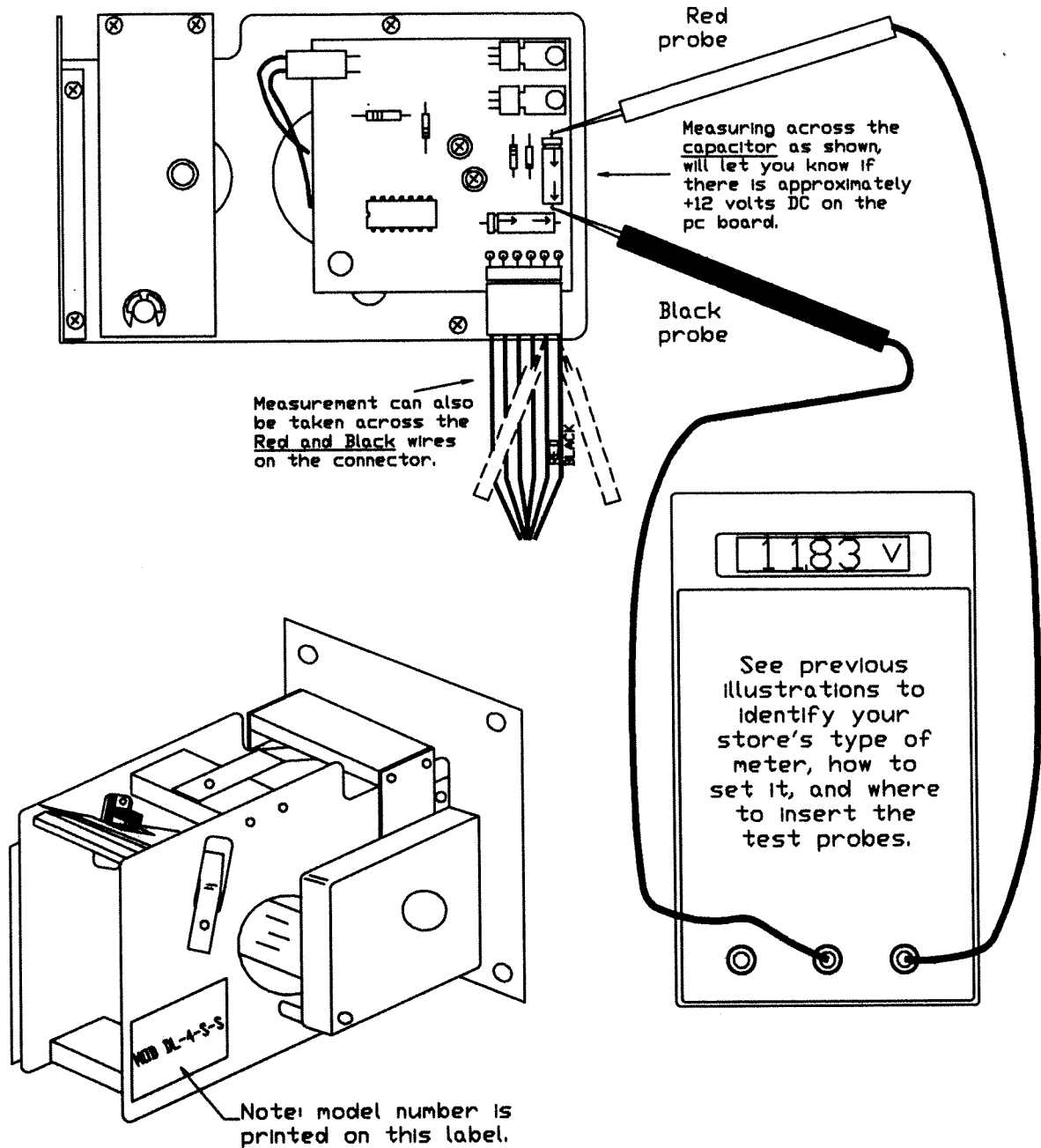


Figure 27-E Testing +12 Volts DC On a Deltronic Model DL-1275, and DL-1005-BSR Ticket Dispenser With a Digital Multimeter (DMM)



**Figure 27-F Testing +12 Volts DC On a Deltronic
Model DL-4-P-S, or DL-4-S-S
Ticket Dispenser With a Digital Multimeter (DMM)**

TESTING THE DL-1275 TICKET DISPENSER'S NOTCH SIGNAL WITH A DMM

Before beginning this test, it is advised that you exchange the suspected bad ticket dispenser with a known good one to determine if the problem is with the dispenser, or with the game's wiring or circuitry.

Deltronic Model DL-1275 dispensers have an output signal called "NOTCH." This signal is usually connected to the game's logic board. The Notch signal tells the game's circuitry each time the notch between two tickets passes through the optical notch sensor. This allows the game to know when the appropriate number of tickets has been paid.

The voltage level of the Notch signal can be different from game to game. When a notch between two tickets is in the optical notch sensor (not blocking the infrared light path), or when there are no tickets in the dispenser, the Notch signal will be approximately 0 (zero) volts. When a ticket is in the optical notch sensor (blocking the infrared light path) the Notch signal will be approximately +12 volts (or approximately +5 volts if the game is designed for a +5 volt notch level). Refer to Table 27-A for a listing of common Notch voltages. The Notch signal is "Open Collector", meaning that if you disconnect the Notch wire leading back to the game's logic board, the voltage will become zero and will not change as the Notch detector is blocked and unblocked by tickets. Therefore, the ticket dispenser must properly connected to the game and the wires must be intact before valid test results can be achieved.

PERFORMING THE TEST

Note: before you test the Notch voltage, you must first make sure there is +12 volts DC on the ticket dispenser's PC board. If the ticket dispenser PC board does not have +12 volts DC, the Notch voltage will not be correct. Refer to this same section under the earlier heading "TESTING +12 VOLTS DC ON A TICKET DISPENSER WITH A DMM" for +12 volts DC testing instructions.

Determine which type of DMM your store has. Do this by comparing your meter with the diagrams in this section.

Determine the model number of the ticket dispenser by reading the sticker on the side plate of the dispenser and/or by comparing the appearance of the PC board to the diagrams. This procedure is for the Deltronic Model D-1275 unit, NOT the DL-4-P-S or DL-4-S-S.

Once you have found the correct diagram:

1. Set the meter's switches and insert the test probes exactly as shown in the diagram which closely resembles your type of DMM.
2. Turn the game's power OFF.
3. Place the meter's probe tips on the points (connector pins) shown in Figure 27-G. Be extremely careful so as not to let the test probe tips touch anything but the connector pins that are shown. Make sure the probes are firmly touching the metal connector pins inside the

connector housing - it can sometimes be quite difficult to get a good connection.

4. Have someone else turn the game's power switch on so that you don't have to move your hands.
5. Read the numbers on the meter's digital display as you slide ticket notches through the Optical Notch Sensor. In a game designed for a 12 volt Notch signal, the reading should change from approximately 12 volts (between 10 and 12 volts) to approximately zero volts (between zero and .18 volts) as the Optical Notch Sensor is unblocked and blocked by a ticket. If the reading is lower or higher than this, refer to Table 27-A for a listing of common notch voltages. If your game is not listed, compare it with a working game of the same type in your store, or contact your service center or supervisor for assistance.
6. In a game designed for a 5 volt Notch signal, the reading should change from approximately 5 volts (between 4.5 and 5.2 volts), and zero volts (between zero and .18 volts). If the reading is lower or higher than this, refer to Table 27-A for a listing of common notch voltages. If your game is not listed, compare it with working game in your store, or contact your service center or supervisor for assistance.

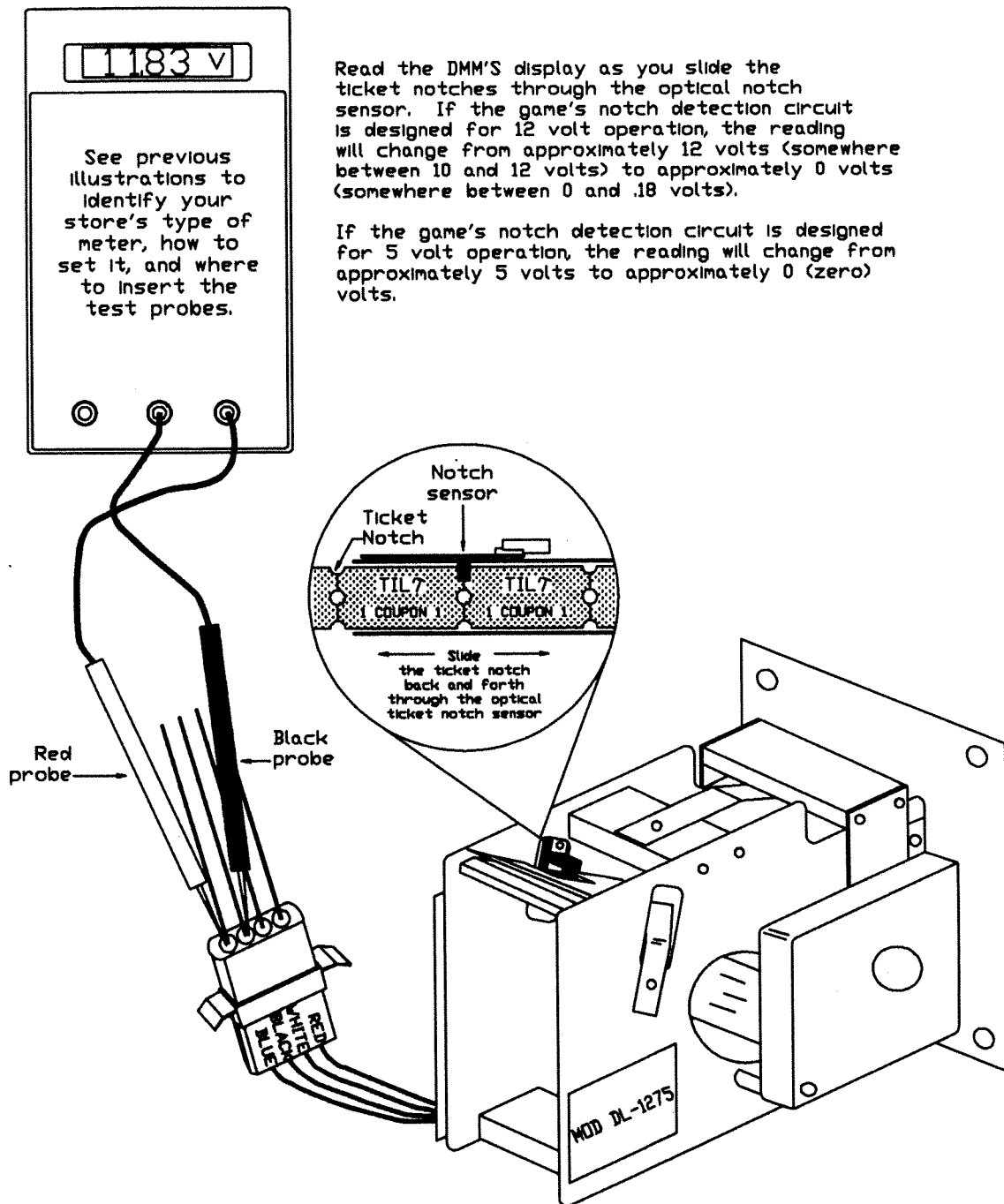


Figure 27-G Testing the Notch Signal On a Deltronic Model DL-1275 Ticket Dispenser With a Digital Multimeter (DMM)

GAME NAME	APPROXIMATE DC NOTCH VOLTAGE WITH TICKET BLOCKING THE NOTCH DETECTOR OPTIC	APPROXIMATE DC NOTCH VOLTAGE WITHOUT TICKET BLOCKING THE NOTCH DETECTOR OPTIC
Bank-It	11.9	.5
Big Mouth	2.8	.13
Bull's Eye	12.0	.05
Hoop Shot model 406 <i>(games with electro-mechanical coin meter, NOT games with an LCD display on the logic board)</i>	12.0	.15
Hoop Shot model 407 <i>(games with an LCD display on the logic board)</i>	3.6	.02
Knockdown	2.8	.08
Pop-A-Ball	5.0	.05
Skee-ball	4.7	.08
Water Race	9.2	.13
Wacky Gator	4.9	.07

Table 27-A Common Ticket Dispenser Notch Voltages

SECTION 4 PREVENTATIVE MAINTENANCE

One of the most essential aspects of store operation is that of preventative maintenance. Taking steps to curb mechanical and electrical failure ahead of time can save many hours of wasted time and effort on needless breakdowns. This of course means income for your store. Spending just a little time preventing a problem, can in many cases, save days of down-time.

This section of the manual includes instructions that you are to follow in maintaining your equipment. Follow all of the procedures completely and on time. Many of these items are inspected by your supervisor on a regular basis and can count against you if not done properly.

Keep in mind that many different types of equipment will enter the market after the writing of this manual. Not finding preventative maintenance steps in this manual for a piece of equipment is certainly not an excuse to neglect that equipment. Use common sense and take initiative in this area of preventative maintenance.

- 4-1 Routine Changer Service
- 4-2 Routine Pinball Service
- 4-3 Laser Disc Games
- 4-4 Games with Air Compressors
- 4-5 Coin Counters

4-1 ROUTINE CHANGER SERVICE

WEEKLY

Items to Check	Procedure
HOPPERS	<p>Clean the hopper coin path using a long handle NYLON brush. DO NOT USE A WIRE BRUSH, AS IT WILL CAUSE SEVERE DAMAGE TO THE TEFLON COATING ON THE COIN PATH. If you do not have the proper brush, notify your supervisor so that one may be ordered. See Section 3-13 for cleaning instructions.</p> <p>Check the hopper agitators for wear. If they are worn, consult with your supervisor immediately for replacement instructions.</p> <p><i>NOTE: Failure to perform hopper maintenance on a regular basis will result in the changer shutting down while the hoppers still have coins in them.</i></p>
BILL ACCEPTOR (Transport) on Rowe BC-9, BC-25, and BC-35 machines	<p>Use a tooth brush to clean the white nylon roller wheels on the top plate of the bill acceptor.</p> <p>Check the black rubber wheels for wear and dirt buildup. Clean them with pinch-roller cleaner or warm soapy water and rinse well. Do not use any cleaner containing alcohol. Alcohol will dehydrate the rubber, causing it to shrink. Fantastik will leave a wax build-up on the rubber if not rinsed off. Formula 409 will also dehydrate the rubber if not rinsed thoroughly.</p> <p>Check belts for proper tension. The drive belt should be as loose as possible, but tight enough that it will not jump or skip on the drive pulleys when the transport is under a heavy load such as reversing a badly wrinkled bill. Do not over tighten the belt!</p> <p>Clean the magnetic head with a Q-Tip and Radio Shack Tape Head Cleaner. DO NOT USE ANYTHING OTHER THAN A Q-TIP AND TAPE HEAD CLEANER.</p> <p>Check the P6 Flipper Lever¹ for smooth non-stick operation.</p> <p>Check for proper alignment of lamps over the lenses.</p> <p>Clean dust from the underside areas of the acceptor.</p> <p>Check wiring harness for wear.</p> <p>Check Bill Pressure Roller² for dirt buildup and wear (a bad pressure roller can cause rejection of good bills).</p> <p>Thoroughly test the entire changer for <i>perfect</i> operation of all hoppers and acceptor.</p>

¹ The P6 Flipper Lever is described in the Glossary.

MONTHLY

Items to Check	Procedure
HOPPER MOTORS and CHANGE BUCKET ASSEMBLY	Inspect hopper motors and hopper motor brakes for dust. Use a paint brush and blow with your mouth to remove dust. Inspect change bucket parts for dust.
CABINET	Vacuum inside of changer cabinet, including the stacker area and behind hopper motors.

² The Bill Pressure Roller is described in the Glossary.

4-2
ROUTINE PINBALL SERVICE

WEEKLY

JET BUMPERS (Thumper Bumpers)

1. Check for broken ring. (this is the part that hits the ball)
2. Look for cracked or chipped plastic parts.
3. Check for bent, broken, or cracked coil stops and brackets.
4. Make sure all mounting screws are tight and are the correct size and type.
5. See if switches are adjusted properly, and if BOTH switch mounting screws are tight.

FLIPPERS (See section 3-10 before proceeding)

1. Inspect all solder connections.
2. Does the E.O.S. switch open when the flipper reaches 3/4 of the way up? Are the contacts worn, the screws tight, and are the blades worn or bent?
3. Are the Return springs broken or the wrong size? Do the springs get caught when the flipper is operated?
4. Examine the Pawl (sometimes called the lever or crank). Look for loose screws and for wear (indicated by excessive play) at the joint where the linkage is attached to the lever and also to the plunger. Williams games have a bushing lining the hole in the linkage. Sometimes this bushing is accidentally left out, this will damage the linkage. Look for any signs of wear or fatigue on all of the moving parts.
5. Make sure that the mounting brackets have the proper hardware and that it is fully tightened.
6. Is coil seated properly (i.e. not crooked) and is the coil sleeve in place and the right size?

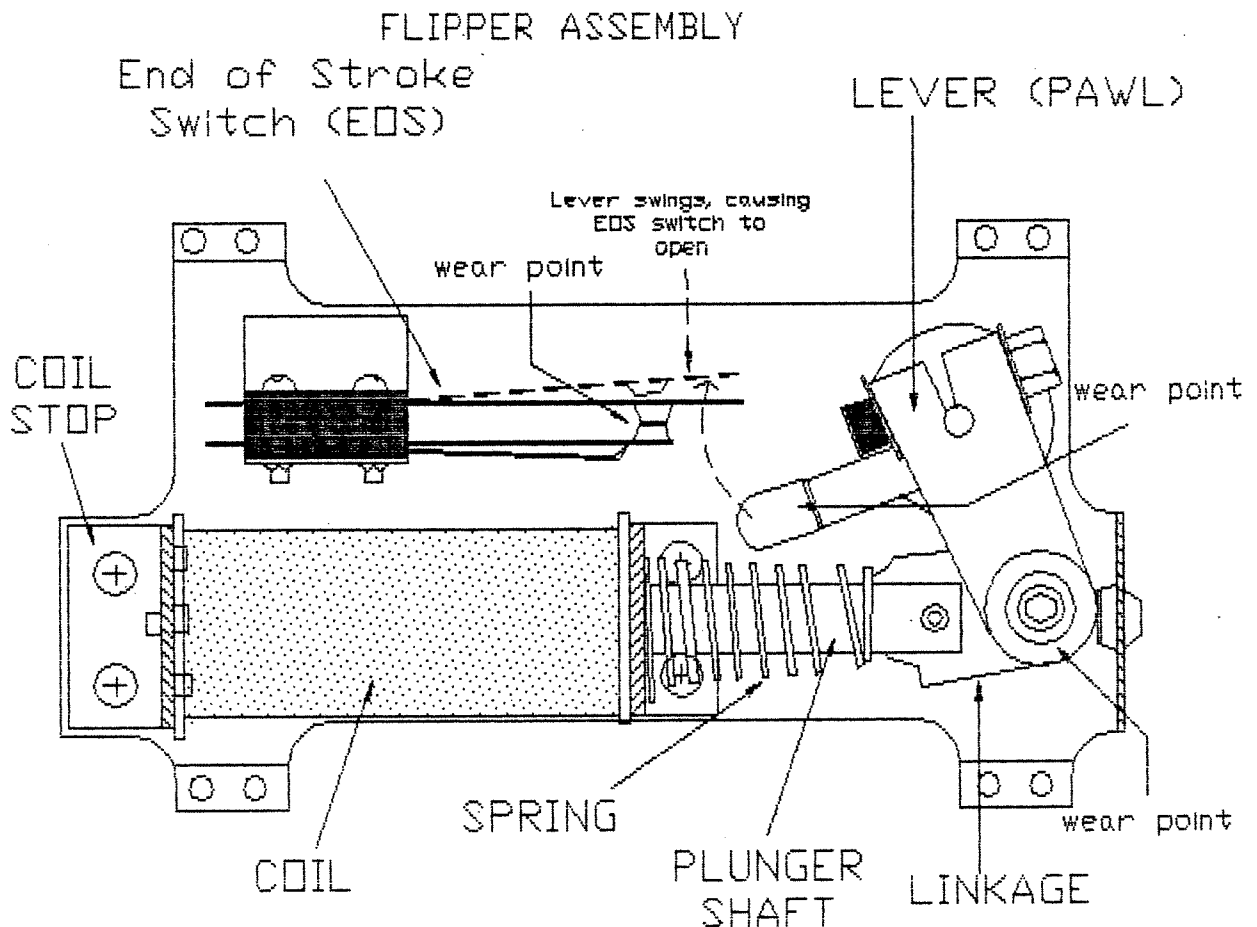
If your flippers are weak, that's how your profits will be! Make sure each part is as good as new. Never improvise or cut corners when repairing a flipper. Always keep spare ORIGINAL parts on hand before you need them. Never use a switch kit to build a replacement switch; always replace them with the original manufacturer's part.

cont.

GENERAL

1. Run game through self test and check ALL of the coils, switches and lamps.
2. Run two coins through each coin slot. If a slot does not work perfectly -- fix it.
3. Make sure game is level.
4. Test and inspect all Drop Targets for proper operation of ALL of the targets.
5. Clean according to Nickels and Dimes policy governing frequency and method.

Fig. 2-A



SECTION 4-3 LASER DISC GAMES

Dust is the worst enemy of laser disc players. If dust enters the disc player, it will damage the optic unit. Before proceeding, read section 3-7 and section 3-8.

WEEKLY

Clean the disc and disc compartment as described in section 3-7.

EVERY TWO WEEKS

Vacuum the inside of the game completely and clean or change the air filter (if the game has one).

NEVER REMOVE ANY SCREWS FROM THE PLAYER, OR MAKE ANY ATTEMPT TO OPEN THE BOTTOM COVER.

4-4
GAMES WITH AIR COMPRESSORS

DAILY

1. Drain water from the water trap.
2. Check oil level (use SAE-10W-40 non-detergent motor oil).
3. Make a visual inspection of all parts.

WEEKLY

1. Turn power off and drain moisture from the tank by opening the drain cock underneath the handle end of the tank.
2. Visually inspect all belts and moving parts for proper tightness and for excessive wear.
3. Check for air leaks.

MONTHLY

1. Replace air filters.
2. Change oil.

Refer to the compressor owners manual for more information.

4-5
COIN COUNTERS

Nickels and Dimes Inc. uses several different types of coin counters. The most common is the Scan 3001. This section will not cover all brands and models, however, maintenance is similar for most coin counters.

WEEKLY

1. Brush the entire coin path with a stiff paint brush and hard bristle tooth brush to remove all dust and dirt.
2. Inspect for loose, worn, or broken parts.
3. Clean the cabinet with glass cleaner.
4. Clean any greasy dirt build-up in the coin path with 409 (or similar cleaner).

MONTHLY

1. Remove the top cover and vacuum the entire inside of the machine.

DO NOT REMOVE THE BOTTOM COVER

Never make any type of adjustment to the machine. For service -- contact your supervisor.

4-6 DISK DRIVES

WEEKLY

Items to Check	Procedure
GAME CABINET	Vacuum the game's cabinet thoroughly.

EVERY THREE MONTHS

Read Section 3-22 of this manual before proceeding.

Items to Check	Procedure
DISK DRIVE	Clean the Disk Drive using a Disk Drive Cleaning Kit (available at Radio Shack). Be sure you replace the drive's dust cover.

Never use a Degaussing Coil to demagnetize the picture tube on a game with a disk drive. Doing so could permanently damage the disk drive and erase the disks in the game.

4-7 MOTION CABINET GAMES

All motion cabinet games require some type of regular preventative maintenance. Procedures vary from game to game, depending on what types of mechanisms are used in the game.

Among the many possible preventative maintenance tasks for motion cabinet games are the following:

- Games with motors will need motor brushes checked and/or changed.
- Oil-filled gearboxes must have levels checked and oil changed.
- Gear assemblies need to have old grease removed and new grease applied.
- Cabinets must be vacuumed.

For specific information about your motion cabinet games, refer to their individual manuals. Most manuals for these types of games include a schedule and chart showing what must be done and how often. If you do not have a manual, contact your supervisor to obtain the information. Not having a manual is no excuse for neglecting these important games.



4-8 TICKET DISPENSERS

(Deltronic Brand)

Refer to diagram on the following page

EACH TIME TICKETS ARE LOADED

Items to Check	Procedure
OPTICAL TICKET NOTCH SENSOR ¹	Use a small soft brush to dust out the optical ticket notch sensor. A small clean paint brush or make-up brush will work well to remove the ticket dust ² . This brush can be carried by the attendant in their smock or vest pocket.
GENERAL	Look for jammed pieces of tickets, broken ticket guide plates ³ , missing or loose hardware, and broken wires.

MONTHLY

Items to Check	Procedure
OPTICAL TICKET NOTCH SENSOR	Spray a quick shot of <i>fast evaporating</i> Cleaner/Degreaser spray into the Optical Ticket Notch Sensor to remove ticket dust. DO NOT USE ANYTHING THAT WILL ATTACK PLASTIC! Check with your service center to be sure you are using the correct type of spray.
GENERAL	Look for jammed pieces of tickets, broken ticket guide plates, missing or loose hardware, and broken wires.

CAUTION...DO NOT INSERT SCREWDRIVERS OR OTHER TOOLS BETWEEN THE TICKET GUIDE PLATES TO UNJAM TICKETS. THIS WILL BREAK THE PLASTIC TABS WHICH HOLD THE PLASTIC GUIDE PLATE INTO PLACE.

¹ The Optical Ticket Notch Sensor is the small black plastic component on the PC board that the edge of the tickets pass through. This device uses infrared light to sense (see) the notches in the tickets. This enables the game to count the tickets and know when to stop feeding them out.

² Small particles rub off of the tickets forming a powder, or dust. This dust collects inside the Optical Ticket Notch Sensor and blocks the infrared light. When this happens, the ticket notches cannot be detected (seen), and the computer cannot correctly count the tickets. This can cause incorrect payouts and other problems.

³ Broken plastic ticket guide plates are the number one cause of ticket jams and therefore must be replaced immediately. (See Section 3-27 for replacement instructions.)

4-9 CURRENCY (BILL) COUNTERS

AFTER EACH USE

Items to Check	Procedure
HOPPER AND STACKER AREA	Use a paint brush to clean the dust out of the machine. Dust will cause malfunctions of the system's optic sensors.

TWICE PER WEEK

Items to Check	Procedure
BILL PATH	Look for torn pieces of bills and remove them if found.

WEEKLY

Items to Check	Procedure
FEED ROLLERS	Clean the rollers with tape player pinch roller cleaner or warm soapy water and a toothbrush - rinse well to prevent a soap film build-up. Do not use any cleaner containing alcohol. Alcohol will dehydrate the rubber, causing it to shrink. Fantastik will leave a wax build-up on the rubber if not rinsed off. Formula 409 will also dehydrate the rubber if not rinsed thoroughly.

KEEP THE CURRENCY COUNTER COVERED WITH AN APPROPRIATE DUST COVER WHEN IT IS NOT IN USE.

4-11 TICKET SCALES

DAILY

Items to Check	Procedure
SCALE	Dust platform. Do not apply pressure to the platform. Clean keypad with glass cleaner or Fantastik.

WEEKLY

Items to Check	Procedure
SCALE	Check for counting accuracy. Some scales require periodic calibration at service center.

SECTION 5 BASIC TROUBLESHOOTING

It is very important to establish a good foundation upon which you can build your troubleshooting skills. This section covers many of the troubleshooting steps that are necessary to build this foundation. Do not skip over any of these steps or perform them sloppily. Even the most skilled technician will always cover the areas listed in each of these sub-sections.

Most failures are found in the wiring harness and switches. Broken and crimped wires are very common and can cause many problems. Good troubleshooting always includes a visual inspection of all connections and wires. This inspection should be made in good lighting so that nothing will be overlooked.

If you have not read section 1 of this manual, do so before proceeding.

VIDEO GAMES

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5-1 NO PICTURE

If header (marquee) light is on, check to see if the game will trip the meter and see if you hear it give a credit. Press the start button to see if you hear it start. If it does take a credit, and you do hear it start:

Check all fuses with a meter (see section 3-1).

Check for 115 VAC to monitor (see section 3-15).

If 115 VAC is present, test the monitor (see section 3-14).

If the header light IS on but the meter does not trip, and you do not hear sound when you press the start button:

Check all fuses with a meter (see section 3-1).

Check for +5 VDC (see section 3-6).

If there is no +5 VDC, the power supply is probably bad.

If there IS +5 VDC, the logic board is probably bad.

5-2 GARBAGE ON SCREEN (blocks, lines in characters, etc.)

Check all fuses with a meter (see section 3-1).

Re-seat I.C.s (see section 3-2).

Look for burned connectors (see section 3-3).

Check for loose connectors.

Check for +5 VDC (see section 3-6).

If +5 VDC is low, contact your supervisor for instructions. Sometimes you may swap the power supply with an identical one from another game.

5-3 GAME REPEATEDLY BLOWS FUSES

Fuses are protective devices that are designed to blow when there is a problem in the system which will cause further damage to circuits or cause a fire.

There are many possible causes for fuses blowing. A faulty power supply or monitor is the most common. Shorted wires on the coin door or control panel are also a possibility. Because of the wide range of possible failures, you should always contact your

supervisor for directions.

5-4 GAME DISPLAYS AN "ERROR MESSAGE" ON THE SCREEN

Check all fuses with a meter (see section 3-1).

Re-seat I.C.s (see section 3-2).

Check for burned connectors (see section 3-3).

Check for +5 VDC (see section 3-6).

If all the above are ok, contact your supervisor. Sometimes power supplies or boards may be exchanged with other games that have identical parts.

5-5 PICTURE OK BUT WILL NOT ACCEPT CREDIT

If meter clicks or screen quickly flashes when tripped:

Re-seat I.C.s (see section 3-2).

Check for +5 VDC (see section 3-6).

Check for loose connectors.

Check for burned connectors (see section 3-3).

If meter DOES NOT click or screen does not flash:

Check coin door wiring. Look for wires broken off the coin switches. Look for wires pinched or broken by the coin door hinge.

5-6 BUTTON(S) (SWITCHES) DO NOT WORK

If only one button affected:

Check switch for broken wires.

Check connector for wires pulled out.

Check switch with ohm meter (see section 3-4).

Check switch with Volt meter (see section 2-2 "CONTROL PANEL" and section 2-3 "BASIC GAME ARCHITECTURE for instructions and an explanation).

Check the switches' wires going back to board visually

and check continuity with ohm meter (see section 3-16).

If more than one switch is affected:

Check "switch common" wire for breaks (see section 2-3 "BASIC GAME ARCHITECTURE"). Check all the way back to the board using ohm meter to check continuity (see section 2-16).

5-7 TESTING A DISC PLAYER

Read sections 3-7 and 3-8 before proceeding.

The most reliable method of testing a disc player is to try it in a known good game. Locate the model number on the player and find another game that has the same model disc player. Here is a list of some possibilities:

LDV1000

Dragons Lair, Space Ace, and Thayer's Quest will all interchange.

PR8210 (without ribbon cable jack on back panel, i.e. Mach 3)

Will test in a Cobra Command, Cliff Hanger, Goal to Goal, Mach 3.

PR8210A (with ribbon cable jack on back panel, i.e. Star Rider).

Will test in Cobra Command, Cliff Hanger, Goal to Goal, but NOT Mach 3.

LD1100

Cobra Command, Cliff Hanger, and Goal to Goal will all interchange.

An alternate method of testing is to completely remove the questionable player from the bad game and plug its Video output directly into the video cable of a Dragons Lair, Space Ace, or Thayer's Quest (you may need a cable adapter from Radio Shack to match the connectors). This will allow you to view the picture from the questionable player on the monitor. Turn on the power to the game whose monitor you are using and plug the disc player's power cord into a wall outlet. Press the play button on the player and wait 15 or 20 seconds for the player to spin up to speed. If it does not spin the disc or if the picture does not appear on the screen, the player is probably bad.

This is not a completely reliable method of testing because there are several failures that will only surface when the player is being controlled by the game's computer by way of its remote control. Testing the player in a known good game is the most reliable method of troubleshooting.

5-8 NO LIGHTS OR SCORE DISPLAY

Check all fuses with a meter (see section 3-1).

Check 115 VAC at line filter (see section 3-14).

5-9 HAS LIGHTS AND SCORE DISPLAY BUT WILL NOT START

See if all the necessary balls are in place.

Check all fuses with a meter (see section 3-1).

Re-seat all socketed I.C.s (see section 3-2).

Test the coin and start switches in the game's Self Test mode (see the game's operating manual for Self Test instructions).

Check wiring for breaks use meter to check continuity (see section 3-16).

5-10 FLIPPERS DO NOT WORK

Check all fuses with a meter. Some fuses may be under the playfield (see section 3-1).

Look for burned flipper coils (see section 3-10 and 3-11).

Check for broken wires on ALL flipper coils. A broken wire on one coil can sometimes affect other flipper coils.

5-11 FLIPPERS ARE WEAK

E.O.S. switch burned or out of adjustment (see section 3-10).

Possible open in the winding of the coil. Use meter to measure voltage on ALL three terminals of the coil while manually holding the flipper in the up position. If the coil is good, all three terminals will have the same voltage on them. If it is bad, one or two of the terminals will have a grossly different measurement. Set your Analog meter on the 100 volt DC scale and place the black probe on the grounding braid that runs through the cabinet. Use the red probe to probe the terminals. If you are using a Digital meter, set the range switch on 200 Volts DC.

5-8 NO LIGHTS OR SCORE DISPLAY

Problem	If...	Check Points
No lights or score display		<p>Check all fuses with a DMM (<i>see Section 3-1</i>).</p> <p>Make sure slam switch on coin door is not stuck closed or shorted.</p> <p>Check 115 volts AC at the line filter (<i>see Section 3-14</i>).</p>

5-12 COIL(S) NOT WORKING

Check All fuses with a meter (see section 3-1).
Some fuses may be located under the playfield.

Examine all the coils inside the game. If you find a burned coil that is not a flipper coil, the logic board will have damage also. Notify your supervisor. Do not attempt to repair the board. You may replace the coil according to the instructions outlined in section 3-11, but you must leave the single wire disconnected from its terminal until the logic board is repaired. Do not leave the two wires that are both connected to the same terminal disconnected. This is the + solenoid bus.

Check the + solenoid bus wires that are soldered to each coil's terminal which has the banded side of the diode. You must check this on ALL the coils. If one of the wires is broken, every coil which follows that connection will be affected.

5-13 ONE OR MORE SWITCHES WILL NOT WORK OR GIVES AN INCORRECT RESPONSE
(i.e. pressing credit button caused tilt)

Use Self Test function described in game's manual to test all switches. If only one switch does not work, check for a broken wire on one of its terminals. If several switches act improperly during self test (i.e. pressing one switch causes several switches to register as being pressed), the logic board is probably at fault.

SECTION 6 INSTALLING CONVERSION KITS

ONLY PERSONS DETERMINED TO BE QUALIFIED BY THEIR SUPERVISOR MAY
INSTALL A CONVERSION KIT. STORE EMPLOYEES ARE NOT TO ATTEMPT
CONVERSIONS WITHOUT THEIR DISTRICT AND REGIONAL MANAGERS
APPROVAL!

There are two basic types of conversion kits; Generic and Dedicated. A generic kit is one that can be installed in many different games and requires complete, or almost complete, rewiring of the game. Dedicated conversion kits are designed to fit only one specific game or group of games. These dedicated kits often require only simple changes of the control panel, some I.C.s, and the cabinet graphics.

This section of the manual will cover only generic conversion kits. Most dedicated kits come with simple and complete installation instructions, therefore, no further explanation is needed.

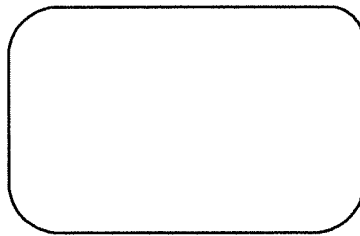
- 6-1 Selecting a Game
- 6-2 Cabinet Changes
- 6-3 The Control Panel
- 6-4 Cabinet and Control Panel Wiring
- 6-5 In Case of Difficulty
- 6-6 Tools and Supplies
- 6-7 The JAMMA System

6-1 SELECTING A GAME

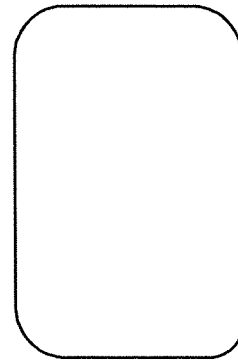
Nickels and Dimes Inc. policy is to achieve the highest standard of excellence when converting a game. The finished product should look and play as close to a factory made game as possible. Remember that you are in fact *building a new game*. A trashy looking conversion will not earn well and is an embarrassment to the company.

There are several things to consider when making a decision about which game to convert:

1. Is the kit designed for a horizontally or a vertically mounted monitor?
Sometimes the existing monitor can be turned the other direction.



HORIZONTAL



VERTICAL

Figure 1-A Monitor Orientation

- 2 Will the control panel be adequate? For example:
 - Will the pre-existing holes be too difficult to work around? (Most of these obstacles can be overcome by using a piece of properly sized Plexiglass to cover the panel.)
 - How thick is the control panel, and will the buttons be too short for it?
 - Will the size, shape, and positioning allow for the player's comfort (i.e. too crowded or buttons too hard to reach)?
 - Will the overlay decal supplied with the kit fit properly on the panel?

A lot can be done with a control panel if you are thoughtful and patient.

3. Does the cabinet style interfere with the game theme? (i.e. you probably would not put a karate game into a sit-down game cabinet.)

8-2 CABINET CHANGES

PAINTING

If your game has graphics on the side or the front of the cabinet, they must either be painted over, or covered with contact paper. Games with high-gloss graphics (most Atari games) will have to be covered with contact paper because paint will not adhere very well unless the cabinet is thoroughly sanded before painting. Here are some painting guidelines:

1. Mask off all surfaces that are not to be painted. Use masking tape and cardboard to do this. Remove all T-molding from the edges of the cabinet. Remove the coin door and cash box door assemblies if you are painting the front of the game.
2. Do not paint in areas where there is carpet, or where ventilation is poor.
3. Use oil base paint. Latex, and some enamel paints will peel and scratch easily. Oil base Porch and Patio paint covers very well with one coat and is extremely durable -- it comes in five or six colors and is available at most K-Mart stores.
4. Sand all surfaces to be painted (if necessary).
5. Use a disposable foam paint roller to apply the paint. Using a bristle brush may leave streaks.
6. Do quality work. Do not let the paint drip or run.

SIDE DECALS

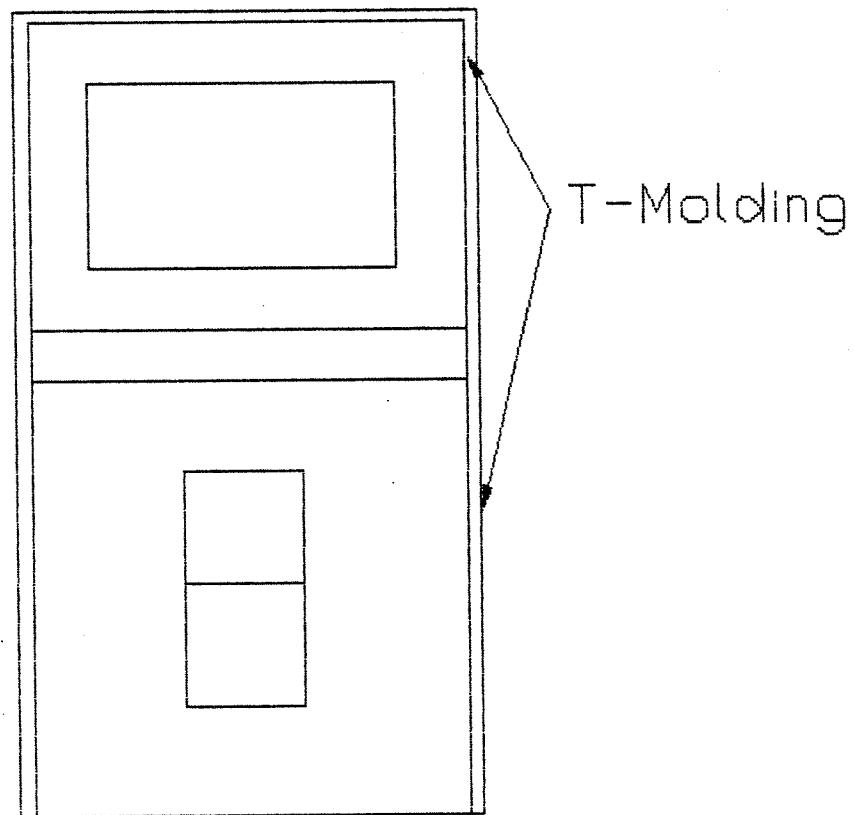
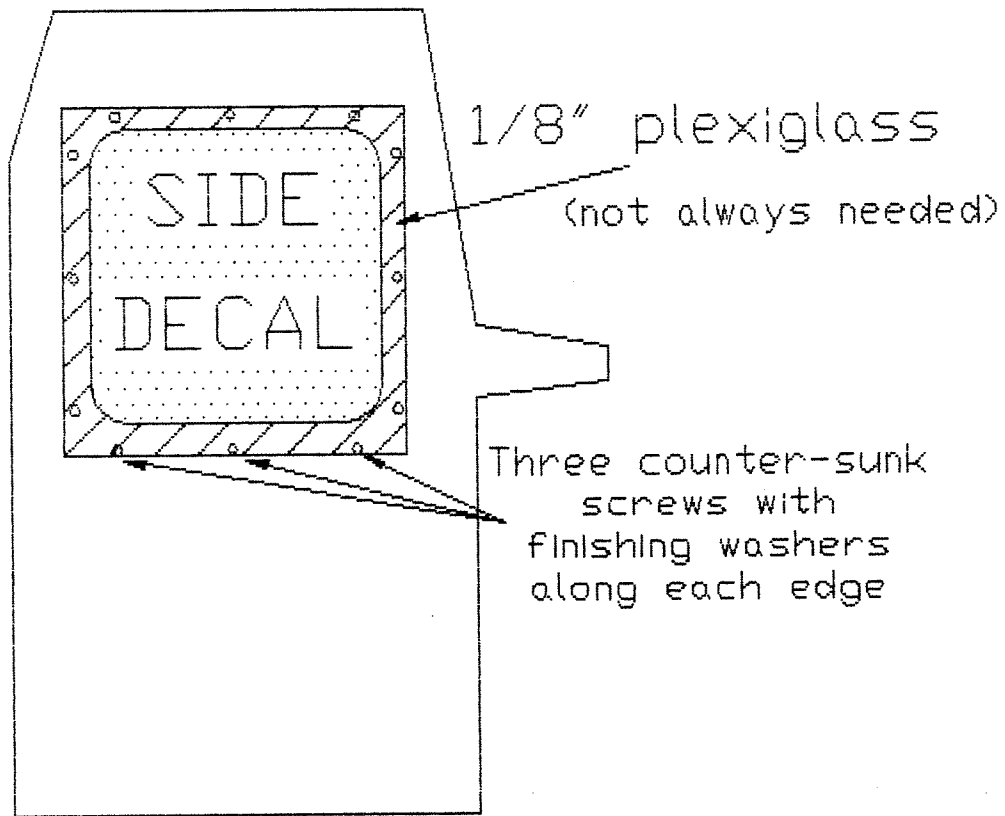
If the game being converted has side or front decals, they must be removed or covered. Many games have solid color or wood grain contact paper on the sides. In these cases, you can usually apply the new decals directly to the contact paper. Often times the picture on the side of the cabinet is painted on and must be covered with new paint or contact paper.

Removal of old decals can be accomplished by using a hair dryer. The hot air will loosen the adhesive, allowing you to easily peel the decal off. Any adhesive residue can be cleaned off with acetone and a soft dry cloth. **DO NOT USE ACETONE ON SURFACES PAINTED WITH FLAT PAINT.** "Klean - Klean" and "Goof - Off" are two commercially available products that make removal of decal glue easy. Do not use paint remover.

To apply the new decal or contact paper:

1. Spray area of cabinet where side panel decals are to be applied with glass cleaner. This will allow you to move the decal without it sticking.
2. If you are applying contact paper over the entire side of the cabinet, remove the "T-molding" from the edge of the cabinet.
3. Remove protective backing from decal.
4. Position decal using a ruler and T-square. Two persons may be required for this to obtain a smooth and bubble free application.
5. Beginning from the center of the decal, slowly and evenly press out excess glass cleaner with a soft squeegee, until you achieve a smooth finish.
6. Fold the edge of the decal or contact paper over the edge of the cabinet and trim to fit your cabinet.
7. Re-install the T-molding using wood glue where needed.
8. Attach a piece of 1/8" plexiglass or plastic over the decal. Use three counter-sunk finishing screws and finishing washers upon each edge of the plexiglass. (See figure 2A)

When applying large decals, it is helpful to lay the game on its side. Two persons are usually required when working with large decals.



MARQUEE

The acrylic (or plexiglass) header marquee must be cut to fit your new game. DO NOT REMOVE THE PROTECTIVE MASK UNTIL YOU HAVE FINISHED CUTTING.

Carefully mark the cutting lines on the new marquee by placing the old one directly on top of it. Be careful not to cut letters or pictures off the new marquee. Once it is cut, you cannot undo what you have done, so plan and measure carefully.

Be sure to protect painted side of plexiglass from any surface which may scratch or mar its finish.

An acrylic sheet up to 3/16" thick may be cut by a method similar to that used for cutting window glass. Use a Plexiglass scribing knife or a knife with a sharp point to "score" the sheet. Hold the straight edge firmly in place and use the scribe to repeatedly score the plexiglass. Do not remove the protective masking. Make the cuts carefully using a firm, even pressure. For best results make each stroke cleanly off the edge of the sheet.

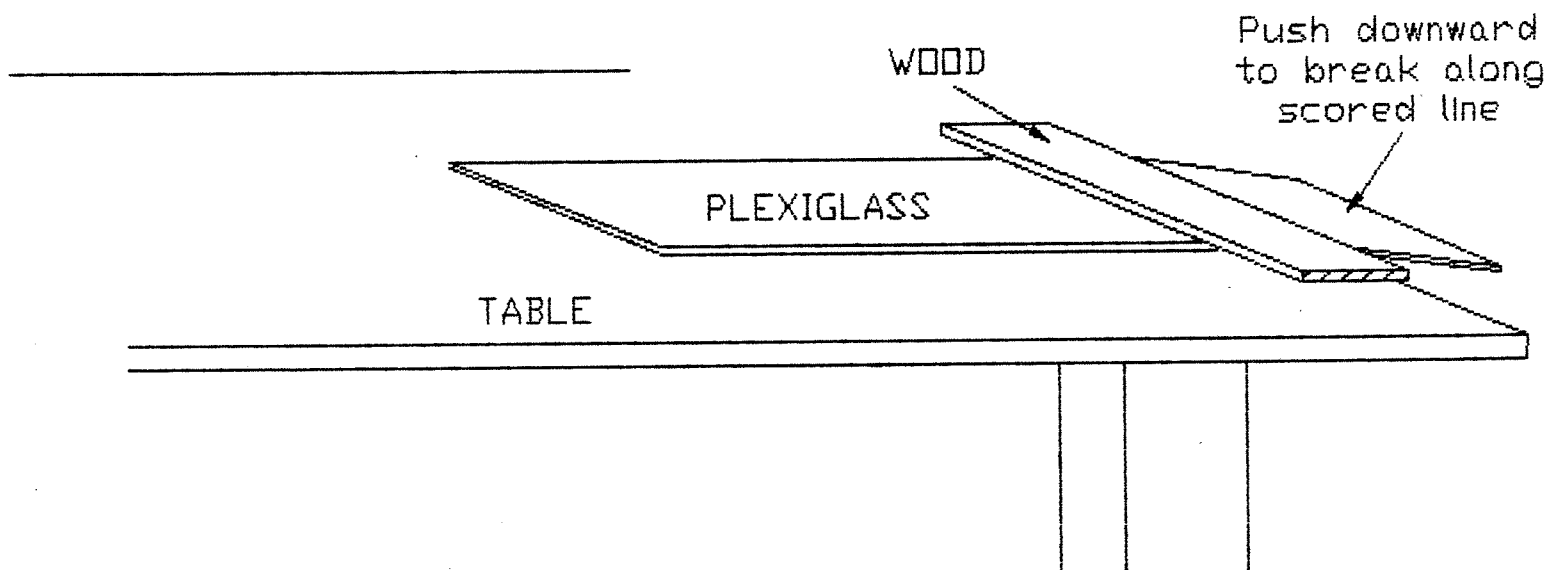
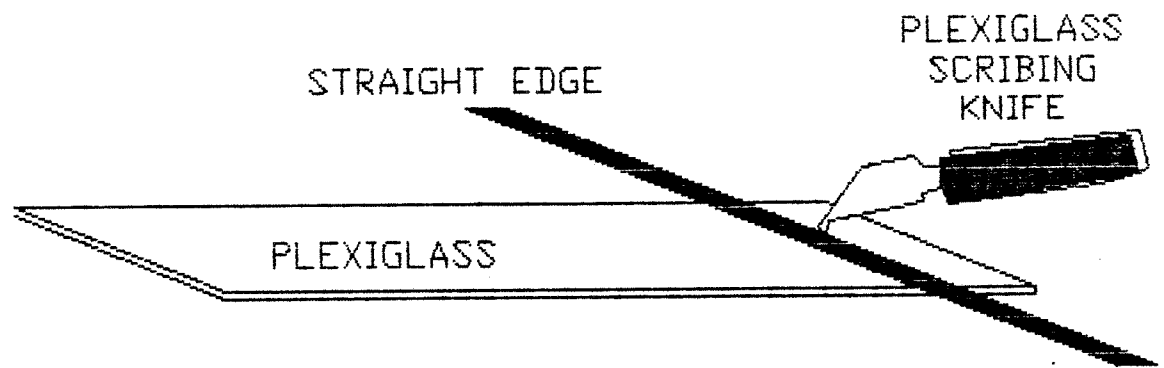
Clamp the plexiglass sheet or hold it rigidly under a straight edge such as a board, with the scribe mark hanging just over the edge of a table. Protect your hands with a cloth, and apply a sharp downward pressure to the other side of the sheet. If you have scored it deep enough, the sheet will break along the scoring line.

Sand or file the edges and smooth any sharp corners.

If the scoring is too close to an edge it will be difficult to obtain a good clean break. Placing the edge between a door and door frame can sometimes provide enough clamping and leverage to overcome this problem.

CUTTING PLEXIGLASS

Fig. 2b



6-3 THE CONTROL PANEL

Plexiglass must be cut to cover the new decal which will be applied to the control panel (USE 3/16" THICK PLEXIGLASS). There two reasons for this Plexiglass:

- It provides protection for the new decal and prevents the small labels that are provided with some kits (*i.e.*: *Start, Fire, Jump, etc.*) from peeling off.
- It covers all unwanted holes in the control panel that are left from the old game.

DRILLING AND HOLE CUTTING

Remove all wiring, switches, and buttons from the old control panel.

Cut the Plexiglass to the proper size and clamp it on top of the control panel (be careful not to break it). Using a ruler and T-Square (or carpenter's square), carefully mark the positions of the new holes on the protective masking. Placing a bright light under the control panel will help you see where the control panel's existing holes are so you can work around them.



Wait until you have drilled all holes in the control panel before you remove the old decal.

With a 3/8" drill bit made for Plexiglass, drill holes wherever you have marked them. **Do not drill into the metal control panel, but do let the tip of the drill bit leave a mark in the metal so that the holes will line up properly.** Make sure that you have drilled holes for the joystick mounting bolts and for several bolts that will be used to fasten the corners and middle of the Plexiglass to the control panel (*see Figure 3-A*).

Do not drill holes too close to the edge of the Plexiglass or it will break!

Remove the Plexiglass and finish drilling the holes all the way through it. Use a 13/16" hole saw to drill the large holes for the buttons and the joystick center using the pilot holes you have already drilled. Place a piece of scrap wood under the Plexiglass to aid drilling and prevent breakage while drilling. Use a Plexiglass drill bit that is larger than the heads of the joystick mounting bolts to drill the holes larger at the places where the mounting bolts attach. The reason for this is that the mounting bolts should attach the joystick to the metal control panel - not to the Plexiglass. This will reduce the chances of the bolts cracking the Plexiglass.

Using a regular 3/8" drill bit (not a Plexiglass bit), drill the holes completely through the control panel at the places where the large holes are to be made for the buttons and joystick handles. With a 1 3/16" "GREENLEE" chassis punch, cut the large holes by turning the bolt head on the

MONITOR PLEXIGLASS

Although most kits come with a cardboard frame for the monitor, some kits provide a new piece of Plexiglass to frame the monitor. It is desirable to use this Plexiglass whenever possible. These pieces usually have artwork silk-screened on them and add a great deal to the total appearance of the game. Cut this Plexiglass (or acrylic) in the same way as you cut the marquee.

If the kit does not contain a monitor Plexiglass, or the one provided cannot be cut to a useful size, you may be able to re-use the existing one. If the old monitor's shield is glass, and the artwork does not complement the new game, the paint should be removed. You can scrape the paint from it with a single-edged razor blade, then use paint remover to clean to a clear finish. After the old paint is completely removed you can mask off the center area (the viewing area), with cardboard and tape, then paint a frame around it. Do this to the inside surface of the glass.

If the old monitor shield is Plexiglass, do not attempt to remove artwork from it, as paint removal from Plexiglass or acrylic material usually results in a cloudy haze. Instead, use a new Plexiglass sheet cut to the correct size as previously described in the marquee section.

6-4 CABINET AND CONTROL PANEL WIRING

SAFETY GROUND

All games **MUST** have a safety ground wire connected to every metal assembly in the game (all dead metal). This wire must be at least #16 gauge or thicker. Many games already have a thick braided or solid metal (with yellow insulation) wire serving this purpose. The wire must connect to the following places:

1. The center (ground) terminal of the line filter.
2. The metal mounting bracket of all transformers.
3. The FG (frame ground) terminal of the power supply.
4. The monitor frame.
5. The coin door and cash box door.
6. The control panel.
7. Speaker frame and grill.
8. All other metal that a person could touch.
9. The green wire of the power cord.



This wire may not be routed through connectors.

GETTING STARTED

Important note: JAMMA cabinets (see Section 6-7 for explanation) should not require wiring harness replacement if you are installing a JAMMA kit.

Remove all the existing wiring from the cabinet **EXCEPT** for the following:

- Primary wiring: line cord, line filter, line fuse, isolation transformer, power switch and wiring, marquee light, power wiring to the monitor, interlock switches, and the safety grounding wire that connects to all metal objects in the game.
- Coin door wiring: coin switch wiring, coin entry lamp wiring, and the in-line connector that connects the coin door to the rest of the cabinet wiring. You may however, remove all wires leading up to the coin door connector.
- Speaker wires.

All other wires should be removed from the cabinet because they will not be used (there are exceptions to this).

Remove all boards and power supplies (unless the game already has a switching power supply that is rated at the proper amperage). Disconnect all fans and completely remove their wiring.

Separate the wires in the new harness into bundles that connect to the different assemblies of the game.

- Control Panel
- Monitor
- Coin Door
- Speakers
- Power Supply
- Coin Meter

Locate an area in the cabinet where the logic boards can be mounted safely and securely. This place should not be near the primary wiring or the transformer. Transformers get hot, and their magnetic fields may cause interference with the logic boards. Make sure that all the wires in the new harness will be able to reach their destination with the boards mounted in your chosen spot.

Use all the hardware supplied with the kit to mount all four corners of the boards to the cabinet. Be careful not to damage the boards with your tools while doing this!

A well thought-out plan is necessary before starting the wiring of the game. All wiring is to be done in neat and orderly bundles. All turns and angles are to be at 90 degrees. The harness should be routed through the cabinet neatly and must have a professional appearance. Wires may not be hung across one side of the cabinet to the other. Wires should be cut to the proper length as they are installed.

ISOLATION TRANSFORMER AND POWER SUPPLY

SAFETY REQUIREMENTS

The primary wiring must meet National Electrical Safety Standards! Some video games are already wired according to these safety codes, so it is important that you not tamper with these 115 volt AC wires and components unless absolutely necessary. Doing so may result in a possibly lethal shock hazard for you and your customers!

All games MUST have a safety ground wire connected to every metal assembly in the game (all dead metal). This wire must be at least #16 gauge or thicker. Many games already have a thick braided or solid metal (with yellow insulation) wire serving this purpose.



SAFETY GROUND CONNECTION

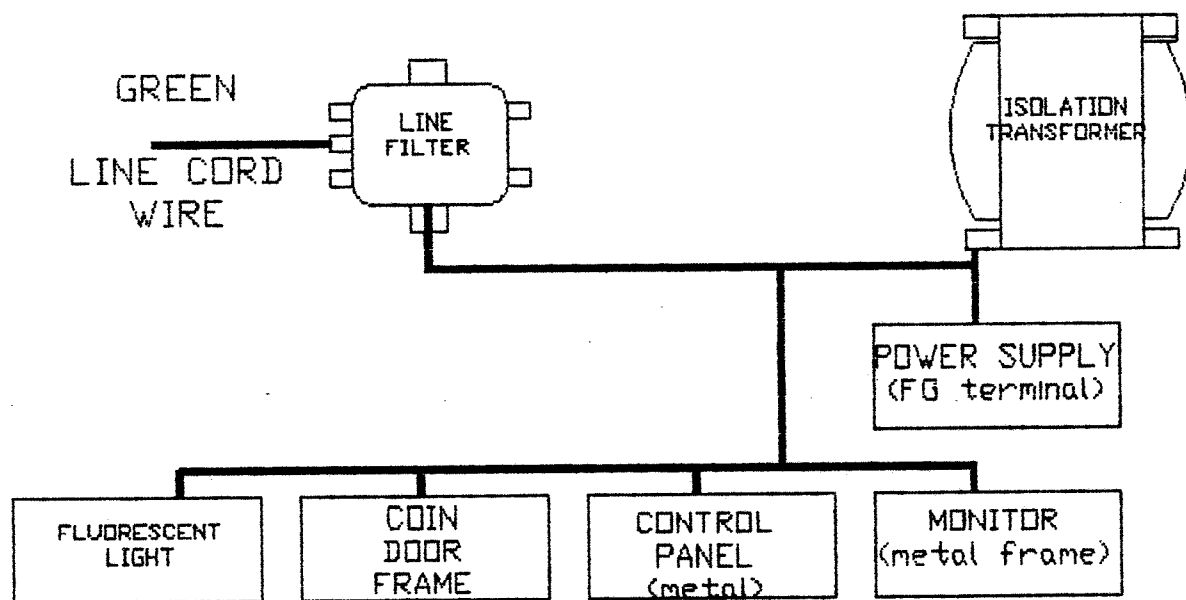
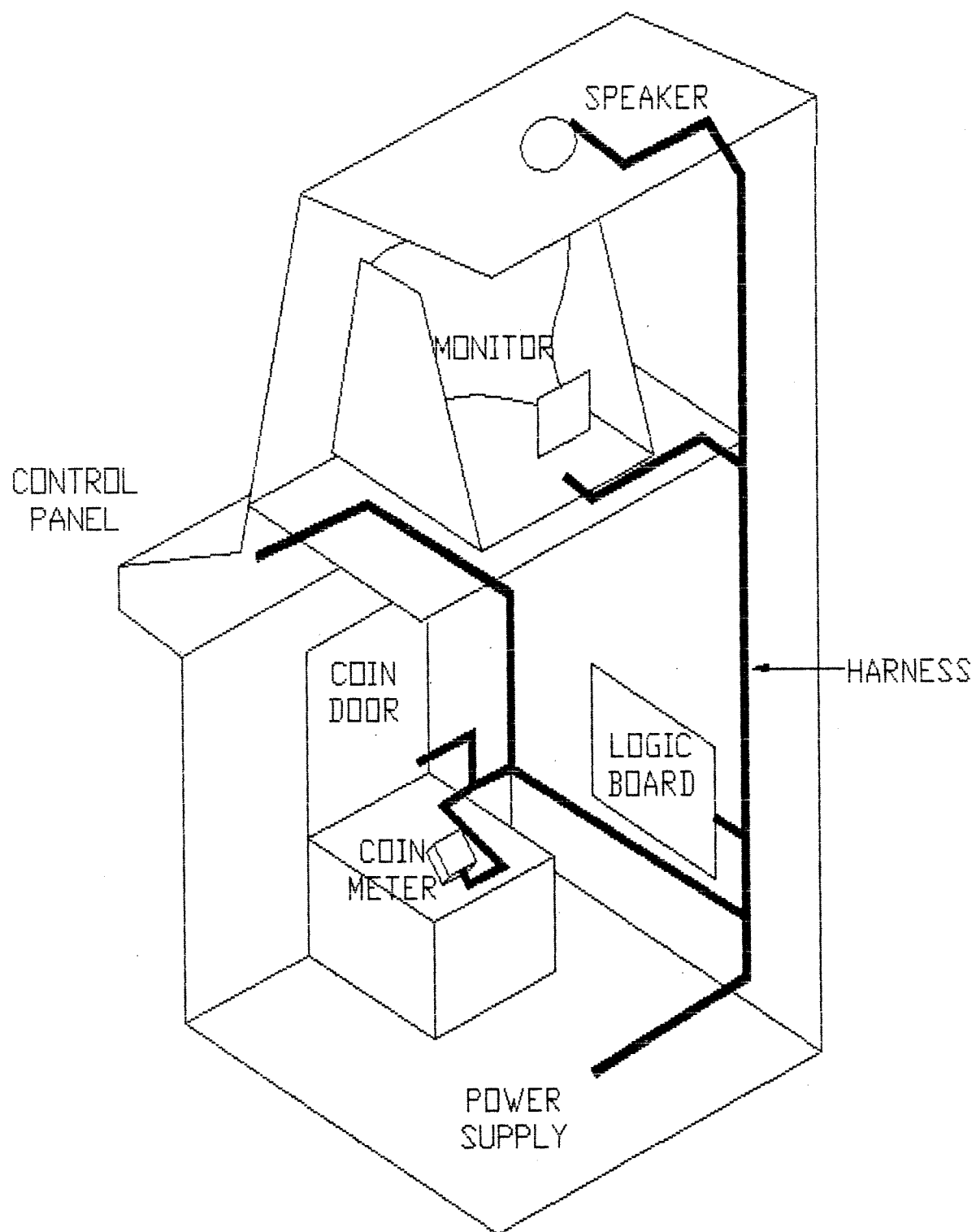


Fig. 3b



SUGGESTED HARNESS ROUTING

If the kit requires -5 volts, connect that wire to the power supply in the same manner. **DO NOT CONFUSE +5 VOLTS WITH -5 VOLTS!**

Locate all the +5 volt wires and connect them to the +5 volt terminal of the power supply.

Double check all the wiring that you have done. If you are certain that all is well, use your DMM to check the voltages at the logic board edge connector **WITH THE LOGIC BOARDS UNPLUGGED!** If you have mistakenly mis-wired something, now is the time to find out - not after the boards are destroyed!

The fluorescent light must be wired to the primary (input) side of the transformer - not to the output side.

MONITOR WIRING

Locate the wires going to the monitor. Their names should be:

- Video Red
- Video Green
- Video Blue
- Video Ground (ground or common)
- Sync (Composite Sync, CSYNC)

Note: the monitor's 115 volt AC connections were covered in "ISOLATION TRANSFORMER AND POWER SUPPLY."

Sync Connections

There are four ways that sync are usually wired. Most manufacturers use " *Negative Composite Sync.*" *Composite sync* is a mixture of negative Horizontal and Vertical Sync. Sometimes " *Positive Composite Sync*" is used - but not often. Other times the two sync signals are run separately to the monitor, this is called " *Separate Sync*" and can be either Positive or Negative.

To determine which type of sync your kit is using, you must check the installation manual. If the manual does not state which one is used, you may assume that Negative Composite Sync is being used. If you are incorrect, or if you wire the sync wrong, the picture will roll vertically, and possibly tear horizontally. In most cases, wiring the sync lines incorrectly will cause no damage.

Two Molex connectors are used for Neg. Sync: a six pin and a three pin connector. Positive sync requires only one six pin connector. Refer to the diagrams for the pin configurations of different sync types.

Often times, the picture will be a mirror image or will be upside-down. When this happens, it is necessary to re-wire the monitor's yoke connector. If this happens, contact your service center for instructions. **NEVER ROTATE THE YOKE!**

Make sure the safety ground wire is connected to the metal frame (chassis) of the monitor.

MONITOR CONNECTIONS

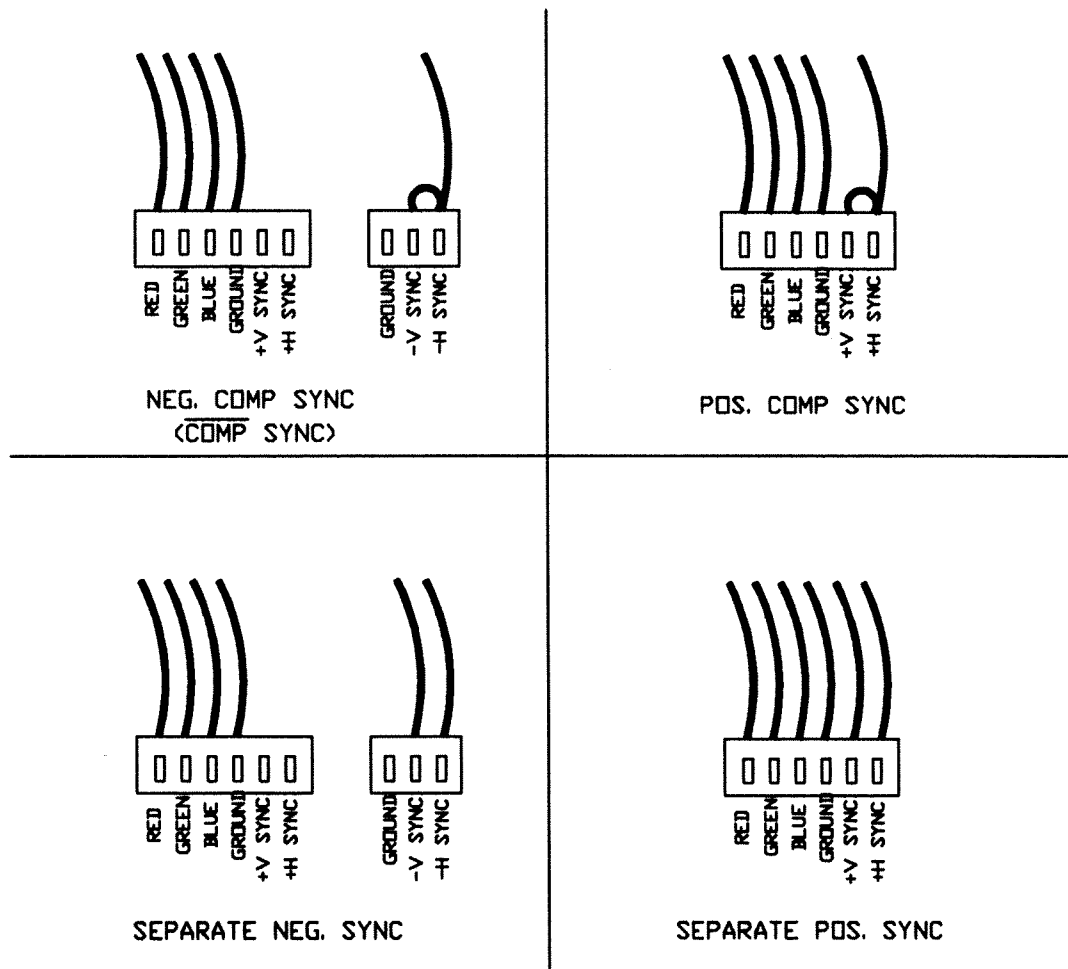


Figure 4-D Monitor Video and Sync Connections

COIN DOOR WIRING

Most kits have two separate coin switch wires: "*Coin One*" and "*Coin Two*."

- The "*Coin One*" wire connects to the N.O. (*Normally Open*) terminal of the left coin switch.
- The "*Coin Two*" wire connects to the N.O. (*Normally Open*) terminal of the right coin switch.
- Connect a common (*ground*) wire to the C (*Common*) terminal of each coin switch.

Some kits will have a third, and sometimes a fourth coin wire. These will connect to the N.O. terminal of the third and fourth coin switches.

To connect the coin entry lamps, run a separate ground and +5 volt wire from the power supply to the coin door connector. Install pins and insert them into the connector at the socket corresponding to the coin lamp wires.

COIN METER CONNECTION

<p>Coin meter connection must be done by the district manager. Store personnel are not allowed to wire the coin meter.</p>

SPEAKER WIRING

Speaker wiring is usually very simple. Connect one of the speaker wires to Speaker + (or Audio +) and connect the other wire to Speaker - (or Audio -, Speaker Gnd, Speaker Common, etc.). Never connect more than two speakers in parallel without first consulting with your service center.

Occasionally the kit will supply you with an external volume control (pot or potentiometer). This is usually pre-wired and just needs to be mounted with screws in a convenient location. Remember to connect the green safety ground to the metal bracket that the volume control is attached to.

CONTROL PANEL WIRING

YOU MUST INSTALL A CONNECTOR BETWEEN THE CONTROL PANEL AND THE GAME HARNESS! NEVER CONNECT THE WIRES FROM THE HARNESS DIRECTLY TO THE SWITCHES!

Before you start, examine several control panels from different game manufacturers to learn the proper way to route wires and make connections.

Use "push on" 3/16" wide insulated crimp-on connectors that are made for #16 through #22 gauge wire. These connectors fit the terminals of most leaf switches. (See figure 3A)

Hopefully the wiring harness has enough length to the control panel that you can cut the harness a few inches from the control panel and still have enough wire to connect the switches and controls. If there is not enough wire supplied with the kit, you must provide extra wire yourself. Use the same colors that the kit uses. Many times you will find the wires you need in the harness you took out of the old game.

At this point, all the buttons, joysticks, and other controls should be mounted in a neat and orderly fashion. Locate the switch common wire (switch ground, usually black) and make a "Daisy Chain" (Buss) that will loop from switch to switch using crimp on connectors (push on type). Make sure that there is enough length between switches. A good rule of thumb is to make the length of each loop twice the distance between the switch connections. This will give you enough extra wire to bundle the wires neatly and safely without causing tension or binding on the switches. Use wise planning as you do this! One end of the daisy chain must have a wire that will be inserted into the connector that attaches to the rest of the game harness. Remember that each of the switches on the panel will have one of its terminals connected to the switch common.

Identify which wires belong to which switches by looking at the wiring diagram and crimp push on type connectors onto one end of each wire. If your panel has two fire buttons (one for right-handed players -- the other for left-handed players), they will both connect to the same switch input wire using the "Daisy Chain" method. This will cause them to be wired parallel.

After making sure your wires are running in the correct direction to connect with the rest of the game's harness, attach each of the connectors to the unused terminal of its corresponding switch. Make sure your connections are very tight and that the wires cannot be pulled out of the connectors easily. Route your wires neatly using 90 degree turns and straight lines.

Once you have attached the correct wires to all the switches, bundle them in neat lines using wire ties (tie-wraps).

Put one every three inches or so. Cut the ends of the wires to the same length and crimp an Amp or Molex pin on each wire (depending on what type of connector you are using for the control panel). Use adhesive tie-down blocks to attach the wire bundles to the underside of the panel with tie-wraps. There are other types of wire fasteners available at most electronic stores that also work well. If your panel is made of wood, you should use screw down cable fasteners.

Insert each pin of the control panel harness into the new connector in a logical order. Crimp pins onto the game side of the control panel wires and insert them into the other half of the new connector matching them color-for-color with the connector on the control panel.

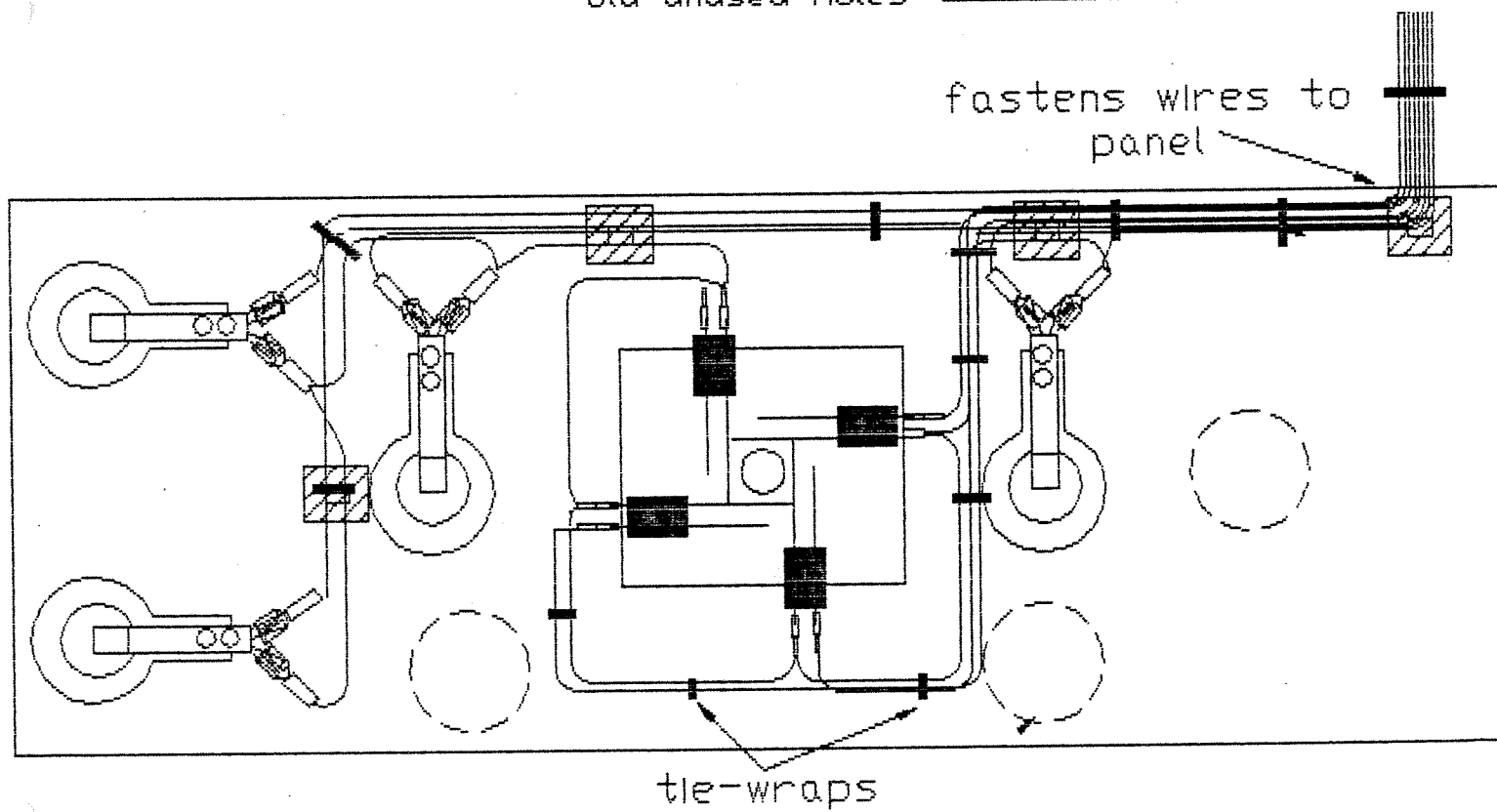
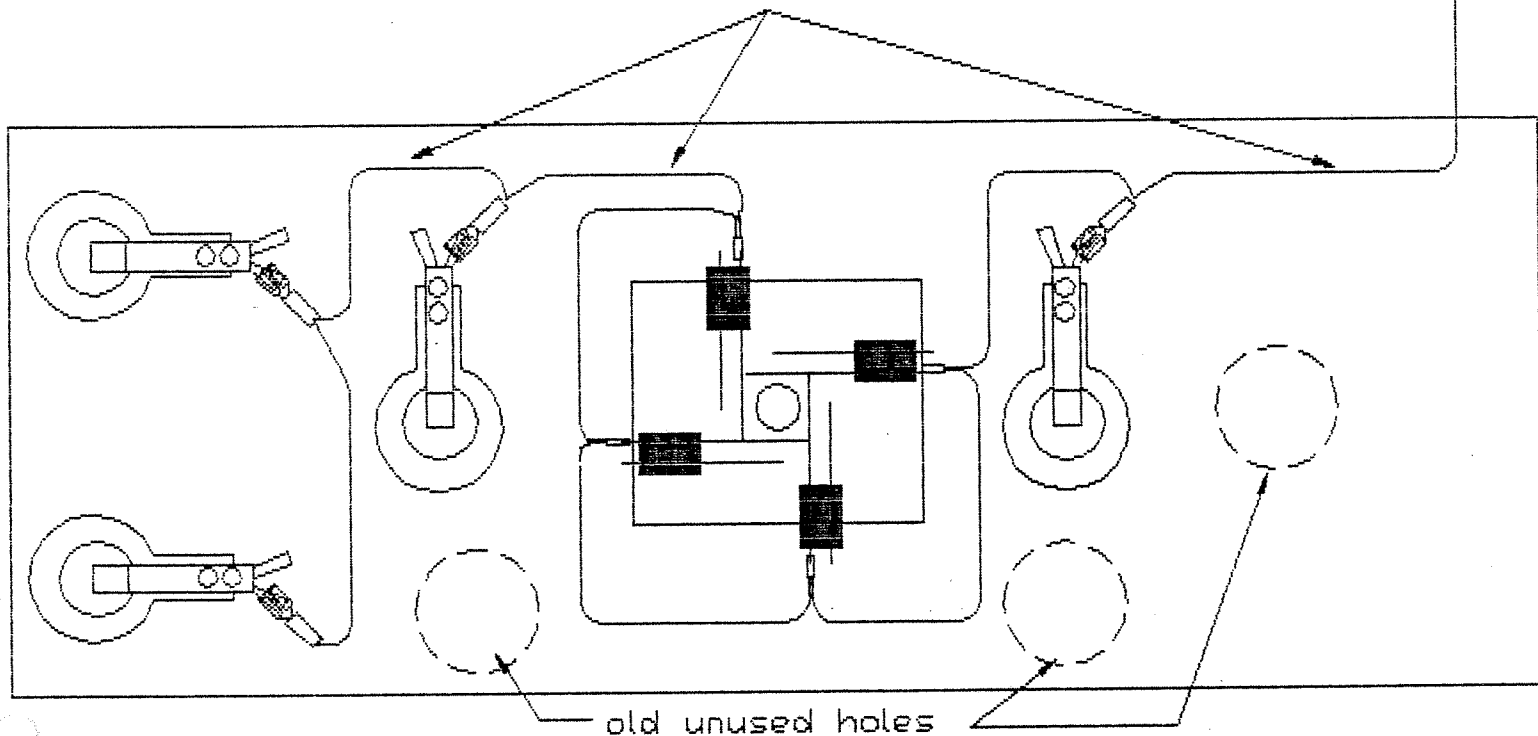
Check all your work carefully. Remember that touching switch input wires together can destroy I.C.s on the logic board.

Make sure that pulling on the wires will not cause the switches to be pulled. The tie-down blocks should prevent this.

CONTROL PANEL WIRING

Fig. 3f

Switch common wire in a "Daisy Chain" pattern



BEFORE YOU TURN IT ON

Have someone else check each connection along with you. After everything checks out fine, re-check your voltages with the boards unplugged.

- Did you use an isolation transformer for the monitor and is it wired correctly?
- Are all 115 volt AC connections made with the proper connectors and with the correct gauge wire?
- Did you connect ALL metal assemblies to the safety ground? (Monitor frame, switching power supply frame, FG terminal of power supply, control panel, coin door, line filter, speaker frame, etc.)
- Are all low voltage connections properly insulated with heat shrink tubing?
- Are the boards mounted safely and securely with all supplied hardware?
- Does the power cord have all three prongs intact?
- Is the diode correctly installed across meter?

POWER UP

Check the installation manual to find out which side of the connector goes to the component side and which goes to the solder side of the logic board and plug the connector onto the logic board. **MAKE SURE YOU PLUG IT IN THE CORRECT DIRECTION!**

If you are not sure which side is correct, **CALL YOUR SERVICE CENTER.** Do not experiment!

Get ready with your DMM to check the +5 volts on the logic board (*see Section 3-6*). Have someone else turn the power on while you hold the meter probes. If the meter reads above +5.1 volts, **TURN THE POWER OFF IMMEDIATELY!** Use the voltage adjustment pot on the power supply to adjust the voltage to **EXACTLY +5.1 volts** on the logic board.

DRESS IT UP

After you are sure that all is well, place tie-wraps every 6 to 8 inches and use hold-down blocks at several places to secure the harness to the cabinet. Make its appearance something you will be proud of. Using a permanent marker, write the store number and the name of the person doing the conversion on the inside of the cabinet.

6-5 IN CASE OF DIFFICULTY

No Raster and No Video

- Check AC line cord.
- Check line fuse.
- Check monitor brightness.
- Check power switch and/or interlock switch.
- Check all connections on line filter and transformers.
- Check for proper orientation of edge connectors.

Raster visible but No Video

- Check all monitor connections.
- Check power supply voltage on logic board.
- Check for proper orientation of edge connectors.

No Video but game sounds can be heard

- Check monitor brightness.
- Check all monitor connections.

Incorrect colors

- Monitor needs degaussing.
- Check for proper wiring to monitor.
- Check monitor adjustment (contact service center).

Wavy picture

- Check monitor ground (video ground).
- Check Sync inputs to monitor.
- Check horizontal hold adjustment.

Vertical roll/Horizontal roll/Horizontal tear

- Check horizontal and/or vertical hold adjustments.
- Check for proper sync and common (ground) wiring.

No sound

- Check volume control adjustment.
- Check for +12 volts on edge connector of logic board.
- Check for -5 volts on edge connector (if new game uses this voltage).
- Check wiring to speaker.
- Check speaker with DMM (*see Section 3-24*).

Bad sound

- Check wiring to speaker for loose connections.
- Check sound with another speaker.
- Re-seat I.C.s.

Switch(es) don't work at all

- Check ground (common) connection to switches.
- Check wiring to switch.
- Check switch as per Section 3-4.

Switch operates the wrong feature

- Check wiring to each switch for proper orientation.
- Check wiring for shorts between switch inputs.

When coin switch is tripped, the meter pulses and the screen blanks out and/or game resets

- Have your DM verify that a diode has been installed correctly across meter.
- Check +5 volts.
- Re-seat I.C.s.

See Section 5 for additional troubleshooting information.

6-6 TOOLS AND SUPPLIES

Tools:

Plexiglass cutting knife
Straight edge
Plexiglass drill bits (1/4", 3/8", and 1/2")
Metal drill bits (1/4" and 3/8")
Hole saw (1 3/16 ")
Round "Greenlee" chassis punch (1 3/16")
Fine grit sandpaper
File
Jig saw (for cabinet work)
Clamps
Squeegee
Single edge razor blades
Wire cutter and stripper
Soldering pencil
Solder
Molex and Amp pin extraction tools
Molex (or Amp) crimping tool
Assorted hand tools

Electrical supplies:

Wire ties
Adhesive or screw mount cable fasteners
Molex (.093) and Amp (.790) pins and housings (male and female)
Molex trifurcon crimp-style terminals (for monitor) Molex
part #08-50-0189
Molex female housing for monitor (.156 hole centers) Molex
part #09-50-7201
Heat shrink tubing (assorted sizes)
In-line tap connectors (#18 - #14 wire gauge) for 115 VAC
Solderless insulated connectors:

Ring (eyelet) #18 - #14 gauge
Spade tongue with turned-up ends #14 - #18 gauge
Push-on 3/16" wide #16 - #22 gauge

White, black and green wire (#16 gauge) for 115 VAC connections
Isolation transformer
Switching power supply (proper ratings)

Misc:

Oil base paint
Foam paint applicator
Wood glue
"Klean-Klean" or "Goof-Off"
Vinyl contact paper

MOST OF THESE PARTS AND SUPPLIES ARE AVAILABLE FROM THE PARTS
DEPARTMENT.

6-7 THE JAMMA SYSTEM

JAMMA (Japanese Amusement Machine Manufacturers Association) is a standard edge connector wiring configuration that is often used throughout the video game industry. In a JAMMA harness, the power supply voltages, coin inputs, monitor outputs, control panel inputs, audio outputs, etc. are always in a standard location in the edge connector. Therefore, if a cabinet is wired with a JAMMA harness, any logic board with the JAMMA edge connector pin configuration may be plugged into that harness and the game will work. There are however, two important things to consider:

1. The power supply may need to be upgraded to a higher Amperage rating in order to accommodate a logic board that requires more current than the existing power supply can provide. To determine whether or not this will be necessary, simply look up the voltage and amperage requirements listed in the kit's manual. If these are less than, or equal to those printed on the power supply, you will not need to change the power supply. However, if the new board requires more current (amperage) than the cabinet's power supply is rated at, you must install a power supply with higher current ratings. Make sure you check the amperage ratings of the +5V, the -5V (if used), and the +12V. If you are not sure about a power supply or a logic board, contact your supervisor - do not risk damaging the components.

2. The control panel may require removal, installation, or relocation of joysticks, buttons, or other controls.

Identifying JAMMA Equipment

Logic boards usually have the word JAMMA printed on their component side, near the edge connector.

Wiring harnesses sometimes have the word JAMMA printed on the edge connector, but quite often they do not. There are two ways to find out if the harness is JAMMA. The easiest way is to see if the game's existing logic board has JAMMA printed on it. If it does not have JAMMA printed on it, you will have to compare the existing wiring harness to the JAMMA pin out provided in this section (or in the kit's manual). The wire locations must be **EXACTLY THE SAME** as those in the standard JAMMA configuration. Contact your supervisor or your service center for help if you are unable to determine whether or not it is JAMMA by either of these methods.

Power Supply Adjustment

Since different types of logic boards require different amounts of current, the voltage may need to be adjusted after installing a new (or different) JAMMA board. This must be done with a DIGITAL voltmeter, and the measurement must be taken on the logic board - not on the power supply. Refer to Section 3-6 of this manual for instructions in measuring +5 volts with a digital meter on a logic board.

JAMMA CONNECTOR

Solder Side

Parts Side

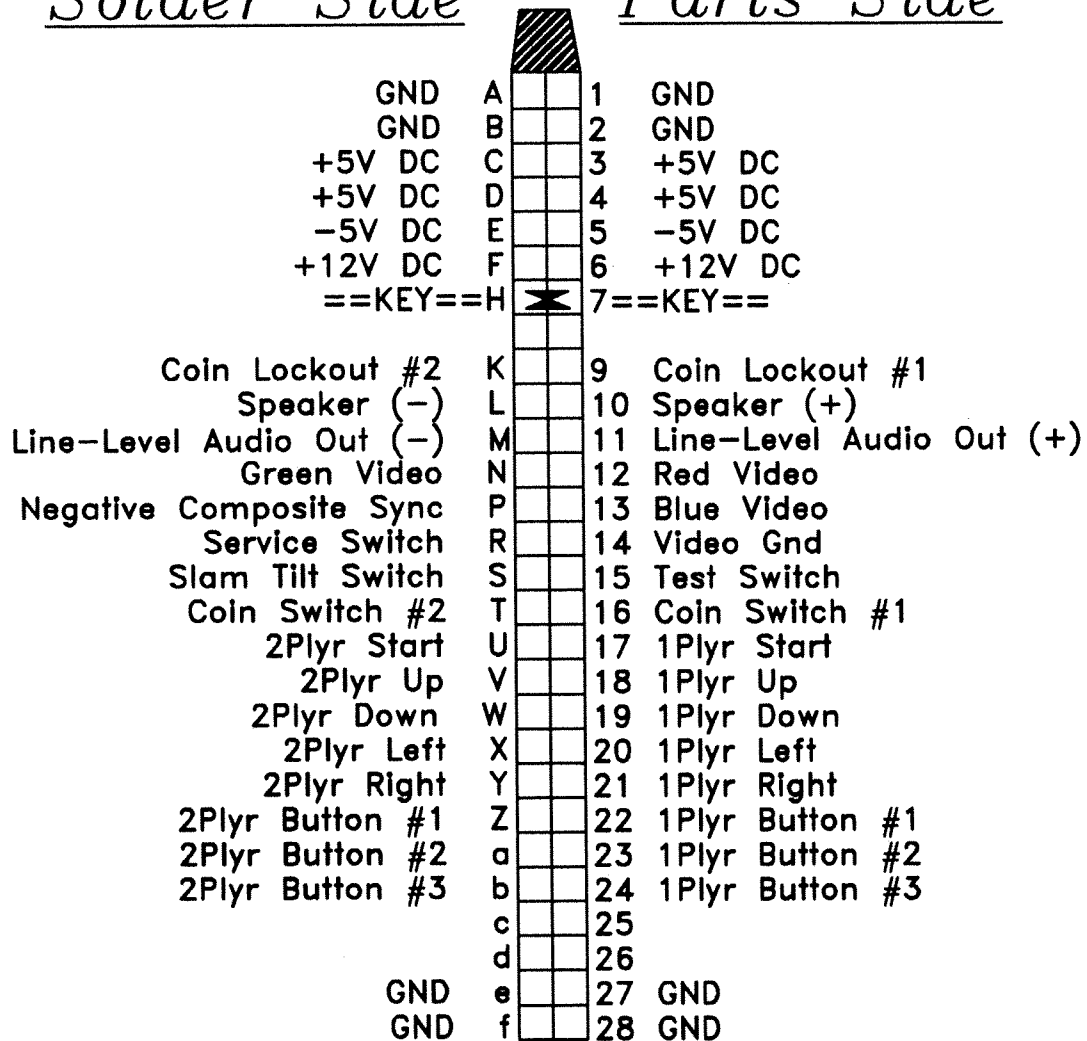


Figure 7-A JAMMA Connector Pin-Out

JAMMA (Japanese Amusement Machine Manufacturers Association) A set of standards by which many games are manufactured. Most importantly, these standards dictate the size and pin configuration of the logic board's main edge connector. Many logic boards which have a JAMMA edge connector can be plugged into other cabinets that have JAMMA wiring.

Key Pin (Keying Pin) In an edge connector or a plug, a pin that is used to block a space to prevent the connector from being plugged in backwards or offset.

Laser Disc A disc which resembles a CD that is used to store video and audio information. A laser disc is played in a Laser Disc Player. Some video games use laser discs to generate video images and audio.

Lamp Matrix A method of wiring and controlling a large number of lamps using a minimum of wires and components. In a lamp matrix, there is no common ground. Instead, there are columns and rows of lamps connected at intersections through isolation diodes. The computer turns a lamp on and off by feeding ground (-) pulses to the lamp's row connection, and feeding + voltage to the lamp's column connection. In a lamp matrix, the lamps are turned on and off at such a rapid rate, it appears that they are on constantly.

Laser Disc Player Laser Disc Players play a "laser disc." This laser disc is much like an audio CD. The video recorded on the disc is sent to the monitor where it is displayed. Sometimes the computer (logic board) generates its own picture that is mixed with the laser disc video.

LED (Light Emitting Diode) An electronic component which emits light (visible or invisible) when turned on by an electrical current. LEDs have an anode and a cathode (+ and - terminal) and must therefore be installed in the correct direction (polarity).

Limit Switch A switch that is activated when a mechanical assembly reaches a certain point or position (i.e. all the way to the right or to the left, or fully up or down).

Line Filter A device used to remove some of the 'noise' and small voltage fluctuations from the AC line that are present when air conditioning units, motors, power tools, and other devices are being used. It also helps keep noise being generated by the game off of the AC line. The line filter is usually wired between the power cord and the all of the game's circuitry.

Line Level Audio (+ and/or -) An audio (sound) signal which is not powerful enough to directly drive a speaker and must therefore be amplified by some type of audio amplifier circuit.

Load A device such as a logic board, resistor, lamp, etc., which uses current from the power supply. Some power supplies must have a certain amount of load connected to them in order to operate. In some cases, the game's logic board is not enough load for the power supply to work correctly. When this is a problem, a *load resistor* is usually installed to provide additional load.

Load Resistor A resistor that provides an additional load for the power supply to operate correctly. See *Load*. Typical load resistance is 5 Ω 50 Watts; sometimes more than one

resistor is used to achieve the correct value. Load resistors usually get hot and should be handled with caution to avoid burns.

Matrix See *Switch Matrix* or *Lamp Matrix*.

MDL Prefix for a slow-blow fuse.

Microfarad (μf) The unit of measure for the amount of capacitance of a capacitor.

MOLEX A manufacturers brand-name for certain types of connectors and connector pins (i.e. MOLEX connector pins).

NC (N.C.) 1. The abbreviation often used to identify the normally closed terminal of a switch. The NC terminal makes electrical contact with the Common terminal of the switch when the switch is in the open (not activated) position. When the switch is closed (pressed), the Common and NC terminals open (no longer make contact).
2. An abbreviation for No Connection.

Neck Board The small PCB plugged onto the neck of a CRT (picture tube).

Neutral Usually refers to the White or Brown wire in the AC power wiring.

NO (N.O.) The abbreviation often used to identify the normally open terminal of a switch. The NO terminal makes contact with the Common terminal when the switch is closed (activated).

Notch Sensor An infrared optical sensing device on a ticket dispenser, used to sense the notch in a string of tickets. See *Optic Switch*.

Ohm (Ω) Unit of measure used to express an amount of resistance in an electrical circuit. Example: 10 Ω , 1.2K Ω , 20M Ω . K=Kilohms (1,000 ohms), M=Megohms (1 Million ohms).

OEM Original Equipment Manufacturer. Usually refers to replacement parts supplied by the original manufacturer of the equipment.

Ohmmeter See *DMM*.

Open Circuit A circuit with no path for current to flow through, as in a switch that is not closed, or a wire that is broken.

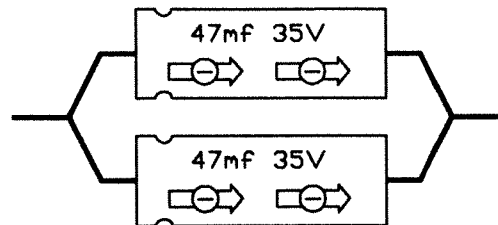
Optic Switch (Optointerrupter) An electronic device containing an infrared LED and a photo-transistor, used to optically sense a mechanical action such as a ticket notch passing through it, a steering wheel turning, a joystick movement, etc.

P1 A lamp and photocell pair located at the front of a Rowe BC-9, BC-25, or BC-35 bill acceptor.

P4 A lamp and photocell pair located at the rear of a Rowe BC-9, BC-25, or BC-35 bill acceptor.

P6 Flipper Lever (Anti-Cheat Lever) A moving lever (usually black) located at the back of a Rowe BC-9, BC-25, BC-35 bill acceptors (transports). This lever covers or uncovers a photocell as the bill passes through the unit.

Parallel To connect or wire two or more components or devices in a side-by-side configuration.



Two capacitors wired in Parallel

PCB (Printed Circuit Board, PC Board) An electronic circuit board which has electrical connections made between components with conductive strips called traces.

Polarity The direction in which a device or component is installed or wired. Positive (+), negative (-). See *Polarized*.

Polarized Having a positive (+) and a negative (-) direction. Ex: a battery is polarized and cannot be installed backwards without causing damage.

Polarizing Key See *Key Pin*.

Potentiometer (Pot) A resistor that has a moving contact (wiper) which is generally mounted on a rotating shaft. As the shaft is rotated, the resistance between the wiper (usually the middle terminal) and the outside terminals increases or decreases. A variable resistor. Potentiometer are manufactured in numerous ohm and wattage values. Ex: 5K Ω 1Watt.

PSI (Pounds Per Square Inch) A measure of pressure, usually expressing an amount of air or fluid pressure in a system.

RAM (Random Access Memory) An integrated circuit (I.C.) that stores computer information (data) temporarily.

Raster The illumination of a monitor's CRT without a picture. When the brightness or screen control is turned up too high on a monitor without video being applied, a raster will be seen (usually white - depending on the amount of brightness and the adjustment of other monitor controls).

Rectification The conversion of AC current to DC current. The most common use of a diode.

Rectifier See *Diode* and/or *Bridge Rectifier*.

Regulate To control or hold a voltage, air pressure, water pressure, current, etc. at a constant level.

Relay An electromechanical device containing a coil (electromagnet) and one or more switches. When an electrical current is applied to the coil, the switch(es) change position, either closing or opening their contacts (depending of the type of switch configuration inside the relay). There are many different types of relays with varying voltage and current requirements, switch configurations, and current handling capability of the switch contacts.

Resistance Opposition to current flow through an electrical circuit when voltage is applied. Usually expressed in ohms (Ω).

Resistor A device used to introduce resistance into an electronic circuit. Resistors are manufactured in a variety of values, wattages, sizes, and shapes. Resistors are rated in ohms (Ω) and watts (W). Values are usually printed on the resistor in a *Color Code* or in numerals. Never substitute a different ohm value or a different wattage resistor without contacting your service center for assistance.

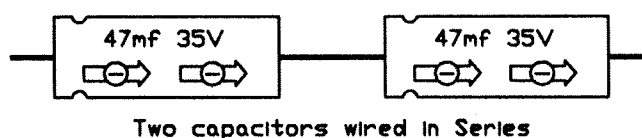
RGB (Red-Green-Blue) The three separate video color signals that are sent to the monitor's input from the computer's output. The computer generates these three separate color signals in addition to the *Sync* signal(s). These signals contain the picture information that is to be displayed on the monitor.

ROM (Read Only Memory) An integrated circuit (I.C.) which contains instructions and information for the computer. The information (data) stored in the ROM is permanent and cannot be erased.

Safety Ground See *Frame Ground*.

Schematic A diagram, using various symbols, which shows the electrical connections and components of a circuit.

Series To connect or wire two or more components or devices in an end-to-end configuration.



Short Circuit (Short) An abnormal low-resistance connection between two or more points of a circuit. The result is an abnormally high current flow which often damages the components. Ex: when the +5 volt and Ground wires touch each other.

Solenoid (Coil) A device made from wire, wound around a spool or core, which creates a magnetic field when a current is applied. Many solenoids have a diode, commonly known as a clamping or suppression diode, across the terminals. This diode suppresses voltage spikes which can damage electronic components.

Solid State Device Any device that can control current without moving parts, heated filaments, or vacuum gaps.

Solid State Flipper A pinball flipper which has no End of Stroke Switch and is controlled by solid state semiconductors on a printed circuit board (PCB).

Strain Gauge A device which increases or decreases in resistance when bent. Strain gauges are usually bonded to metal devices and provide a method of sensing when and how much the metal is bending.

Switch A mechanical or electrical device which opens or closes a circuit. Ex: leaf switch, enclosed microswitch, pressure switch.

Switch Matrix A method of wiring and monitoring a large number of switches using a minimum of wires and components. In a switch matrix, there is no common ground. Instead, there are columns and rows of switches connected at intersections through isolation diodes. The computer sends strobe pulses to each column one at a time, while monitoring the rows. If a switch is closed, the strobe pulse will appear at the corresponding row input to the computer.

Sync A signal, or pair of signals, generated by the computer and sent to the monitor along with the RGB and Video Ground, that synchronizes (locks-in) the monitor's and computer's timing in order to display the picture without rolling, tearing, or shaking. Without a good Sync signal, the picture will not be stable. There are several types of Sync:

Sync Type	No. of Wires	Description
$\overline{\text{CSYNC}}$ *CSYNC Neg. Composite Sync	One	Negative Composite Sync (the line above the word, or the asterisk in front of the word indicate that it is <i>Negative</i>). This one wire contains both the horizontal and the vertical sync information. This is the most common type of sync used in video games.
CSYNC Pos. Composite Sync.	One	Positive Composite Sync. This one wire contains both the horizontal and the vertical sync information.
$\overline{\text{Separate Sync}}$ *Separate Sync Neg. Separate Sync	Two	Negative Separate Sync (the line above the words, or the asterisk in front of the words indicate that it is <i>Negative</i>). One wire carries the horizontal sync signal and the other carries the vertical.
Separate Sync Pos. Separate Sync	Two	Positive Separate Sync. One wire carries the horizontal sync signal and the other carries the vertical sync signal.

Transformer An electrical device used to either step-down (decrease) or step-up (increase) the voltage. A transformer has an input (primary) and one or more outputs (secondary).

Transistor A solid-state electronic component with three connections, Base, Emitter, and Collector, which is commonly used as an electronic switch or amplification device. Transistors are manufactured in thousands of different types and case styles. A number is usually printed on the transistor (ex: 2N3904, MPS-A06, TIP102). This number identifies the transistor type. Never replace or substitute a transistor with a different number without first consulting your service center.

Voltage (V) Electron pressure in an electrical wire or circuit. Games use several AC and DC voltages, the most common being 115VAC, +5VDC, -5VDC, +12VDC.

Voltmeter See *DMM*.

Wire Nut A conical plastic twist-on cap used to connect the bare ends of two or more wires. Wire nuts come in several different sizes to accommodate various gauge wires.

X/Y Monitor A type of monitor which draws images on a CRT screen by rapidly moving the electron beam(s) in the shapes of the images being drawn, much like a pencil would be used to draw shapes on the inside face of CRT. An X/Y monitor is different from a Raster monitor.

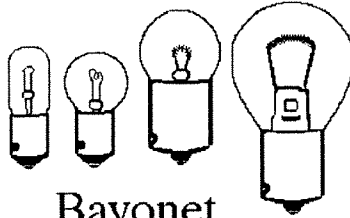
Yoke An electromagnetic device which is carefully positioned around the neck of a CRT that is used to deflect the beams of the CRT's electron guns horizontally and vertically. The yoke is carefully positioned at the factory so as to perfectly align the electron guns with the color dots on the inside surface of the CRT. This alignment process is called *convergence*. Never remove, or reposition a yoke.

ZRAM (Zero Voltage Random Access Memory) An integrated circuit (I.C.) which temporarily stores computer information (data) but will not lose the information when the power is turned off.

R-2 LAMPS {Incandescent}



Mini-screw



Bayonet



Wedge



Midget-flange

LAMP NUMBER	N&D PART NUMBER	VOLTS	BASE TYPE	SPECIAL APPLICATION
40	11990	6.3	Mini-Screw	
44 (1844)	10680	6.3	S.C. Bayonet ¹	44 and 47 lamps are interchangeable.
47 (1847)	10680	6.3	S.C. Bayonet	44 and 47 lamps are interchangeable.
53	10671	14.4	S.C. Bayonet	
57	10686	14	S.C. Bayonet	Also use 1815.
63	10684	7	S.C. Bayonet	
67	11989	13.5	S.C. Bayonet	
73	10678	14	Wedge	Skee-ball display. Hoopshot model No. 407 display.
74	12507	14	Wedge	Skee-ball display.
89	10681	13	S.C. Bayonet	
152	10670	28	Wedge	Big Choice coin door. Same as 656.
158	11056	14	Wedge	
161	10669	14	Wedge	
194	11988	14	Wedge	
257	12521	14	S.C. Bayonet	
313	10674	28	S.C. Bayonet	
382	13506	14	Midget-Flange	Silver Splash jackpot slide.
455	10673	6.3	S.C. Bayonet	Flashing lamp.
555	10668	6.3	Wedge	
656	10670	28	Wedge	Big Choice coin door. Same as 152.
755	10677	6.3	S.C. Bayonet	Rowe BC-9, BC-25, & BC-35 - P1 & P4 lamps.
904	10990	13	Wedge	Same as 906.
906	10990	13	Wedge	Same as 904.
908	11829	14	Wedge	
912	10984	12.8	Wedge	
1251	10687	28	S.C. Bayonet	
1446	11457		Mini-Screw	Treasure Island flashing side lamps. Triple Way / Triple Skill coin door.
1683	10688	28	S.C. Bayonet	
1815	10686	14	S.C. Bayonet	Also use 57.
1819	12599	28	S.C. Bayonet	Rowe BC-9 transport entry faceplate.
1844	10680	6.3	S.C. Bayonet	Same as 44.
1847	10680	6.3	S.C. Bayonet	Same as 47.
1892	10685	14.4	S.C. Bayonet	
1895	10672	14	S.C. Bayonet	Triple Way marquee.
2578	10683		S.C. Bayonet	Bob's Space Racers games.
6S6 Clear	11831	120	Candelabra	Store canopies.

¹ S.C. Bayonet = Single Contact Bayonet. (One contact on tip of base, one filament.)

6S6 Red	12760	120	Candelabra	Store canopies.
10C7DC	10846	120	D.C. ² Bayonet	Meltec games.
20-6822	11521	140/110	E-14 Screw	Power Tower.
24A9969	10458	250/220	E-14 Screw	Triple Skill marquee.
24A9971	10467		Mini-Screw	Triple Way / Triple Skill coin door. Treasure Island flashing side lamps. Same as 1446.
24MB	12890	24	S.C. Bayonet	Wacky Gator.
161-4831	10480	60	E-14 Screw	All Big Choice Marquees.
Wet Lamp	13108	120	Standard Screw	Water Race
	13001	130 11Watt	Standard Screw	Blue Bob's Space Racers games.
	12989	130 11 Watt	Standard Screw	Red Bob's Space Racers games.
	12988	130 11 Watt	Standard Screw	Clear Bob's Space Racers games.

² D.C. Bayonet = Double Contact Bayonet. (Two contacts on tip of base, connected to two separate filaments.)

R-5 LUBRICANTS

LUBRICANT	USES	APPLICATION NOTES
GEAR OIL (80 to 90W)	Certain motor gearboxes such as Afterburner Deluxe cradle and gondola motor gear assemblies.	Drain old oil from gearbox. Pour new oil into gearbox. Fill to the appropriate level. DO NOT OVERFILL! <i>Note: overfilling gearboxes will damage seals, causing them to leak oil.</i>
LITHIUM GREASE FOR GREASE GUN RED HEAVY DUTY (Thick consistency, often colored red, but not always.)	Lubrication of heavy duty moving parts such as: <ul style="list-style-type: none"> • Pillow-blocks. • Worm gears. • Bearing assemblies. • Axle assemblies. 	Usually applied with a grease gun. When lubricating pillow blocks and grease fittings, place the nozzle of the grease gun over the grease fitting nipple and pump grease into the fitting. Be generous with the grease.
LITHIUM GREASE WHITE (Thick consistency.)	One of the most useful lubricants for game purposes, including: <ul style="list-style-type: none"> • Worm gears • Bushings • Gear assemblies • Bearings • Sliding plastic and metal assemblies <p>Excellent on:</p> <ul style="list-style-type: none"> • Plastic to plastic. • Plastic to metal. • Metal to metal. <p>Water resistant.</p> <p>Prevents rust and corrosion..</p> <p>Will not melt or run.</p>	
LIGHT OIL (3-In-1 Household Oil)	Light oiling applications. Trak-Ball bearings. Small bearings. <i>Note: although this type of oil has its uses, Teflon based light oils are better suited for the above listed applications.</i>	

<p>LITHIUM SPRAY GREASE WHITE (Thin consistency.)</p>	<p>A light lithium-based grease spray which thickens after application.</p> <p>Light gear assemblies, bearings and other light duty parts.</p> <p>Excellent on:</p> <ul style="list-style-type: none"> • Plastic to plastic. • Plastic to metal. • Metal to metal. <p>Will not melt.</p>	<p>Shake can well before using.</p> <p>Spray on parts and remove excess grease with a paper towel.</p>
<p>LUBRIPLATE</p>	<p>One of the most useful lubricants for game purposes, including:</p> <ul style="list-style-type: none"> • Worm gears • Bushings • Gear assemblies • Bearings • Sliding plastic and metal assemblies <p>Very slick.</p> <p>Will not run off.</p> <p>Prevents rust.</p> <p>Will not melt.</p>	
<p>WD-40</p>	<p>Loosens rusted parts and frees sticky mechanisms.</p> <p>Prevents rust and corrosion.</p> <p>Displaces moisture.</p> <p>Do not use this product to clean switch contacts - use switch contact cleaner instead. Using WD-40 on leaf switch assemblies which have phenolic (fiberglass) wafers can cause the switch to fail.</p>	<p>Use to loosen rusted or frozen parts only. For lubrication applications use lithium products.</p> <p>Spray on the rusted or frozen part and wait a few minutes before attempting to loosen. Repeat until part is loose.</p>