IBM Field Engineering Maintenance Manual

Motors, Generators, Relays, Circuit Breakers, Test Instruments, Miscellaneous Components

S225-3422-1

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Preface

This manual contains general information and does not cover procedures that have been developed for a particular machine. When servicing a machine, refer to the manuals for that particular machine.

Second Edition (January 1970)

This edition, S225-3422-1, is a major revision of and obsoletes 225-3422-0. Extensive changes have been made throughout to update both style and grammar. Significant changes to the text are indicated by a vertical line to the left of the change; changed figures are indicated by the symbol (●) to the left of the affected figure title.

Significant changes or additions to the specifications contained in this publication are continually being made. Any such changes will be reported in subsequent revisions or FE Supplements.

This manual has been prepared by the IBM Systems Development Division, Product Publications, Dept. 171, P.O. Box 6, Endicott, N.Y. 13760. A form for reader's comments is provided at the back of this publication. If the form has been removed, comments may be sent to the above address.

Contents

Abbreviations

μ	micro
Ω	ohm
A	ampere
ac	alternating current
C	common
COM	common
CONT	contact
dc	direct current
F	farad
HD	heavy-duty
hi	high
k	thousand
lo	low
m	milli-
max	maximum
meg	million
min	minimum
ms	millisecond
N/C	normally closed
N/O	normally open
NID	number of index divisions
nom	nominal
osc	oscillator
PM	preventive maintenance permissive make (relay)
rpm	revolutions per minute
R	resistance
R/C	resistor-capacitor
RES	resistance
TD	thermal delay
V	volt
W/D	wiring diagram

CE SAFETY PRACTICES

All Customer Engineers are expected to take every safety precaution possible and observe the following safety practices while maintaining IBM equipment:

1. You should not work alone under hazardous conditions or around equipment with dangerous voltage. Always advise your manager if you MUST work alone.
2. Remove all power AC and DC when removing or assembling major components, working in immediate area of power supplies, performing mechanical inspection of power supplies and installing changes in machine circuitry.
3. Wall box power switch when turned off should be locked or tagged in off position. "Do not Operate" tags, form 229-1266, affixed when applicable. Pull power supply cord whenever possible.
4. When it is absolutely necessary to work on equipment having exposed operating mechanical parts or exposed live electrical circuitry anywhere in the machine, the following precautions must be followed:
   a. Another person familiar with power off controls must be in immediate vicinity.
   b. Rings, wrist watches, chains, bracelets, metal cuff links, shall not be worn.
   c. Only insulated pliers and screwdrivers shall be used.
   d. Keep one hand in pocket.
   e. When using test instruments be certain controls are set correctly and proper capacity, insulated probes are used.
   f. Avoid contacting ground potential (metal floor strips, machine frames, etc. — use suitable rubber mats purchased locally if necessary).
5. Safety Glasses must be worn when:
   a. Using a hammer to drive pins, riveting, staking, etc.
   b. Power hand drilling, reaming, grinding, etc.
   c. Using spring hooks, attaching springs.
   d. Soldering, wire cutting, removing steel bands.
   e. Parts cleaning, using solvents, sprays, cleaners, chemicals, etc.
   f. All other conditions that may be hazardous to your eyes. REMEMBER, THEY ARE **YOUR** EYES.
6. Special safety instructions such as handling Cathode Ray Tubes and extreme high voltages, must be followed as outlined in CEM's and Safety Section of the Maintenance Manuals.
7. Do not use solvents, chemicals, greases or oils that have not been approved by IBM.
8. Avoid using tools or test equipment that have not been approved by IBM.
9. Replace worn or broken tools and test equipment.
10. Lift by standing or pushing up with stronger leg muscles — this takes strain off back muscles. Do not lift any equipment or parts weighing over 60 pounds.
11. All safety devices such as guards, shields, signs, ground wires, etc. shall be restored after maintenance.
12. Each Customer Engineer is responsible to be certain that no action on his part renders product unsafe or exposes hazards to customer personnel.
13. Place removed machine covers in a safe out-of-the-way place where no one can trip over them.
14. All machine covers must be in place before machine is returned to customer.
15. Always place CE tool kit away from walk areas where no one can trip over it (i.e., under desk or table).
16. Avoid touching mechanical moving parts (i.e., when lubricating, checking for play, etc.).
17. When using stroboscope — do not touch ANYTHING — it may be moving.
18. Avoid wearing loose clothing that may be caught in machinery. Shirt sleeves must be left buttoned or rolled above the elbow.
19. Ties must be tucked in shirt or have a tie clasp (preferably nonconductive) approximately 3 inches from end. Tie chains are not recommended.
20. Before starting equipment, make certain fellow CE's and customer personnel are not in a hazardous position.
21. Maintain good housekeeping in area of machines while performing and after completing maintenance.

KNOWING SAFETY RULES IS NOT ENOUGH
AN UNSAFE ACT WILL INEVITABLY LEAD TO AN ACCIDENT
USE GOOD JUDGMENT — ELIMINATE UNSAFE ACTS

229-1264-1

Artificial Respiration

GENERAL CONSIDERATIONS

1. **Start Immediately, Seconds Count**
   Do not move victim unless absolutely necessary to remove from danger. Do not wait or look for help or stop to loosen clothing, warm the victim or apply stimulants.
2. **Check Mouth for Obstructions**
   Remove foreign objects — Pull tongue forward.
3. **Loosen Clothing — Keep Warm**
   Take care of these items after victim is breathing by himself or when help is available.
4. **Remain in Position**
   After victim revives, be ready to resume respiration if necessary.
5. **Call a Doctor**
   Have someone summon medical aid.
6. **Don't Give Up**
   Continue without interruption until victim is breathing without help or is certainly dead.

Reprint Courtesy Mine Safety Appliances Co.

Rescue Breathing for Adults
Victim on His Back Immediately

1. **Clear throat** of water, food, or foreign matter.
2. **Tilt head back** to open air passage.
3. **Lift jaw up** to keep tongue out of air passage.
4. **Pinch nostrils** to prevent air leakage when you blow.
5. **Blow** until you see chest rise.
6. **Remove your lips** and allow lungs to empty.
7. **Listen** for snoring and gurglings, signs of throat obstruction.
8. **Repeat mouth to mouth breathings** 10-20 times a minute.

Continue rescue breathing until he breathes for himself.

Thumb and finger positions

Final mouth to mouth position

DANGER 1-6, 1-12
Motor shafts often use keyways. These keyways may have very sharp edges and can cause injury to the hands. Shafts can be taped or wrapped as a safety measure.

DANGER 4-9
Be extremely cautious when measuring high voltages. The meter should be connected and disconnected with the power off. *Do not touch the meter or test leads while taking the reading.*

DANGER 4-3
Use extreme care when checking high voltage. Always turn off the power before making connections and do not touch meter or test leads while taking the reading.

DANGER 2-35
2. *No attempt should be made to disassemble a mercury relay.* The glass capsule contains a high pressure hydrogen atmosphere which can explode and cause possible injury if tampered with. Observe the warning labels on each relay or SMS card.

DANGER 4-9
Connect and disconnect leads with the power turned off. Do not touch the leads or meter while the power is on.

DANGER 4-12
HIGH VOLTAGE

GENERAL INFORMATION

Motors are being used in ever increasing numbers by IBM to provide power for accounting machines, tape drives, and cooling fans to name just a few applications. Some machines use only one motor, while others may use several ranging in size from small timer motors to larger, more powerful drive motors. This manual contains operational and service information only on the motors that are used as a source of mechanical drive power. General service information on generators used in IBM machines is also included in this section. Generally, it is not practical to repair smaller fan and timer motors; therefore, replacement is recommended for these types.

Protective Devices

Fuses or thermal overload switches are used to provide for protection of the motors in IBM equipment in the event the motor stalls from any cause.

Thermal Fuses

Motor fuses usually are the thermal type. The thermal fuse accommodates large overloads for short durations, but blows when subjected to a small overload for an extended period of time. Figure 1-1 illustrates the construction of a thermal fuse.

When subjected to a steady overload, the heater unit gradually heats the soldered junction until the spring pulls the fuse link loose, thus opening the circuit. In case of a direct short circuit, the fuse link blows as in a common fuse.

Thermal fuses are made in various current values. Replacement of a thermal fuse with one of a different value or a different type is not recommended. Generally, when a machine consistently blows fuses a motor problem exists, and every effort should be made to correct the cause.

Thermal Switches

Some motors are protected by thermal switches rather than fuses. The switches provide overload protection for the entire machine. Two common types of thermal

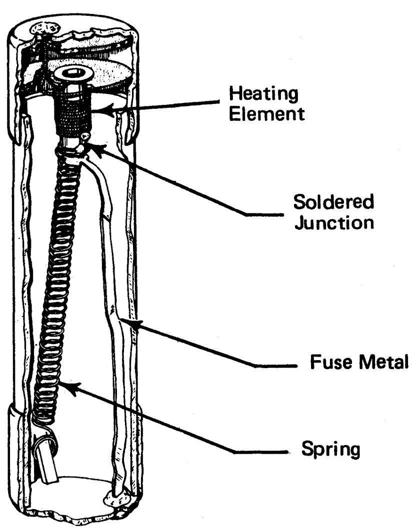


Figure 1-1. Thermal Fuse

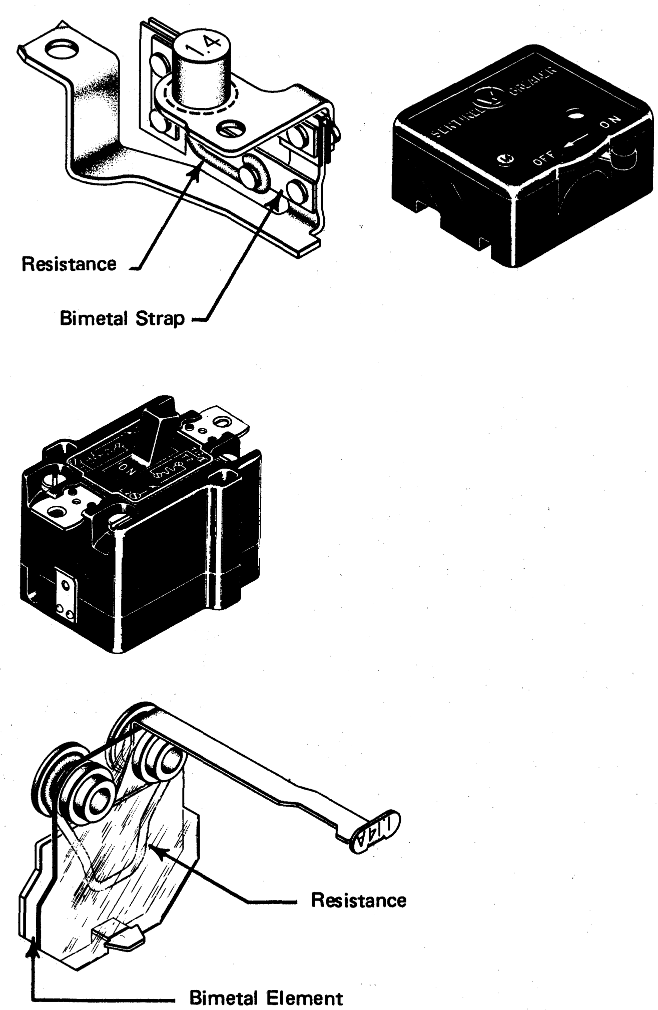


Figure 1-2. Thermal Switches

overload switches and their heater or thermal elements are shown in Figure 1-2. The principle of operation is the same in both types; the current to the motor must pass through a thermal element which is mounted beside a bimetallic element. If the current rating of the thermal element is not exceeded, the bimetal element does not bend and trip the latch. If an excessive amount of current flows through the thermal element, additional heat is developed. The additional heat trips the latch and the switch snaps to the off position. To reset the switch, push the handle to the extreme off position after a sufficient period of time to let the element cool. This relatches the toggle mechanism and the switch may then be turned on.

Bearings

Two general types of bearings are used in motors; ball bearings and bronze sleeve bearings (Figure 1-3). The ball bearings are pressed on the rotor shaft. If these bearings are properly lubricated, they seldom require replacement. However, if it is necessary to replace a ball bearing, and if a press is available, the bearing may be replaced in the field.

The replacement of bronze sleeve bearings requires line reaming. Since such facilities are not generally available, it is not advisable for the customer engineer to replace this type of bearing.

Lubrication

Proper lubrication and cleaning is the best preventive maintenance. Lubrication is generally provided by one of two methods; either wool packed oil wells or grease cups.

Motors with ball bearings are provided with grease cups. Generally one full turn of each cup is recommended for each 2 to 6 months of normal operation, 8 hours per day. The manufacturer's notice on the motor indicates what the optimum lubrication period is. About every 2 years, remove the old grease and clean the bearings. Refill the grease cups with IBM 21.

Motors with bronze sleeve bearings are provided with oil cups or ball closing type oil wells. Bearings should be lubricated according to the particular machine PM schedule. For machines that do not specify bearing lubrication, approximately four drops of IBM Lubricant 9 in each end bearing cup per month is recommended for machines under a normal 8-hour day operation. A little oil regularly each month is preferable to a larger amount at the end of a longer period.

Too much lubricant is as bad as too little. Excessive lubricant travels along the rotor shaft and gathers on the commutator or is thrown onto the starting switch or field windings. Grease and oil cause deterioration of the insulation and gather dust and dirt.

Most motors are equipped with a fan for ventilation and cooling. Air drawn through the motor by the fan contains particles of dust and dirt. This dust and dirt clings to those parts of the motor which are oily. The start switch and commutator are situated in a position to catch any excess lubricant from the shaft bearings and to collect the dust and dirt drawn in by the fan. Dirt on the starting switch points causes failure to start.

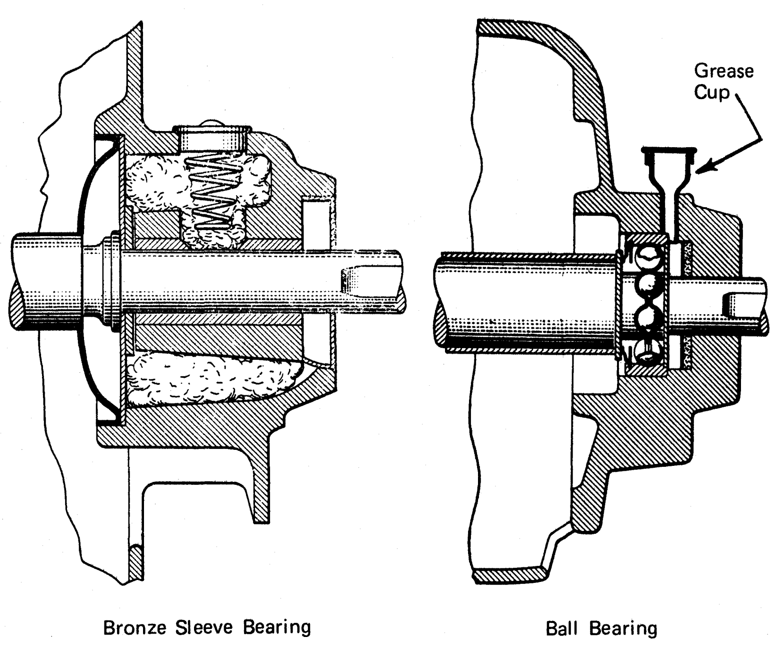


Figure 1-3. Motor Bearings

Dirt on the commutator may prevent the brushes from making contact with the commutator and thus prevent the motor from starting. Dirt may also short commutator segments together which causes the motor to run slowly and overheat. Dust on the motor windings prevents proper ventilation and results in overheating.

Checking for Wear

Sleeve bearings should be checked for wear as follows. Grasp the motor shaft and try to move it up and down as shown by AA in Figure 1-4. If perceptible movement is detected (over .005-inch), the front bearing is worn and both bearings should be replaced. Replacement of sleeve bearings by a motor shop is recommended because most offices lack facilities to ream the bearings properly.

If any vertical movement of the shaft is detectable in a motor equipped with ball bearings, the bearings require replacement. The motor generally has already been the source of noise and trouble. Some offices may have replacement bearings. In an emergency, have an outside vendor supply a replacement.

Ball bearings may be replaced in the field if a bearing press (or a satisfactory substitute method of removal and installation) is available. Bearings should be installed on a motor shaft by pressure on the inner race only. Careful installation is necessary to prevent any dust, metal chips or foreign material from being lodged in the bearing. A bearing subjected to poor installation wears out very quickly.

Checking for End Play

Motors should be checked for proper end play of the rotor as shown by BB in Figure 1-4. About .010-inch to .020-inch movement is acceptable. If the end play exceeds this amount, install shims on the shaft until the proper end play is obtained. To install shims requires the motor to be dismantled.

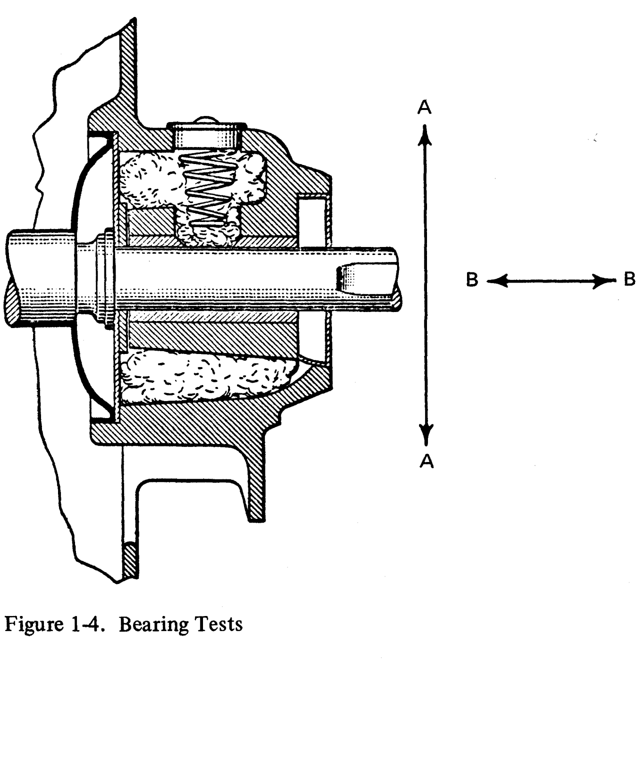


Figure 1-4. Bearing Tests

When installing shims, it is necessary to know where they should go on the shaft. They may be required on one end or both ends. Refer to "Centrifugal Mechanism" or "Commutator and Brushes."

AC MOTORS

Principles

One of the two main types of single-phase ac motors used on IBM equipment is the capacitor-start (Figure 1-5). Essentially, the capacitor-start motor is a split-phase type with a capacitor added in the start winding circuit to give greater starting torque with less current draw. Some motors may use an additional, smaller capacitor in the run winding circuit to improve the running torque characteristics of the motor. Figure 1-6 shows the schematic wiring diagrams of both capacitor-start and split-phase motors.

The run winding on a single-phase induction motor exerts no turning force on the rotor. Therefore an additional winding, called the start winding, must be used to obtain the revolving magnetic field necessary to provide starting torque. When the motor reaches about 80% of its normal speed, this start winding which produces a false second phase is cut out of the circuit by a centrifugal switch, and the motor runs on the single run winding.

The starting switch consists of a set of contact points and a throwout mechanism which operates by centrifugal force to open the points when the rotor approaches its rated speed. Figure 1-7 is a photo of a start switch and centrifugal mechanism that have been removed from a motor. Figure 1-8 shows the switch and mechanism as they appear in the motor. Figures 1-12 and 1-13 show the start switch operation in greater detail.

Multi-phase motors have no capacitor or starting switch. The only care, therefore, is regular lubrication.

Some single-phase motors do not use start switches and centrifugal mechanisms. Instead they use a special relay for starting (Figure 1-9). The relay is designed to pick up and drop out when predetermined values of current pass through its coil. The relay coil is wired in series with the run winding of the motor. The normally open points of the relay control the circuit to the start winding. Briefly, it operates as follows. With line voltage applied to the motor, heavy current flows through the run winding and the start relay coil, causing the relay to pick. The start winding is energized through the relay points. As the motor reaches its normal speed, current

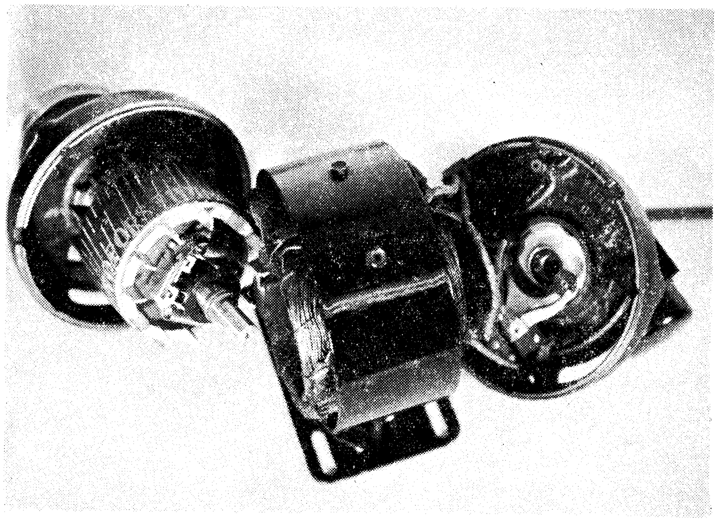
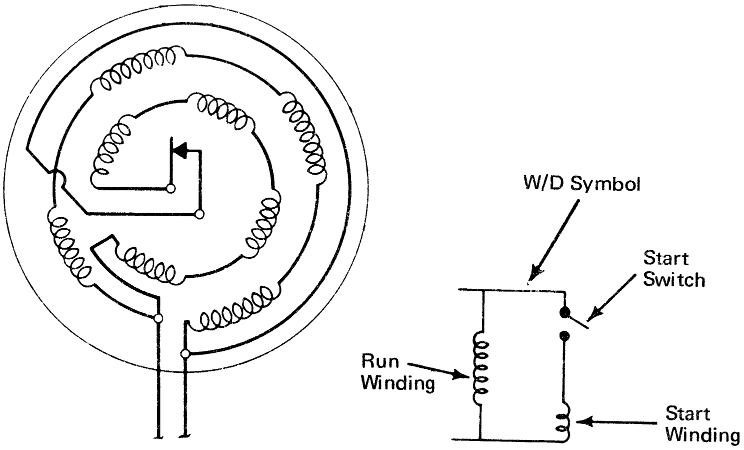
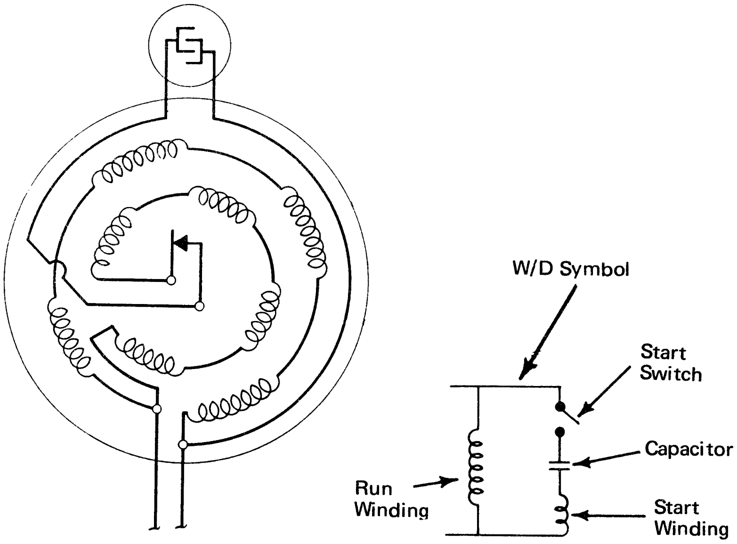


Figure 1-5. Typical AC Motor



Split-Phase Motor



Capacitor-Start Motor

Figure 1-6. Split-Phase and Capacitor-Start Motor Diagrams in the run winding drops to a point below that needed to keep the relay up. The relay drops and deenergizes the start winding. The motor continues to run on the run winding. Figure 1-9 also shows the schematic wiring diagram for a relay-start motor.

The start relay is a sealed unit; no attempt should be made to adjust it. When replacement is indicated, use the correct type furnished under an IBM part number for the particular motor.

Motors have been used in IBM equipment which run on ac or dc voltages and are referred to as universal or series-wound motors. Motors of this type use a wound armature with a commutator upon which a set of brushes ride. The brushes allow the current from the stationary field windings to flow through the windings on the armature and thus provide the turning force to cause the motor to run. These motors were used extensively on the older models of the keypunch.

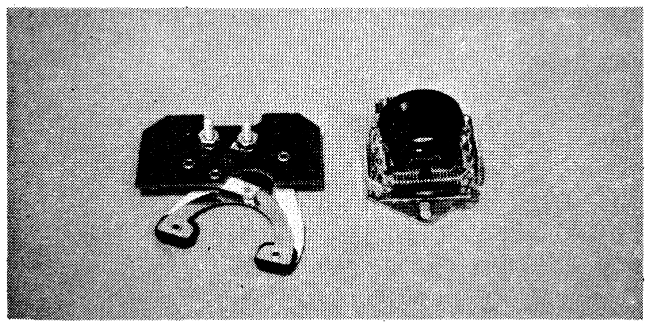


Figure 1-7. Typical Motor Start Switch and Centrifugal Mechanism

Although their usage has dropped to a negligible amount, they may still be found on machines that customers have assigned to specific applications and have found no reason to replace with more recent types. See "DC Motors."

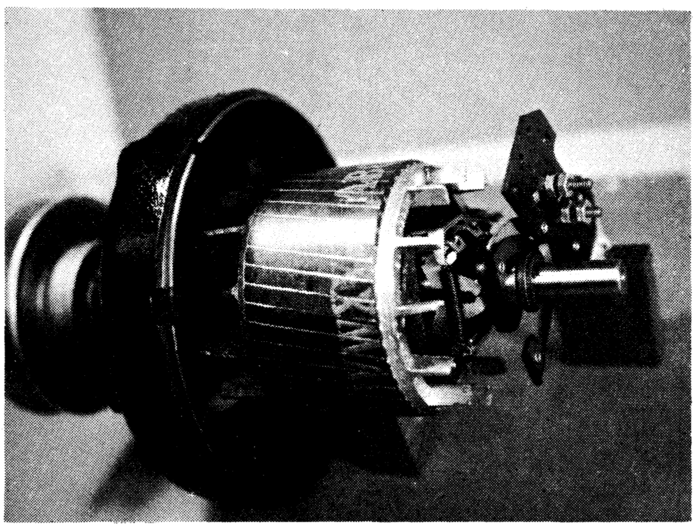


Figure 1-8. Actual Position of Switch and Mechanism

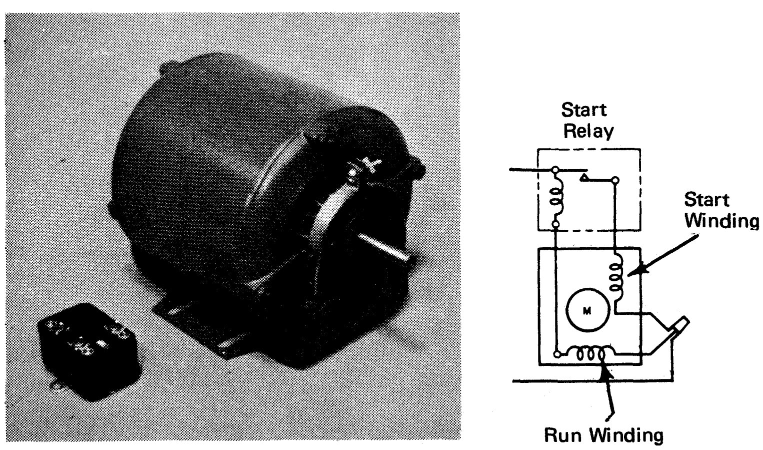


Figure 1-9. Typical Relay-Start Motor

Service Information

Disassembly and Reassembly

DANGER
Motor shafts often use keyways. These keyways may have very sharp edges and can cause injury to the hands. Shafts can be taped or wrapped as a safety measure.

The following steps are the procedure for complete disassembly and reassembly of ac motors.

1. Spot or scribe alignment marks on the end bells and the frame. These marks are used to properly align the end bells during reassembly.
2. Remove the bolts that hold the end bells to the frame. There are usually four bolts.
3. Remove the rear end bell. It may have to be pried off. The start switch and centrifugal mechanism may now be removed.
4. Remove rotor and front end bell. Removal of the pulley is not necessary unless the rotor is to be removed from the front end bell.
5. To reassemble the motor, reverse the preceding steps. The following precautions should be observed during reassembly.
   a. If the rotor shaft had shims on either end, make sure they are in place before reassembly. The placement and thickness of the shims affect the relationship between the start switch and the centrifugal mechanism.
   b. Make sure that the internal motor wires (to the start switch, capacitor, and stator windings) are properly positioned. They should not touch the rotor, shaft, or fan blades and should not interfere with the action of the start switch and centrifugal mechanism.
   c. Before tightening the end bell holding bolts, align the spot marks. Make sure the end bells are not pinching any internal wires.
   d. Before energizing the motor, manually rotate the rotor shaft. It should turn freely. Make sure applicable ground wires are reconnected.

Testing Motor Windings

Motor windings may be checked for continuity with an ohmmeter. The range selector switch should be turned to the R range and meter adjusted for zero ohms. The windings are more easily checked if the motor is dismantled. The run winding is the heavier gage wire. The start winding is wound with finer wire. Trace the leads from each winding to the centrifugal switch terminal board. The meter can be connected to the terminals on the board. If the ohmmeter leads are connected across the terminals for each winding in turn and full scale deflection of the meter is not observed, the winding under test is open.

Each winding should be tested for possible ground or short to the motor frame. Turn range selector switch on meter to R X1000 position. One meter test lead should be clipped to either end of the run winding. Clip the other meter lead to the frame of the motor. The meter should not give an indication. Move the test lead on run winding terminal to start winding terminal and leave the other lead clipped to the frame. Again, the meter should not give a reading. A motor which gives a reading during this test should be checked thoroughly for the ground. If the actual windings (rather than connecting leads) are grounded, the motor cannot be repaired by the CE. No data can be given on resistance of the windings in a motor. Shorted turns do not necessarily show a significant change in the ohmmeter reading. If a thorough check does not reveal the cause of the trouble of a motor which is low on torque, overheats, or blows fuses, it should be tested in a motor repair shop where special equipment is available for testing motor windings for shorted turns.

Testing Capacitors

The start capacitor on a motor may be tested with an ohmmeter for a shorted condition and, in many instances, for a weak or open condition.

To test a capacitor with the ohmmeter, proceed as follows.

1. Turn the ohmmeter range selector switch to R X100 range.
2. Discharge capacitor, then disconnect leads.
3. Clip one meter lead to each terminal on the capacitor.
4. The meter should read approximately zero ohms (Ω) during the initial charge, and then slowly return to infinity (∞). (The pointer need not return to infinity because to charge the capacitor completely might require considerable time.) If the meter continues to read zero ohms, the capacitor is probably shorted. A low infinity reading or no reading on the meter indicates that the capacitor is probably open or has changed capacity to a lower value. Substitution with a capacitor of equal ratings is the best way to prove conclusively that a capacitor is the cause of motor trouble.

Capacitor Replacement

Whenever motor trouble is traced to a faulty capacitor, a replacement of equal ratings and voltage should be obtained. The information printed on the outside of a capacitor often includes the IBM part number. If an IBM part is not available a replacement capacitor can be obtained from a motor shop. The information needed to obtain a replacement is the minimum and maximum capacity values and the voltage rating. For example, the printing on the capacitor reads 97-108 mfd, 125 volts ac. A motor shop, given this information, should be able to furnish the correct replacement.

Sometimes motor troubles occur when down time of a machine could cause extreme inconvenience to a customer. If the motor trouble is found to be the result of a faulty capacitor and *no replacement of equal rating is immediately available,* consideration should be given to the *temporary* use of a capacitor which is somewhat higher in capacity. Higher capacity substitution up to possibly 30% or 40% more than the original, should not cause improper operation of a motor. *Permanent repair of the motor by replacement with the correct type should follow as soon as possible.*

Avoid the substitution of a capacitor with lower capacity than the original. Capacitors with a rating lower than the specified rating can cause the motor to have decreased starting torque and increased current requirements.

Centrifugal Mechanism

To inspect or replace the centrifugal start mechanism:

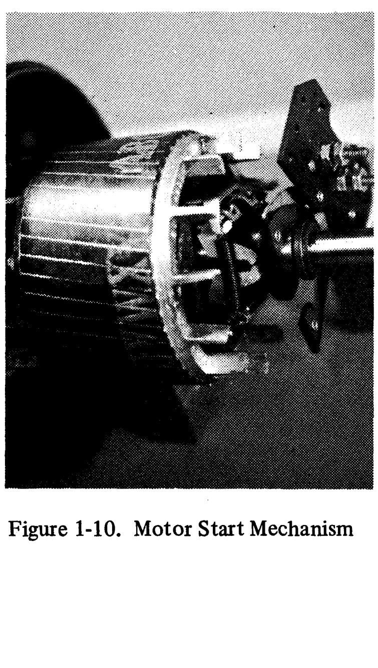
1. Remove rear end bell.
2. Remove the centrifugal mechanism at this time, if considerable dirt, rust or any foreign material is present which might prevent proper operation.
   a. Examine the portion of the shaft where the collar operates for burrs, rust, or any foreign material which could cause the collar to bind on the shaft. Approximately .010-inch clearance should be between inside of collar and shaft. *Light sanding* of this portion of the shaft is permissible when required. All dust must be removed. One drop of oil which has first been rubbed between fingers should be applied to the shaft to prevent any future rusting. Avoid excess oil. Thoroughly clean the centrifugal mechanism of all dust, grease, and oil with IBM cleaning fluid. Make sure inside of plastic collar is thoroughly clean.
   b. Check for wear in the arms or plastic collar in the areas indicated by the arrows in Figure 1-10.
   c. Check for weak or worn springs, and for wear on arms where springs are attached.
   d. When replacing or installing the centrifugal unit on the rotor shaft, make sure that the shaft is centered in the collar and no binds are present.
   e. Check the relationship of the centrifugal mechanism to the start switch. This ensures that the two components work together properly and also establishes a part of the required motor end-play tolerance (refer to "Start Switch," steps 5 and 6).

   Note: Many viewpoints exist on the question of lubrication of centrifugal mechanisms. Because of varying conditions under which motors may be operated, operating the unit without any lubrication is recommended. A motor serviced with no lubricant to attract and retain dust and dirt should work well under most conditions of service.

Start Switch

Most motors have air vents in the end bells to provide air circulation. Observing the start switch contacts is usually possible through the vent in the rear end bell. However, to properly inspect and clean the start switch, the switch may have to be removed:

1. Remove the rear end bell.
2. Remove the switch mounting plate to prevent foreign material from getting into the bearing.
3. Clean the contacts with IBM cleaning fluid. The contact points may be further cleaned or smoothed with a folded strip of sandpaper or a point file. Be careful not to bend the contact straps or alter the



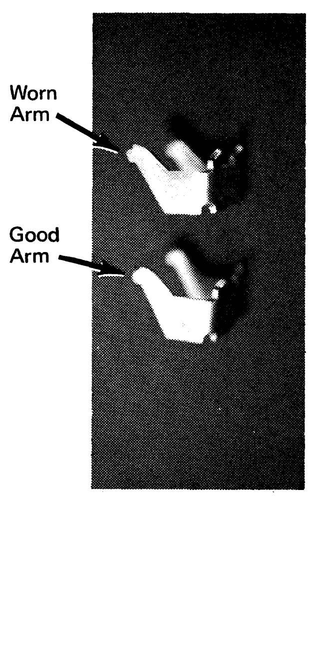


Figure 1-10. Motor Start Mechanism

spring tension. Any switch assembly showing signs of burning on the mounting plate or having contacts worn to less than .020-inch should be replaced.

4. If the switch is the type shown in Figure 1-11, examine the portion which rides against the plastic collar. Replace if worn.

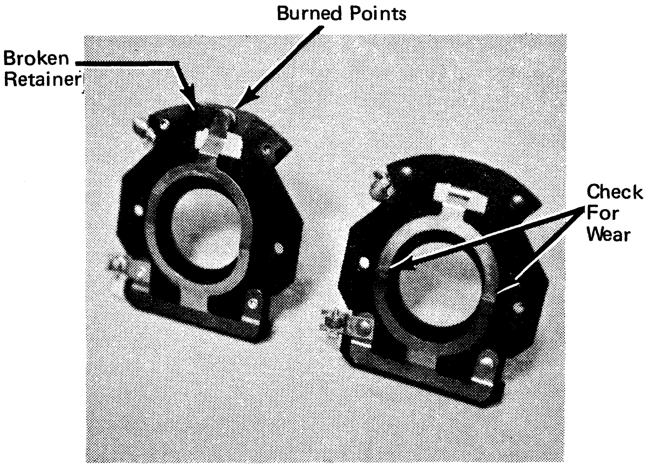


Figure 1-11. Motor Start Switch

5. Many switches have felt or plastic wipers which operate against the centrifugal collar (Figure 1-12). If these wipers are badly worn it is sometimes possible to rotate them a half turn to secure a new surface. This should be done only if a replacement switch is not readily available. A switch which has been repaired in this manner should be replaced as soon as practical.
6. With the rear end bell on a table, place the rotor shaft in bearing as shown in Figure 1-14 (any shims on the switch end of the rotor must be in place for this test). Check to be sure that the fingers of the switch close the contact when in the normal position (Figure 1-12) and allow the contact to open when the throwout mechanism is moved to its running position (Figure 1-13).
7. Assemble the motor and check the amount of end play. Any play in excess of .010-inch to .020-inch should be removed by adding shims. The preceding step establishes the clearance which must be maintained at the switch end of the motor, therefore, any additional shims would be placed on the pulley end of the rotor shaft.

Motor Replacement

Whenever it becomes necessary to replace a motor, the voltage, speed, shaft size, horsepower, and *direction of rotation* should be compared. Do not assume a motor furnished under a replacement part number has the proper rotation. The drive belts should not be installed until it is certain the rotation of the replacement motor is correct. Failure to observe these precautions can cause serious damage to a machine.

To change the rotation of a capacitor or split phase motor:

1. Make certain that power to the motor has been disconnected.
2. Remove the cover over the motor terminal (Figure 1-15). Two screws hold the cover in place.
3. Normally there are two leads coming from inside the motor and fastened to the terminal posts (Figure 1-16 or 1-17). These two leads are usually from the start winding. The leads from the run winding are usually soldered to the back side of the terminal board (Figure 1-18).

The two leads from the start winding should be

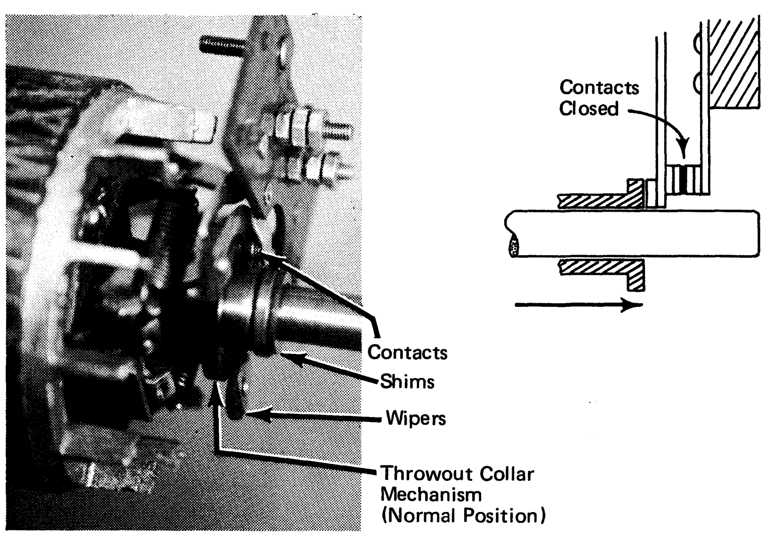


Figure 1-12. Start Switch in Normal Position

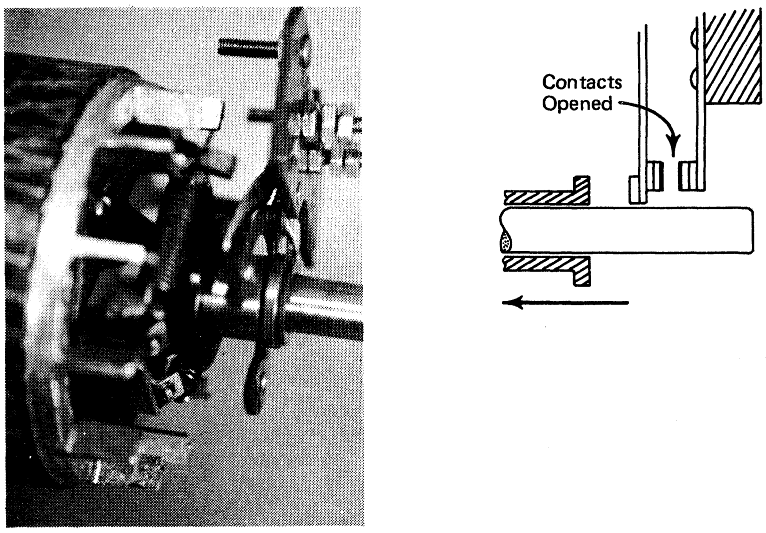
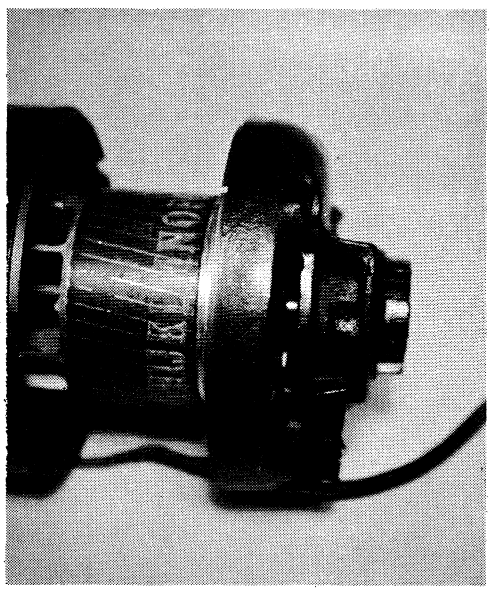


Figure 1-13. Start Switch in Running Position



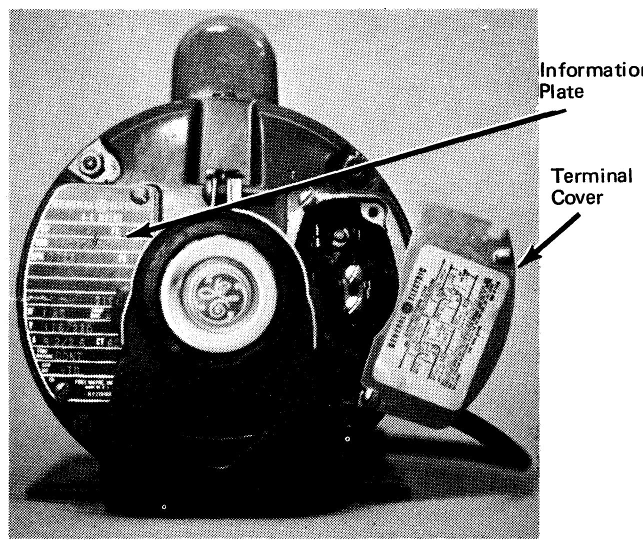


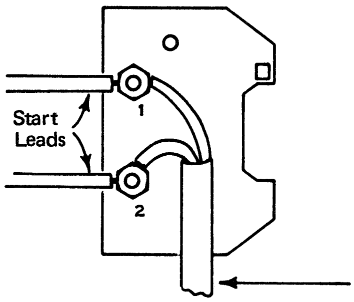
Figure 1-15. Typical End View of AC Motor

reversed from their original connection. A motor wired as in Figure 1-16 requires the leads to terminals 1 and 2 be reversed. A motor wired as in Figure 1-17 requires the leads on terminals 2 and 3 to be reversed.

4. Replace any wires previously removed, replace cover and momentarily turn power on to the motor. Observe rotation and if correct proceed to install motor on machine.

Motors used on 3-phase power lines do not have a start winding, capacitor, or centrifugal switch mechanism. To change rotation on a motor of this type, reverse any two of the three wires in the terminal box on motor.

To change the direction of rotation of a dual voltage type motor, leads are reversed in a manner similar to the single-voltage types. Motors of this type usually have terminal boards wired as shown in Figure 1-19 or Figure 1-20. The procedure for changing rotation is usually given on a drawing fastened on the inside of the terminal board cover or on a plate fastened to the end bell (Figure 1-15). The start winding leads must be *positively identified* before making any changes, or damage to the motor may result when power is applied. The drawing that shows the procedure for changing rotation also shows the proper connections for the various voltage applications.



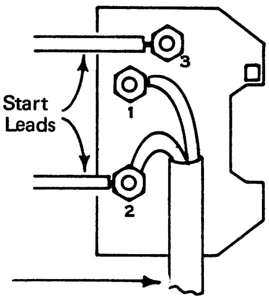


Figure 1-16. Figure 1-17.
Terminal Board Connectors

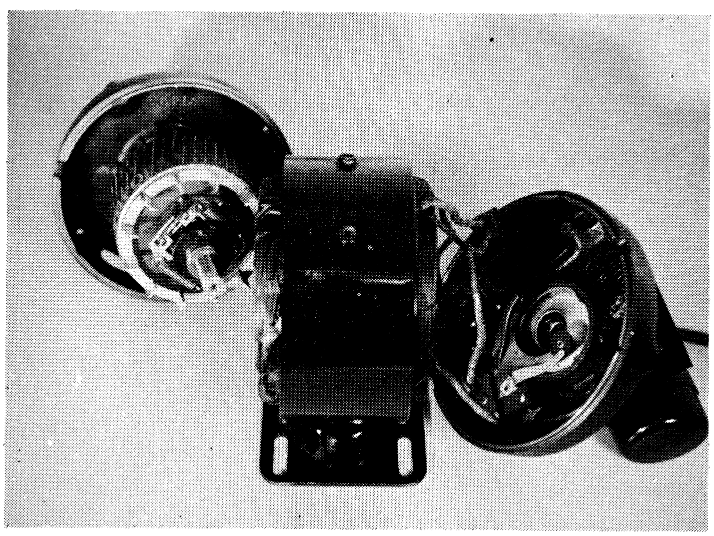
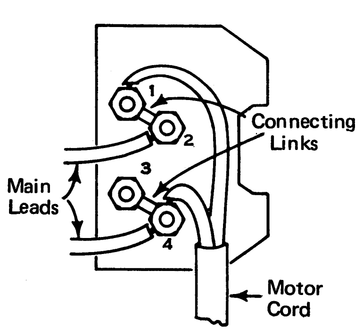


Figure 1-18. AC Motor Showing Internal Connectors



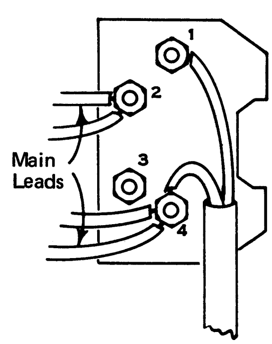


Figure 1-19. Figure 1-20.
Typical Dual Voltage Motor Terminal Board Connectors

Corrective Methods Summary for ac Motors

Symptom	Possible Causes	Corrective Action
Fails to start - no hum	Blown fuse, HD relay, mainline switch, motor plug, motor cord wires	Check each item and repair as required.
	Open windings	Check windings for evidence of overheating. Check continuity.
Fails to start - hums	Start switch fails to make	*Check centrifugal mechanism. Clean start switch.
	Defective capacitor	*Check or substitute.
	Start winding open	*Check continuity.
	Motor or driven device jammed.	Remove belt and rotate motor and driven device.
With no load, starts slowly and and develops little torque	Low line voltage	Check.
	Grounded winding	Check for grounds.
	Shorted winding	Motor shop can test windings.
	Defective capacitor	Check or substitute.
With load, runs slow and/or overheats	Start switch fails to open	Check centrifugal mechanism. Clean start switch.
	Bearings worn or gummy	Check for wear. Clean.
	Excessive belt tension or load	Adjust.
	Misalignment with driven device	Align.
	Low line voltage	Check.
Excessive noise	Loose pulley	Tighten.
	Worn bearings	Have bearings replaced.
	Bent shaft	Motor shop can repair.
	Run winding shorted	Motor shop can test windings.

*Quick check: Remove belt, manually spin pulley, and energize motor. If motor runs, the trouble is probably in the start circuit.

DC MOTORS AND GENERATORS

Principles

Direct current motors and generators are of the wound-armature type. They are divided into three groups: series, shunt, and compound wound. The majority of the dc motor applications in IBM machines use either the series- or shunt-wound type. Generators are usually the compound-wound type. Each type of winding has characteristics which make it best suited for its particular job. Figure 1-21 illustrates a typical dc motor.

At one time generators were used in almost all IBM machines to generate the 40 volts dc needed for machine operation. Selenium and other types of rectifiers have replaced generators in most machines. However, machines are in the field which still use generators. Figure 1-22 illustrates a typical dc generator.

These motors and generators use ball bearings or sleeve bearings. Refer to "Bearings."

Service Information

For most service procedures, the complete generator need not be removed. Removing the armature alone is sufficient to allow access to bearings, commutators, and brushes.

Disassembly and Reassembly

DANGER
Armature shafts often have keyways, which may have very sharp edges and can cause injury to the hands. Shafts can be taped or wrapped as a safety measure.

Procedure for complete disassembly and reassembly of dc motors and generators follows.

1. Remove the brushes and note the direction of the bevel. Be sure to replace each brush with the bevel in the same relative position as it was before the brushes were removed.
2. Spot or scribe alignment marks on the end bells and the frame. These marks are used to properly align the end bells during reassembly.

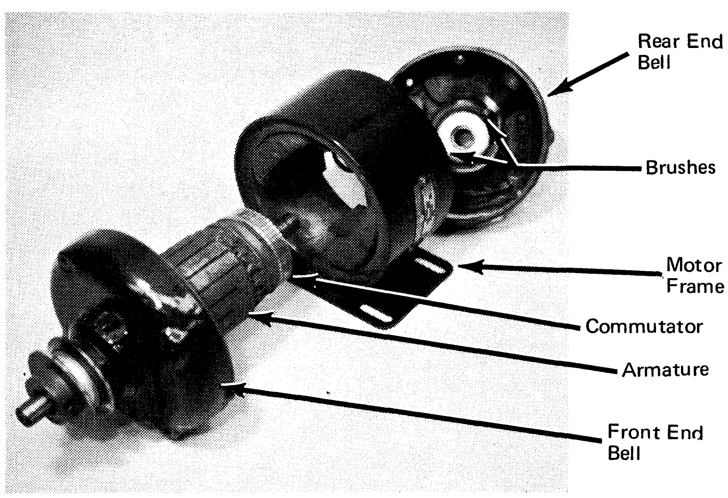


Figure 1-21. Typical DC Motor

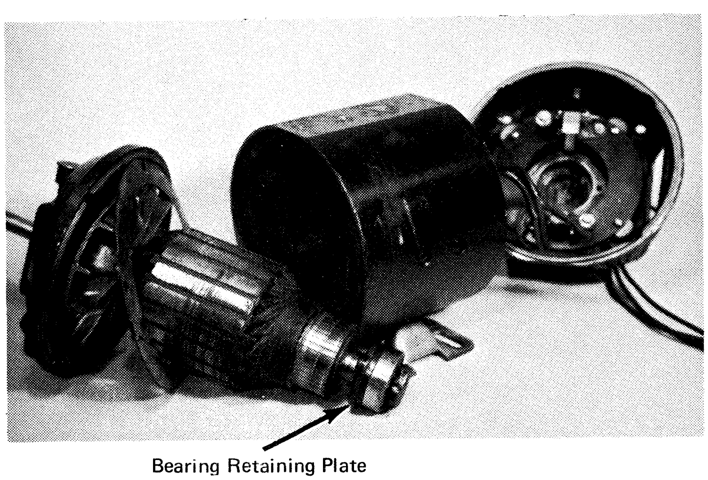


Figure 1-22. Typical DC Generator

3. Remove the bolts that hold the end bells to the frame. There are usually four bolts.
4. Remove the rear end bell. Ball bearing types may have screws holding a bearing retaining plate. Remove these screws (Figure 1-22). The end bell may have to be pried off.
5. Remove the armature and front end bell. Removal of the pulley is not necessary unless the armature is to be removed from the front end bell.
6. To reassemble the motor or generator, reverse the preceding steps. The following precautions should be observed during reassembly.
   a. If the armature shaft had shims on either end, make sure they are in place before reassembly. The placement and thickness of the shims affect the relationship between the brushes and the commutator.
   b. Be sure the brushes are removed from their slides or that the spring tension is relieved by placing a spring hook or rubber band beneath the brush tension spring. See that the brushes are pushed back in their slides, otherwise the commutator can jam against the brushes and damage them (Figure 1-23).
   c. Make sure that the internal wires (to the brush holders and field windings) are properly positioned. They should not touch any part of the armature and should not interfere with the brushes.

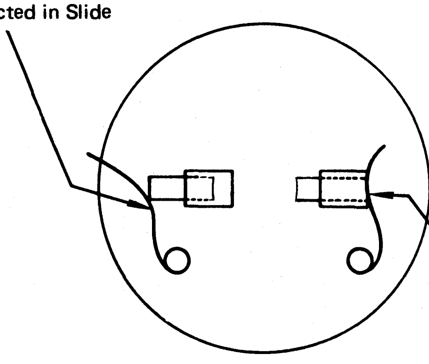


Figure 1-23. Brush Tension

   d. Before tightening the end bell holding bolts, align the spot marks. Make sure the end bells are not pinching any internal wires.
   e. Before connecting the motor or generator, manually rotate the armature shaft. It should turn freely.

Commutator and Brushes

All dc motors and generators employ a wound armature, a commutator, and brushes (Figure 1-21). The commutator is perhaps the most important component because it is the most sensitive to abuse. For satisfactory operation, the brushes and commutator on a generator must be kept in good condition. Under proper operating conditions, the commutator should run smoothly with a dark, glossy surface and without excessive heating. To keep these parts in good order, guard against excessive sparking at the brushes. Some causes of sparking are:

1. The brushes may be sticking or wedged in the brush holder. The brushes should be kept free from binds and the brush holder should be kept clean of carbon dust and oily deposits. Before a new brush is inserted, it may be filed lightly to remove any roughness which might cause a brush to stick in the holder.
2. The machine may be overloaded. Motors may be overloaded mechanically, and generators may be overloaded electrically. The overload may be due to a ground or leak on the line, or a dead short-circuit which should cause the fuse to blow or the thermal overload switch to trip.
3. The brushes may not be set exactly at the point of commutation. This is set at the factory and should not require changing unless they have loosened and shifted during shipment or have possibly been bumped. This can be corrected by moving the brush holder plate back and forth until sparking is at a minimum.
4. The brushes may be burned on the ends. If they are badly burned the brushes should be replaced.
5. The brushes may not be fitted to the surface of the commutator. The brushes can be properly fitted to the commutator surface by using the brush seating stone, part 450426. This stone is pressed lightly against the surface of the commutator until it powders slightly. It has abrasive qualities that cause the brush wear to conform to the surface of the commutator. When brushes are removed, mark the direction of the bevel and the position of the brush and be sure to replace the brushes in the same position and with the bevel in the same direction as it was before the brushes were removed.
6. The commutator may be rough, dirty, oily, or worn out. A commutator may be smoothed and cleaned with fine sandpaper (5-0 or finer). *Never* use emery cloth. Emery dust is a conductor and will cause shorts between the segments of the commutator. As one segment becomes shorted with another, the motor runs slower and hotter. For the same reason oil and dirt should be kept from between the segments of the commutator. If the space between the commutator segments becomes filled and dirt

piles up on the surface of the commutator, the brushes bounce. The commutator becomes blackened, and low spots form from continual sparking. If the brushes wear a deep slot in the commutator, the brushes may bind on the sides of the slot and bouncing results (Figure 1-24).

7. The carbon in the brushes may be unsuitable, making a change of brushes necessary.

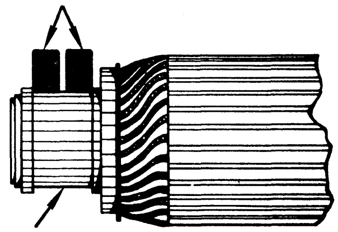


Figure 1-24. Worn Commutator

8. If the mica insulation between the commutator segments projects above the segments, it causes the brushes to spark (Figure 1-25). The mica should be undercut to eliminate this condition (Figure 1-26). The saw edge of the chute blade cleaner makes a satisfactory tool for cleaning between the commutator segments and for undercutting the mica. The commutator should be checked at least once every six months. Removing the brushes before the armature is removed from any motor or generator is advisable.

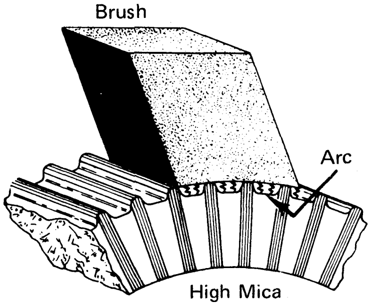


Figure 1-25. Commutator Improperly Undercut

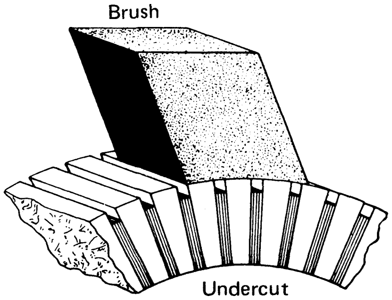


Figure 1-26. Commutator Properly Undercut

9. The armature may have open circuits or loose connections. This condition may be recognized by a bright spark that appears to pass completely around the commutator.

Two general kinds of sparking can be readily distinguished. One kind of sparking, due to bad adjustment of the brushes, a short circuit, open circuit, or ground in the armature, can be identified by the bluish color of the spark. This spark is small when the brushes are near the neutral plane, and increases in size and brilliancy as the brushes recede from the correct positions on the commutator.

Sparking due to a dirty commutator can be identified by the reddish color of the spark and a sputtering or hissing sound.

As the brushes wear, carbon dust accumulates inside the frame. The carbon dust causes internal shorts and grounds unless it is periodically removed.

Armature

The easiest method of checking for an open armature coil is by observation. If an armature has an open coil, a bright blue brush spark appears at the point where the open coil exists.

Speed and Voltage Adjustments

Universal or series wound motors normally wired for ac voltages run faster when used on a dc supply of the same voltage. This variation should be taken into consideration when replacing motors of this type or when changing the supply voltage from one type to the other. Motors of different voltage ratings are available to compensate for the changeover.

The speed of a shunt wound motor may be changed by varying a resistance wired in the field circuit. An increase in resistance causes an increase in speed. If an open circuit occurs in the speed control resistor circuit, the motor runs at extremely high speed.

Changing Polarity of Generator Fields

At times reversing the polarity of a generator may be necessary to make it conform to the polarity of the generator in an auxiliary machine. (A summary punch operation is an example.) When a summary punch machine and an accounting machine are connected together, the relays of both machines must operate with the same polarity for proper operation. Normally, generators are supplied from the factory with the proper polarity. The procedures outlined here may be used in the event repolarization is necessary.

1. Turn on the power to the machine and check the present polarity of the generator with a voltmeter. Turn power off.
2. Disconnect the F generator lead at the shunt resistor

terminal. Refer to the machine wiring diagram to determine where the generator leads terminate to the machine wiring.

3. Connect one wire to each of the positive and negative terminals of 40 volts dc from another machine which has power on. Momentarily connect these two wires to the F and L leads on the generator to be polarized.
4. Reconnect the F lead to the terminal it was originally connected to (step 1 above). Run the generator and check the polarity with a voltmeter. If the polarity is not changed, reverse the wires from the external 40-volt supply to the generator field windings. Repeat step 3. Recheck the polarity with the voltmeter.

Note: If no other 40-volt dc source is available, a 110-volt dc source may be used.

After completing steps 1 and 2, follow the diagrammed instructions in Figure 1-27. Connect the leads (indicated with arrows) to the F post and the L post on the generator. *Momentarily* plug into the 110-volt dc supply. Reconnect the F lead on the generator to the terminal from which it was removed in step 2. Turn on the machine and check the polarity. If the polarity has not been changed, repeat the procedure by removing the F leads from the machine post (step 2), reverse the leads (indicated with arrows), and again *momentarily* plug into the 110-volt dc supply. Recheck generator polarity.

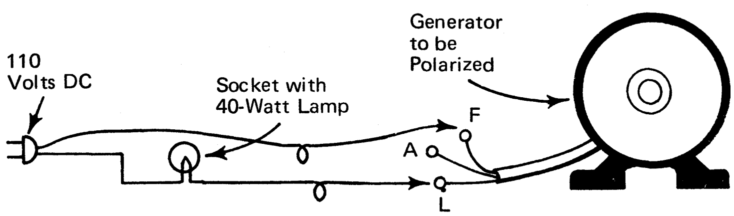


Figure 1-27. Temporary Wiring to Use 110 Volts DC for Polarization of a Generator

Corrective Methods Summary for dc Motors

Symptom	Possible Causes	Corrective Action
Fails to start	Blown fuse, mainline switch, motor plug, motor cord wires	Check each item and repair as required.
	No continuity between brushes and commutator	Check for: binding of brushes in holders, brush tension, broken brush leads, dirty commutator.
	Open speed control resistor Open armature or field winding	Check for continuity.
	Jammed motor or driven device	Uncouple driven device. Rotate motor and device.
Runs slow and/or overheats	Speed control resistor	Check resistance. Adjust.
	Brushes and commutator	Check for: binding of brushes in holders, arcing, dirty commutator.
	Mechanical overload	Uncouple motor and check.
	Shorted armature or field winding	Motor shop can test windings.
	Worn bearings	Check shaft for play.

Corrective Methods Summary for dc Generators

Symptom	Possible Causes	Corrective Action
No output	Open field resistor	Check continuity.
	No continuity between brushes and commutator	Check for: binding of brushes in holders, brush tension, broken brush leads, dirty commutator.
	Open field winding	Check continuity.
Low output	Voltage adjustment (field) resistor	Adjust.
	Brushes and commutator	Check for: binding of brushes in holders, arcing, dirty commutator.
	Shorted armature or field winding	Motor shop can check windings.
	Worn bearings	Check shaft for play.
	Incorrect generator speed	Check drive motor and belt or coupling.
Output has incorrect polarity	Residual field magnetism has reversed	Repolarize fields.

GENERAL INFORMATION

Engineering requirements and specifications are becoming increasingly more exact in regard to the relays used in IBM equipment. Relays must perform definite functions within specified time limits. In order that trouble-free operation may continue after machine installation in the field, these relay units must be properly maintained by customer engineers.

This section provides the customer engineer with a source of information about relays, their care, and adjustment.

Types of Relays

Several distinct types of relays are used in IBM machines:

1. Wire contact relays – relays using flexible wires as contacts.
2. Duo relays – relays using contact piles made of contact points on blued steel straps.
3. Reed relays – relays with contacts enclosed in small glass envelopes and with a coil wound around the envelope.
4. Heavy-duty relays – relays with contacts that are designed for heavy current requirements.
5. High-speed relays – relays designed specifically to operate at high speed, but not included in other categories.
6. Miscellaneous relays – all other relays that do not fall into the preceding categories.

Types of Contacts

Contact materials used in relays are determined by the type of service the relay is to give and by the following requirements.

1. The resistance of the contacts should be as low as possible.
2. The contacts should have the highest possible life expectancy.
3. The relays must be small and fast-acting.

Combining all of these requirements is not always possible. For example, when a circuit is broken, an arc occurs and the contact material is subjected to a temperature of about 3000° C. A circuit which is broken frequently, causes the contact material to vaporize and transfer to one or the other points. Polarity of the current determines which contact point receives the metal. The harder the contact material (tungsten for example), the less metal depositing occurs. Therefore, manufacturing all contact points from this material would seem advisable. Tungsten contacts, however, have the tendency to become coated with an oxide which can only be overcome by a high-pressure contact (which relays cannot apply) or an applied voltage of 70 volts or higher. The stability of tungsten as a contact material may be used in relays designed for operation in 110-volt circuits or in circuit breakers which create sufficient contact pressure to overcome the oxide coating.

Using silver as contact material reduces the contact resistance but introduces the disadvantage of being able to control only relatively light loads. The silver-coated wires in wire contact relays are not capable of making or breaking a circuit containing any appreciable current or inductance. The wires, however, may be a carrier of the circuit if the actual making or breaking of the circuit is controlled through a circuit breaker.

Relay Operating Speed

The operating speed of relays is affected by factors such as the number and type of contacts, the voltage and current available, the armature-to-core air gap, the contact air gap, and the contact strap tension. Shorting the hold coil of a relay slows the operating time by tending to resist any change in the condition of the magnetic field. By inserting a normally open point of the relay in series with the shorted hold coil, the dropout time is increased but the pickup time is not affected. With the pick coil energized, the shorted hold coil tends to prevent the magnetic field from collapsing when the circuit is opened. A rectifier can be used to produce the same effect.

Another form of delayed dropout is employed in relays used on alternating current. See the explanation of the shading coil under "Heavy Duty Relays."

The pick time of a relay may be accelerated within certain limits by special wiring. In the IBM 108, the hold coil of a relay is energized through a resistor. The resulting hold coil current is just below that required to pick the relay. As a result of such preenergization, a comparatively small change in magnetic field suffices to pick the relay. To maintain dependable operation, the pick impulse for a relay should be twice the specified pickup time. This is a 100% safety factor.

Resistor-capacitor (R/C) combinations, placed in parallel with relay and magnet coils, are for arc suppression. Without them, the inductive surge of a coil being deenergized can produce a destructive arc at the circuit breaker point or at the relay point that opens the circuit.

Two of the more common types of arc suppression used in IBM machines are shown in Figure 2-1. The R/C type is generally used where a fast decay of the magnetic field is necessary (fast dropout time). In

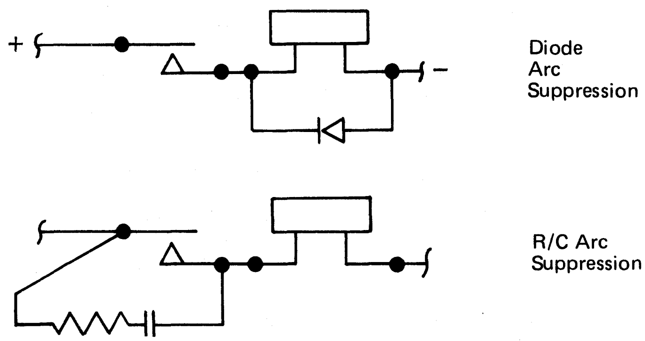


Figure 2-1. Relay Arc Suppression

NID	RPM	MS/ID
360°	60	2.777
360°	80	2.083
360°	100	1.666
360°	130	1.28
360°	150	1.111
360°	200	.833
360°	240	.694
360°	450	.37
360°	1000	.1666
360°	1200	.1388
14 pt.	100	42.85
16 pt.	75	50.00
16 pt.	100	37.50
16 pt.	120	31.25
16 pt.	150	25.00
16 pt.	450	8.34
16 pt.	650	5.77

Figure 2-2. Machine Speed-to-MS Conversion

applications where a delay in dropout time is not critical, a diode may be used.

The dynamic timer should be used wherever applicable to determine relay operating speeds and safety margin.

Relay operating time is commonly express in milliseconds. A millisecond is 1/1000 second (or .001 second) and is abbreviated ms. The formula for converting machine speed to milliseconds is as follows:

$$\frac{MS}{ID} = \frac{60{,}000}{RPM \times NID}$$

$\frac{MS}{ID}$ = milliseconds per index division

RPM = the speed at which the index turns. This is generally the machine speed in cards per minute.

NID = the number of divisions on the index. For most machines this is 360°, for others, it is either 14 or 16.

Figure 2-2 shows the conversion for some of the more common machine speeds.

WIRE CONTACT RELAYS

Description

The wire contact relay was developed to meet the need for a compact high-speed relay for use on 40 volts dc. The relay is available in 4, 6, and 12 position sizes. The 4-position size is available with single, double, and triple coils. Using transfer contacts provides a flexible capacity that eliminates the need for several different relay assemblies having various contact combinations. The relay is pluggable, employing a terminal molding connector that permits completion of wiring before the relays are installed in a machine. The unit is readily removable for inspection or replacement and does not require removing screws or wires. The wire contacts were not designed for circuit interruption, but the silver alloy now used can stand some arcing. Figure 2-3 illustrates the component parts of a 4-position non-latch relay.

Terminal Wiring

The relay contacts are numbered from left to right facing the yoke end (Figure 2-3). When a holding contact is required, contact 1 should be used. The common side of a wire contact relay coil is the side on which the high-numbered contact is located. When wiring into the terminal molding, take care to prevent excessive pressure that may result in cracking or breaking the terminal molding. The space between plugs in adjacent contact positions is sufficient when the plugs are inserted straight and not bent to one side. No more than two wires may be wired to each terminal.

Preventive Maintenance

CAUTION

When relays are removed from the machine, use relay puller tool 454065. Attach the tool to the relay and pull straight out. Do not move the tool and relay up and down or sideways during the pulling operation, as this causes damage to the relay terminal receptacle contact springs, which may result in intermittent circuit failure.

1. Examine the relay contact terminal prongs. They should be clean and in alignment with each other. They should also be positioned so that, when the relay is inserted in its receptacle, the prongs line up properly with the contact springs of the receptacle.

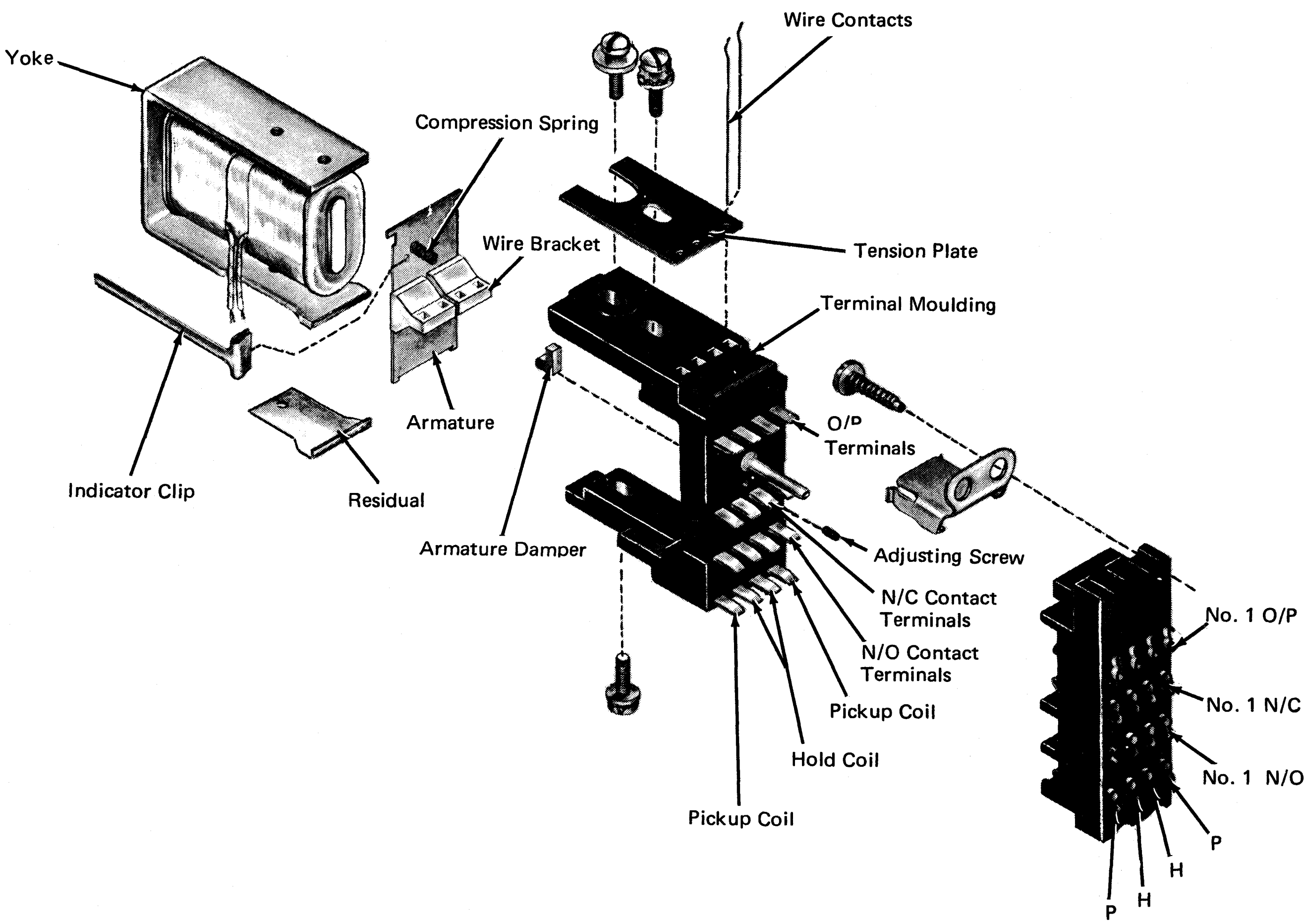


Figure 2-3. Wire Contact Relay

2. Examine the contact springs of the relay terminal receptacle on the machine. These springs must have sufficient tension to ensure good electrical contact. If they are burned, have lost their tension, or are badly bent, replace. Springs that are only slightly bent may be correctly formed by using tool part 450660 (Figure 2-7).
3. Clean burned points of a wire contact relay with a burnishing tool, part 450567, by forming a slight S curve in the tool. Pull the wires up so that they clear the contacts but are still in the wire bracket (Figure 2-4). The burnishing tool can now be moved back and forth between the stationary contacts (Figure 2-5). As the wires are pushed back into place, check each wire visually for signs of wear or burning. Replace wires in poor condition.
4. Check the wires periodically to determine if they are bent, burned, or pitted. A convenient method of checking for bent wires is to hold the relay up so that it is in line with a bright background such as a sunny sky or bright wall. By carefully sighting through the contacts (Figure 2-6) and moving the armature, bent wires can be quickly detected. Be careful to move the armature evenly by applying pressure on both sides.
5. Lubricate the pivot points and latching surfaces of latch-type relays periodically with small amounts of part 310960 Relay Oil. Frequency of lubrication depends on the amount of use, but should be at least once a year. *Do not over-lubricate.* Only small amounts of lubricant are necessary.

Adjustments

Wire contact relay adjustments are made at the factory and have been found to be very critical. Faulty relays should be replaced and not adjusted in the field.

To determine whether a relay is causing trouble or not, exchange the relay with one of the same type from within the machine, or replace temporarily with a new one. This is a better indication than attempting to check relay adjustments. If relays are exchanged, make certain that they are replaced in their original positions before you leave the machine. If a new relay is installed, number it according to the position in which it is installed.

If a replacement relay is not readily available the following service checks may be used to check a relay which appears to be in doubtful condition.

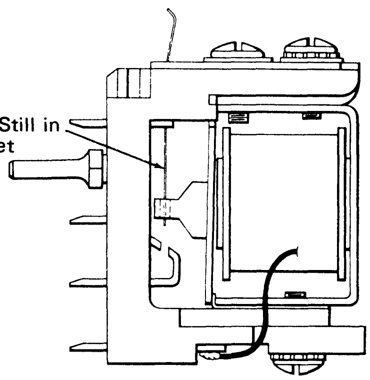


Figure 2-4. Checking Contacts

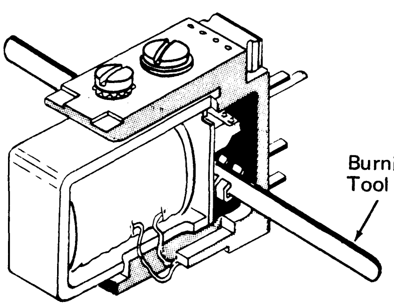


Figure 2-5. Cleaning Contacts

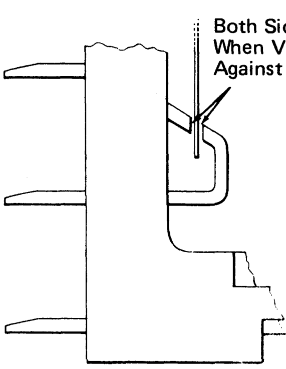
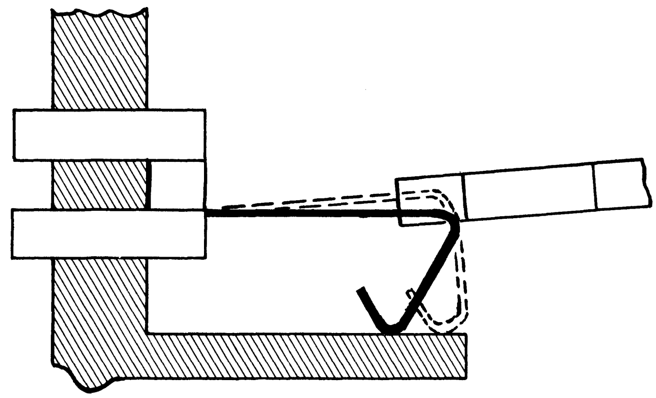


Figure 2-6. Checking Wires



●Figure 2-7. Contact Springs

Non-Latch Relays

1. Check to be sure the residual is flat against the face of the yoke (Figure 2-8). The residual must be kept flush at all times and should be checked whenever any adjustments are necessary on a relay.
2. Check for a clearance between the armature and the core with the armature attracted. Four- and six-position relays should have .004-inch clearance, and twelve-position relays should have .003-inch clearance (Figure 2-8). Form the armature at the center to obtain this clearance.

   Note: Relay part 226628 is adjusted for .0015-inch.
3. The contact air gap is machined to .025-inch ± .001-inch (Figure 2-8). Any attempt to change this gap results in an out-of-parallel condition, and may prevent proper contact with the wires. Clean the contact air gap as described in "Preventive Maintenance."
4. Adjust the magnet yoke assembly (Figure 2-9) so that with a .010-inch thickness gage between the armature and yoke at the free end of the armature and the armature attracted, all contact wires make contact on the normally open side. With a .015-inch gage between armature and yoke and the armature attracted, none of the wires are to make contact on the normally open side. This adjustment is obtained by shifting the yoke assembly at the lower end sufficiently so that the wire holder adjustment does not change. If it is necessary to loosen the entire yoke to correct an out-of-parallel condition, the wire holder must be repositioned for proper wire tension. Be sure the residual remains in the proper position.

   Note: When the magnet yoke is being adjusted, the contact tension plate holding screws may have to be loosened. The proper make of the wires depends on contact tension. Therefore, adjustments 4 and 5 should be made together.

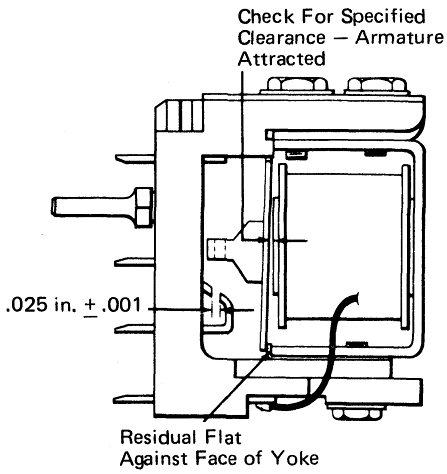


Figure 2-8. Armature Air Gap

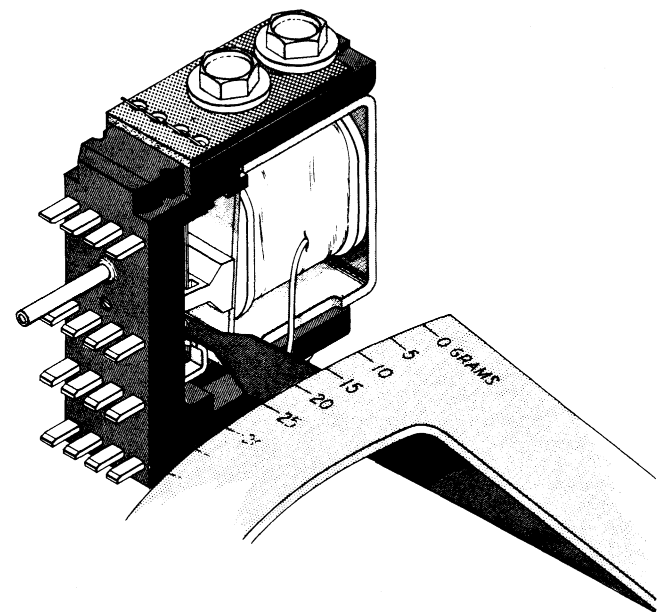


Figure 2-10. Contact Wire Tension

5. Adjust tension on the contact wires (Figure 2-10) by shifting the wire holder so that a 50-gram pressure applied at the center of the free end of the armature just moves the wires away from the contacts on the normally closed side. The 6- and 12-position relays require a 70- and a 130-gram pressure.
6. The damper screw is adjusted at the factory for minimum armature release bounce and the specified operate time. The relays must have a minimum of .003-inch clearance between the damper and the wire bracket. When this clearance is being measured, the wire bracket must be against the wires but must not move them (Figure 2-11).

   Note: The damper on relay part 226628 is adjusted so that either the number 1 or the number 4 N/C contact just breaks.

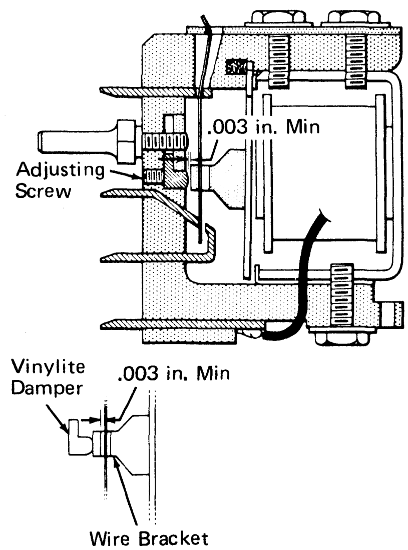


Figure 2-11. Damper Position

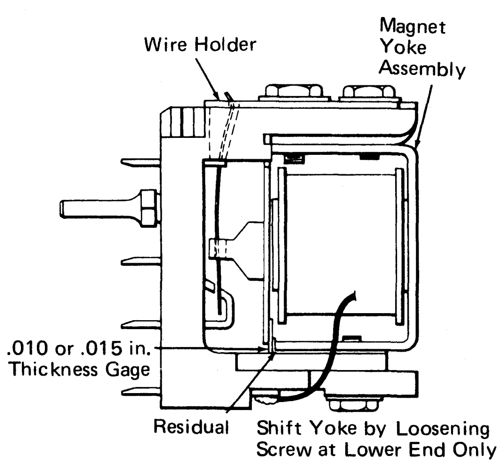


Figure 2-9. Yoke Position

Latch Relays

1. With the relay coil energized, .003-inch to .005-inch latching clearance should exist between the relay armature and the latch at the point of latching. Add or remove shims (part 214459–.003-inch or part 344519–.002-inch) between the relay yoke and the latch magnet yoke as required (Figure 2-12).

2. With the latch magnet energized, the latch armature should clear the relay armature by .005- to .010-inch at the latch point. At the same time, check for a minimum clearance of .005-inch between the bottom of the latch armature and the relay molding. No interference should exist with the movement of the latch armature at this point. If any change is necessary, form the latch armature at point A (Figure 2-13).

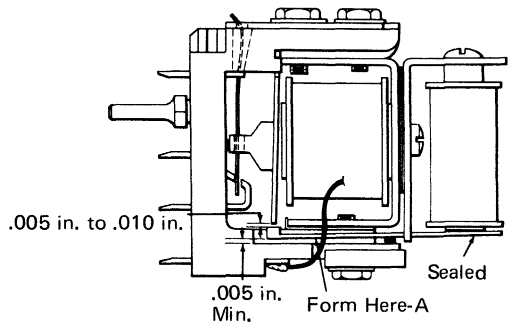


Figure 2-13. Unlatching Clearance

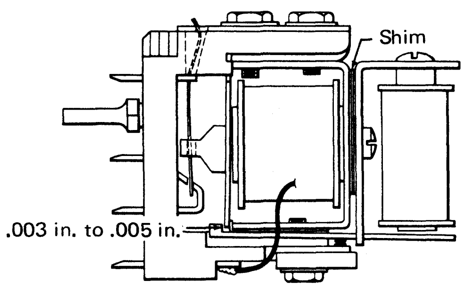


Figure 2-12. Latching Clearance

Wire Contact Relay Characteristics Chart

The charts in Figure 2-14 show the characteristics of most wire contact relays used in IBM machines. The relays are listed by part number.

Size	Relay Part	Coil Part Clamped Connections	Coil Part Soldered Connections	Coil	Resistance	Pick Time ms-max	Dropout Time ms-max	Coil Connections A-Side	Coil Connections B-Side	Voltage
4	104753	344549	228881	HSPU HOLD	424 865	4.0 7.6	2.2 2.0	bl grn	bl grn	48 48
4	186696	770094 770095	186693 186699 186259	HSPU HSPU HOLD	560 234 770	4.8 4.4 9.8	2.7 3.4 2.8	wh wh wh	bl bl grn	48 48 48
4	196206	344540	198881	PU	720	5.2	2.4	wh	blk	48
4	196207	344543	198884	PU PU	624 622	4.9 5.2	4.1 4.2	blk ye	blk ye	48 48
4	196208	344502	198887	PU HRH	624 1735	5.1	3.7 3.0	blk red	blk red	48 48
4	226628	770097	344535 344537	HSPU HOLD	234 770	2.5 6.5	4.5 4.5	wh wh	bl grn	48 48
4	327218	as 196207 except with 2 Gold and 2 Silver Contacts								
4	333242	770004	333245	HRPU	7250	6.5	5.0	wh	blk	100
4	360670	as 196208 except with 4 Gold Contacts								
4	518128	770005	518129	PU	220			wh	blk	8
4	769003	769000		PU	175	6.0	5.0	wh	bl	20
4	769041	as 104753 except with 4 Gold Contacts								
4	769052	769051		HSPU	350	4.0	5.0	wh	bl	20
4	770000	as 196206 except with 4 Gold Contacts								
4	770009	770007		HSPU	100	4.0	5.0	wh	bl	20
4	770011	as 196208								
4	196247	344532 770016	186249 249337	PU PU LT	400 410 332	5.2 5.3	 4.1	blk ye wh	blk ye ye	48 48 48
4	186685	344539 344538	186708 249337	PU LT	395 332	5.2	 3.8	wh wh	blk ye	48 48
4	239188	344532 770016	186249 249337	PU PU LT	400 410 332	6.0 5.7	 3.6	blk ye wh	blk ye ye	48 48 48
4	333243	770004 344538	 249337	HRPU LT	7250 332	9.0	 3.7	wh wh	blk ye	100 48
4	769055	769054 769053		PU LT	170 130	6.0	 5.0	wh wh	blk ye	20 20
4	769056	as 186685 except with 4 Gold Contacts								
4	770012	as 186685								
6	107558	770006	107559	HSPU	216	4.2	4.1	wh	bl	48
6	107560	344530	107566	HSPU HOLD	261 578	4.7 6.6	4.2 3.3	bl grn	bl grn	48 48
6	196196	344541	198882	PU	622	5.5	3.6	wh	blk	48
6	196197	344544	198885	PU PU	622 695	6.1 6.4	3.2 3.2	blk ye	blk ye	48 48

Figure 2-14. Wire Contact Relay Characteristic Chart (Part 1 of 2)

Size	Relay Part	Coil Part Clamped Connections	Coil Part Soldered Connections	Coil	Resistance	Pick Time ms-max	Dropout Time ms-max	Coil Connections A-Side	Coil Connections B-Side	Voltage
6	196198	344547	198888	PU HRH	622 1080	5.7 7.0	3.9 3.3	blk red	blk red	48 48
6	257113	770002	257112	HSPU HRH	388 1120	4.5 9.8	3.9 3.2	 red	 red	 48
6	257659	770003	257658	HSPU HRH	247 1080	4.7 7.0	4.2 3.3	bl red	bl red	48 48
6	327216	as 196198 except with 3 Gold and 3 Silver Contacts								
6	327217	as 196197 except with 3 Gold and 3 Silver Contacts								
6	360675	as 196198 except with 6 Gold Contacts								
6	765210	344534		HSPU	310	4.5	4.0	wh	blk	48
6	765336	as 770015 except with 6 Gold Contacts								
6	769004	769001		PU	150	6.0	5.0	wh	bl	20
6	769021			PU	6250	8.0	5.0	wh	blk	100
6	769044	as 107560 except with 6 Gold Contacts								
6	770001	as 196196 except with 6 Gold Contacts								
6	770010	as 196198								
6	770015	770014		HSPU	80	4.5	5.0	wh	bl	20
6	770026	as 107560								
6	770027	as 196198								
6	770046	as 765210 except with 6 Gold Contacts								
6	186686	344534 344538	 249337	HSPU LT	310 332	5.3	 5.8	 wh	 ye	48 48
6	769038	770014 344538		HSPU LT	80 332	6.0	 5.8	wh wh	bl ye	30 48
	6 Gold Contacts									
12	107556	344529	107557	HSPU	205	4.7	5.3	wh	bl	48
12	108388	344531	108389	HSPU HOLD	157 613	4.5	4.5 3.1	bl grn	bl grn	48 48
12	196186	344542	198883	PU	395	5.9	3.2	wh	blk	48
12	196187	344545	198886	PU PU	395 411	6.0 6.0	3.0 3.0	blk ye	blk ye	48 48
12	196188		198889	PU HRH	390 870	5.5	 3.3	blk red	blk red	48 48
12	255735	344552	255644	PU HRH	395 600	6.3	3.1 2.5	blk red	blk red	48 48
12	327214	as 255735 except with 6 Gold and 6 Silver Contacts								
12	327215	as 196187 except with 6 Gold and 6 Silver Contacts								
12	338393	as 255735 except with 1 Gold and 11 Silver Contacts								
12	344554	as 255735 except with 12 Gold Contacts								
12	360679	as 196187 except with 12 Gold Contacts								
12	360680	as 196186 except with 12 Gold Contacts								
12	769005	769002		PU	104	4.5	5.0	wh	blk	20
12	769050	769049		PU	4400	10.0	4.0	wh	blk	100

Figure 2-14. Wire Contact Relay Characteristic Chart (Part 2 of 2)

PERMISSIVE MAKE RELAYS

Description

The permissive make (PM) relay is a fast working multiple-transfer contact relay capable of higher speeds and higher work load capacities. See Figure 2-15 for the components of a six-position relay.

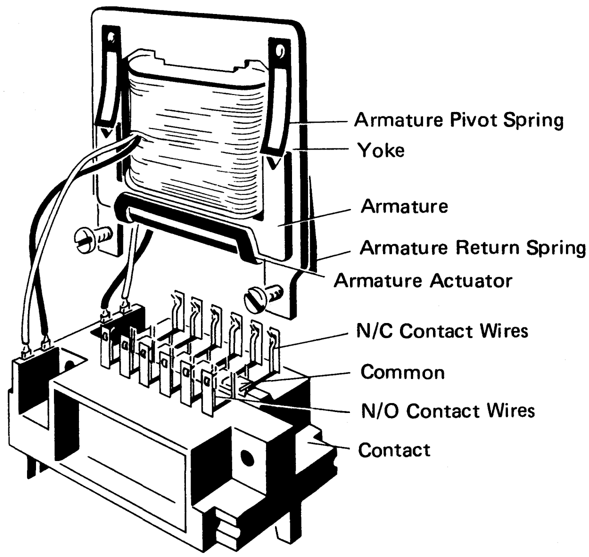


Figure 2-15. Permissive Make Relay

The special construction of these relays makes possible a relay which picks in approximately half the time needed for a normal wire contact relay and with practically no rebound. These characteristics make the PM relay especially valuable in electronic circuits.

The principles of operation involved in the PM relays made it necessary to abandon the usual method of construction whereby the movable point in a transfer contact was moved by armature movement from the N/C to the N/O point. Each transfer point in a PM relay consists of two separate U-shaped wires which are under tension. Figure 2-16 illustrates the position of the wires when the relay is in a normal or deenergized condition. Note that the wires are not connected to each other or the armature. This makes it possible to maintain contact pressure independent of the armature movement. The

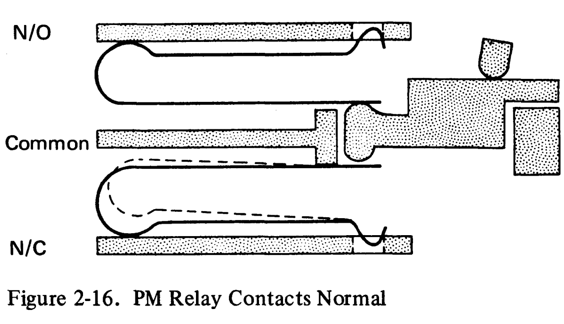


Figure 2-16. PM Relay Contacts Normal

tension of the contact wire is the only requirement for satisfactory contact. The armature remains in the normal (N/C) position as a result of tension from the armature return spring holding it away from the yoke. By means of their own tension the N/C contact wires are pressed on the common contact. When the relay is picked, the armature moves in the direction towards the yoke (Figure 2-17). The N/C wires are forced by the armature actuator away from the common contact at the same time the N/O wires, through their own tension, follow the armature and make contact on the common. This

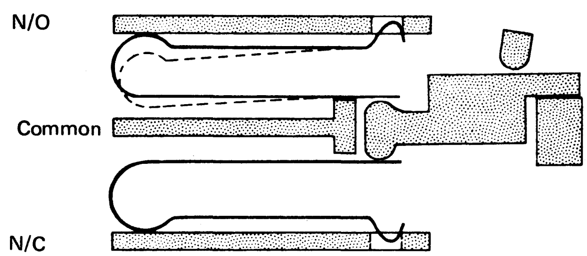


Figure 2-17. PM Relay Contacts—Operated

construction minimizes the bouncing of the contact because the wires are permitted to make contact as a result of their own tension and not as a result of direct armature action as is done in wire contact relays. Also, contact make is not subject to variations in speed of the armature (high-speed photographs have shown the armature completes its travel before the contact wires start to move) and each contact make is of uniform characteristics.

At the time of manufacture, the core is undercut to provide approximately .003-inch between the armature and core; therefore, no residual is necessary (Figure 2-18).

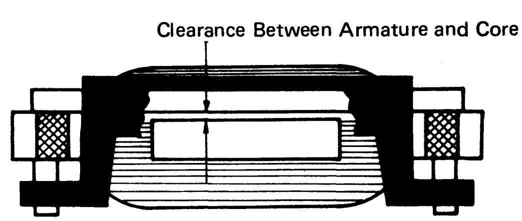


Figure 2-18. PM Relay Armature and Core

PM relays are presently being manufactured in 4- and 6-position sizes. The arrangement of contact terminals for the 4- and 6-position PM relays is shown in Figure 2-19. Note that the contacts are positioned in such a way that only the correct relay may be inserted.

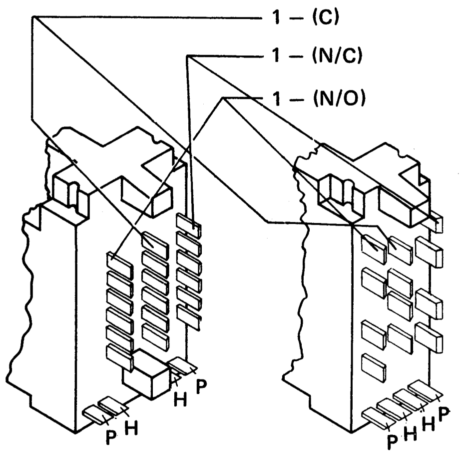


Figure 2-19. PM Relay Moldings

Adjustments

PM relays have a few but extremely important adjustments. The tension of the armature return springs is adjusted to 65, +11 –2, grams for the 4-point relay and at 85, +11 –2, grams for the 6-point relay (Figure 2-20). Armature tension in conjunction with contact wire tension determines the pick time of the relay; therefore, this adjustment should be performed carefully and held to the tolerances given.

New wires should be checked for proper adjustment. Wires should be formed using Figure 2-21 as a guide.

To remove a wire, a scriber point, tool part 451907, or pointed instrument may be inserted in the loop end of the contact wire and the wire lifted from the molding (Figure 2-22). When the wire has been removed, the common contact can be seen more clearly. The tip of tool part 451907 may be used to burnish a dirty or corroded common contact. *Do not attempt to clean a burned or pitted stationary contact as this results in an increased air gap and a loss of contact tension.*

To replace wires, disassembling the relay is not necessary if the special tool part 451907 is available. Insert the wires until they strike the stationary contact, as shown in Figure 2-23. Then insert the tool under the straight portion of the wire and push into position as shown in Figure 2-24.

4-Point 65 +11 -2 Gram
6-Point 85 +11 -2 Gram

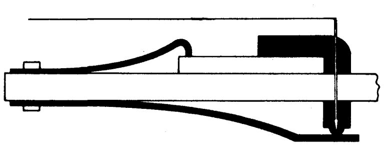
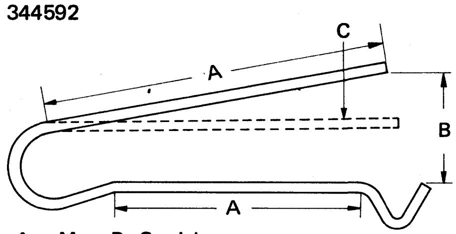


Figure 2-20. Armature Tension

Part 344592



A – Must Be Straight
B – 0.25 in.
C – 10 ± 1 Gram

Figure 2-21. Contact Wire

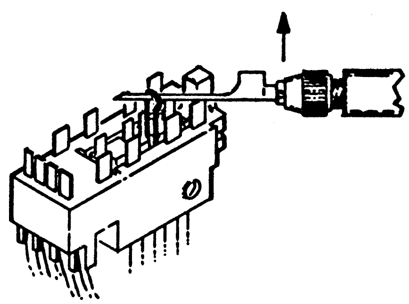


Figure 2-22. Removing Contact Wire

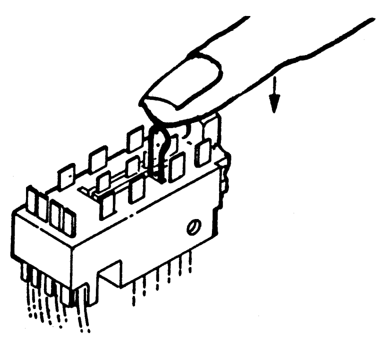


Figure 2-23. Replacing Contact Wire

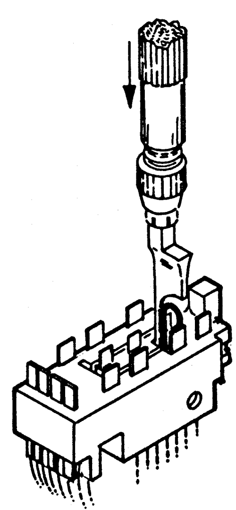


Figure 2-24. Positioning Contact Wire

To replace wires when tool part 451907 is not available it is advisable to disassemble the relay. To disassemble the relay, remove both yoke fastening screws and pull the contact block away from the yoke (Figure 2-25). The contact wires and common contacts are now exposed.

Note: Use care in handling the relay to prevent damage to the coil leads.

To remove the wires from a disassembled relay, push the contact wires out through the guide slits (Figure 2-26).

The common contact should be checked for dirt or corrosion (Figure 2-27). A dirty or corroded common contact may be burnished lightly with the burnishing blade (part 450567). *Do not attempt to clean a common contact which is pitted or burned as this results in an increased air gap and loss of contact tension.*

Note: The tip of tool part 451907 may also be used to burnish the common contact. Insert the new contact wires singly so that they do not turn or twist in the guide slits (Figure 2-28).

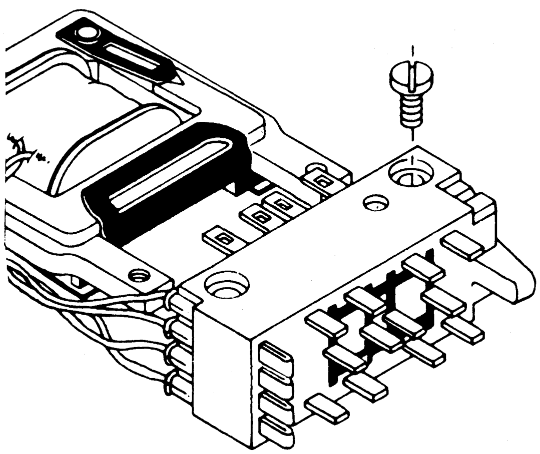


Figure 2-25. Disassembling Relay

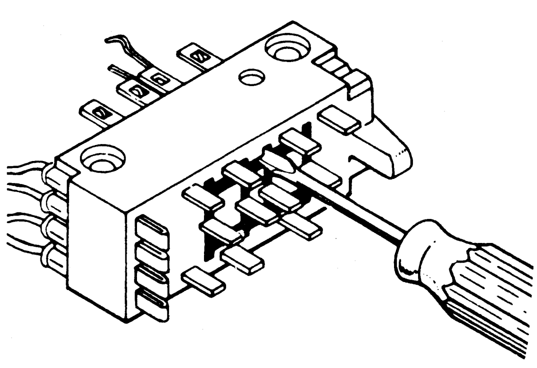


Figure 2-26. Removing Contact Wire

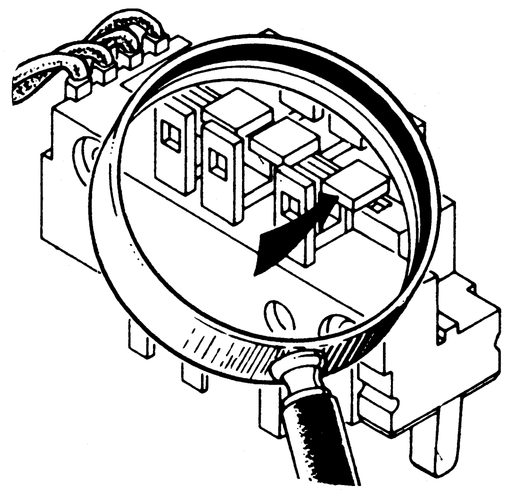


Figure 2-27. Checking Common Contact

When reassembling the relays, the armature must be centered exactly between the contacts at A, so the resultant force exerted by the armature is evenly distributed (Figure 2-29). Also apply sufficient pressure to the yoke and contact molding to ensure that the yoke is fully seated on the molding (Figure 2-29). No clearance should be between the tips of the yoke and the molding pads at B (Figure 2-29).

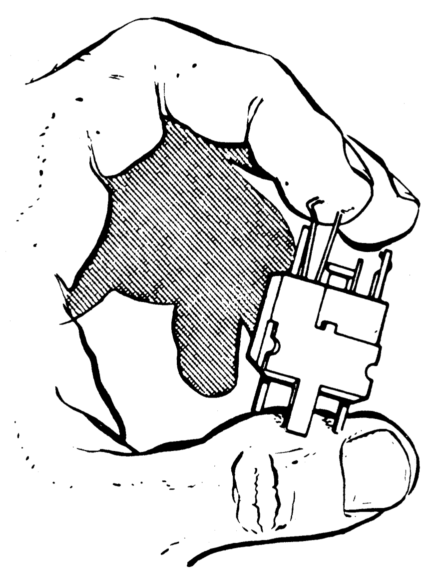


Figure 2-28. Replacing Contact Wires

PM relays must be handled very carefully. In view of the short distance of travel of the armature, which is one of the requirements for fast operating speed, any dust or foreign material between the armature and yoke causes contact errors (Figure 2-30). To minimize the

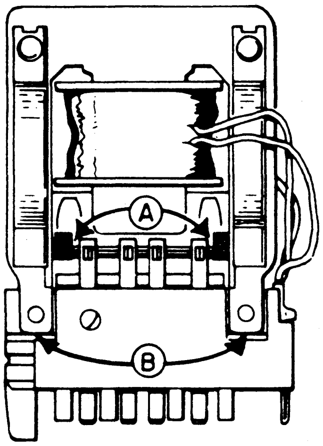


Figure 2-29. Reassembly

possibility of any contamination during storage, relays are encased in plastic. The container should not be removed or opened until the relay is to be put into service. Every relay in a machine is provided with a dust cover (part 609255), which should prevent dust from falling between the armature and the yoke.

The possibility of a cracked or broken PM relay socket molding should not be overlooked in the event trouble is experienced in an individual position and a temporary replacement of the relay on that position does not remedy the trouble. See Figure 2-31 for molding contact arrangement and part numbers.

Cracks may appear in the plastic actuator (Figure 2-32). Those which occur between the portion indicated by Xs will cause no trouble. Cracks that occur in the portion formed around the armature (indicated by the arrows) are possible sources of trouble and the relay should be replaced.

The coils on some relays may loosen on the core making it possible for the coil to move into a position where it can interfere with armature movement. An approved adhesive should be applied to the core and the coil then brought back to its normal position where it can be held by the adhesive.

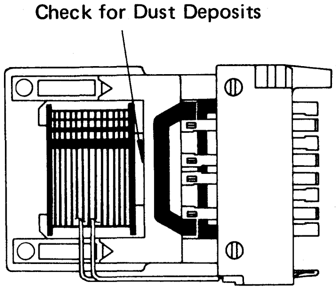


Figure 2-30. Dust Deposits

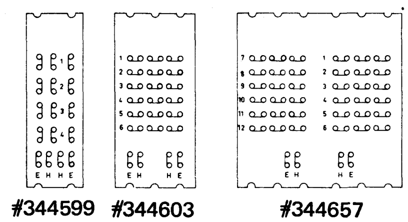


Figure 2-31. Moldings

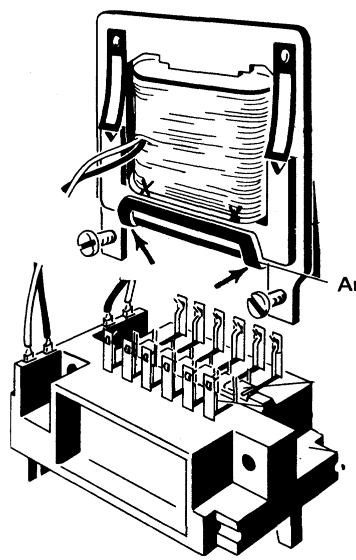


Figure 2-32. Defective Armature

Permissive Make Relay Characteristics Chart

The chart in Figure 2-33 shows the characteristics of most permissive make relays used in IBM machines. The relays are listed by part number.

Size	Relay Part	Coil Part	Coil	Resistance	Pick Time ms-max	Dropout Time ms-max	Coil Connection Color	Voltage
4	311712	311708	PU HRH	680 1300	3.2 5.0	2.5 2.5	black red	48
4	311713	311709	HSPU HRH	400 1300	2.5 5.0	2.5 2.5	blue red	48 48
4	344600	344580	PU HOLD	680 700	3.2 3.3	2.5 2.5	black green	48
4	344601	344581	HSPU HOLD	400 700	2.5 3.3	2.5 2.5	blue green	48
4	369775	311709	HSPU HRH	400 1300	2.5 5.0	2.5 2.5	blue red	48
4	719003	719009	HSPU HOLD	70 700	2.5 3.3	2.5 2.5	blue green	20 48
4	719005	719010	PU HOLD	126 700	3.2 3.3	2.5 2.5	black green	20 48
4	765030	765028	HSPU HRH	400 1300	2.5 5.0	2.5 2.5	blue red	48
6	311714	311710	PU HRH	600 1000	3.2 5.0	2.5 2.5	black red	48
6	311715	311711	HSPU HRH	360 1000	2.5 5.0	2.5 2.5	blue red	48
6	344620	344616	PU HOLD	600 600	3.2 3.3	2.5 2.5	black green	48
6	344621	344617	HSPU HOLD	360 600	2.5 3.3	2.5 2.5	blue green	48
6	369776	311711	HSPU HRH	360 1000	2.5 5.0	2.5 2.5	blue red	48
6	719007	719011	PU HOLD	105 600	3.2 3.3	2.5 2.5	black green	20 48
6	765031	765029	HSPU HRH	360 1100	2.5 5.5	2.5 2.5	blue red	48

Figure 2-33. Permissive Make Relay Characteristic Chart

DUO RELAYS

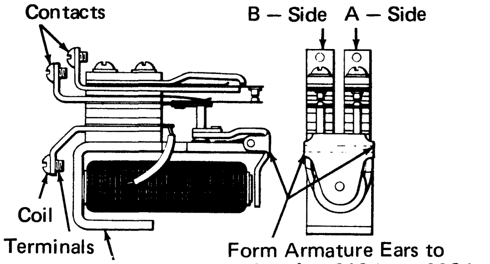
Description

The duo relay provides simultaneous control over several different circuits. It is used over a wide range of operating speeds and contact point combinations in most IBM machines. There are short and long frame relays; also one- and two-core relays. Various combinations of coils and contact points provide relays of large or small current capacity, slow or fast pickup speed, and slow or fast dropout speed. Suitable circuit combinations and relay designs may provide for delayed action in either the pickup or dropout time of these relays. Figure 2-34 illustrates several types of duo relays.

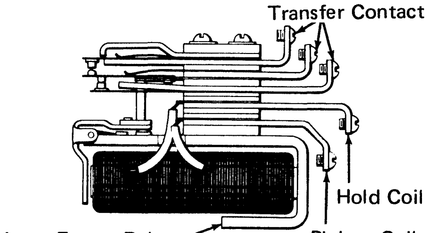
Preventive Maintenance

Before adjusting any duo relay, a visual check should be made of the following items.

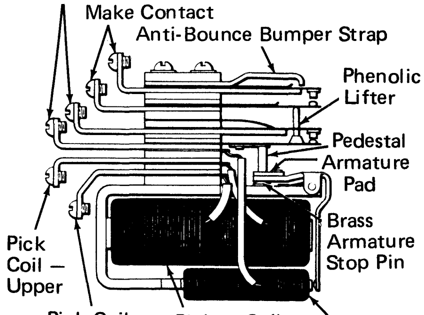
1. The core should be firmly secured to the frame.
2. The contact points should not be loose or burned. Contact points which are loosely held to the strap may cause bouncing and poor contact.
3. All contact points should be aligned vertically and horizontally, so that all points utilize the greatest contact area both in deenergized and energized positions.
4. The contact pile holding screws should be tight.
5. The contact points should be clean.
   a. If excessive oily dust has collected, remove by



A. Single Coil Duo Relay – Single Core



B. Two Coil Duo Relay – Single Core



C. Three Coil Duo Relay – Double Core

Figure 2-34. Typical Duo Relays

moistening and flushing out with IBM solvent. This should only be done on extremely dirty relays. Any relays below those being cleaned should be protected from the dirty solvent. The IBM solvent should be placed in a small container such as an accounting machine ribbon box and replaced when it becomes dirty. Dirty solvent does more harm than good. Use a clean brush. Remove any remaining solvent film with a burnishing tool.

b. A burned surface deposit on silver contact points can be removed with a good quality contact file followed by the use of a burnishing tool. Do NOT use a flexstone on silver points. A burned tungsten point can be cleaned with a flexstone followed by the use of a burnishing tool. Wipe the contact surfaces with a clean cloth.

6. Remove and check the armature. Check for a worn or sticking armature. The pivot pin must turn freely in the armature ears. Any armature movement lost due to worn armature pivots is multiplied in the amount of rise and causes lost wipe. Saturate a pipe cleaner with light oil and draw it through the pivot holes in the armature to remove the foreign matter and lubricate the pivot points.
7. The armature should be clean. Remove foreign particles between armatures and magnet core; armature and brass stop pin.
8. The armature should be lubricated. Lubricate the armature pad with a *small* amount of light oil at the point where the contact pedestals rest on the pad. This prevents wearing the pad and accumulating reddish dust as this point (Figure 2-34).

Adjustments

General

The function of a relay is the dependable opening and closing of circuits within given time limits. Proper adjustment is as important as proper design for successful relay operation.

There are two basically different kinds of duo relay groups. The older style uses a cadmium-plated armature with a copper residual pin (Figure 2-35). This residual provides a break in the magnetic path. Without this break, the relays may hang up or drop out slowly due to residual magnetism.

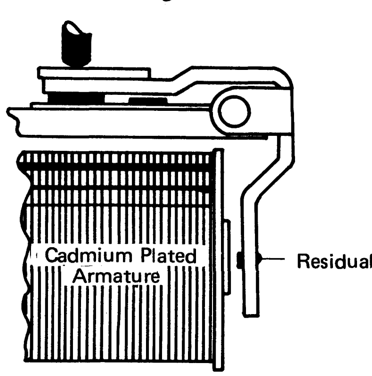


Figure 2-35. Residual Type Armature

Later style relays use copper-plated armatures with no residual pin. These relays are assembled with a brass screw and washer at mounting end of the coil (Figure 2-36). The washer provides the break in the magnetic path necessary to prevent hang up or slow drop out. The copper plating on the armature is to reduce red rust (fretting corrosion) at the pivot that causes the pivot pin to freeze to the armature. This new style also eliminates the problem of armature travel changing due to flattening of the residual pin. *Never replace the cadmium-plated armature that has a residual with the copper-plated armature unless a brass washer and screw are also used to mount the coil.*

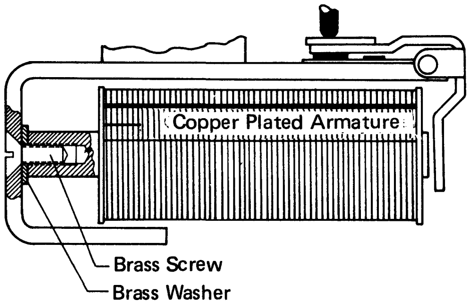


Figure 2-36. Copper Plated Armature

Maintaining specified air-gap dimensions is of utmost importance. Any deviation from this specified gap affects pickup and dropout time. Variations in these adjustments may improve operation on one application but may cause failures on another; for example, decreasing the air gap decreases the pickup time but also increases the dropout time.

A specific air-gap dimension is determined for proper operation on all applications for which a relay is selected to operate. Air-gap dimensions are shown in Figure 2-49 under "Armature Air Gap." These dimensions apply to armatures with or without residuals.

Proper contact strap tension is essential to dependable relay operation. This tension is measured in terms of grams by applying a gram gage to each contact strap. Figure 2-37 illustrates the various types of relay contacts. The individual straps of these contacts are labeled by the letters C, E. D, and F. The gram gage is to be applied to the contact strap at the point of contact in the opposite direction to the normal spring tension as indicated in Figure 2-37.

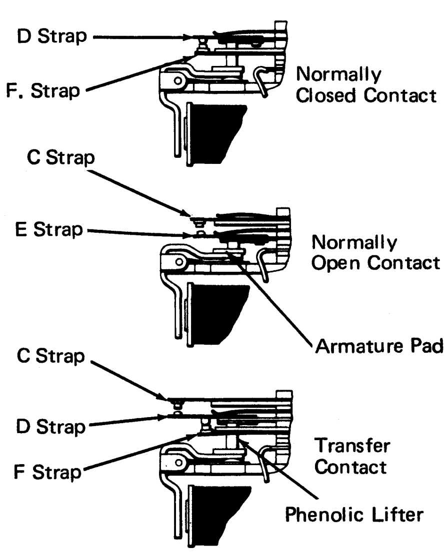


Figure 2-37. Contact Strap Tension

Most relay contact points are made of solid silver; some are made of tungsten. Silver points are usually used where the pressure is light, and the point is not breaking a heavy current. Tungsten points are usually used where the pressure is heavy, and the point is breaking a heavy current.

Silver points tarnish and appear black and dirty; however, this tarnish is conductive and should not cause trouble.

Maximum current and voltage capacities for duo relay contact points are five amperes at 130 volts.

Contacts are mounted on these relays in two piles, right and left. When facing the armature, those on the left side are designated A; upper and lower, AU and AL. Those on the right are known as B; upper and lower, BU and BL.

The term "seal" is used to describe the position of the armature in fully energized position with the armature or residual pin touching the core. Relays using 40-volt coils should not require more than 25 volts to seal. Relays using 110-volt coils should not require more than 80 volts to seal.

The coils of two-coil relays must be of the same polarity, except for the coils of relay number 159758, which have unlike polarity. The latter is used in the IBM 803 Proof Machine.

Three-coil relays must be checked for like polarity of the coils on the upper core. The coil on the lower core must be unlike polarity, relative to the upper coils. To check polarity, a small permanent bar magnet may be effectively used in determining like and unlike polarity between relay coils by the comparison method. Remove armature from relay and energize one coil. Hold bar magnet to core face. It should either attract or repel. Deenergize first coil and repeat same operation on coils 2 and 3. By holding same pole of bar magnet to core, the action (attraction or repulsion) may be compared to action when first coil was energized, thus permitting a determination of like and unlike polarity.

Procedure

1. Remove any burrs on the pivot pin or armature ears. Adjust the ears by forming to provide .005-inch to .015-inch end play. Be sure there are no binds (Figure 2-34A).
2. Form the armature so that when held in attracted position, the armature and core face are parallel (Figure 2-38).
3. On relays with armatures containing residuals, check for .003-inch to .010-inch projection of the residual by inserting the proper thickness gage between the fully-attracted armature and core on each side of the residual pin. In all cases, a .003-inch gage should be free, and a .010-inch gage should not go (Figure 2-39).

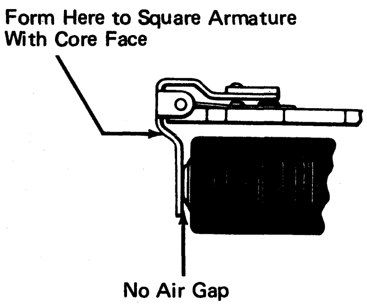


Figure 2-38. Armature Squareness

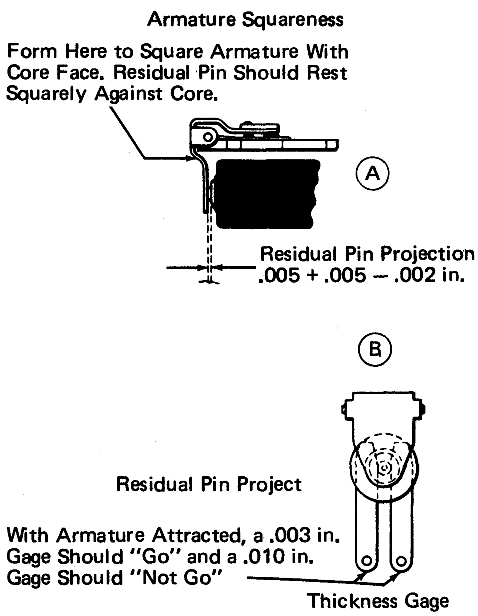


Figure 2-39. Residual Pin Projection

4. With the armature in the fully deenergized position, insert the specified thickness gage completely through the core face to measure the gap. To adjust, form the armature at the point indicated in the illustration (Figure 2-40). The armature air-gap dimensions for double-core relays are measured between the armature and the lower core. Also, with the armature attracted, there should be .003-inch to .005-inch

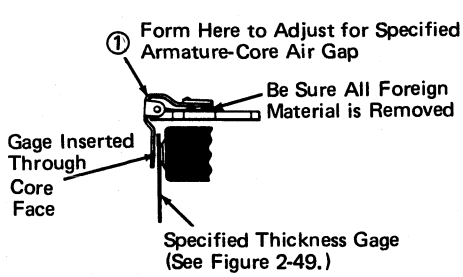


Figure 2-40. Armature Air-Gap Single Coil

clearance between the armature and the upper core (Figure 2-41).

Note: Armature air gap dimensions are specified in Figure 2-49.

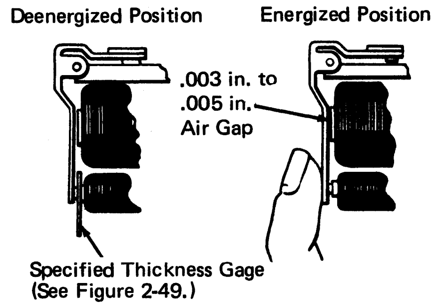


Figure 2-41. Armature Air-Gap Double Coil

5. Adjust the contact straps by forming so that they conform to the tensions in Figure 2-42 when pressure is applied to the point of electrical contact (Figure 2-43).
   a. When adjusting, be sure no other strap is influencing the adjustment.
   b. When the tension in column 1 is applied, the contact strap should not move.
   c. When the tension in column 2 is applied, the contact strap should move.

      Example: With the normally closed contact strap held away from the transfer contact strap and pressure applied with the gram gage to the point of electrical contact on the C-strap, the strap should not move with 17 grams applied but should move with 45 grams applied (Figure 2-43).
6. Contact air gap is adjusted as follows:
   a. Choose the proper thickness gage as specified in Figure 2-44.
   b. Insert the gage between the back of the armature and the brass armature stop pin. Allow the

	Tension in Grams	
Strap	1	2
C	17	*45
D	24	44
E	13	21
F	15	**

*Tension 2 must be 29 grams for relays number 121837, 122499, and 142368.
**No tension need be noted. When the relay is operated by hand, the pedestal should not rise off of the armature pad.

Figure 2-42. Contact Strap Tension Table

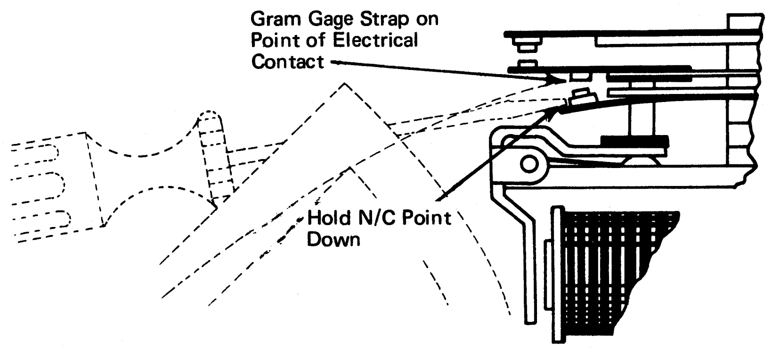


Figure 2-43. Contact Strap Tension

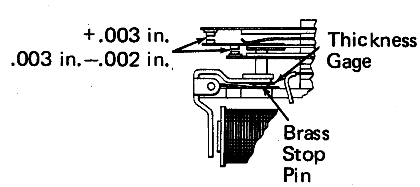
armature to rest freely on the gage and hold the gage in place.

c. The contact air gap should be .003-inch + .003-inch, – .002-inch (Figure 2-44).

Note: Adjustment 6 may change the adjustment made in 5. Adjustment 5 should be checked after 6 has been made.

Example: If the relay being adjusted is part 121877 (armature air gap of .017-inch, a normally open A-point, and a transfer B-point), place a .005-inch thickness gage between the armature and the brass stop pin, and check the normally open A-point for .001-inch to .006-inch clearance. Then place a .007-inch feeler gage between the armature and the brass stop stud and check the transfer B-points for .001-inch to .006-inch clearance.

7. Adjust bumper straps so that contact strap C just touches bumper with the armature in the fully attracted position. All C contact straps (upper) of relays having a pickup time of 10 ms or less are equipped with these bumper straps (Figure 2-45).



Contact Air Gap Table

	Armature Air Gap	.013 in.	.017 in.	.021 in.	.025 in.
Type of Points	Transfer Contact	.005 in.	.007 in.	.009 in.	.011 in.
	Normally Open Contact	.004 in.	.005 in.	.005 in.	.006 in.
	Normally Closed Contact	.007 in.	.010 in.	.014 in.	.018 in.

Figure 2-44. Adjusting Contact Air-Gap

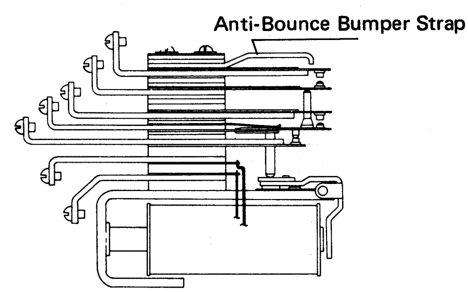


Figure 2-45. Bumper Strap

Thermal Delay Type Relay

An interval of time must be allowed for the cathodes of vacuum tubes to warm up before the machine is placed in operation. This time delay or warm-up is effected by a thermal delay relay.

One contact strap of this relay is made of two strips of metal placed one on top of the other and bonded together. These two metals expand at different rates when heated. A coil of high-resistance wire wound around the strap is the heating element. The greater expansion of the lower strip of metal causes the bimetal strap to bend upward until it makes contact with another point. This second point is in the form of a screw tipped with contact metal. This screw provides a means of varying the time interval required for the relay to be energized (Figure 2-46). The distance between the contact points determines the time required for energization. If more time is desired, increase the air gap by backing off the screw; if less time is desired, decrease the air gap by turning in the screw. The lock nut locks the upper point in position to maintain the adjustment. The adjusting screw is normally set to provide 50 seconds delay with a tolerance of plus 10 seconds, minus 5 seconds. Use .095-inch as a starting point when making this adjustment. This time is applicable when starting with a cold machine. If, when this relay is being adjusted, the machine is turned on and off several times, the temperature of the heat unit has a cumulative effect,

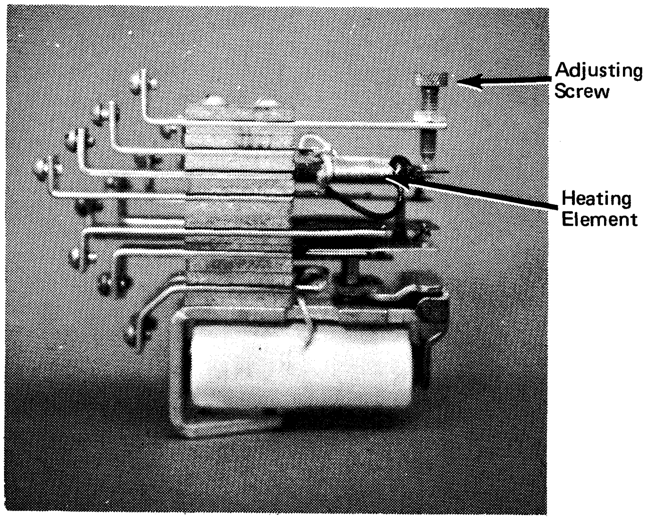


Figure 2-46. Thermal Delay (TD) Relay

and the time required for pickup decreases.

Thermal relays can be identified in Figure 2-49 letters TD in the column labeled "Max. Time."

Three-Coil Relays

There are two types of three-coil relays (Figure 2-47).

1. Type 1 has a pickup and a hold coil on the upper core and a pickup coil on the lower core. On this relay, coil number 128024 is wound on the lower core serving as a pickup coil, and is designed to provide as fast and powerful a pickup as the pickup coil on the upper core. Pickup coils of this relay are isolated on different cores to prevent the possibility of magnetic interference between coils.
2. Type 2 has two pickup coils wired on the upper core and the hold coil on the lower core.

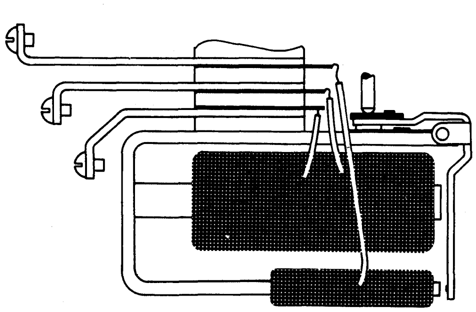


Figure 2-47. Three-Coil Duo Relay

Latch Relay

This relay is special in that the AU N/O contact points are equipped with a latching mechanism. When the relay becomes energized, the latch moves under the contact and holds the AU points closed. These points are opened when the unlatching coil (lower core) is energized, moving the latch away from the contact AU. This prevents the operator from releasing the circuit by turning the machine mainline switch off (Figure 2-48).

Latch relays may be identified in Figure 2-49 by the word LATCH in the column labeled "Max. Time."

The following adjustments pertain to the latch type relay.

1. Use gages specified in Figure 2-49 to adjust the armature air gap.
2. C contact strap tension – 23 grams.
3. D contact strap tension – 34 grams.
4. E contact strap tension – 17 grams.
5. F contact strap tension – 17 grams.
6. .062-inch air gap when contact strap is latched.
7. .005-inch latching clearance, when relay armature (upper) is attracted.
8. Latch spring should have a tension of 40 grams, measured at point indicated.
9. The AU contact points must be made when resting on the latch and the mainline switch is turned off.

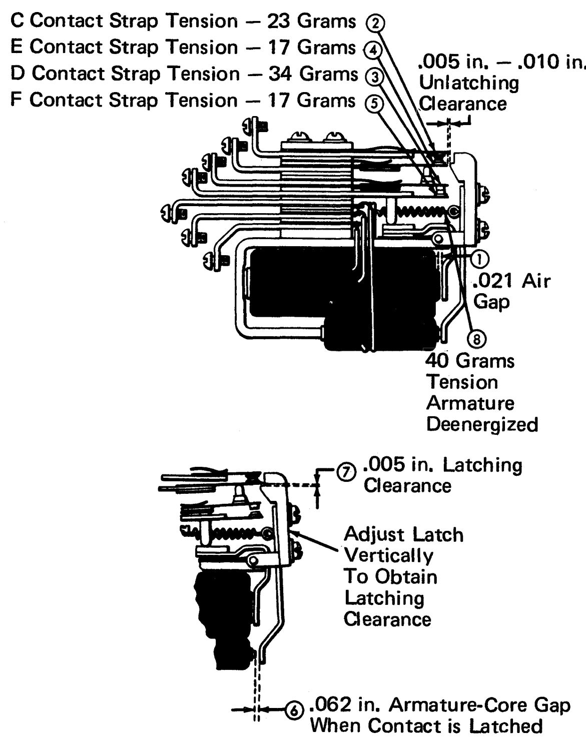


Figure 2-48. Duo Latch Relay

Duo Relay Characteristic Charts

The charts in Figure 2-49 show the characteristics of most of the duo relays used in IBM machines. The relays are listed by part number. Duo relay part numbers may be identified in a machine by referring to the rear section of the machine wiring diagram.

The column labeled "Number Stamped on Coil" is to assist in recognizing the relays. This number is a coil identification number and should *never* be used when ordering a new relay coil. Disregard prefix and suffix letters as they refer only to manufacturer and manufacturing date. Some relays have their coil and clip assembly part number listed in the relay section of the parts catalog. The resistance column shows the average resistance. The value may vary depending on temperature, etc.

The column headed "Armature Air Gap" has already been explained in "Duo Relays – Adjustments."

The pickup and dropout time of the relays is shown in milliseconds, which is the approximate time required for: (1) the N/O contacts to close, (2) the N/C contacts to open, and (3) the transfer contacts to transfer. All points on a given relay may be considered as operating simultaneously, as the difference is only a few microseconds. This time is approximate and varies depending on such factors as voltage and relay strap adjustment.

All relays have a contact assembly code number. This number corresponds to a number in Figure 2-50 that shows contact arrangement. No indication is made as to whether the points are silver or tungsten. Some individual contact spring (strap) part numbers are listed in the relay section of the parts catalog.

The normal operating voltage is used to obtain the corresponding operating time. This should be used only as a guide to general relay usage. Relays may be used at other voltages with special considerations. All voltages are dc unless otherwise stated. All ac is 60 cycles.

Relays with an asterisk (*) next to the part number have their air gap measured by putting the thickness gage only to the center of the core face instead of all the way through. The thickness gage is inserted from the bottom of the relay. Relays with a double asterisk (**) next to the part number should be adjusted so that the N/O points make before the N/C points break.

Most duo relays are included in Figure 2-49. These relays have their pickup and dropout time specified in milliseconds. For some relays, the minimum pickup voltage, maximum dropout voltage, and hum-free voltage are more important than operating speed. These relays are listed in Figure 2-51.

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Max. Time (ms)		Contact Assembly Code	Operating Voltage
		Pick	Hold	±.002 unless otherwise noted	Pick	Drop		
23714	145216	247	450	.013	7	10	4	40 dc
72874	111350	482		.021	22	5	33	40 dc
73439	111310	80		.017			31	6 dc
73440	111370			.017			31	
92958	111330	176		.021	18		35	40 dc
101959	127154	160	161	.021		Latch	16	40 dc
	128024		166					
101994	111360	706		.021	18	24	11	40 dc
101995	111360	706		.021	20	26	6	40 dc
103286	113573	422	1546	.017	5.5	7.5	35	40 dc
104324	104326			.017	10	11	2	
104951	26476	160	455	.030	7	8	10	40 dc
	118013		166					
111241	111240	3		.021	5.5	5	35	40 dc
111244	111240	3		.017	4.5		2	40 dc
111281	111280	19		.021	4.5	7	35	110 dc
111284	111280	19		.017	3	8.5	2	40 dc
111311	111310	80		.021	7	4.5	35	110 dc
111314	111310	80		.017	6.5	4.5	2	110 dc
111331	111330	176		.021	7	7	35	110 dc
111334	111330	176		.017	5.5	7	2	110 dc
111341	111340	284		.021	8	4	35	110 dc
111351	111350	482		.021	18	7	35	40 dc
111354	111350	482		.017	12	7	2	40 dc

Figure 2-49. Duo Relay Characteristic Chart No. 1 (Part 1 of 5)

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Max. Time (ms)		Contact Assembly Code	Operating Voltage
		Pick	Hold	±.002 unless otherwise noted	Pick	Drop		
111371	111370	1060		.017	20	7	35	40 dc
111374	111370	1060		.017	17	7	2	40 dc
111381	111380	1900		.021	20	7	35	40 dc
111384	111380	1900		.017	16		2	40 dc
111391	111390	2500		.021	13.5	7	35	110 dc
111394	111390	2500		.017	9	9	2	110 dc
111401	111400	5100		.021	20	7	35	110 dc
111404	111400	5100		.017	15	7	2	110 dc
113600	113573	422	1546	.017	6	8	2	110 dc
117371	117370	1320		.017	29	8	35	40 dc
117374	117370	1060		.017	29	8	2	40 dc
120247	121059	218		.017	7	11	28	40 dc
121053	121059	218		.017	6.5	7	2	40 dc
121054	121059	218		.021	7	11	28	40 dc
121058	26476	160	455	.017	6	8	2	40 dc
121837	111360	706		.021	24	5	38	40 dc
121841	111360	706		.017	26	8	6	40 dc
121842	111350	482		.017	17	5	13	40 dc
121843	111350	482		.021	18	5	32	40 dc
121877	26476	160	455	.017	7	8	4	40 dc
122439	175236	111	1150	.017	7	8	4	40 dc
122499	121059	218		.017	8.5	5	13	40 dc
122532	111350	482		.017	16	5	6	40 dc
123009	122716	109	452	.017	7	5	10	40 dc
123875	26476	160	455	.021	9.5	10	18	40 dc
123998	111370	1060		.017	27	8	17	40 dc
124842	118014	160	455	$.017^{+.002}_{-.000}$	9	5	24	40 dc
124843	111350	482		$.017^{+.002}_{-.000}$	23	5	37	40 dc
124844	121059	218		.017	10.5	5	14	40 dc
124981	111350	482		.021	26	7	9	40 dc
125828	111330	176		.017	9	7	32	110 dc
125880	111370	1060		.021	20		12	110 dc
126841	111350	482		.017	7	8	11	110 dc
127009	127154	160	161	.030	5	10	2	40 dc
	122181		500					
127050	26476	160	455	.017	8.5	5	7	40 dc
127277	121059	218		.017	10.5	5	6	40 dc
127307	121059	218		.021	9	7	8	40 dc
127394	121059	218		.017	7.5	8	17	40 dc
127498	122716	109	452	.017	5.5	8	2	40 dc
127679	118014	160	455	.017	8	5	22	40 dc
127700	191225	109	452	.017	9	5	23	40 dc
127705	121059	218		.017	7	7	4	40 dc
127858	127154	160	161	.030	7.5	12	29	40 dc
	122181		500					
128022	26476	160	455	.030	6	10	4	40 dc
	118013		166					
128293	111350	482		.017	17	6.5	7	40 dc

Figure 2-49. Duo Relay Characteristic Chart No. 1 (Part 2 of 5)

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Max. Time (ms)		Contact Assembly Code	Operating Voltage
		Pick	Hold	±.002 unless otherwise noted	Pick	Drop		
128299	128297	17.5	17.5	.030	8	10	4	40 dc
	122181		500					
128327	111330	176		.017	10	5	6	40 dc
128428	280225	1215	1220	.030	14	10	2	40 dc
	122181		500					
129036	121059	218		.021	9	7	35	40 dc
129052	111340	284		.017	16.5	5	39	40 dc
129353	145216	247	440	.017	13	8	35	40 dc
132008	132000	4	428	.021	6	8	1	110 dc
134839	145216	247	440	.021	13	7	8	40 dc
136802	111280	19		.022	4		28	110 dc
140461	167424	153		.030	8.5	9	22	40 dc
	122181		500					
142368	127154	160	161	.030	7	10	10	40 dc
	122181		500					
142443	170187	1145	3200	.017	7	8	4	110 dc
145215	145216	247	440	.017	7	8	2	40 dc
150482	111370	1060		.021	23	5	27	40 dc
151688	145216	247	440	.017	9	8	35	40 dc
152271	152272	15	422	.021	8	7	1	40 dc
152848	145215	247	440	.021	10.5	8	5	40 dc
153073	26476	160	455	.017	8	6.5	10	40 dc
155665	170187	1145	3200	.017	10	6.5	16	110 dc
155666	170187	1145	3200	.017	9	6	7	110 dc
155667	170187	1145	3200	.017	8	8	35	110 dc
157007	127154	160	161	.030	5.6	12	3	40 dc
	122181		500					
157436	111350	482		.021	19	7	8	40 dc
157747	26476	160	455	.017	16	9	8	40 dc
158787	26476	160	455	.021	12		10	40 dc
159558	170187	1145	3200	.030	5	12	2	110 dc
	122181		500					
159758	167424	153		.040	9	12	5	40 dc
	122181		500					
161233	127154	160	161	.030	7	10	10	40 dc
	122181		500					
167436	111350	482		.017	16.5	8	17	40 dc
167855	111390	2500		.017	10	6	1	110 dc
173133	113573	422	1546	.017	7	7	4	110 dc
176079	26476	160	455	.021	10		30	40 dc
176296	113573	422	1546	.017	7	4	16	110 dc
177287	111390	2500		.021	18	5	37	110 dc
178103	111350	482		.017	17	7	16	40 dc
178811	127154	160	161	.030			6	40 dc
	122184		500					
182693	26476	160	455	.017	9.5	5	6	40 dc
**182976	111370	1060					35	
184180	111400	5100		$.017\ ^{+.002}_{-.000}$	23	6	21	110 dc

Figure 2-49. Duo Relay Characteristic Chart No. 1 (Part 3 of 5)

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Max. Time (ms)		Contact Assembly Code	Operating Voltage
		Pick	Hold	±.002 unless otherwise noted	Pick	Drop		
184466	167424	153		.017	7.5	8	35	40 dc
186346	111350	482		.017	7	6	11	110 dc
186524	186520	12500		.017	20	7	2	110 dc
189220	132000	4	428	.017	5		35	40 dc
189221	170187	1145	3200	.017	8.5	5	22	110 dc
189223	170187	1145	3200	.017	12	5.5	23	110 dc
191815	111400	5100		.021	20	9	35	110 dc
197260	170187	1145	3200	.017	5	5	6	110 dc
197261	111390	2500		.017	12	6	6	110 dc
197262	111390	2500		.017	13	6	16	110 dc
197264	111390	2500		.021	14	6	32	110 dc
197265	170187	1145	3200	.017	8	5	10	110 dc
198400	127154	160	161	.040	9	8	36	40 dc
	122181		500					
199384	280225	1215	1220	.030	34	10	16	40 dc
206314	111350	482		.021	TD	7	42	40 dc
206672	111400	5100		.017	20	5	6	110 dc
214224	214222	505	565	.017	16.5	5	23	40 dc
222634	127154	160	161	.040	9	7	36	40 dc
	122181		500					
228210	170187	1145	3200	.021	12	5	43	110 dc
252857	111370	1060		.021	TD		42	40 dc
280227	280225	1215	1220	.030	19	6	10	40 dc
	122181		500					
280467	170187	1145	3200	.017	10	5	20	110 dc
281077	111350	482		.017	23	4	37	40 dc
281251	26476	160	455	.017	9.5		23	40 dc
281261	111400	5400		.021	21	5	13	110 dc
282361	121059	218		.017	7	4	22	40 dc
282408	26476	160	455	.017	10.5	5	37	40 dc
282648	127154	160	161	.030	6	5.5	35	40 dc
	122181		500					
282745	111400	5100		.017	26	4	37	110 dc
283313	280225	1215	1220	.017	8	5	20	110 dc
283517	26476	160	455	.017	7	8	35	40 dc
284359	280225	1215	1220	.030	19	7	35	40 dc
	122181		500					
285021	285020	348	392	.017	15	5.5	37	40 dc
300702	186520	12500		.021	42			110 dc
301610	111400	5100		.021	TD		42	110 dc
304465	170187	1145	3200	.021	5	5	6	110 dc
304856	111350	482		.021	TD		42	40 dc
304879	73433	172		.021		Latch	25	
306511	26476	160	455	.021		Latch	16	
	118013		166					
311868	111350	482		.017	15	5	14	40 dc
318955	111370	1060		.017			1	
333110	111350	482					35	40 dc

Figure 2-49. Duo Relay Characteristic Chart No. 1 (Part 4 of 5)

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Max. Time (ms)		Contact Assembly Code	Operating Voltage
		Pick	Hold	±.002 unless otherwise noted	Pick	Drop		
351574	111350	482		.021	TD		42	
437003	145216	247	450	.027 $^{+.003}_{-.000}$	10		35	65 dc
*440331	253464	.55		.017	TD		42	
440387	111350	482		.021	TD		None	
480558	480556	83		.017	23	5	37	18 dc (Armature must seal at 12 dc)
609149	609150	83		.017	23	5	37	18 dc (Armature must seal at 12 dc)
804684	111350	482		.017 $^{+.002}_{-.000}$	23	5	37	40 dc (Armature must seal at 28 dc; min. contact voltage is 30 dc)
804687	26476	160	455	.017	10.5	5	37	40 dc (Min. contact voltage is 30 dc)
1127035	U111350H			.017	18			48 dc
2102442	111330	176		.021	TD		26	40 dc (Min. pickup voltage is 30 dc)
	118013		166					

Figure 2-49. Duo Relay Characteristic Chart No. 1 (Part 5 of 5)

Code	A SIDE	B SIDE
1	M	Blank
2	M	M
3	M	B
4	M	T
5	2M	M
6	2M	2M
7	2M	MB
8	2M	B
9	2M	2B
10	2M	T
11	2MC	2MC
12	3MC	2MC
13	3MC	3MC
14	3MC	MT
16	MB	MB
17	MB	B
18	MB	2B
19	MT	3MC
20	MT	MT
21	MT	BT
22	MT	T
23	MT	2T
24	2MCT	BT
25	B	Blank
26	B	M
27	B	2MC
28	B	B
29	BM	B
30	2B	2B
31	T	Blank
32	T	2M
33	T	MT
34	T	B
35	T	T
36	TM	2T
37	2T	2T
38	(T2MC)	(T2MC
39	(T2MC)T	(T2MC)T
40	T	MB
41	T	2B
42	Therm Delay	MT
43	2M	(T2MC)T

Figure 2-50. Contact Assembly Code Chart

Relay Assembly Part	Number Stamped on Coil	Resistance in Ohms		Armature Air Gap	Hum-Free Voltage	Min. Pickup Voltage	Max. Release Voltage	Contact Assembly Code
		Pick	Hold	±.002 unless otherwise noted				
70236	73433	172		.013	85±5 ac	85±5 ac		3
75397				.017	85 ac			
76201	76204	395		.017	85 ac	85 ac		31
76202	73433	172		.017	85 ac	85 ac		31
*253467	253464			.018		5.1±0.5 ac		35
*253468	73433	172		.015	100 ac	100 ac	Latch	16
	122181		500					
*253469	253480	85		.018	92 ac	92 ac		35
*253470	253480	85		.018	92 ac	92 ac		37
*253472	111360	706		.018	185 ac	185 ac		35
*253497	111360	706		.017	30 dc	30 dc	Latch	26
	118013		166					
321516	73433	170			95 ac	75 ac		26
321519	111310	80		.015 - .020		6 dc		26
440540	253464	.55		.017	5 ac	5 ac TD	40 ac	42
440586	440576	1470		.017		28 dc	14 dc	7
440587	440577	5400		.017		56 dc	28 dc	7
440588	186520	12500		.017		80 dc	46 dc	7
440589	440578	7400		.017		48 dc	24 dc	3
440590	440577	5400		.017		40 dc	20 dc	3
440591	186520	12500		.017		47 dc	28 dc	3
440592	440579	3280		.017		28 dc	14 dc	2
440593	440580	5600		.017		40 dc	20 dc	2
440594	440578	7400		.017		56 dc	28 dc	2
440595	111360	706		.017	170 ac			3
440596	253464	.55		.017	5 ac			3
440597	111360	706		.017	170 ac	170 ac TD		42
440602	73433	170		.017	85 ac	85 ac TD		42
*440604	253464	.55		.018		5.1 ac		6
530731	111350	482		.033 ±.005		30 dc		35
594283	111350	482		.033 ±.005		30 dc		35

Figure 2-51. Duo Relay Characteristic Chart No. 2

REED RELAYS

Description

Reed relays fulfill the need for a small-sized relay with faster operating speeds, dependability, and ruggedness. A reed relay picks in about 1 ms with no significant bounce of the contacts.

Each set of contacts in a reed relay consists of 2 straps. The straps are formed with enough tension to remain apart and are enclosed in a glass envelope into which an inert gas has been introduced. A pin projecting from each end of the envelope is used to connect the contact into a circuit (Figure 2-52). This contact, which is also referred to as a switch, is in an N/O form. In order to cause the contacts to close, an external magnetic field is required. The contact, with each end mounted in a plastic holder, is inserted inside a coil (Figure 2-53). When the coil is energized, the resultant magnetic lines of force cause one contact strap to assume a north polarity while the other strap assumes a south polarity. Because unlike poles of a magnet attract, the straps are attracted to each other and the contacts close. They remain closed as long as the coil is energized.

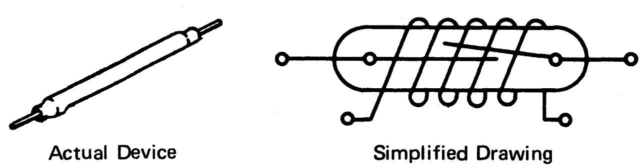


Figure 2-52. Single N/O Reed

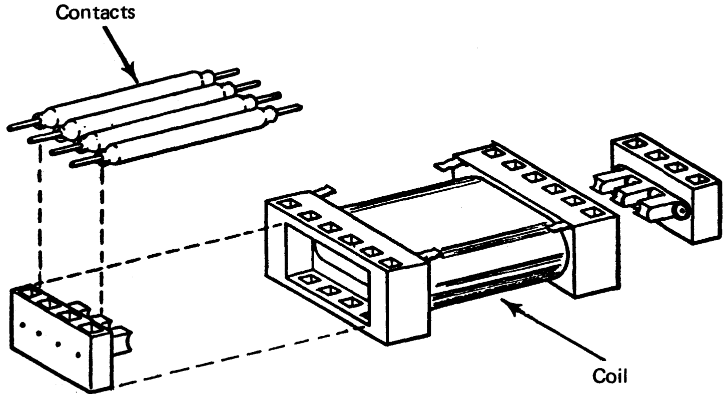


Figure 2-53. Reed Relay Construction

All contacts are manufactured in the N/O form. N/C contacts are converted from N/O contacts. The N/O contacts are used in pairs with a permanent magnet cemented to the side of the envelopes (Figure 2-54).

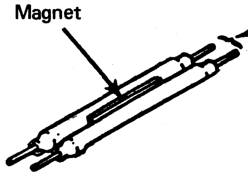


Figure 2-54. N/C Reed Pair

The magnetic field from the permanent magnet causes one contact strap in each group to assume a north polarity while the other strap assumes a south polarity. Because of the opposite polarity, the straps are attracted and the contacts are held closed. They remain closed until the magnetic field from the permanent magnet is nullified by some other source of magnetism. When the coil that surrounds the contacts is energized, the resulting magnetic field opposes the field from the permanent magnet.

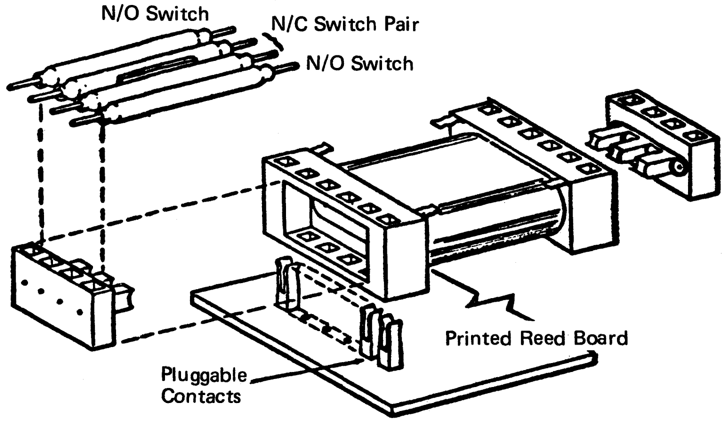


Figure 2-55. Position Reed Relay

A null point in the magnetic field is reached and the contact straps are no longer attracted to each other. They open due to the tension formed in the straps and remain open as long as the coil is energized.

Reed relays are made with various coil combinations and in sizes of 1, 2, 4 or 6 contacts. A four-position relay with two N/O contacts and two N/C contacts is shown in Figure 2-55. Reed relay charactertistics are shown in Figure 2-56.

Servicing

Because of the construction of the reed relay, no preventive maintenance routines are needed. Precautions should be taken, however, in the removal of a relay from the SMS card, the clips may get bent and fail to make with the contact pins. The relay should not be disassembled or points interchanged. At the time of manufacture, the coil characteristics are matched to the contact characteristics. Any attempt to replace individual contacts may result in a mismatch and possible failures. The contact points should never make or break a circuit carrying more than .5 amperes. Therefore, use care when shooting troubles in circuits

No. of Contacts	Contact Type	Coil Type	Coil Part	Relay Part	dc Coil Resis. nom Ω ±8%	Coil Current (nom) mA	% Duty Cycle	Operate Range Volts	Release Range Volts
1	N/O	P	765656	765654	966	12.4	100	4.75 8.00	1.5 5.0
1	N/O	P & H	765674	765664	770 1095	15.6 11.0	100 100	4.5 8.3	2.1 4.8 2.9 7.4
2	N/O	P	765675	765665	377	31.8	100	3.5 5.5	1.4 3.0
2	N/O	P & H	765677	765666	377 765	31.8 15.7	100 100	4.3 7.2	1.8 4.1 3.0 7.5
2	N/C	P	765675	765692	377	31.8	100	2.8 4.7	0.7 2.4
2	N/C	P & H	765677	765667	377 765	31.8 15.7	100 100	3.7 6.1	0.8 3.0 1.2 5.1
4	N/O	P	765680	765668	195	61.5	100	2.9 6.1	1.5 3.5
4	N/O	P & H	765679	765669	191 269	62.8 44.6	100 100	3.9 7.1	1.8 4.0 3.2 8.1
4	N/C	P	765680	765670	195	61.5	100	2.5 6.5	0.6 2.8
4	N/C	P & H	765679	765688	191 269	62.8 44.6	100 100	2.7 7.8	0.6 3.1 1.1 6.6
4	2 N/O 2 N/C	P	765680	765671	195	61.5	100	2.9 6.2	0.5 3.6
4	2 N/O 2 N/C	P & H	765679	765689	191 269	62.8 44.6	100 100	2.8 7.5	0.5 4.1 0.9 8.3
6	N/O	P	765682	765619	116	103	100	3.2 7.0	1.2 3.9
6	N/O	P & H	765684	765683	119 147	101 81.6	50 100	3.4 7.0	1.5 3.9 2.9 7.8
6	N/C	P	765682	765672	116	103	100	2.3 6.6	0.5 3.4
6	N/C	P & H	765684	765690	119 147	101 81.6	50 100	2.8 6.8	0.5 3.4 1.0 6.5
6	4 N/O 2 N/C	P	765682	765673	116	103	100	3.4 7.0	0.5 4.4
6	4 N/O 2 N/C	P & H	765684	765691	119 147	101 81.6	50 100	3.2 6.8	0.5 3.9 1.0 7.8

Figure 2-56. Reed Relay Characteristic Chart

which use reed relays. If something occurs which could possibly cause excessive current in a circuit, several relays may be damaged. All relays involved should be checked to make sure that burned points are detected and any defective relay should be replaced.

A contact may fail intermittently. A light tap or jar on the SMS card or individual relay may cause the failing contact to make. It may possibly work several times in succession thereafter. Relays with contacts which perform this way should be replaced to eliminate future intermittent troubles.

HEAVY-DUTY RELAYS

Description

Heavy-duty relays are normally used in those circuits drawing a comparatively high current, usually in excess of 5 amperes. They are generally applied to all the motor circuits of the various machines and are used in many other heavy current circuits. Large tungsten contact points are employed in order to withstand the destructive arc that results when these circuits are opened.

Heavy-duty relays operated from an ac voltage source are equipped with a shading coil. This coil consists of a heavy, single, closed turn and is mounted in the split core (armature end) of the relay. Its purpose is to produce a second magnetic field that is about 90° out of phase with the main field. This prevents the armature from dropping away from the core during the time that the alternating current in the relay coil circuit approaches and passes through the zero value of the sine wave. The tendency of the armature to drop back to the deenergized position at zero time, followed by the reenergization of the relay coil as the current builds up in the opposite direction, would cause a vibrating or chattering armature action.

Relay Assembly Number	Number Stamped on Coil	Resistance in Ohms	Volts to Seal	Volts Hum Free (ac)	Normal Operating Voltage	Hz
72751	72754	18		19	24	60
72892	72635	.41		4.8	6	60
72893	72636	3		9	12	60
72894	72637			38	48	60
72895	72638	380		93	110	60
72896	72640	2000		176	220	60
72898	72641	30		18	24	25
72899	72642	117		38	48	25
72900	72643	745		93	110	25
72901	72644	3350		176	220	25
72912	72645	7.6	1.9		3	dc
72913	72646	30	3.8		6	dc
72914	72647	124	7.5		12	dc
72915	72648	1197	25		40	dc
72916	72649	2000	28		48	dc
72918	72800	7700	60-70		96-110	dc
76725	76726	468	15		24	dc

Figure 2-57. IBM Unit-Type Heavy Duty Relays

During the cycle when the current is dropping from its maximum value to the zero value, the magnetic lines of force cutting across the shading coil cause an induced voltage in the shading coil. Current flowing in the single-turn shading coil produces a magnetic field that provides the necessary holding or sealing action for the armature, until the voltage and current builds up in the opposite direction to a point where the relay coil again becomes energized. Thus, the shading coil functions to provide a continuous holding effect on the armature and overcomes the tendency of the armature to fall to its deenergized position.

There are two general types of heavy-duty relays.

1. GE Heavy-Duty Relays. These relays were used in the past on IBM equipment and are still to be found in many of the older machines in the field. When replacement is necessary, IBM Unit-Type Relays are substituted.
2. IBM Unit-Type (HD) Relays (ac and dc). Figure 2-57 indicates the various relays available, the part number, and the voltages and frequencies of each.

Preventive Maintenance

1. Check the armature for freedom of movement.
2. Clean the contact points of these relays periodically with either a flexstone or a good metallic point file to remove the burned and pitted surface usually encountered. Complete the operation by thoroughly cleaning away any remaining filings or abrasive from the points.
3. Make sure that both contact points make and break simultaneously to eliminate arcing at one point only. This is important.
4. Check the contact plate compression spring for sufficient tension to ensure good contacting conditions.
5. Check the armature return springs for sufficient tension to ensure proper opening of the contact points.
6. Apply a small amount of IBM 17 at the armature pivot points.

Adjustments

The following adjustments are recommended for the IBM Unit-Type Heavy-Duty Relays. The number of the adjustment refers to sequence of adjustment and to Figure 2-58. Adjustment 1 is made only on alternating current unit-type relays.

The adjustments are as follows.

1. On alternating current unit-type relays, a .005-inch to .010-inch clearance should be between the armature and the lower part of the split core face when the

armature is fully attracted. This clearance is obtained by filing. It is important that this adjustment be adhered to in order to eliminate a noisy chattering relay operation.

2. With the armature attracted, a 1/32-inch clearance should be between the insulating block on the armature and the contact plate. Adjust by loosening the clamping screw and moving the contact terminal block assembly. After getting correct lift of the contact plate, check to ensure that the contacts close simultaneously so that the arc will be evenly distributed.
3. With the relay in a horizontal position, the armature should balance with a contact air gap of 1/32- to 5/64-inch. Adjust by loosening the armature stop retaining screw A and moving armature stop to obtain correct armature spring tension. A 100- to 150-gram weight applied at the point should seal the armature.
4. With the relay in operating position and the contacts fully open, a clearance no greater than .020-inch should be between the insulating block on the armature and the armature stop.

Note: When relays are used on alternating current, a characteristic hum is present under some conditions. If the relay does hum, the armature may not be seating flat on the yoke and the core. The upper part of split core face and the armature pivot points should be checked for burrs or foreign material.

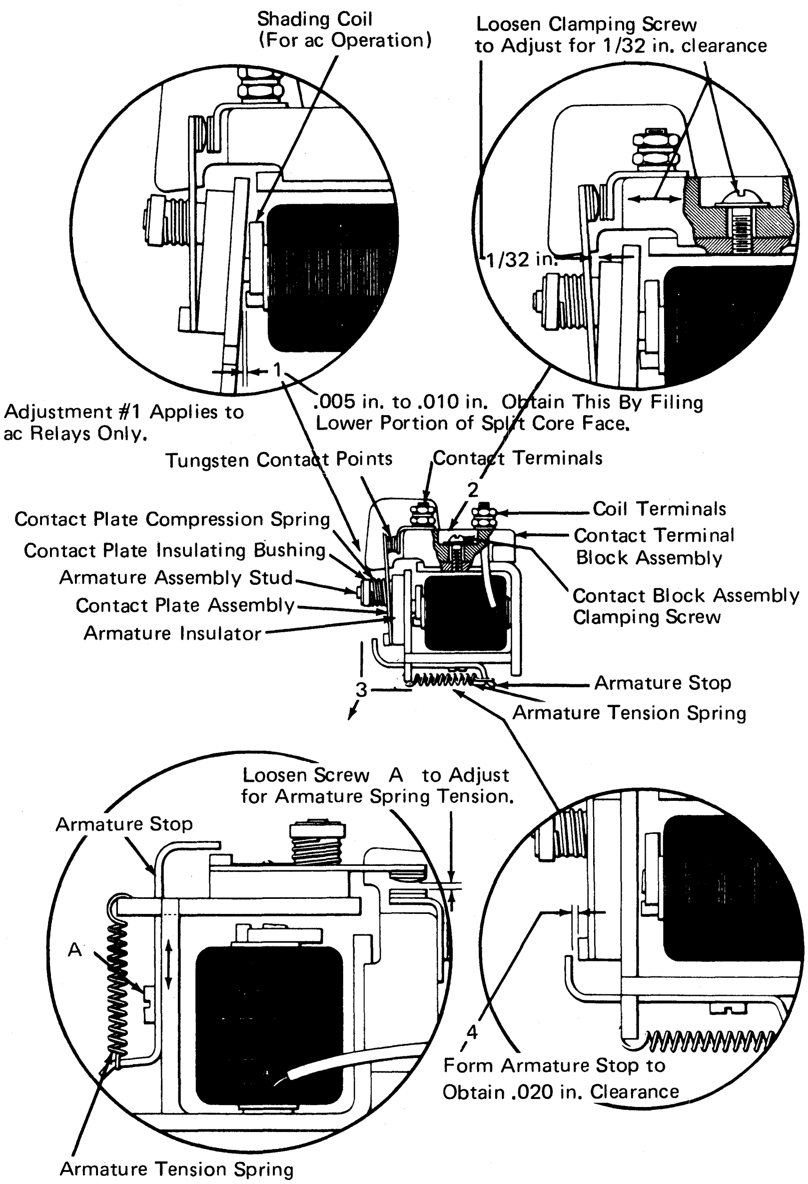
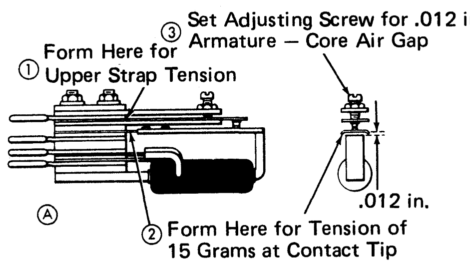


Figure 2-58. IBM Unit Heavy-Duty Relay Adjustments

HIGH-SPEED RELAYS

Pluggable Relays

This relay (Figure 2-59) operates very rapidly; the pickup time ranging from 2 to 2.5 milliseconds. It is used in 40-volt circuits, and is designed to be operated by short or momentary impulses only. This relay controls only one set of contact points, which may be either N/O or N/C. One of these contact straps also serves as the armature of the relay. This is a pluggable relay and may be readily removed from the machine for inspection and adjustment without removing any wires or screws.



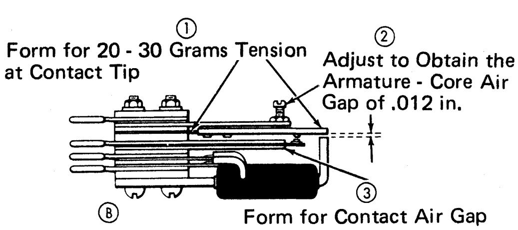


Figure 2-59. Pluggable High-Speed Relay

Preventive Maintenance

1. Contact points should be in perfect alignment to ensure good contacting conditions.
2. Contact and coil terminal prongs should be clean and in perfect alignment with their corresponding receptacle plug hubs.
3. Contact pile holding screws should be tight, so that all relay adjustments may be maintained.
4. Contact points should be clean and free of film and burned deposits. A metallic burnishing tool (part 450567) is recommended for cleaning these points.

Adjustments

Adjust the normally closed type relay (Figure 2-59) as follows:

1. Upper contact strap must have sufficient tension to lie snugly against its support without assistance from adjusting screw.
2. Lower contact strap must be so formed that its tension tends to hold the points closed. With a gram gage applied and a reading of 15 grams, the points should just open.
3. Set armature-core air gap for a .012-inch clearance by the adjusting screw.

Adjust the normally open type relay as follows:

1. Form the upper contact strap so that tension holds strap against adjusting screw. With gram gage applied and a scale reading of 20 to 30 grams, this strap should just clear the adjusting screw.
2. Adjust for an armature (upper contact strap) core air gap of .012-inch ± .002-inch. Use adjusting screw to obtain this clearance.
3. Adjust contact point gap by forming lower contact strap supports for the following conditions:
   a. Insert a .006-inch thickness gage in the armature-core gap. With the armature held attracted, a minimum clearance should be between points.
   b. Insert a .005-inch thickness gage in the armature-core gap. With armature attracted, the points should just close.

Octal-Base Pluggable Relays

This relay (part 286500) is a purchased assembly (Figure 2-61). The manufacturer assembles and adjusts the relay to meet IBM's specifications for voltage and current requirements, as well as the pickup and dropout operating time.

Preventive Maintenance

Check the contact points for burns or pits. If necessary, clean points carefully with a flexstone and follow this by dressing the points with a burnishing tool blade (part 450567).

Adjustments. No adjustments are recommended. In case of relay failures, replace the entire assembly.

Non-Pluggable Relays

This high-speed relay (Figure 2-62) may be considered a modern version of the slate-base relay. It meets high-speed operation requirements, while its physical dimensions permit it to be mounted in the same amount of space allotted to a duo relay.

The unit consists of a single pair of contact points (either N/O or N/C), a gooseneck contact and armature stop assembly, and a pair of magnets. The armature is light in weight and operates on conical-shaped pivots; both tend to facilitate fast operation. The relay is designed to operate in 40-volt circuits and has a pickup time of 1-2 ms and a dropout time of approximately 2 ms. The N/C points must open in 1 ms. The part number of the relay that has N/C points is 202800. The relay with N/O points is 112627.

Relay Part	Relay Coil	Armature-Core Air Gap	Contact	Operating Time in Milliseconds		Resistance in Ohms
				Pickup	Dropout	
166739	166743	.012 in. ±.002 in.	N/O	2-2.5	1-4	176
166740	166743	.012	N/C	2-2.5	1-4	176

Figure 2-60. Pluggable Type Characteristic Chart

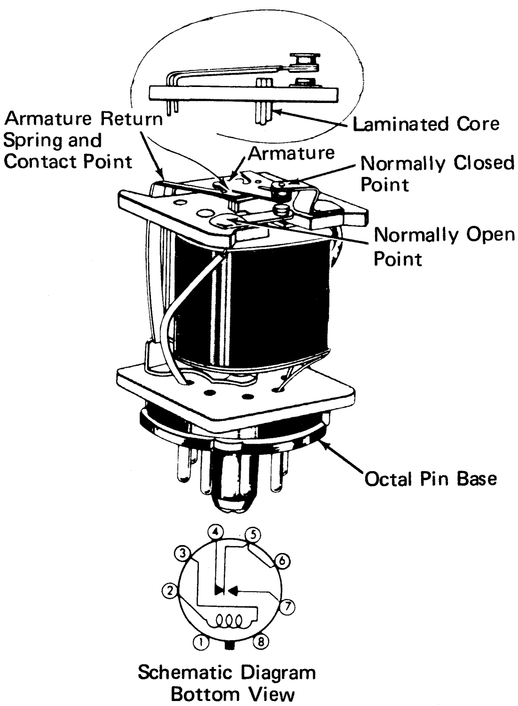


Figure 2-61. Octal-Base Pluggable High-Speed Relay

Preventive Maintenance

1. Check the armature pivot screws for wear. Replace them if they are worn elliptically. Place a small amount of IBM 17 on these pivot points periodically to reduce wear.
2. Make sure the contact points are clean, square with each other, and in alignment. Clean and adjust as required.
3. Clean any foreign substance from between the armature and the cores of the magnet.

Adjustments

1. Core faces (Figure 2-62) should be parallel to each other and should be free of burrs and roughness. Stone faces to make corrections.
2. The armature pivot screws should fit relatively tight in the tapped holes in the pivot screw ears of the yoke assembly to prevent these screws from moving during operation and destroying the adjustment. To provide a tighter clamping action on the pivot screw, remove the screw and drive the two sides of the split screw ear of the yoke assembly closer together.
3. Adjust for vertical alignment of contact points by

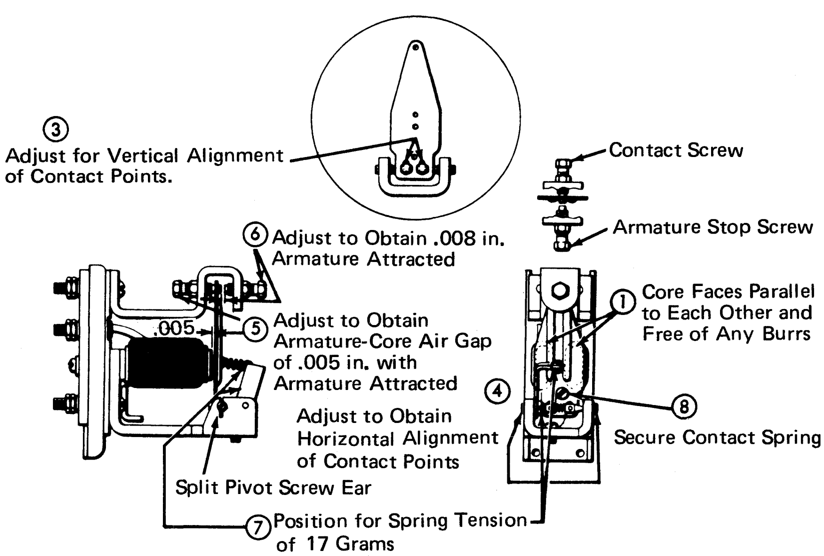


Figure 2-62. Non-Pluggable High-Speed Relay

raising or lowering the armature in relation to the pivot shaft. With points aligned, armature sides should be parallel to the core faces. Lock holding screw securely when adjustment is complete.
4. Apply a small amount of IBM 17 to the armature pivots before adjusting. Adjust the armature pivot screws to obtain the horizontal alignment of the contact points. They should also be adjusted for minimum end play of the pivot shaft and still maintain absolute freedom of armature movement.
5. Adjust stop screw (N/C point relay) for a .005-inch air gap between armature and core with armature in the energized position. Form armature to secure this same clearance across entire core face.
6. Adjust contact screw for an .008-inch air gap between points with armature in the energized position (N/C point relay).
7. Position the armature return spring adjusting arm for a spring tension of 17 grams (N/C point relay). Do not overload with spring tension.
8. Be sure the ends of contact spring on the armature pivot shaft are securely fastened under the respective screws of the armature and yoke.

Note: The N/C relay may be converted to a N/O relay by reversing the armature and interchanging the adjustable stop and contact screws. A N/O high-speed relay requires 35 grams to operate the armature.

SLATE-BASE RELAYS

The slate-base relay (Figure 2-63) is one of IBM's oldest relays and is used in those applications requiring high-speed operation. It is designed to operate on 110 volts dc and has an operating pickup speed of 1 to 2 ms. Dropout time is approximately 2 ms. These relays are supplied in three general classifications:
1. Three-terminal post
2. Four-terminal post
3. Five-terminal post

The 3-post relay is applicable where the N/O contact points and the coil are wired into the same circuit.

The 4-post relay is used where the coil is wired into one circuit, and the contact points (either N/O or N/C) are used to control an entirely separate circuit.

The 5-post relay may consist of a set of transfer contact points, requiring three terminal posts and a coil requiring two posts.

Another type of 5-post relay is equipped with a pick coil, wired into one circuit while a hold coil and a N/O contact are applied to another circuit.

Preventive Maintenance

1. Check the armature pivot screws for wear. Replace them if they are worn elliptically. A small amount of IBM 17 should be placed on these pivot points periodically to reduce the wear.
2. The contact points should be square with each other so that contact is made over the entire surface. Forming the armature slightly may be necessary to obtain this condition.
3. The contact points should be clean and in perfect alignment. Pitted or burned points should be carefully cleaned with a flexstone to remove the carbonized material, and then dressed with a metallic burnishing blade (part 450567).
4. Remove any foreign substances that may be found between the armature and the cores.

Adjustments

1. Adjust pivot screws (Figure 2-63) to hold armature laterally so that its point lines up with the contact point in the upper or lower screw. Back off one pivot screw 1/6 turn from fingertight position and tighten lock nuts.
2. Set armature perpendicular to the slate base. Hold it in this position by the contact screw and stop screw. Tighten lock nut on contact screw at this time.
3. With the armature perpendicular to the base, loosen the yoke holding screws and position the yoke

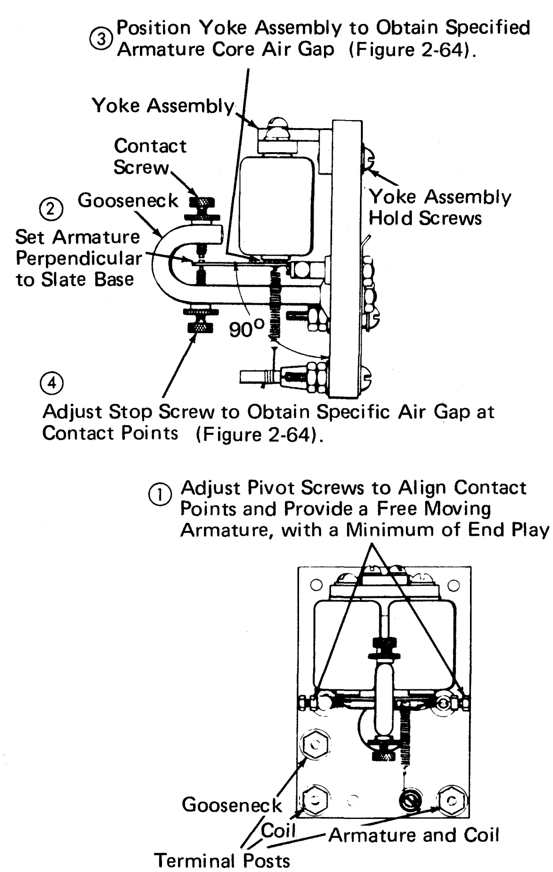


Figure 2-63. Slate Base High-Speed Relay

assembly to obtain the specified clearance between the armature and cores. Specific air-gap dimensions for the various relays may be secured from Figure 2-64. Tighten yoke holding screws.
4. Adjust stop screw downward to obtain the specified air gap between contact points (Figure 2-64). Tighten locknut.
5. Adjust the tension of the armature return spring by turning anchor screw just to overcome gravity with relay turned upside down. Give anchor screw approximately 1/8 turn more.

Relay Part	Number of Posts	Armature-Core Air Gap	Contact Point Air Gap
18545	4	.005 in.	.008 in.
144222	4	.012 in.	1/32 in.
21824	3	.008 in.	.008 in.
153016	5	.005 in.	.005 in.
21824	3	.005 in.	.005 in.
11597	3	.005 in.	.008 in.
21824	3	.008 in.	.008 in.
21821	4	.005 in.	.005 in.
21824	3	.008 in.	.008 in.
118098	4	.005 in.	.005 in.

Figure 2-64. Slate Base Relay Characteristic Chart

MULTI-CONTACT RELAYS

Description

The multi-contact relay (Figure 2-65) is similar in principle to the duo relay, differing mainly in the number of contacts it is designed to control. It consists of two pairs of magnets, two armatures, and usually twelve contacts. Figure 2-65 shows two multi-contact relays mounted on the same frame. The two pairs of magnet coils in each relay are connected to each other either in series or parallel, depending on their application. The contacts are either normally or transfer type.

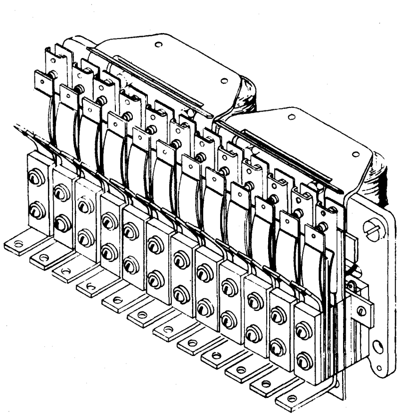


Figure 2-65. Multi-Contact Relay

These relays are not being used to any extent on present machines.

Preventive Maintenance

Refer to "Preventive Maintenance" under "Duo Relay," and follow the items except for the removal of the armature.

Adjustments

1. The armature should be free at its pivot point without having excessive play. Adjust the armature retainer to obtain this condition (Figure 2-66).

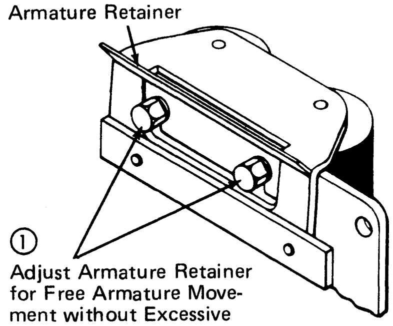


Figure 2-66. Multi-Contact Relay Armature and Core

2. With the armature held in the attracted position, it should be parallel and square with the core faces; both residuals should strike their respective core faces squarely. The residual pin should project .005-inch + .005-inch – .002-inch, and may be checked by the method shown in Figure 2-39.
3. The armature air gap should be .021-inch and may be obtained by forming the armature (Figure 2-67).

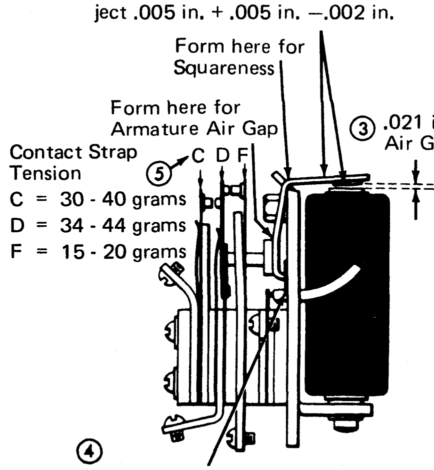


Figure 2-67. Multi-Contact Relay Adjustments

4. With a .009-inch thickness gage inserted between the tail of the armature and the relay frame (Figure 2-67), adjust the contact support straps so that both the N/O and the N/C contacts have a clearance of .001- to .006-inch.
5. The contact strap tension should be as follows:
   C strap – 30 to 40 grams
   D strap – 34 to 44 grams
   F strap – 15 to 20 grams
   Note: Adjustments 4 and 5 affect each other. The two adjustments should be made and checked together.

DIAL RELAYS

Description

The dial relay (Figure 2-68) is a single-position counting mechanism with a capacity of 0 to 9.

Several of these dial relays may be coupled together (control panel plugging) in order to increase the counting capacity. For example, two coupled relays provide a capacity of 0 to 99; three coupled relays, a capacity of 0 to 999; while coupling four relays permits counting variables from 0 to 9999. These counter relays can add only unit impulses, and they can add only once during a machine cycle.

Each time the count magnet (Figure 2-68) is impulsed, the armature is attracted. The armature carries a pawl which engages a ratchet and advances the contact wiper one position clockwise around a dial. This dial consists of ten contact segments corresponding to the characters 0 to 9. Thus, after a variable number of cards or unit impulses have been counted, the contact wiper having advanced one step for each impulse, is positioned on the segment corresponding to the number of impulses counted.

The position of the contact wiper, in relation to the dial contact segments 0 through 9, permits an electrical reading of the figure stored in the relay.

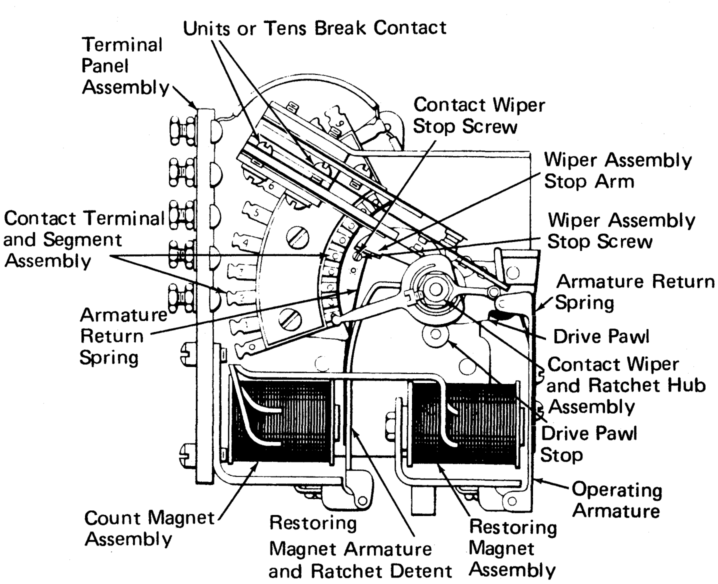
When the restoring magnet is impulsed, the tip of the armature that serves as a detent releases the ratchet and allows the contact wiper to return to its zero position.

Preventive Maintenance

Contact surfaces should be free of corrosive films, burns, and pits. The contact wiper assembly should snap back to its ZERO or OFF position when the restoring magnet armature is attracted. Check in various positions.

Adjustments

1. The end play in the armature pivots should not exceed .005-inch (Figure 2-69).
2. A .004-inch clearance should be between the count magnet armature and yoke, and between the restoring magnet armature and yoke when energized. A .003-inch gage should go and a .005-inch gage should not go (Figure 2-69).
3. Form the stop arm under count magnet yoke for .020-inch to .024-inch armature-core air gap when deenergized (Figure 2-69).
4. A .008-inch to .010-inch clearance (preferably .008-inch) should be between the restoring magnet armature and core when the magnet is deenergized. Adjust by forming armature at point indicated. With .008-inch air gap, the detent tip of the restoring magnet armature should clear the ratchet by at least .010-inch when the magnet is energized. Observe this through a hole in the frame.



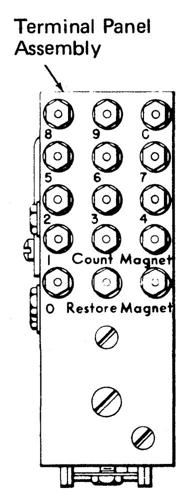


Figure 2-68. Dial Type Relay

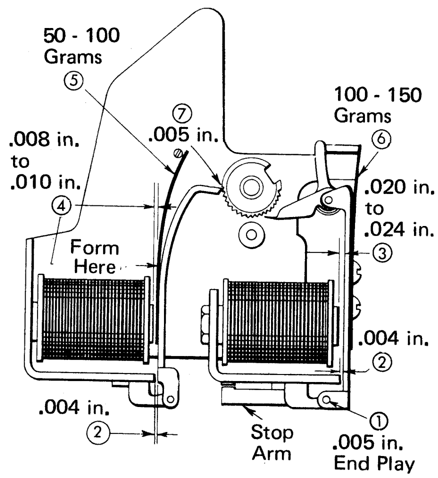


Figure 2-69. Dial Relay Magnets

5. The restoring magnet armature return spring should have 50 to 100 grams of tension at the stop pin when the coil is deenergized.
6. The count magnet armature return spring should have 100 to 150 grams of tension to overcome feed pawl spring tension and fully restore the feed pawl and armature. Do not overload.
7. Form tip of restoring-magnet armature to obtain .005-inch clearance between detent and ratchet tooth when the restoring-magnet armature is deenergized and the contact wiper is fully restored.
8. With the contact wiper and ratchet assembly fully restored, the drive pawl should enter ratchet tooth 9 with .005-inch takeup clearance. Form the wiper assembly stop arm to adjust (Figure 2-70).

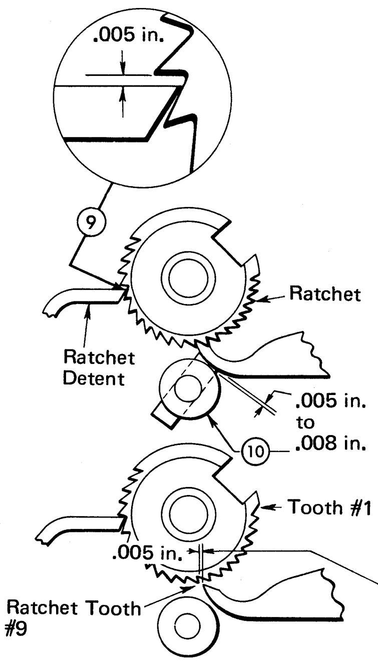


Figure 2-70. Dial Relay Ratchet

9. Form the tip of the count magnet armature to obtain .005-inch overthrow of ratchet. Recheck adjustment 7 (Figure 2-70).
10. Move drive pawl stop to obtain .005-inch to .008-inch clearance between pawl and stop with count magnet armature fully attracted (Figure 2-70).
11. Position collar to permit .003-inch end play of wiper and ratchet assembly on stud (Figure 2-71).
12. Loosen hex nut of wiper and ratchet assembly to center wiper finger on contact segment (Figure 2-71).
13. The break contact should be made on the lower side with a clearance between the center strap and the contact operating arm when the wiper arm is on the one segment (Figure 2-71).

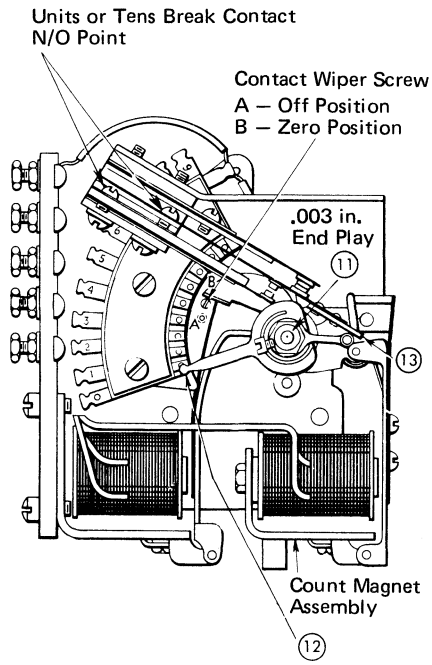


Figure 2-71. Wiper Assembly

MERCURY RELAYS

Description

The contacts in a mercury relay are enclosed in a glass cylinder containing a gas atmosphere under high pressure. The contacts are moistened with quick silver that flows through capillary tubes from a reservoir. A mercury film forms between the stationary contact and the movable contact when the transfer occurs. Any arc that may occur is absorbed by this film as it breaks, thereby preventing burning and pitting of the contact materials. Figure 2-72 shows the internal construction of the mercury relay and Figure 2-73 illustrates the principle of arc absorption of the mercury relay.

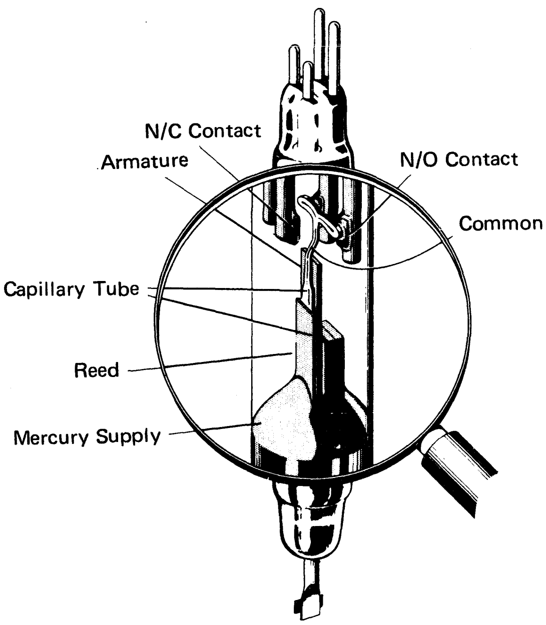


Figure 2-72. Mercury Relay Construction

A coil which surrounds the glass cylinder creates a magnetic field when the coil is energized. The resultant magnetic force attracts the reed which also has the capillary tube and common contact as an integral part, causing the contact to transfer to the N/O side. The tension on the reed causes a return of the common to the N/C side as soon as the coil is deenergized. (Some types use a permanent magnet to cause the reed to return to the N/C condition.)

Mercury relays are made in several contact and coil configurations. The proper replacement relay should be ascertained from the information contained in service material for the particular machine involved. There are two types of mercury relays used in IBM equipment. One type resembles the octal-based metal tube. The other type is mounted on an SMS card in a rectangular slot that allows the coil to be recessed in the card. The glass capsule is inserted in the hollow core of the coil and the complete assembly is then mounted on the card.

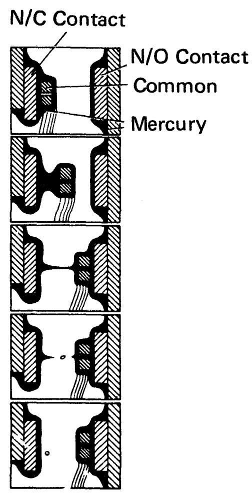


Figure 2-73. ARC Absorption

Two precautions must be observed in the use of mercury relays.

1. The mounting must be such that the glass capsule is in a vertical plane as indicated on the SMS card and with the octal base down in the metal tube type.

DANGER

2. *No attempt should be made to disassemble a mercury relay.* The glass capsule contains a high pressure hydrogen atmosphere which can explode and cause possible injury if tampered with. Observe the warning labels on each relay or SMS card.

GENERAL INFORMATION

The proper inspection, lubrication and adjustment of circuit breakers, and other electrical timing devices is important because of high machine speeds and because of the use of circuit breakers in electronic circuits. The impulse duration has, in some cases, been reduced to a relatively short impulse with a very limited tolerance.

A high resistance short caused by dirt or carbonized oil between the circuit breakers may be the cause of intermittent failures in electronic circuits. In a relay or magnet circuit this same short might not cause any trouble.

If the circuits are to perform their functions properly, circuit breakers and cam contacts must receive regular and thorough preventive maintenance.

When an adjustment is necessary, the circuit breakers should first be cleaned, inspected, and lubricated, using the procedure outlined for each type.

A complete row of circuit breakers with the wires attached can, in most cases, be loosened and moved out from the machine for easier cleaning and inspection. Take care that the wires are not stretched, broken, or pulled loose from the circuit breaker terminals. Do not allow circuit breaker assemblies to be supported only by the wires.

Circuit breakers should be cleaned thoroughly using an authorized solvent to remove all old oil, grease, and dirt. Be careful to clean the spaces between circuit breakers and to clean the insulating strips in the contact pile-ups.

Grasp each row of circuit breaker cams and attempt to rotate the shaft in one direction and then the other, checking the gear train for play. The only play that is allowable is caused by the normal wink between the gears. If the play seems to be excessive, check carefully to determine the cause.

When the contacts are timed, the end of the cam duration, which has the degree given on the timing chart, is to be accurately set. This may be either the make or the break time for the contact. A split-block adjustment is provided on the drive gear of most units to allow all the cams to be timed more closely than could be done by moving the drive gear one full tooth. The split block should be adjusted only if the majority of circuit breakers requires the same amount of change in timing.

Use a dynamic timer when possible, to check the make or break timing and the duration. Refer to "Dynamic Timer" for complete instructions. The dynamic timer gives an accurate picture of the duration only; it does not show contact condition. An ohmmeter can be used to determine the quality of the circuit through the connecting wires and contact points. Machine power must be off when using an ohmmeter.

The screws holding the contact pile-ups, the brass jumpers, and the wire terminals should be checked for tightness.

The adjustments for each type of circuit breaker are listed in the order in which they should be made.

Note: Before using the information in this manual to service a circuit breaker, refer to the maintenance manual for the particular machine type that uses the circuit breaker. If service information on circuit breakers is available in the machine maintenance manual, use it. Use the service information in this manual only when the information is not available in the machine maintenance manual.

ROCKER ARM CIRCUIT BREAKER

Preventive Maintenance

Use an authorized solvent to clean cam surfaces of all old grease and dirt. Check to see that the cam is not loose, warped, or eccentric (Figure 3-1).

Cam rollers should be checked to see if they are loose or binding. Replace the rocker arm when the roller bearing is bad.

The rocker arm pivot should be checked to see if it is loose or binding. Replace the rocker arm when the pivot bushing is worn.

Circuit breakers should be cleaned with an authorized solvent. If the points are badly pitted, replace them. After cleaning with a solvent or with an abrasive, make certain that all particles have been removed from the

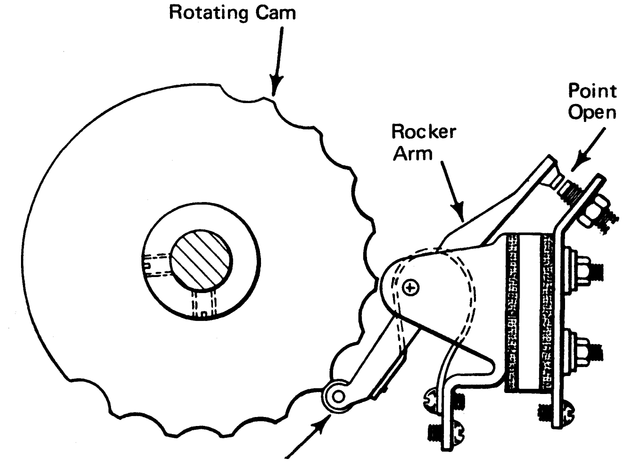


Figure 3-1. Rocker Arm Circuit Breaker

contact surfaces. A good method to follow is to rub the surfaces with a finger and then to polish thoroughly with a burnishing tool (part 450567).

A rocker arm is available that has a removable point. It is to be used in positions where frequent replacement of points is necessary. The part numbers of the arm and point are:

contact breaker arm, part 198247
contact point only, part 198247
nut, part 27073
lock washer, part 6364
circuit breaker arm only, part 198275.

Check the screws holding the contact pile-ups for tightness.

Make certain that the contact surfaces are parallel and that they meet squarely.

If any of the rocker arms seem to have noticeably less spring tension than the others, replace them.

When any of the component parts of the circuit breaker assembly are replaced, check the adjustments.

Lubrication

IBM 6 – The cam follower roller.
– The rocker arm pivot.
IBM 17 – A very light film on the cam surface.
– The cam follower roller (apply IBM 6 first).

Be careful in lubricating contact assemblies. Where the contact points are lower than the pivot point, do not use too much lubricant because it runs down the arm and may prevent the points from making contact.

Adjustments

1. Align the points so that the sides and faces are parallel (Figure 3-2).
2. The cam follower roller must be clear of the cam surface when the points are closed (Figure 3-2).
3. With the cam follower roller on the high surface of the cam, set the contact air gap with the adjustable contact point as specified on the electrical timing chart for the machine (Figure 3-3).
4. Loosen the setscrews in the circuit breaker cam and turn the cam to obtain the proper timing as specified on the electrical timing chart for the machine (Figure 3-3). Use a dynamic timer whenever possible to check the timing of the circuit breaker contacts. Be sure to tighten the setscrews if they have been loosened.
5. The minimum spring tension to ensure adequate contact pressure for the rocker type contact is 225 grams to just move the contact strap (Figure 3-4). This adjustment can be checked with the roller on either the high dwell or the low dwell. Reforming the blue steel spring may be necessary to obtain this tension. This minimum tension reduces the bounce. To prevent excessive wear, the maximum tension should never exceed 400 grams.

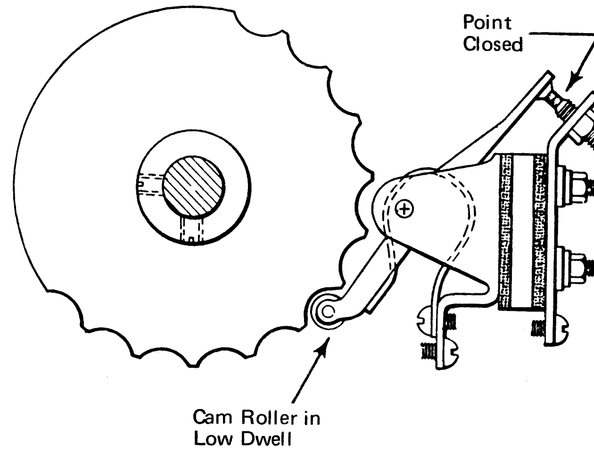


Figure 3-2. Rocker Arm Circuit Breaker–Closed Position

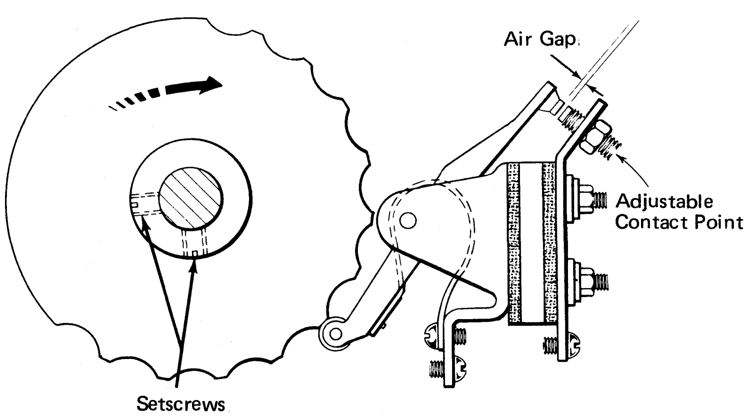


Figure 3-3. Rocker Arm Circuit Breaker–Open Position

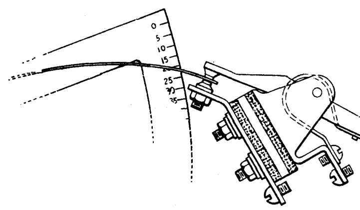


Figure 3-4. Rocker Arm Circuit Breaker–Tension

UNITIZED ROCKER CIRCUIT BREAKER

The unitized rocker circuit breaker (Figure 3-5) is similar in all respects of operation to the rocker arm circuit breaker, except that instead of being assembled on a bar, it is a complete unit in itself. This makes removal easier.

Preventive Maintenance

The most common problem of the unitized rocker circuit breaker is the failure of the contacts to make. Low voltage circuits are especially critical.

When failures occur, the circuit breakers should be checked in order to locate the following possible problems (Figure 3-5).

1. Contact surface resistance.
2. Binding at the operating arm pivot. (Check with spring removed.)
3. Improper positioning of the braided bonding strap.
4. Binding between operating arm and the non-operating spring support.
5. Operating arm cam roller loose or worn.
6. Insufficient spring tension to close contacts.

Contacts may be cleaned with cleaning fluid and/or burnished. The contact surface must be dome shaped, never ground flat.

Do not assume the circuit breaker can pass current just because it has been cleaned. Test the circuit under operating conditions. If it fails, reclean the contacts using a burnishing tool.

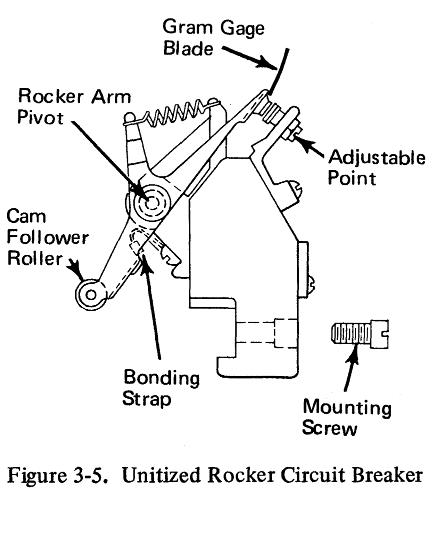


Figure 3-5. Unitized Rocker Circuit Breaker

Lubrication

IBM 9 – Roller and arm pivot.
IBM 17 – Cam

Adjustments

Most unitized rocker circuit breaker adjustments are similar to those used on the rocker arm circuit breaker. The following adjustments pertain only to the unitized rocker circuit breaker.

The contact tension should be 400 grams ± 25. To measure tension, the tip of the gram gage is placed on the outboard radius of the operating arm, next to the contact (Figure 3-5). The tension is measured as the contacts just break. For this measurement, the contact screw should be equally spaced through its support. The tension can be increased by removing two or three loops from the spring, or by forming the operating arm at the point where the spring is connected.

PLUNGER CIRCUIT BREAKER

Preventive Maintenance

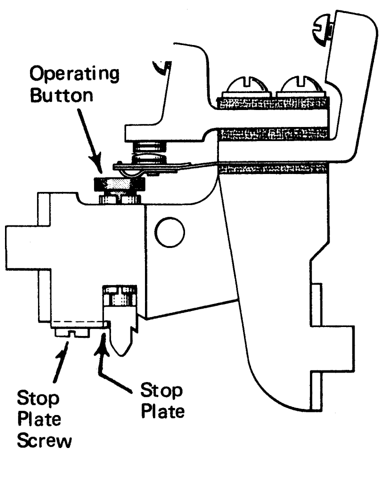
Inspect for a build-up of carbonized oil or other foreign material which could cause a short circuit between the contact straps. This accumulation occurs around the points and between the straps.

The plunger type circuit breakers (Figure 3-6) cannot be properly cleaned in the machine. The complete contact bar assembly can usually be removed from the machine with the wires attached. These bars may not be doweled, so it is necessary to use some means of ensuring that they are reinstalled in their original position. One method is to check the timing of a few cams on each end before the bar is removed. Then reinstall the bar so that these cams have their original timing.

When the circuit breaker assemblies are removed from the machine, they should be flushed out with an authorized solvent. Be very careful not to damage the wires and cables. The circuit breaker assemblies should never be supported by wires alone.

This cleaning procedure must be repeated periodically to reduce machine failure by minimizing the accumulation of dirt and carbon. The recommended maximum length of time between cleanings is six months. When compressed air is available, blow the solvent out of the circuit breakers after cleaning.

A burnishing tool (part 450567) should be used to polish the circuit breaker points after they are cleaned. It can be used to burnish normally closed and normally open plunger type circuit breaker points. This removes any particles or any film that is left by the cleaning process.



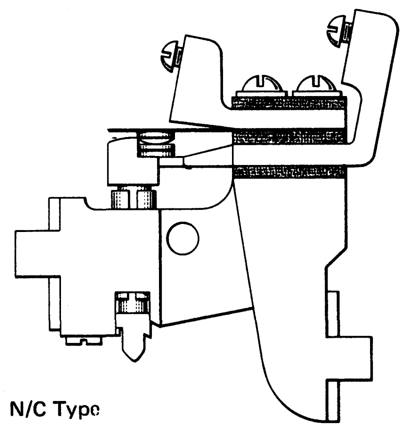


Figure 3-6. Plunger Circuit Breaker

Check the cable connections to the circuit breakers. Screws holding the brass jumpers and contact pile-ups should be tightened periodically. Also tighten the stop plate screw holding the plunger. The taper plugs that plug into the circuit breaker contact block may become loose due to vibration or movement of the cable. They should be tightened with pliers.

Circuit breakers with badly pitted points or with worn plungers should be replaced as an assembly. Changing component parts is not advisable. The contact tension must be exact if the circuit breaker is to operate correctly. This tension cannot be properly obtained by the customer engineer when he replaces the contacts. The plunger has a tendency to stick when it becomes worn. Therefore, replacing the old contact with a new assembly is better.

Lubrication

Plunger and Latching Plunger Circuit Breakers.

IBM 9 – Place a small amount on the contact operating plunger. Never lubricate the plastic contact operating plunger of the roller cam follower circuit breaker.
– One drop on the pivot of the contact latch of the latching plunger circuit breaker.

IBM 9 – On the IBM 602 machines, the oil lines to the felt cam wipers and bearings of the circuit breaker unit should be removed and plugged with the closure plug, part 190278. This is done to reduce the amount of oil received by these units. Periodic light applications of IBM 9 on the felt cam wipers will be necessary.
– A small amount should be applied to the circuit breaker cam shaft bearings.
– Care must be exercised not to overlubricate the circuit breaker units.

Plunger Circuit Breaker with Roller Cam Follower.

IBM 9 – Use sparingly on the roller arm pivot stud.
IBM 12 – One drop on each end of the roller shaft.
IBM 24 – Apply a light film to the cam surface.

Do not lubricate the plastic contact operating plunger of the roller cam follower circuit breaker.

Adjustments

Either a normally open or a normally closed circuit breaker may be used to give the desired contact duration. If the contact duration is to be less than 180°, a normally closed circuit breaker is used. The contact is opened by the cam for the number of degrees that the contacts should not be made.

Normally Open Type

1. The lower strap should be formed at point A to provide proper tension (Figure 3-7). At the factory

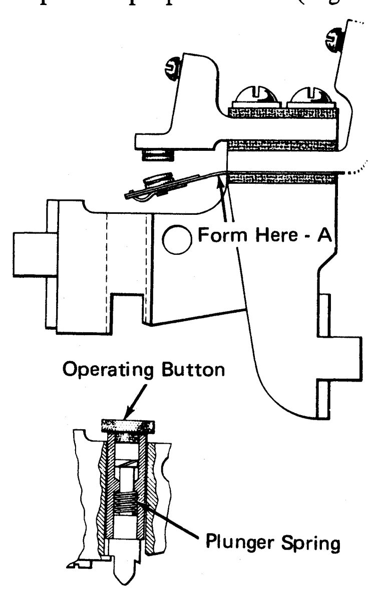


Figure 3-7. Plunger Circuit Breaker–Adjustment

these straps are adjusted so that a force of 160 grams plus or minus 10 grams (approximately 6 oz.) applied at the tip of the lower strap just closes the points. This tension must be maintained accurately to prevent a bouncing condition.

2. The upper contact support should be formed at point B (Figure 3-8) to provide a .015-inch to .018-inch clearance between the upper contact and the lower contact when in its normal position resting on the plunger.

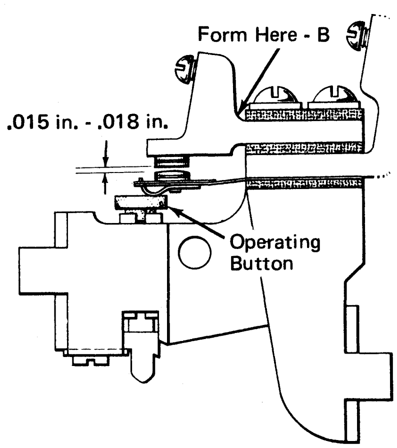


Figure 3-8. Plunger Circuit Breaker–Adjustment 2

3. Check to be sure that the plunger does not bind (Figure 3-9). The coil spring spreads the bushing to create a drag between the bushing and frame. This increases the pressure required to close the contact (measured at contact strap) from 160 grams to 225 grams (measured at plunger). This friction dampens the rebound when the contact closes. Check to be sure that a maximum of 240 grams applied to the *plunger* closes the contact.

4. Locate the cam contact unit on the mounting bar with the plunger on the highest point of the cam lobe and the contact points just closed (Figure 3-10), and advance the adjusting screw one-half turn to obtain a .010-inch to .015-inch additional movement of the plunger. The total rise from the low dwell to the high dwell of the cam is .065-inch. With the air gap set for .015-inch to .018-inch and the contact assembly correctly located on the mounting bar, the clearance between the cam plunger and the low dwell should not be greater than .018-inch. This may be checked by inserting an .018-inch gage between the low dwell of the cam and the plunger and observing any perceptible movement of the contact strap. This indicates that the additional travel of the plunger, after the contact is closed, is sufficient to compress the plunger spring and provide good contact tension.

5. To adjust the make time of the contact, loosen the screws holding the cam to the shaft until the cam is just snug on the shaft (Figure 3-10). Turn the machine to the index point corresponding with the make time of the cam. Move the cam on the shaft in the direction of rotation until the contact just closes. The machine may now be turned to a point where the cam holding screws can be tightened. The circuit breaker cam clamp is provided with notches and accurate adjustment of the cam may be obtained by tapping lightly against the notch with a screwdriver.

When the cam time duration is a number of degrees not supplied by a standard cam, an additional adjustment must be made. Raising or lowering the contact assembly is necessary until the desired condition is satisfied. Check the duration with a dynamic timer after the adjustment is changed. A contact which is dirty or is making with little tension may indicate proper duration on the dynamic timer, yet it may not be capable of carrying a heavier current load such as required to operate one or more relays. Be sure of the contact condition.

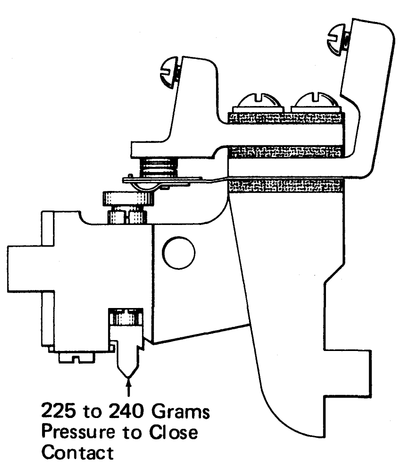


Figure 3-9. Plunger Circuit Breaker–Adjustment 3

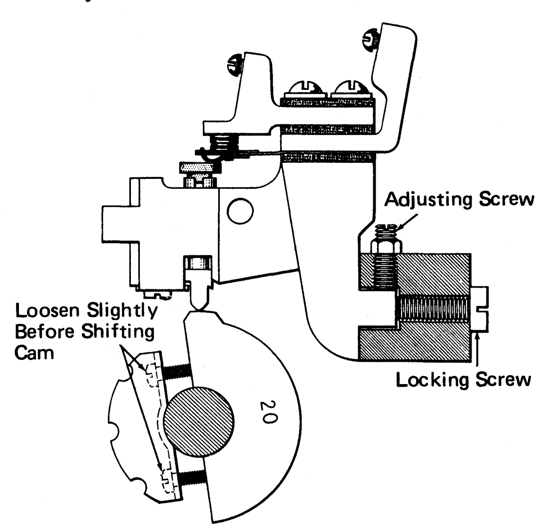


Figure 3-10. Plunger Circuit Breaker–Adjustments 4 and 5

Normally Closed Type

The sides of the contact operating button of the normally closed circuit breaker have been cut away to prevent an accumulation of carbon and dirt at the contact points which cause the points to become shorted.

1. The lower contact support should be formed at point A (Figure 3-11) to provide a .013-inch clearance between the upper contact strap when it is in its normal position and the operating plunger.
2. A maximum pressure of 550 grams (approximately 19.4 oz.) on the contact plunger should be required to just open the contact points (Figure 3-11).
3. Locate the cam contact unit on the mounting bar at its extreme limit of travel away from the cam (Figure 3-12). With the plunger on the highest point of the cam lobe, advance the adjusting screw until the air gap at the contact points is a minimum of .020-inch when the plunger is raised to its limit of travel.

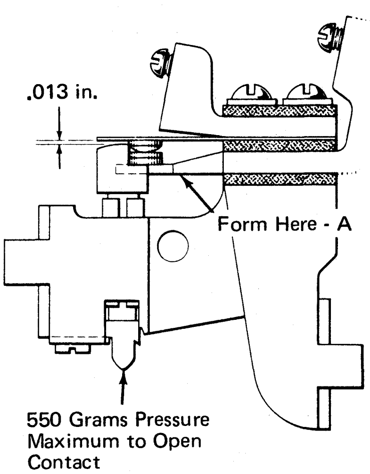


Figure 3-11. N/C Plunger Circuit Breaker–Adjustment 1 and 2

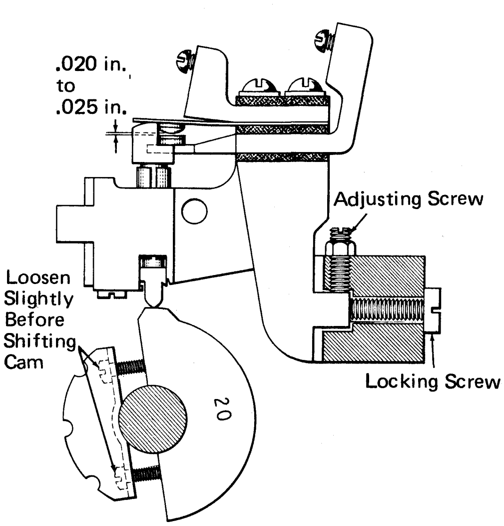


Figure 3-12. N/C Plunger Circuit Breaker–Adjustment 3

Latching Type

The latching plunger circuit breaker (Figure 3-13) makes it possible to obtain any desired duration of contact, ranging from a fraction of a cycle point to a complete cycle.

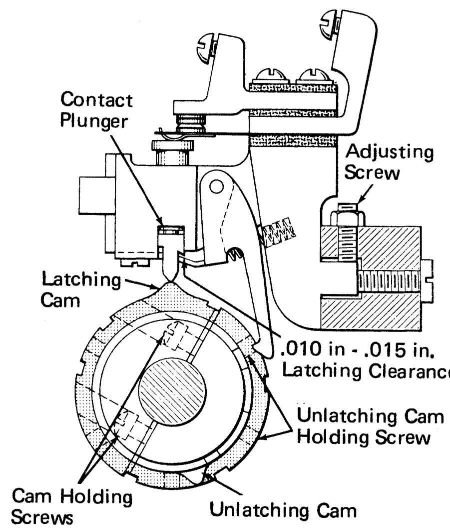


Figure 3-13. Latching Plunger Circuit Breaker

All contacts are closed by a lobe on a bronze cam which operates against the contact plunger and carries it beyond the latching point so that the latch arm may support the contact plunger. The unlatching cam may be adjusted to any position with respect to the periphery of the bronze cam. This cam strikes the latch arm and unlatches the contact plunger. In this manner the contact duration may be adjusted.

1. The lower contact strap should be formed at point A to provide proper tension (Figure 3-14). At the factory these straps are adjusted so that a force of 160 grams, ± 10 grams, applied at the tip of the

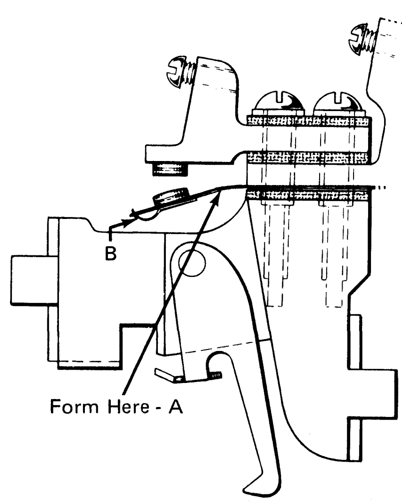


Figure 3-14. Latching Plunger Circuit Breaker–Adjustment 1

lower strap, point B, closes the points. To avoid a bouncing condition this tension must be maintained accurately.

2. Place shims beneath the plunger stop plate as required to obtain a .040-inch to .050-inch travel of the plunger before latching up occurs (Figure 3-15). If the contact plunger is overlapped by the latch by an amount equal to the thickness of the latch metal, the .040-inch to .050-inch travel is provided. When the latch arm is unlatched, a pressure of 45 grams, ± 5 grams, applied at the point where the unlatching cam operates against the latch arm should move the latch away from the plunger.
3. Place shims between the lower contact terminal block and the contact strap to provide a .015-inch to .018-inch air gap between the contact points (Figure 3-16).
4. Check to be sure that the plunger does not bind (Figure 3-17). The coil spring spreads the bushing to create a drag between the bushing and frame. This increases the pressure required to close the contact from 160 grams (measured at the contact strap) to 225 grams (measured at the plunger). This friction dampens the rebound when the contact closes. Check to be sure that a maximum of 240 grams applied to the *plunger* closes the contact.

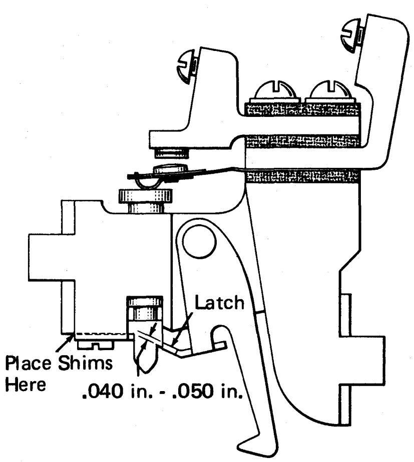


Figure 3-15. Latching Plunger Circuit Breaker–Adjustments

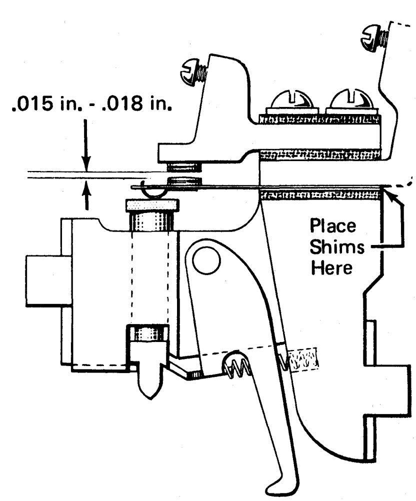


Figure 3-16. Latching Plunger Circuit Breaker–Adjustment 3

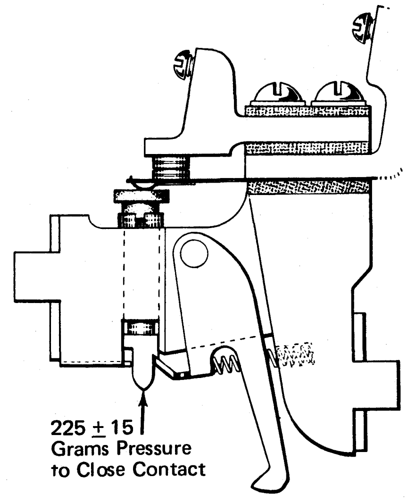


Figure 3-17. Latching Plunger Circuit Breaker–Adjustment 4

5. A pressure of 600 grams, ± 20 grams, on the contact plunger should be required to compress the plunger spring to the latching point (Figure 3-18). These values have been tested and found to provide a good operating condition.

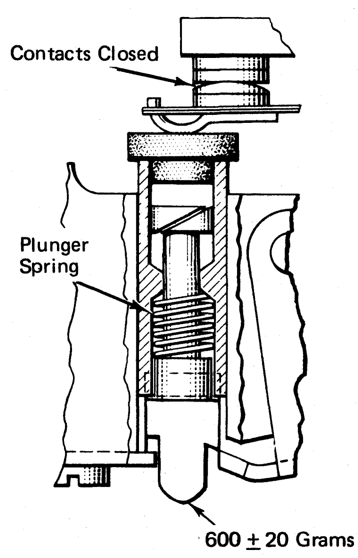


Figure 3-18. Latching Plunger Circuit Breaker–Adjustment 5

6. Locate the cam contact unit on the mounting bar at its extreme limit of travel away from the cam (Figure 3-19), and with the plunger on the highest point of the cam lobe, advance the adjusting screw until the plunger latches; then advance the screw one-half turn

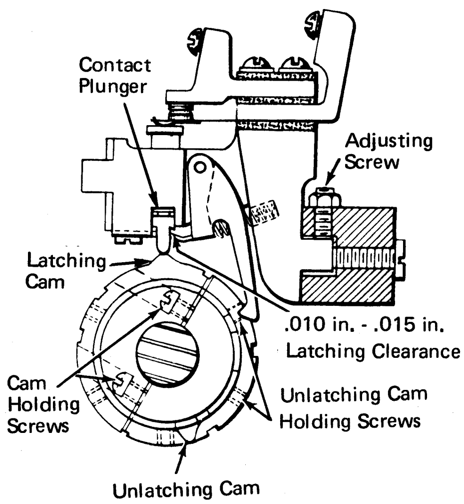


Figure 3-19. Latching Plunger Circuit Breaker–Adjustments 6, 7 and 8

additional to obtain a .010-inch to .015-inch movement of the plunger beyond the latch point. This provides clearance between the low dwell of the cam and the plunger.

7. To adjust the make time of the contact, loosen the screws holding the cam to the shaft until the cam is just snug on the shaft (Figure 3-19). Turn the machine to the index point corresponding with the make time of the cam. Move the cam on the shaft in the direction of rotation until the contact just closes. The machine may now be turned to a point where the cam holding screws can be tightened. An accurate adjustment may be obtained by inserting a screwdriver in slots provided on the periphery of the cam for moving it on the shaft.
8. To adjust the break time of the contact, loosen the contact unlatching cam screws (Figure 3-19). Turn the machine to the proper index point and move the unlatching cam in its slot until the contact opens. Tighten the holding screws. There are six possible positions for holding screws, only two of which can be used at any one time.

Roller Type

The roller cam follower type of plunger circuit breaker (Figure 3-20) is designed to operate at higher speeds than the standard plunger type. A curved flat spring is fastened to the roller arm. This spring operates the contact plunger which, in turn, operates the lower contact strap.

1. A force of 100 to 150 grams should be required to move the operating point to the point where it contacts the stationary point when measured at the end of the operating strap.
2. The contact air gap should be .027-inch to .032-inch when the plunger is resting against the frame (Figure 3-20). Add or remove shims to obtain this adjustment.
3. When measured at the roller, 475 to 550 grams should be required to close the contacts with a .020-inch to .030-inch overtravel (Figure 3-21).
4. With the circuit breaker assembly attached to the mounting bar by the holding screw (Figure 3-22), turn in on the adjustment screw to obtain a contact air gap of .017-inch to .022-inch when in the low dwell of the cam.
5. When positioning the cams, be careful not to tighten the cam holding screws too tightly as their walls may crack.

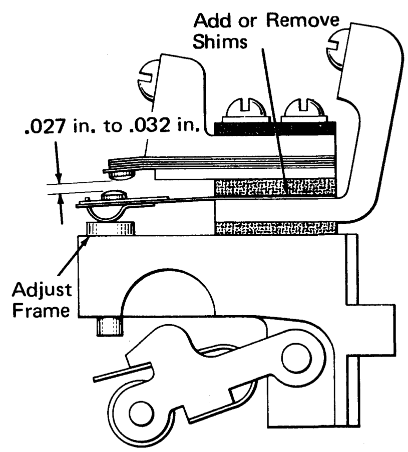


Figure 3-20. Plunger Circuit Breaker Roller Type–Adjustment 2

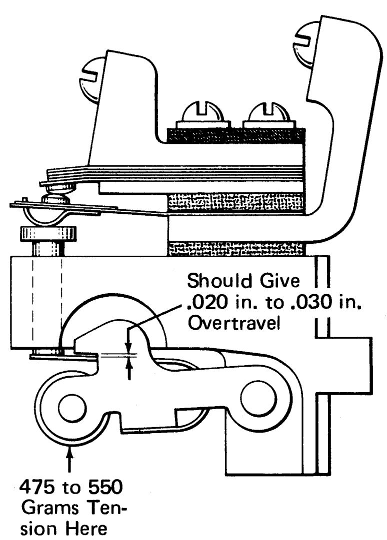


Figure 3-21. Plunger Circuit Breaker, Roller Cam Follower–Adjustment 3

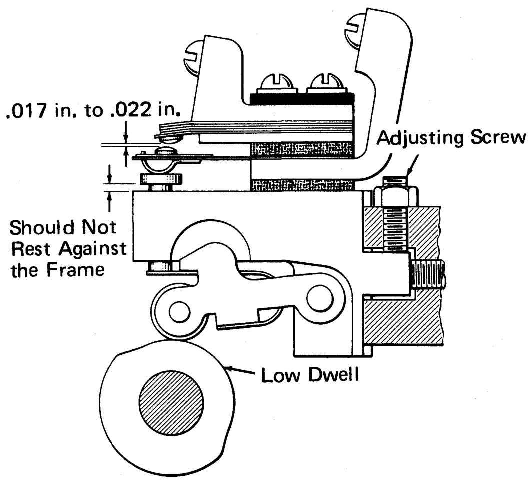


Figure 3-22. Plunger Circuit Breaker, Roller Type—Adjustment 4

Cams

The side of all cams is stamped with the number of degrees of duration of their high point.

Part	Degree	Part	Degree
222796	6	222785	85
222708	8	222790	90
222710	10	222795	95
222712	12	222800	100
222715	15	222805	105
222718	18	222810	110
222720	20	222812	112
222722	22	222815	115
222725	25	222820	120
222730	30	222825	125
222735	35	222830	130
222740	40	222835	135
222745	45	222840	140
222750	50	222845	145
222755	55	222850	150
222760	60	222855	155
222765	65	222860	160
222770	70	222865	165
222775	75	222870	170
222780	80	222875	175
		222880	180

Where it is necessary to have closer tolerances than are available with powdered bronze cams, machined steel cams are used.

SPRING STRAP CAM CONTACTS

Preventive Maintenance

Clean the cam surfaces and contacts of all grease, oil, and dirt. Use an authorized solvent. When a point is badly burned, replace the contact strap assembly.

Check the contact points to see if they are loose in the strap. They can be tightened by peening the point.

Stone the points to a flat surface. After stoning or cleaning the contact points, they must be thoroughly polished with a burnishing tool (part 450567).

Make certain that the contact surfaces are parallel and that they meet squarely. Check the screws in the contact pile-up for tightness.

Lubrication

IBM 17 – A light film should be applied to the cam surface.

Adjustments

There are two types of cam contacts commonly referred to as make or break contacts. They are identified by their position after the operating strap falls off the high dwell of the cam. When the operating strap falls off the high dwell of the cam and the contact opens, a break contact is designated. When the operating strap falls off the high dwell of the cam and the contact closes, a make contact is designated.

1. Align the contact points by loosening the contact mounting screws and shifting straps for proper alignment. Be sure the screws are tightened.
2. Adjust the make contact by forming the nonoperating strap for an air gap of 1/32 inch between points when the operating strap is on the high dwell of the cam (Figure 3-23). The operating strap should have sufficient tension to insure good contact when the points are closed.
3. Adjust the break contact by forming the nonoperating contact support for 1/32 inch rise of the nonoperating strap off its support when the operating strap is on the high dwell of the cam (Figure 3-23). When the operating strap drops off the high dwell of the cam, there should be at least 1/6 inch air gap between the points. Do not put too much tension on the operating strap. Too much tension causes noisy operation and excessive wear on the cams.
4. Adjust the timing of the contacts by loosening the cam setscrews and shifting the cam on the shaft (Figure 3-23). The timing of the individual contact is obtained from the timing chart which accompanies the machine. Make contacts are timed for the making point (the point at which the contact strap falls off the high dwell of the cam). Break contacts are timed for the proper breaking point according to the timing chart (the point at which the operating strap falls off the high dwell of the cam).

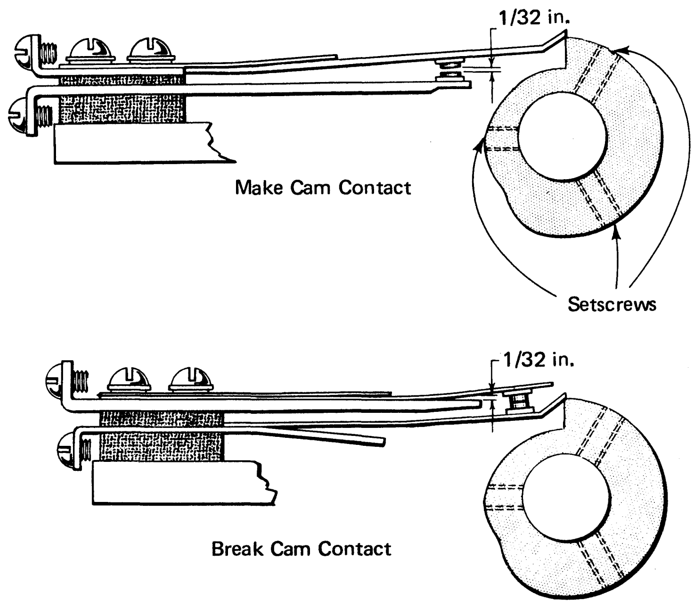
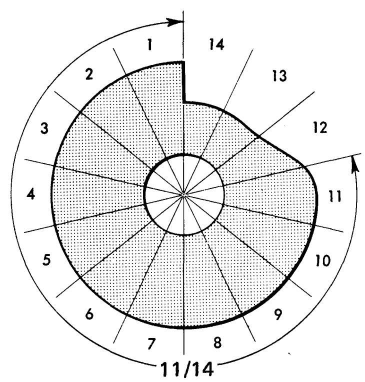


Figure 3-23. Spring Strap Cam Contact Adjustments

Cams

The plastic cams used to operate the contacts are stamped with a fraction indicating the size of the cam. The size is given in fourteenths or a fraction of 1/14, and it indicates the proportion of the circumference that is high (Figure 3-24). Thus, a 4/14 cam has approximately 4/14 of its circumference high and 10/14 low. When used with a break contact, such a contact is closed 4/14 when the operating strap is on the high portion of the cam and is open 10/14 when on the low dwell of the cam. If a make contact is used, the contact is open for 4/14 and closed for 10/14 of the circumference of the cam. A make contact is open when the operating strap is on the high portion of the cam.



11/14 Cam

Figure 3-24. Contact Cam

METERS

General Information

Although a test light could be used to test continuity through a series of relay points on early machines, a test light had no provision for measuring the exact resistance of a relay coil or the voltage on the control grid of a vacuum tube, etc. Meters have the ability to measure these items and many others.

Prefixes

To avoid the use of many zeros when writing electrical quantities, the following prefixes are used. (The most common prefixes are indicated by an asterisk.)

Mega	1,000,000*
Kilo	1,000*
Hecto	100
Decka	10
Deci	0.1
Centi	0.01
Milli	0.001*
Micro	0.000 001*
Nano	0.000 000 001*
Pico	0.000 000 000 001*

Example: 0.000005 ampere can be written "5 microamperes."

Definitions

The ampere is the unit of measure for electric current intensity. It refers to the number of electrons passing a given point in the wire every second.

The ohm is the unit of measure of resistance to electric current. It is arbitrarily defined as the resistance of a standard column of mercury 106.3 centimeters long, weighing 14.4521 grams, at 32° Farenheit.

The volt is the unit of measure of electric force. One volt forces a current of 1 ampere through a resistance of 1 ohm.

The farad is the unit of capacitance. For all practical purposes, the farad is too large a unit to refer to for daily use, so capacitors are rated in microfarads (millionth of a farad) or picofarads (millionth of a microfarad). The pico terminology replaces the former micro micro reference.

The henry is the unit of inductance. An inductance of 1 henry induces an electromotive force of 1 volt when the current through it varies at the rate of 1 ampere per second.

IBM Meter

The IBM meter was developed to meet the need for a light, portable instrument to measure voltage, current, and resistance. The IBM meter has been redesigned several times to meet new demands; however, the changes have been minor.

The test leads that are used with the IBM meter are color-coded with red and black tips. The leads should always be plugged so that the black lead is connected to the (–) or common hub, and the red lead is connected to the (+) or function hub. Connecting the leads in this manner is called polarization of the leads, and decreases the possibility of damage to the meter.

Before the meter is used for any measurement, be sure that the pointer is on zero. If the pointer is off zero, adjust by means of the slotted screw located directly below the meter scale.

Types

Four types of IBM meters are shown in Figure 4-2. To avoid confusion in the text, they are referred to as style A, B, C, and D. The meters have provision for measuring dc or ac voltage and resistance. Current may be read directly on the style C or D meter. Ohm's law can be used to calculate current measurement when the style A or B meter is used. The low battery voltage, used in measuring resistance and in checking continuity, cannot damage circuit elements or shock personnel.

The style C meter has an additional hub located on the top edge of the meter. A common probe may be plugged into this additional hub. This top hub is an additional – common (COM) hub and is internally connected to the corresponding hub on the front of the meter. To use this hub, plug the red test lead into the + volt-ohm-milliammeter (VOM) hub and connect the clip end of the red lead to a positive reference point in the circuits to be tested. Plug the common probe into the top hub, select the correct voltage range on the range switch, and touch the pointed end of the probe to the point(s) to be tested. Read the voltage as measured.

The use of the probe eliminates having to shift the eyes or head each time a new reading point is touched. The meter can be in reading position at the time contact is made.

There are some limitations on the usage of this hub and probe: It can only be used where the positive reference point is common to the various negative points to be measured. *For safety reasons, this method should never be used for high voltage measurements* since it

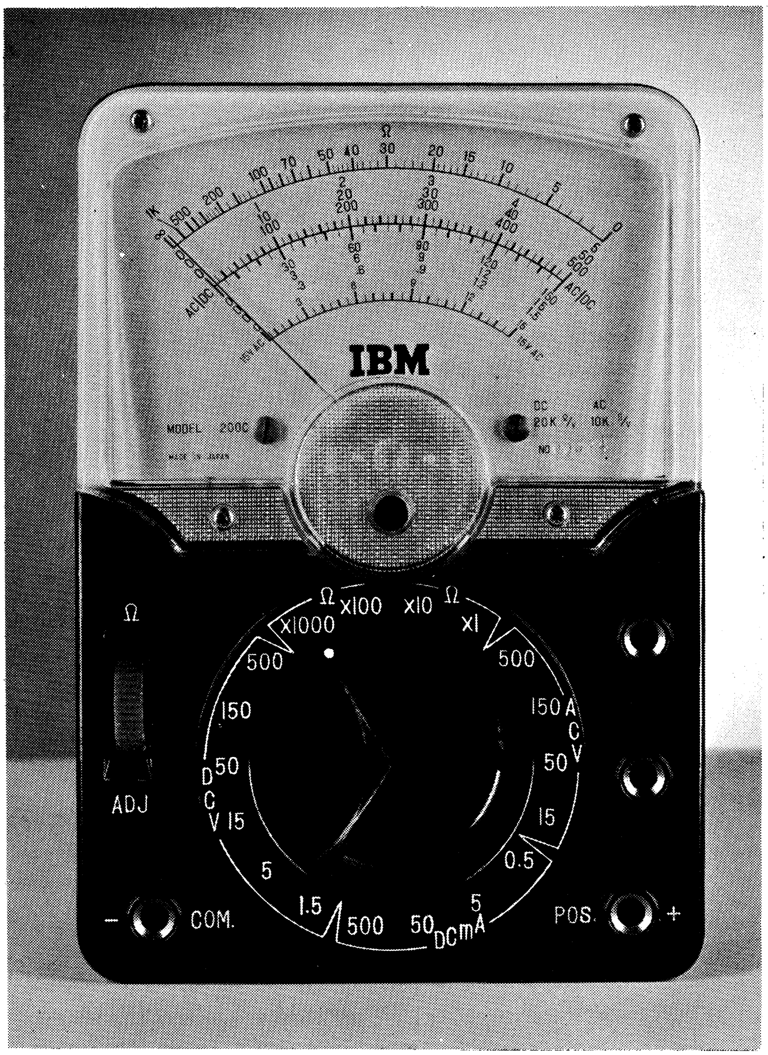


Figure 4-1. IBM Meter Style D

involves holding the meter in the hand while taking a reading.

The style D meter (Figures 4-1 and 4-2) has some features which distinguish it from previous meters. The meter jacks are banana plug type. Therefore, standard control panel wires or previously used meter leads do not fit the style D meter. The red meter lead is fused with a 1/2-amp fuse at the meter end of the lead. Also, the two jacks (on the right side of the meter) above the positive (+) hub are not used. Any other differences between the style D and previous meters is mentioned in the text whenever applicable. The complete style D meter package is part 452796 and includes the following individual items:

Meter (style D)	part 452791
Red Test Lead (fused)	part 452793
Black Test Lead	part 452794
Replacement Fuse	part 452806

Voltage Measurement

When using the meter to measure voltage (Figure 4-3), connect the black lead to the negative (–) hub and the red lead to the positive (+) hub. The actual hub labels for the different style meters are shown in Figure 4-2. The selector switch must be turned to the proper voltage range. The dc positions measure direct current and the ac positions measure alternating current. When direct current is measured, the red lead is always connected to the point of higher positive potential, while the black lead is connected to a lower potential point. Thus, current always flows in one direction through the meter movement, causing the pointer to deflect upscale. If the meter leads were reversed, the current would cause the meter to try to indicate downscale, and because no counterclockwise movement is possible below zero, the meter movement might be damaged.

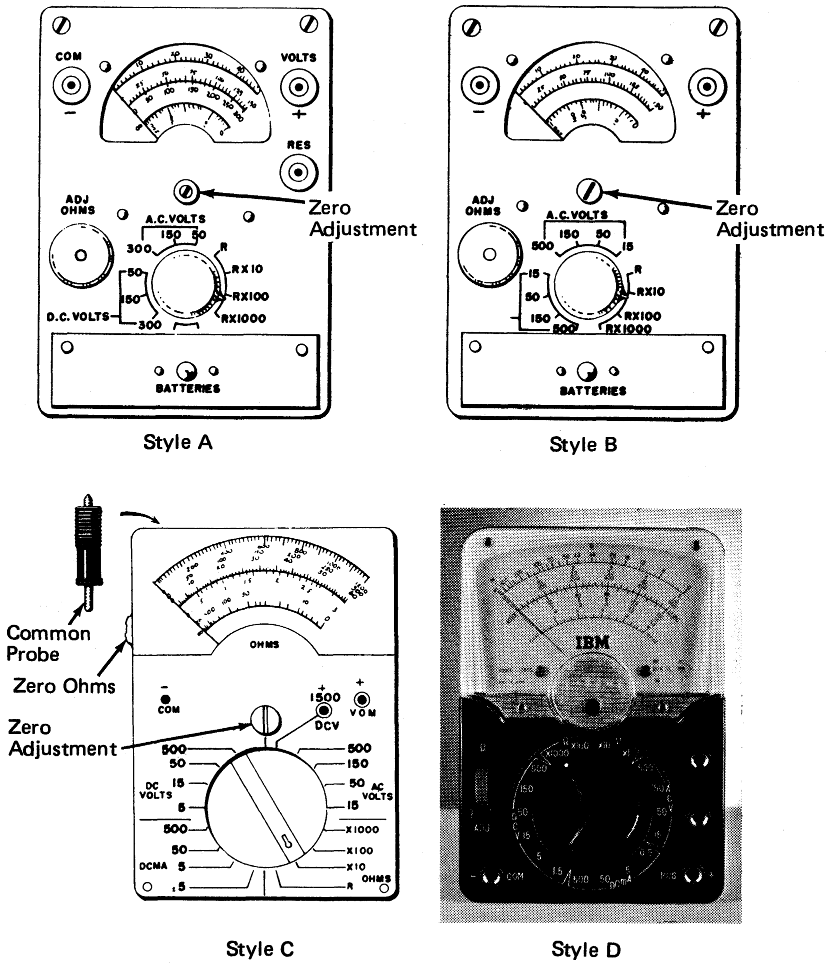


Figure 4-2. IBM Meters

If the leads are properly connected to a voltage source, the pointer moves a distance proportional to the voltage. When ac voltages are measured, it is not necessary to observe polarity.

The setting of the selector switch determines which scale of the meter should be read. The style A meter has three voltage ranges; the style B has four voltage ranges; the style C meter has five voltage ranges; and style D has six voltage ranges (Figure 4-2).

The range should always be selected so that the measured voltage lies near the center of the scale because the meter is more accurate in this portion of the scale. The meter can be severely damaged if the leads are connected to a high voltage while the selector switch is on a low-voltage range. The meter movement would try to go past the upper end of the scale and might be damaged. For this reason, the highest range should always be used first when an unknown voltage is being measured. Progressively lower ranges may then be selected until the reading lies near center scale.

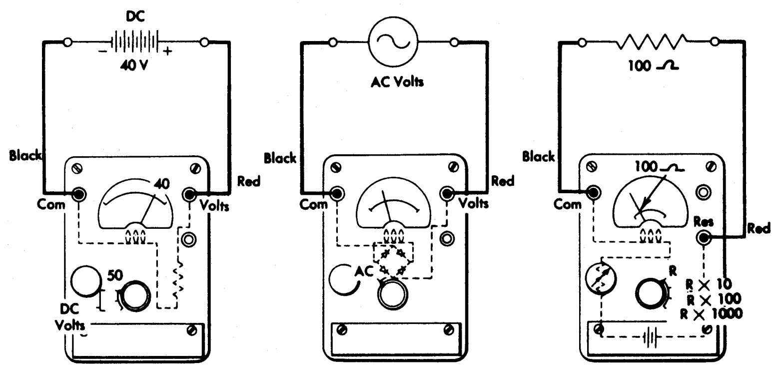
When ac voltages are measured, use the same scales that are used for dc voltages, but turn the selector switch to the ac voltage positions. On the style C and style D meters, a special ac voltage scale is used when the selector switch is set on the 0-15-ac-volt position.

If a dc voltage is measured with the switch on an ac range, an incorrect reading results. Theoretically, no reading should result if an attempt is made to measure ac voltages on the dc ranges, but it is possible to have a slight deflection of the meter.

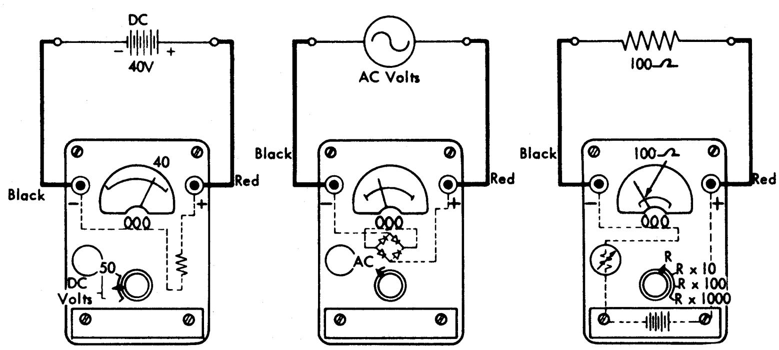
DANGER
Use extreme care when checking high voltage. Always turn off the power before making connections and do not touch meter or test leads while taking the reading.

Resistance Measurement

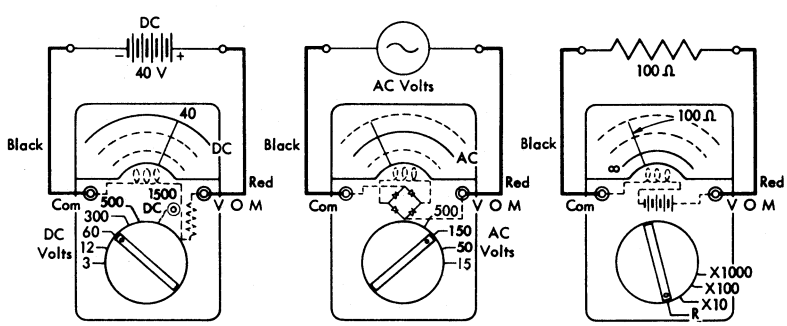
When a style B, C, or D meter is to be used to measure resistance (Figure 4-3), the leads are connected to the meter in the same manner as for voltage measurement. On a style A meter, the red lead is connected to the resistance (RES) hub. The selector switch must be turned to one of the resistance ranges. With the test leads shorted together, turn the ohms adjustment knob



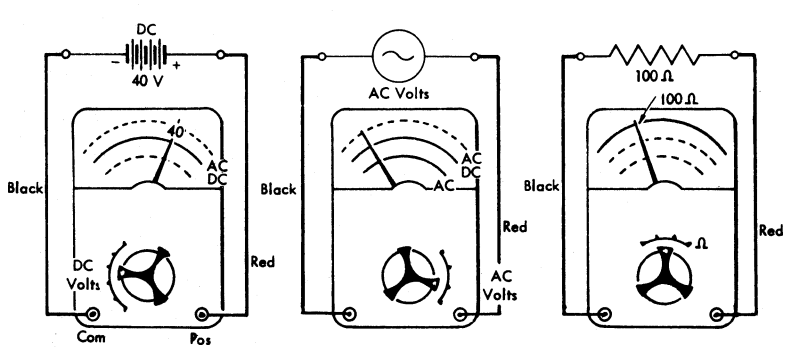
Style A Meter



Style B Meter



Style C Meter



Style D Meter

Figure 4-3. Voltage and Resistance Measurements so that the meter pointer indicates zero ohms. The meter must be adjusted for zero ohms whenever the range selector is changed to a different resistance range. When the range selector is set to R, the ohms scale is read directly. When the range selector is set to R x 10, R x 100, R x 1000, the reading is multiplied by 10, 100, or 1000.

A flashlight battery in the meter supplies a voltage to the leads, and when the leads are connected across a resistance, a small current flows from the flashlight cells to the leads and resistance. This current varies inversely with the resistance (the more resistance, the less current flows) and the meter is caused to deflect a distance proportional to the current. Therefore, when the leads are shorted together (zero resistance), maximum current flows and maximum meter deflection occurs. Accordingly, the meter scale is calibrated backwards, with the zero end of the resistance scale at the right end of the meter, and the infinite resistance end of the scale at the left. Because the flashlight cell potential changes, a variable resistance (ohm adjustment knob) is provided for calibrating the ohmmeter scales. This resistance adjusts the circuit so that a dead short reads zero ohms.

When the meter is set up to read resistance, comparatively low resistances are connected in the internal meter circuits, and extreme care should be taken to avoid connecting the ohmmeter leads to a source of voltage. A moment of carelessness may burn out the ohmmeter circuit and ruin the meter movement. *Do not leave the range selector switch in a resistance measurement position when the meter is not in use, because the test leads may become shorted and run down the meter battery.* The various connections used to measure voltage and resistance are shown in Figure 4-3.

Current Measurement

Direct current can be read directly on the style C and D metters. Four dc-milliampere ranges are provided. The black test lead should be connected to the negative (–) hub, and the red test lead to the positive (+) hub.

Figure 4-4 illustrates the method used to measure the current flow through the sort magnet. Current readings are read on the top scale on the style C meter and on the center scale on the style D meter.

CAUTION
To measure current, the meter must be connected in series with the load and correctly polarized. Establish the correct polarity by measuring the dc voltage drop across the load. If a high current is sent through the meter when the selector switch is set to a low current range, the meter coil may be damaged. Be careful on all current measurements, and, when in doubt, start with the highest current scale.

Style A and style B meters may indirectly be used to determine current in a dc circuit as follows:

To measure the current through a relay coil, the resistance of the coil should be determined by using the ohmmeter. When measuring resistance, disconnect one side of the coil to avoid the possibility of back circuits through the power supply. With the coil reconnected

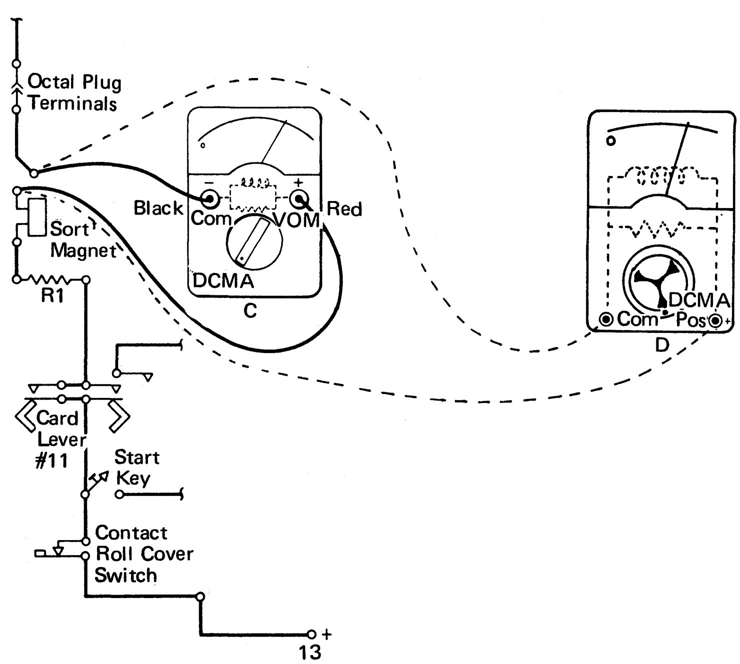


Figure 4-4. Current Measurement Style C and D Meters

and the machine turned on, measure the voltage drop across the coil. Use Ohm's law to calculate the current through the coil. Example: With the machine turned off, the relay coil of Figure 4-5 (A) is measured on the R x 100 scale.

The scale reading of 25 is multiplied by 100 to obtain the coil resistance of 2500 ohms. Then, with the machine on, power is applied to the coil and the voltage drop across the coil is measured with the voltmeter (Figure 4-5 B).

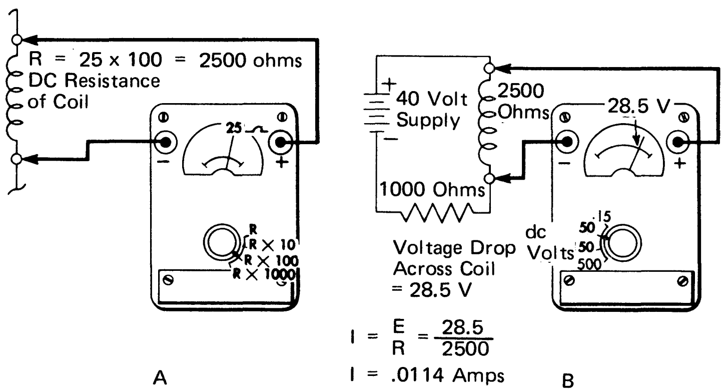


Figure 4-5. Current Measurements Style A and B Meters Selector Switch Scale Relationship

	Selector Switch	Scale	Factor
Meter A	50 ac or dc	0-50	read directly
	150 ac or dc	0-150	read directly
	300 ac or dc	0-300	read directly
Meter B	15 ac or dc	0-150	divide reading by 10
	50 ac or dc	0-50	read directly
	150 ac or dc	0-150	read directly
	500 ac or dc	0-50	multiply reading by 10
Meter C	5 dc	0-500 ac-dc	
	15 dc	0-150 ac-dc	
	50 dc	0-500 ac-dc	
	150 dc	0-150 ac-dc	
	500 dc	0-500 ac-dc	
	1500 dc	0-150 ac-dc	
	15 ac	0-15 ac	
	50 ac	0-500 ac-dc	
	150 ac	0-150 ac-dc	
	500 ac	0-500 ac-dc	
	.5 dcma	0-500 ac-dc	divide by 1000
	5 dcma	0-500 ac-dc	divide by 100
	50 dcma	0-500 ac-dc	divide by 10
	500 dcma	0-500 ac-dc	read directly
Meter D	1.5 dc	0-1.5 ac-dc	
	5 dc	0-5 ac-dc	
	15 dc	0-15 ac-dc	
	50 dc	0-50 ac-dc	
	150 dc	0-150 ac-dc	
	500 dc	0-500 ac-dc	
	15 ac	0-15 ac	
	50 ac	0-50 ac-dc	
	150 ac	0-150 ac-dc	
	500 ac	0-500 ac-dc	
	.5 dcma	0-5 ac-dc	divide by 10
	5 dcma	0-5 ac-dc	read directly
	50 dcma	0-50 ac-dc	read directly
	500 dcma	0-500 ac-dc	read directly

Figure 4-6. Selector Switch to Scale Relationship

The current is obtained by dividing the voltage by the resistance. When the relay is connected directly across the power supply, the power supply voltage must be read, but when the coil has a resistor in series with it, the voltage drop must be taken across the coil.

The actual meter scale that should be read in relation to the selector switch setting is shown in Figure 4-6. For example, when the selector switch on style B meter is set to 15 volts, the middle meter scale (calibrated from 0-150 volts) is used and the reading is divided by 10.

Locating Machine Grounds

No fixed rule can be given for finding and removing grounds because of the random nature of these troubles. However, laying down general rules is possible as a starting point from which the customer engineer can proceed further. The ohmmeter is an invaluable aid in finding where a point in the circuit becomes grounded.

Figure 4-7 illustrates a ground that is comparatively easy to find. The operated strap of R2AU has become grounded to the machine frame.

Disconnect the machine from the receptacle. Disconnect the wire from the machine power supply to the fuse common to eliminate the possibility of back circuits. Set the selector switch to the lowest resistance range and zero the meter. Clip the black lead of the IBM meter on the machine frame, and connect the red lead to the fuse common. If a stable ground exists in the circuits, the meter pointer is deflected. The circuit is traced (Figure 4-7) from the meter common hub, through the black lead to the machine frame, from

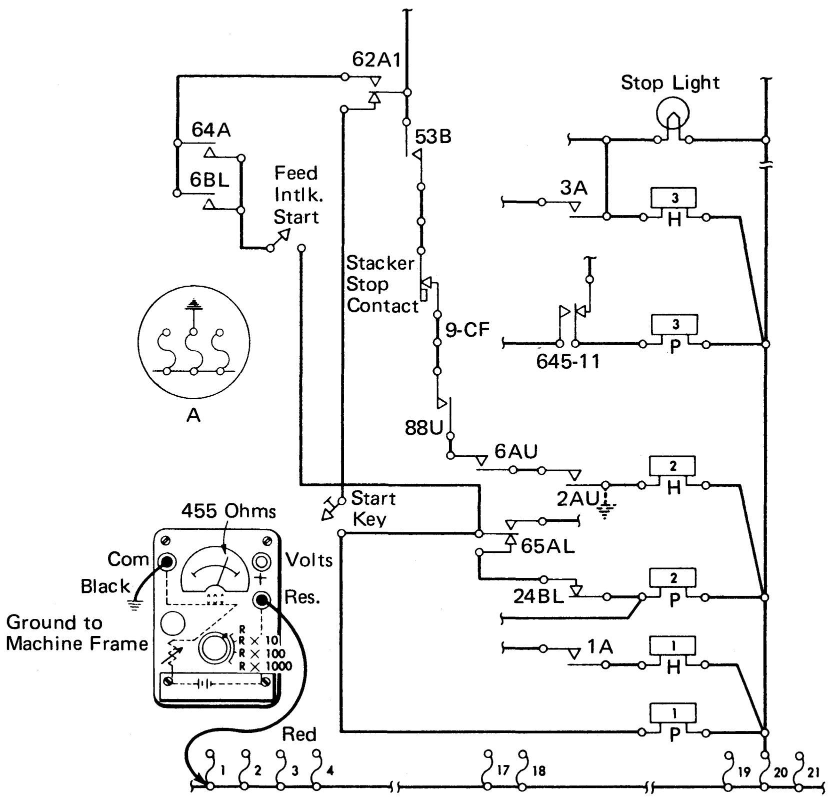


Figure 4-7. Locating a Stable Ground

grounded point of R2AU through R2H, fuse 20 common, through the red lead back to the meter. The meter indicates the resistance of the grounded circuit (455 ohms in this case).

Because a ground exists on the machine, the procedure is to determine which circuit is grounded. Remove the fuses one at a time, simultaneously observing the meter. Obviously nothing changes as fuses 1 through 19 are removed, but when fuse 20 is removed, the meter circuit is broken and the meter pointer moves to the high-resistance end of the scale. This shows that the ground is in the circuits protected by fuse 20.

Move the red meter lead to the upper clip of fuse 20. The meter should again deflect to 455 ohms. Disconnect the wires from the B side of R1 pick coil. The meter pointer moves to the high-resistance end of the scale indicating that the ground has disappeared. Move the red meter lead and determine which of the wires is still grounded. Testing these wires indicates that the ground is in the circuit leading to R2 pick coil. With the red meter lead attached to the wire leading to R2 pick coil, remove the wires from the B side of R2 pick coil. The circuit is again broken and the meter pointer moves to the high-resistance end of the scale. Using the red meter lead, the ground is found to be in the wire going to R2 hold coil. This is indicated by the meter deflecting to 455 ohms, which is the resistance of the R2 hold coil.

Move the red lead to the other side of R2 coil and the meter should read zero ohms. The ground, therefore, lies somewhere between R2 hold coil and the R2AU N/O point; a visual inspection of this area should show the grounded point. Sometimes the ground is of such a nature that it cannot be found by removing fuses. In that event, replace all fuses, remove the connection from the power supply to the line connections and connect the meter between the line terminal and the machine frame. Remove the wires on the line terminal one at a time until the resistance reading increases, and then check through the indicated circuit.

A slightly different procedure can be used for checking for intermittent grounds and grounds that appear only when the machine is running. Sometimes these grounds appear only when a certain cam is making. Here the voltmeter must be used. With the machine running, connect the voltmeter on its highest range between power supply and machine frame in such a manner that the intermittent ground deflects the meter each cycle. With the power on, but with the drive belts disconnected, turn the machine over by hand until the ground appears, and note the timing. This timing frequently indicates which cam controls the defective circuit. The meter leads can then be connected to various points in the suspected circuit to locate the grounded element. Care should be taken to avoid leaving the circuit breakers closed for any length of time on machines where coils or rectifiers may be damaged by overloads.

On some machines the fuse common is connected (through a fuse) to the machine ground (Figure 4-7 A). This fuse has to be removed from the machine when the meter is used to check for grounds.

Checking Dynamic Continuity

Figure 4-8 shows a card-feed clutch control circuit. Relay 656 must be picked by CBs 20 and 21 to cause the card feed to function. The relay points in series condition the pick of relay 656. If one of the conditioning points should fail to make contact, the machine would continue to run but no cards would feed.

With the machine running, a dynamic continuity check may be made and the failing point can be quickly found. Relay 656 is failing to pick. Connect the meter leads to the meter and observe the polarity. Clip the black lead to the fuse block. Touch the red lead to the line side. The meter should indicate 40 to 48 volts. Move the red lead to the 1B operating point. Each time CBs 20 and 21 make, the meter is deflected an amount proportional to the duration of the CBs. Deflection at regular intervals indicates that the CBs are operating properly. If the meter fails to deflect or occasionally misses an impulse, either CB 20 or 21 is probably failing.

The long series of relay points can best be checked by successive halving of the circuit. Move the red lead to a convenient point near the middle of the circuit, (for example, to the 567-9 N/C point). If the meter fails to deflect, the failing point lies between the 567-9 N/C point and the CBs. If the meter deflects, move the red lead down to the 612-7 N/O point. If the meter now fails to deflect, the failing point lies between the 612-7 N/O point and the 567-9 N/C point. This process is followed until the failing point is located.

With practice, this entire procedure can be completed in a few minutes. It saves the time required for checking the circuit elements one by one.

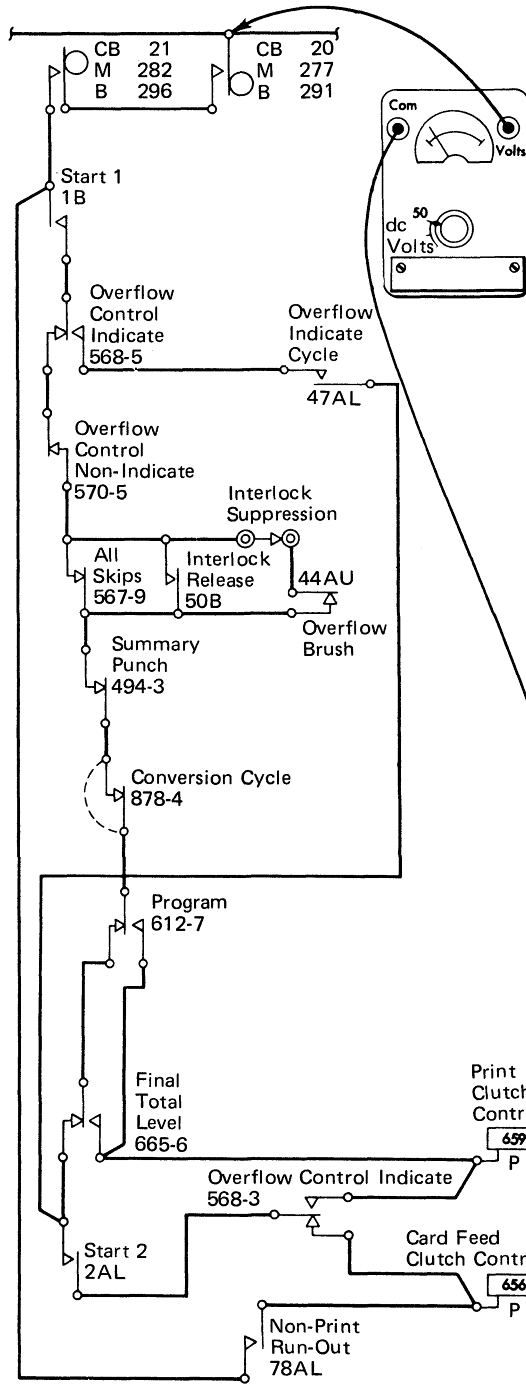


Figure 4-8. Dynamic Continuity Test

Care of the Meter

The IBM meter is a sensitive device. Use it carefully to realize full benefits. The following hints for the use and care of the meter can prolong the usefulness of the meter:

1. The meter should always remain in the leather case. This provides protection for the plastic meter case and cushions shocks to the meter movement.
2. Great care should be taken to avoid dropping the meter. The jeweled bearings may become damaged, thus impairing the accuracy of the meter. If the movement sticks, tap the meter gently; sharp knocks may damage the movement.
3. Never connect the ohmmeter leads to a source of voltage or to a resistance through which current is flowing, because this may burn out the meter resistance and harm the meter movement. When measuring the resistance of a circuit element, turn the machine OFF, and check across the power supply with the voltmeter, because a charged

condenser can seriously damage the meter if discharged through the ohmmeter circuit.

4. When measuring an unknown voltage, use the highest voltage range when first connecting the instrument and then switch to progressively lower ranges until reading is about center scale. If too high a voltage is connected to the meter when the selector switch is set on a lower voltage range, the meter coil may be damaged; the point may be bent by striking it against its full-scale stop pin.
5. Always polarize the meter leads, and take voltage readings with the red lead connected to the point of higher positive potential.
6. Before taking any readings, be sure that the pointer is on zero.

DANGER
Be extremely cautious when measuring high voltages. The meter should be connected and disconnected with the power off. *Do not touch the meter or test leads while taking the reading.*

7. Do not leave the meter in the ohms position because the leads may become shorted and run down the internal batteries.
8. When measuring current with a meter, be sure that the meter is in series with the circuit. Also be careful to observe polarity.
9. Keep meter away from magnetic fields, such as transformers, chokes, motors, generators, and high-current carrying wires (such as filament bus bars). A stray magnetic field can cause erroneous meter readings.
10. Keep the meter horizontal (face up) when taking readings.
11. Replace batteries when they become weak. This prevents damage from leaking batteries.

Simpson 260 Meter

A brief discussion of the use of this meter is included in this manual. An operator's manual is included with each meter.

Before taking readings, be sure that the pointer is on zero. If the pointer is off zero, adjust the slotted screw located directly below the meter scale (Figure 4-9).

When making dc voltage measurements from 0-1000 volts, place the OUTPUT-AC-DC switch in the DC position. Insert the black lead in the common (–) hub and the red lead in the positive (+) hub. Rotate the RANGE-SELECTOR switch to the proper dc-voltage position. Using the red lead on the higher positive potential and the black lead on the lower, read the voltage on the proper scale.

When making ac measurements from 0-1000 volts, move the OUTPUT-AC-DC switch to AC and proceed as just mentioned.

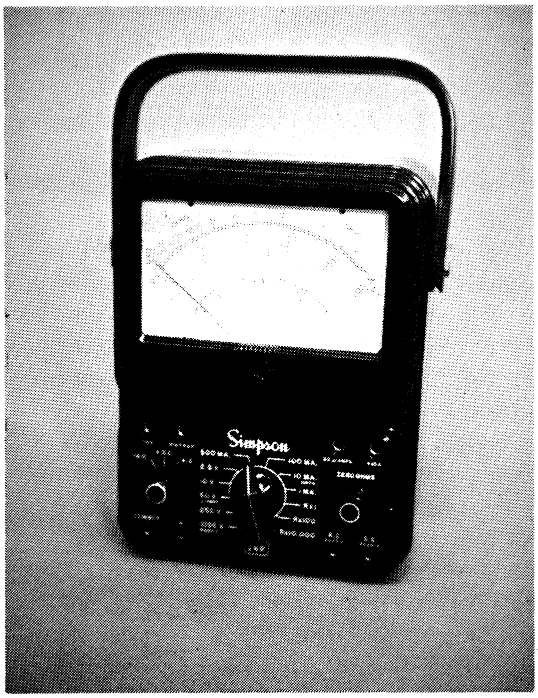


Figure 4-9. Simpson Meter

When measuring voltages from 1000-5000 volts, set the OUTPUT-AC-DC switch to either AC or DC, as required. Place the black lead in the common (–) hub and the red lead in the dc 5000 V or ac 5000 V hub as required. Connect the black lead to the negative side of the line and the red lead to the positive side of the line. Read voltages on the 0-50 scale and multiply by 100.

DANGER
Connect and disconnect leads with the power turned off. Do not touch the leads or meter while the power is on.

When making resistance measurements, be sure the power is turned off. Place the OUTPUT-AC-DC switch on DC. Rotate the RANGE-SELECTOR switch to any of three ranges as required. Short the leads together and zero the meter with the ohms adjustment knob. Read the resistance on the proper scale and multiply by the proper factor.

When measuring current, place the OUTPUT-AC-DC switch in the DC position. Rotate the RANGE-SELECTOR switch to any of the ranges required. When in doubt of the current present, always use the highest range as a protection to the meter.

Plug the black test lead into the common (–) hub and plug the red test lead into the positive (+) hub. For the 10-ampere range, use the hubs marked –10A and +10A. Read milliamperes on the black scale that is second from the top.

For current measurements, the meter must always be connected in series with the circuit, and the meter must be correctly polarized.

Weston 904 Meter

The Weston 904 ac iron vane meter is available as a branch office tool. It is a 1/2 percent accurate meter with 15 V, 150 V, 300 V, and 450 V ranges. This meter should be used on machines whose power supplies use constant voltage transformers or saturable reactor regulating circuits. The regulating action distorts the sine wave of voltage; therefore, the Simpson 260, IBM meter, and the oscilloscope cannot provide a true reading of rms voltage.

AC iron vane meters make use of the repulsion between two pieces of iron of like magnetic polarity. If two pieces of iron are placed side by side within a coil of wire and current is passed through the coil, the two pieces of iron assume magnetic properties and repel one another. If alternating current is passed through the coil, the polarity of the iron bars would keep changing; however, the pieces continue to repel each other.

If a pointer is attached to one of the vanes and the other vane is kept stationary and fixed to the coil, a mutual repulsion results in a movement of the pointer. The force of the repulsion or the amount of movement imparted to the pointer is proportional to the strength of the current flowing through the coil. This is the basic principle of an iron vane meter movement.

Iron vane meters are sensitive instruments and must be handled with extreme care.

DYNAMIC TIMER

Function

The dynamic timer is used to troubleshoot IBM electro-mechanical machines. This instrument, when properly used, supplies information of actual operating conditions that cannot be readily determined in any other manner. Frequent and proper use of this instrument develops invaluable techniques in servicing IBM equipment.

The testing of circuits on IBM equipment involves checking for:
1. The presence of a voltage impulse
2. The time the voltage impulse is available
3. The magnitude of the voltage impulse.

A testing device should be able to simultaneously check these three things. Previous test equipment could only indicate the presence or absence of an impulse, or by turning the machine over manually, the presence, timing, and magnitude of an impulse could be determined. This would be a static reading however, and many times conditions may appear when a machine is operated under power that are not shown by a static test. The need then arises for a device to show the conditions existing in a circuit under actual operating conditions.

The dynamic timer makes possible the simultaneous checking of the presence and timing of a voltage impulse. The dynamic timer cannot show the exact magnitude of the impulse voltage; however, it can indicate whether the observed impulse is greater than 5 volts or greater than 35 volts.

Provision is also made to give an indication of the timing condition of contact points. The chief advantage of the dynamic timer is that testing is done under actual operation, and marginal conditions are made evident.

Construction

The dynamic timer consists of a power pack assembly (Figure 4-10) and a dynamic timer index. The dynamic timer index consists of a transparent index dial behind which two small neon bulbs revolve in synchronism with the machine index in the manner of a pointer on a conventional index dial. It is so timed that at any point of machine rotation the neon bulbs are behind the proper index timing on the transparent index dial.

Connections are brought from the bulbs via a commutator to a connector socket. Forty volts dc is also brought to this connector socket from the machine

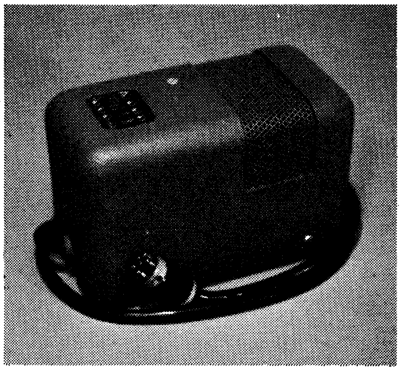


Figure 4-10. Dynamic Timer Power Pack

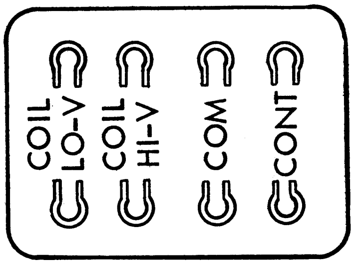


Figure 4-11. Input Terminals

power supply. The power pack is connected to the circuit by plugging its male cable plug into this socket.

The dynamic timer power pack assembly consists of a power supply and two vacuum tube amplifiers through which the neon bulbs are lighted. These bulbs glow for the duration of the impulse or contact closure time when connections are made to the proper test hubs. Thus, the time that an impulse occurs or a contact makes is shown as a bright streak of light on the transparent index dial with the starting and ending times measured in degrees on the machine index.

Input Terminals

Eight terminal jacks (Figure 4-11) appear on the top of the dynamic timer power pack. They are arranged in two rows of four jacks, and each row of four jacks is associated with one of the indicator circuits. The right center jack in each row is the common (C) hub and is always used in testing. The other jacks are used to complete the circuit to the neon light. The terminal labeled CONT is used for contact tests; COIL LO-V is used for low-voltage impulse tests; COIL HI-V is used for high-voltage impulse tests.

Circuit Description

The dynamic timer power pack consists of two indentical power supplies and two indicator tubes that activate the neon lights on the machine index. The neons are mounted behind the scale markings and are shaded so that they appear as spots through the transparent index when they are glowing. One neon is mounted on the outer portion of the scale and is known as the outer neon. The other neon is mounted on the inner portion and is known as the inner neon. The power supplies provide the necessary dc voltages required to operate the 6SL7 indicator tubes. The two index neons are connected in the plate circuits of the indicator tubes and glow when these tubes conduct. Test leads to each element under test are connected so that the indicator tubes are normally cut off and conduct only when a contact is made or an impulse is impressed on each indicator circuit.

A block diagram of the dynamic timer power pack is shown in Figure 4-12. A vibrator, which operates on 40-48 volts dc, supplies 40-48 volts ac to the transformer. The step-up transformer raises the ac voltage to approximately 280 volts and feeds into two identical sections of the power pack. The 280 volts ac is rectified, and by means of a voltage divider network, the various voltages needed to operate the 6SL7 tube are obtained. When the 6SL7 tube conducts, the neon light glows.

One of the control circuits and its associated power supply is shown in Figure 4-13. A vibrator, which operates on 40-48 volts dc, supplies power to the transformer so that the timer can be used whether the power supplied to the machine being tested is ac or dc (40-48 volts dc is always available from the machine rectifier or generator). The vibrator connects the A1 line terminal alternately to the ends of the transformer, and the 40-volt dc supply then appears as an alternating current in the halves of the divided primary winding. Vibrator condenser C3 acts as an arc suppression condenser to prevent burning of the vibrator points.

The power pack is protected by a 1-ampere fuse. If the power pack fails to hum faintly when connected to the 40-volt supply, the fuse may have blown. The fuse is located under the power pack cover. Be sure to use only a 1-ampere fuse.

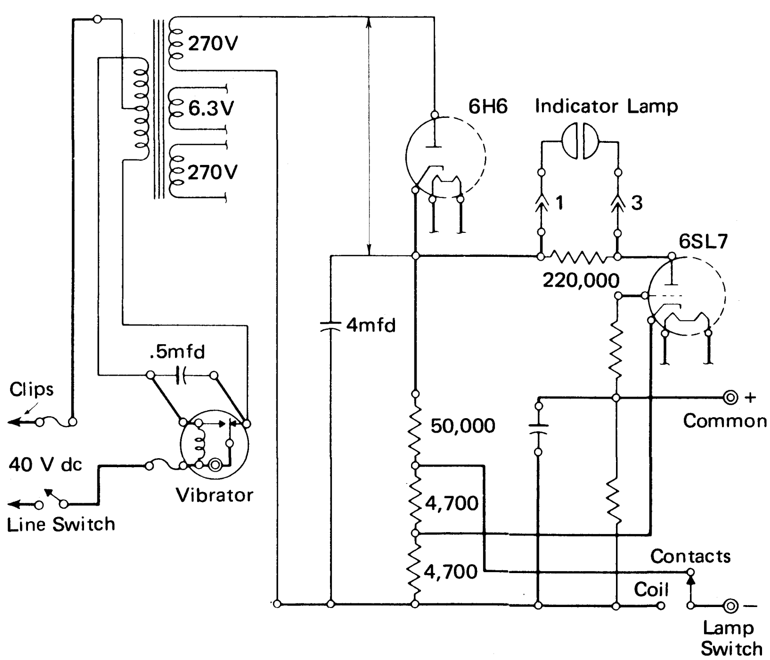


Figure 4-12. Power Pack Block Diagram

Alternating voltages are developed in the secondary transformer windings. A 6.3-volt winding supplies power to heat the filaments of the two tubes, and two high-voltage windings supply 280 volts ac for plate power. This 280-volt potential is applied to the series circuit consisting of a 6H6 diode and R2, R14, R3, R4. On the half-cycles, when the plate of the 6H6 diode is positive, electron current can flow from the 280-volt winding through R4, R3, R14, R2 and the diode, back to the transformer winding. With 56,000 ohms (47,000 + 470 + 1800 + 6800) for a load resistor, about 4.6 mA flows through the circuit. Twenty volts potential drop occurs across the diode and the remaining 260 volts are developed across R2, R14, R3, and R4. On the other half of the cycle no current can flow because of the rectifier action of the diode, but the 4-microfarad capacitor (C1) that charged on the preceding half-cycle now starts to discharge, maintaining current through R2, R14, R3, and R4. Therefore, a fairly constant dc voltage drop is contained across R2, R14, R3, and R4 throughout the whole ac cycle.

The values of the resistors in this voltage divider are such that the following approximate voltage drops are obtained.

R2	220 volts
R14	2 volts
R3	8 volts
R4	30 volts

These relative voltage levels are shown in Figure 4-13 and are available as long as the power pack is connected to the machine and the machine is turned on. For all practical purposes they do not change when the indicating circuits are used.

The 6SL7 is a duo-triode voltage amplifier. One of these triodes is used to control each neon indicator light. Triodes do not conduct as long as the potential of the grid is sufficiently negative with respect to the cathode. As the grid potential is made more positive, a point is reached where the tube just starts to conduct. This is known as the cutoff point. Cutoff for 6SL7 is about –9 volts; that is, when the grid is 9 volts more negative than the cathode.

After the dynamic timer power pack is connected to an IBM machine, *allow time for the tube cathodes to*

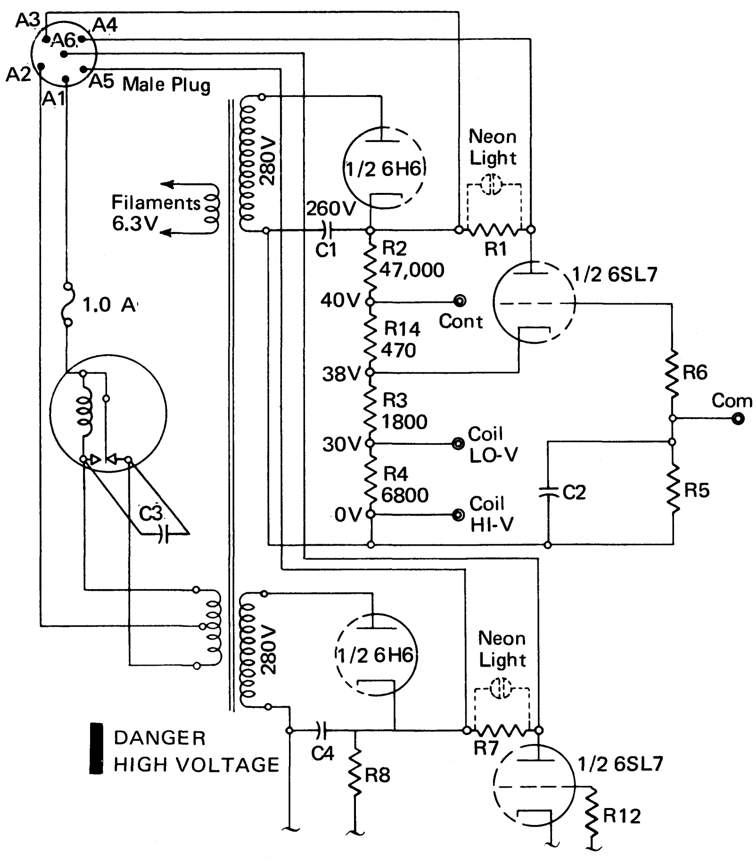


Figure 4-13. Power Pack Circuit

reach operating temperature and for the 6H6 to rectify enough current to develop 260 volts across the voltage divider. Figure 4-13 shows the conditions existing in one of the control circuits when the timer power pack has reached operating potential. The triode is connected in series with 260 volts and the .51-megohm load resistor R1. The grid is 38 volts negative with respect to the cathode so that no current flows in the tube; hence, no voltage drop occurs in the resistor R1.

The neon lamp connected across R1 is an NE-2 that fires (glows) when a 90-volt potential is applied across the terminals. These 90 volts appear when .17 mA flows through R1 and the tube. To get this .17 mA, the grid must be raised to about +35 volts. Therefore, it can be said that the neon light glows when the grid goes above –3 volts with respect to the cathode.

Three methods are provided to cause conduction:

1. Short the (COM) grid to the CONT (40-V output) through the contact under test when it closes.
2. Connect a voltage greater than 5 volts between COIL LO-V (30-V output) and COM (grid).
3. Connect a voltage greater than 35 volts between COIL HI-V (0-V output) and COM (grid).

Each of these applications is covered later.

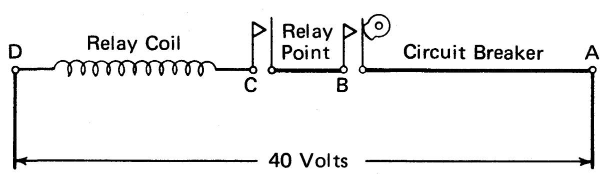
Connections

Each bulb circuit in the dynamic timer can be used in one of two possible ways. To measure an active machine impulse, such as that used to pick up a relay, the timer lead should be plugged to a coil hub and the result observed with the leads connected across the coil in question. To measure the duration of a contact, the timer can be plugged to CONT and the leads connected so that they are shorted out through the contact to be tested.

Dynamic timer applications are shown in Figure 4-14. The table plus the accompanying illustration shows the wide range of uses to which the dynamic timer may be applied.

When the timer is used on contact, care should be taken that the points tested are sufficiently isolated so that no back circuit can occur to give a false indication. Capacitors across such should be disconnected before testing. Keep in mind, however, that the condenser might be defective and the cause of the failure.

The revolving neon bulbs are lighted for the length of the contact, or impulse duration measured across the respective leads, and appear as a bright streak on the



Test Lead Connections

Coil HI-V	Coil LO-V	Cont	Com	Pulse Observed on the Indicator Dial (0 90 180 270 360)	Type Connections	Comments
D			A		High Voltage	Light ON as long as the machine is turned on and at least 35 volts is present between A and D.
D			B		High Voltage	Light ON as long as the circuit breaker is closed and at least 35 volts is present between B and D.
D			C		High Voltage	Light ON as long as the circuit breaker and relay point are both closed, and 35 volts is present between D and C.
	D		A		Low Voltage	Light ON as long as at least 5 volts is present between A and D.
	D		B		Low Voltage	Light ON as long as circuit breaker is closed and at least 5 volts is present between B and D.
	D		C		Low Voltage	Light ON as long as the circuit breaker and the relay point are both closed, and 5 volts is present between C and D.
		C	A		Contact	With 40 volts removed, light ON as long as both the circuit breaker and the relay point are closed.
		B	A		Contact	With 40 volts removed, light ON as long as circuit breaker is closed.
		A	A		Contact	Light ON at all times.

Figure 4-14. Dynamic Timer Applications

face of the dial. The streak begins where the impulse starts and ends where it stops. Bouncing of a contact point may be clearly observed by breaks in the streak on the dial. Correct polarity must be observed to obtain a light on Coil operation. It is especially important to use the dynamic timer in checking and adjusting cam timings because cam contacts break later under running conditions than they do when the machine is turned by hand.

The voltages mentioned in the text are theoretical voltages and vary with individual power supplies and different supply voltages.

There are two identical sets of jacks. Consequently, any two of the three following tests can be performed simultaneously. Therefore, it is possible to compare the timing between any two relays or coils by noting when the neon bulb glows.

When the dynamic timer is used, the lamp on the indicator dial is illuminated when:

1. The CONT and COM hubs are shorted together through a cam or relay point when no voltages are present. This is called contact connection (Figure 4-15).

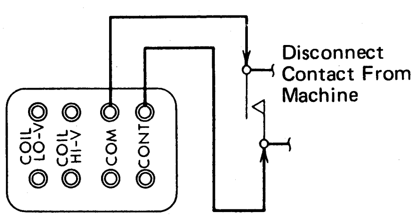


Figure 4-15. Contact Connection

2. Five volts or more dc is applied between COIL LO-V and COM with the COIL LO-V lead on the negative side of the circuit and the COM on the positive side of the circuit. This is the low-voltage connection (Figure 4-16).

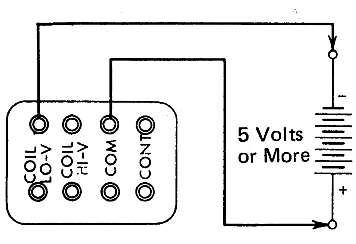


Figure 4-16. Coil Lo-Voltage Connection

3. Thirty-five volts or more dc is applied between COIL HI-V and COM, with the COIL HI-V lead on the negative side of the circuit and the COM on the positive side of the circuit. This is the high-voltage connection (Figure 4-17).

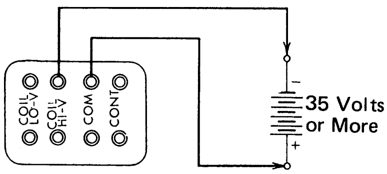


Figure 4-17. Coil High-Voltage Connection

Contact Connection

Whenever a contact, such as a relay point or circuit breaker, is to be tested, the leads are connected so that when the contact being tested closes, the contact hub (CONT) is shorted to the common hub (COM) (Figure 4-18). No external voltage should be present when using the contact connection. Machine power and capacitors should be removed from the circuits being tested to prevent false readings. The neon light glows for the duration of the time the points are closed.

Be sure to test the indicating lamp by shorting the leads together before using (this causes the lamp to glow).

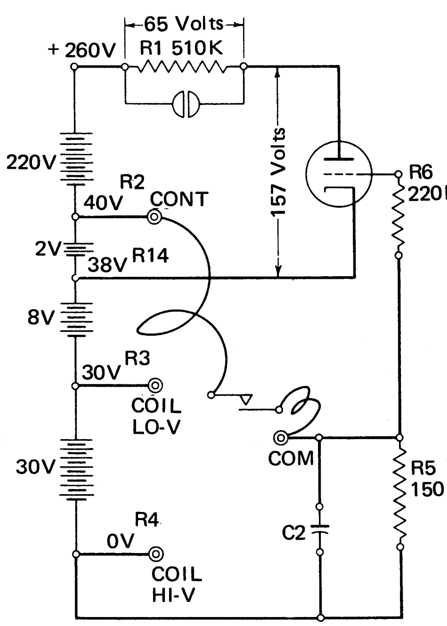


Figure 4-18. Contact Connection Schematic

To simplify the discussion of the indicating circuits, the voltage drops across R2, R14, R3, and R4 (Figure 4-18) can be considered as 220-, 2-, 8-, and 30-volt batteries respectively, connected in series. These are the voltages necessary to control the indicating circuits.

Figure 4-18 shows a schematic of the timer being used to check a contact. The contact should be electrically disconnected to prevent any possibility of the machine voltage causing conduction in the 6SL7.

The grid is normally held at –38 volts (with respect to the cathode) by the voltage applied through R5 and R6.

When the contact closes, the grid is driven more positive than the cathode. This causes the 6SL7 to conduct. This conduction causes a voltage drop across R1. When this voltage reaches about 90 volts, the neon indicator light on the machine index fires.

When the tube goes into conduction, the voltage drop across R1 tends to rise to 170 volts. Because the minimum voltage necessary to fire the neon bulb is 90 volts, the 170-volt value is never reached. When the bulb fires, it becomes effectively a low resistance in parallel with the load resistor, R1, so that the effective value of the load resistance is much less. This effective resistance results in approximately a 65-volt drop across the load resistance.

R6 acts as a current limiting resistor. As the grid starts to go positive, it collects electrons, and grid current flows. This grid current flowing through R6 causes a voltage drop that reduces the positive potential on the grid and tends to limit grid conduction. Excessive current would damage the grid element in the tube.

As soon as the contact opens, the grid returns to –38 volts (with respect to the cathode), the 6SL7 stops conducting, and the neon light turns off.

Coil Lo-V Connection

Whenever the presence of a voltage impulse greater than 5 volts is to be tested, the COIL LO-V connection is used. The timer is connected so that the test voltage is connected between the common (COM) and the COIL LO-V hubs, *with the positive red lead connected to the common hub* (Figure 4-19). Any voltage greater than 5 volts causes the neon light on the machine index to glow during the time that the voltage is present. *If the polarity of the injected voltage is reversed, the neon light does not glow.*

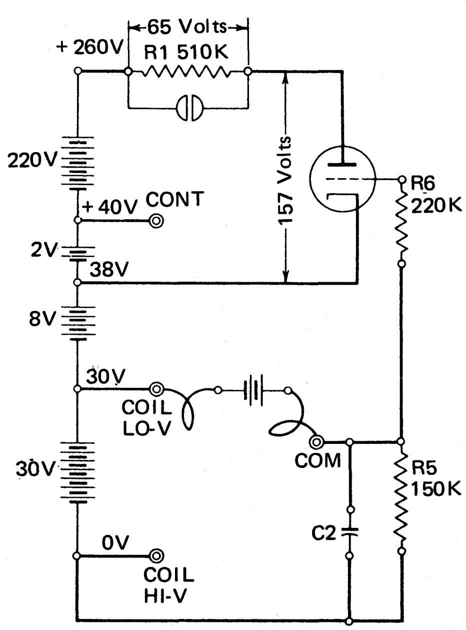


Figure 4-19. Coil Low-Voltage Connection Schematic

Be sure to test the instrument by applying 40 volts to the timer leads to make the indicator light glow.

If a closed circuit is placed between the COM and COIL LO-V hubs, the 6SL7 conducts slightly but not enough to cause the indicator lamp to glow. When a voltage of the *correct polarity* is placed between the hubs, the potential at the grid raises (Figure 4-19). When approximately 5 volts is inserted, the grid potential increases to about –3 volts with respect to the cathode; this is sufficient to cause the indicator to glow.

Coil Hi-V Connection

Whenever the presence of a voltage impulse greater than 35 volts is to be tested, the timer should be connected so that the voltage will appear between the COM and COIL HI-V hubs (Figure 4-20). *The positive voltage is connected to the common hub.* Any voltage greater than 35 volts causes the neon indicator light to glow. *If the polarity of the voltage is reversed, the neon light does not glow.*

Be sure to test the timer by applying 40 volts to the leads before using.

The circuit functions the same as COIL LO-V connection, except that 35 volts is required to cause sufficient conduction through the 6SL7 to make the indicator light on the machine index glow. Figure 4-20 shows how the circuit operates schematically.

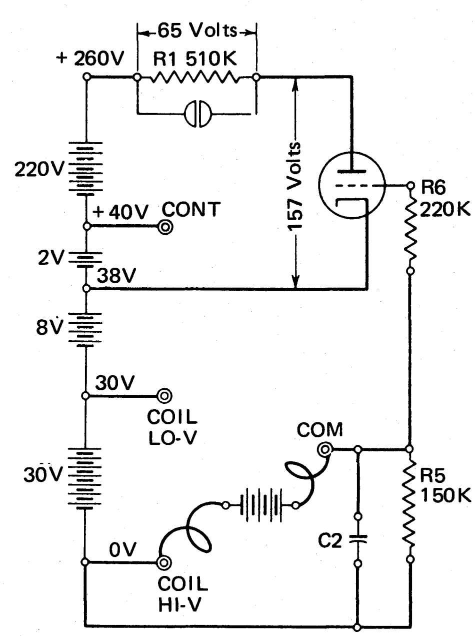


Figure 4-20. Coil High-Voltage Connection Schematic

Applications

Figure 4-21 shows the connections made to measure the timing of voltage impulses. Be sure the capacitors are

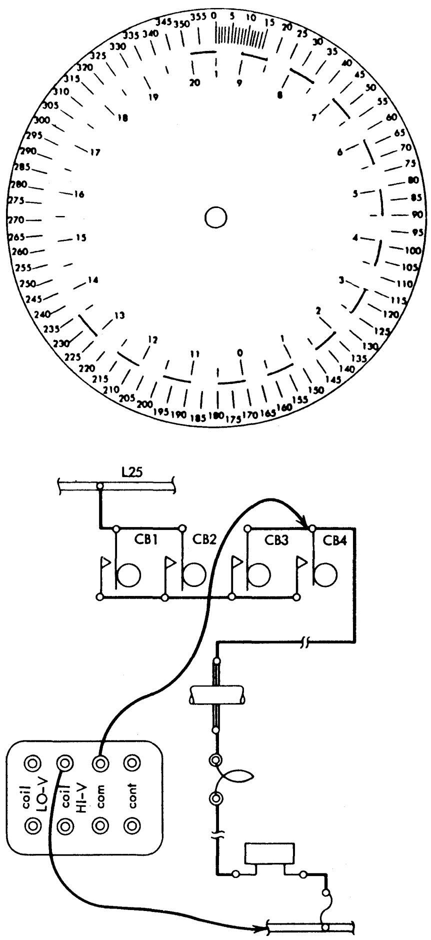


Figure 4-21. Timing Circuit Breakers

disconnected as they may cause the pulses to be extended. The common hub (COM) of the dynamic timer is connected to the circuit side of the circuit breakers, and the COIL HI-V hub is connected to the fuse common. When the circuit breakers make, a voltage is applied to the timer and the neon bulb glows. When properly timed, the circuit breakers cause indications that correspond to the index markings.

In Figure 4-22 the dynamic timer is being used to check a possible cause of machine failure. To add into the counters of this machine, the counters are started at 9-time and stopped with a card impulse. If a 9 is to be added, the start shot from the circuit breakers through C58 must reach the start magnet at the same time that the stop impulse from the circuit breakers reaches the stop magnet through a 9-hole in the card.

If the circuit to the stop magnet does not receive a good impulse, the result may be failure to add 9. A weak pulse may be caused by a relay point not making properly or by a bouncing brush. Insert B in Figure 4-22 shows the inner neon lamp indicating the presence of a 9-time start impulse, but the outer lamp indicates a weak impulse to the stop magnet. The circuit can be traced from the magnet, 438-2, 418-12, control panel wire, to the read brush relay and the brush. When the trouble is located and repaired, the impulses should appear as in insert C in Figure 4-22.

Figure 4-23 is the circuit to pick a relay. To illustrate the use of the dynamic timer on such a circuit, assume that the relay fails to pick because of an open circuit at the 662-4 N/C contact. The first step in the testing procedure is to polarize the dynamic timer by connecting either coil hub to the fuse side of the line and the common hub to the 40-volt side of the line. This causes the neon light to glow. If the coil hub and common hub connections are reversed, the neon light does not glow.

Observe that the coil hub test lead is connected to the fuse common. One can rapidly determine if the fuse is open by moving the test lead to the other side of the fuse. If the neon bulb still glows, the fuse is not open.

To isolate the area of trouble, the common hub test lead is moved from the 40-volt line down past the various points in the circuit. The area of trouble exists below the last point in the circuit that causes the neon bulb to glow. As the 662-4 N/C contact is open, the light glows when the test lead is connected to the N/C contact of R662-4. However, when the test lead is connected to the O/P contact of R662-4, the light does not glow.

A more interesting example to illustrate the use of the dynamic timer would be to assume that the R662-4 N/C contact has a voltage drop across its contacts. In the previous example, either coil hub could be used, but for this example, the choice of coil hubs is important. When using COIL LO-V, the neon light glows when 5 volts is applied across the relay. This is not sufficient voltage to pick relay 662. To prevent this type of erroneous indication when checking circuitry, the COIL HI-V hub should be used.

Figure 4-24 illustrates a circuit in which the relay is connected to the 40-volt side of the line, and the circuit breaker is connected to the fuse side of the line. To polarize the dynamic timer, connect the COIL HI-V hub to the fuse common and the COM hub to the 40-volt side of the line. When checking for circuit continuity, the coil hub test lead should be moved from the fuse side of the line down past the various control points in the circuitry.

In Figure 4-25 the dynamic timer is being used to check the lag in the pickup time of a relay coil. The impulse from a cam is connected to the relay pick coil, and the inner lamp of the dynamic timer is connected to COIL HI-V for coil indication. The outer lamp is connected for contact indication across one of the points of the relay. The delay from the time the relay is impulsed until its contacts close is thus shown in degrees on the timer index. Because the speed of the machine is

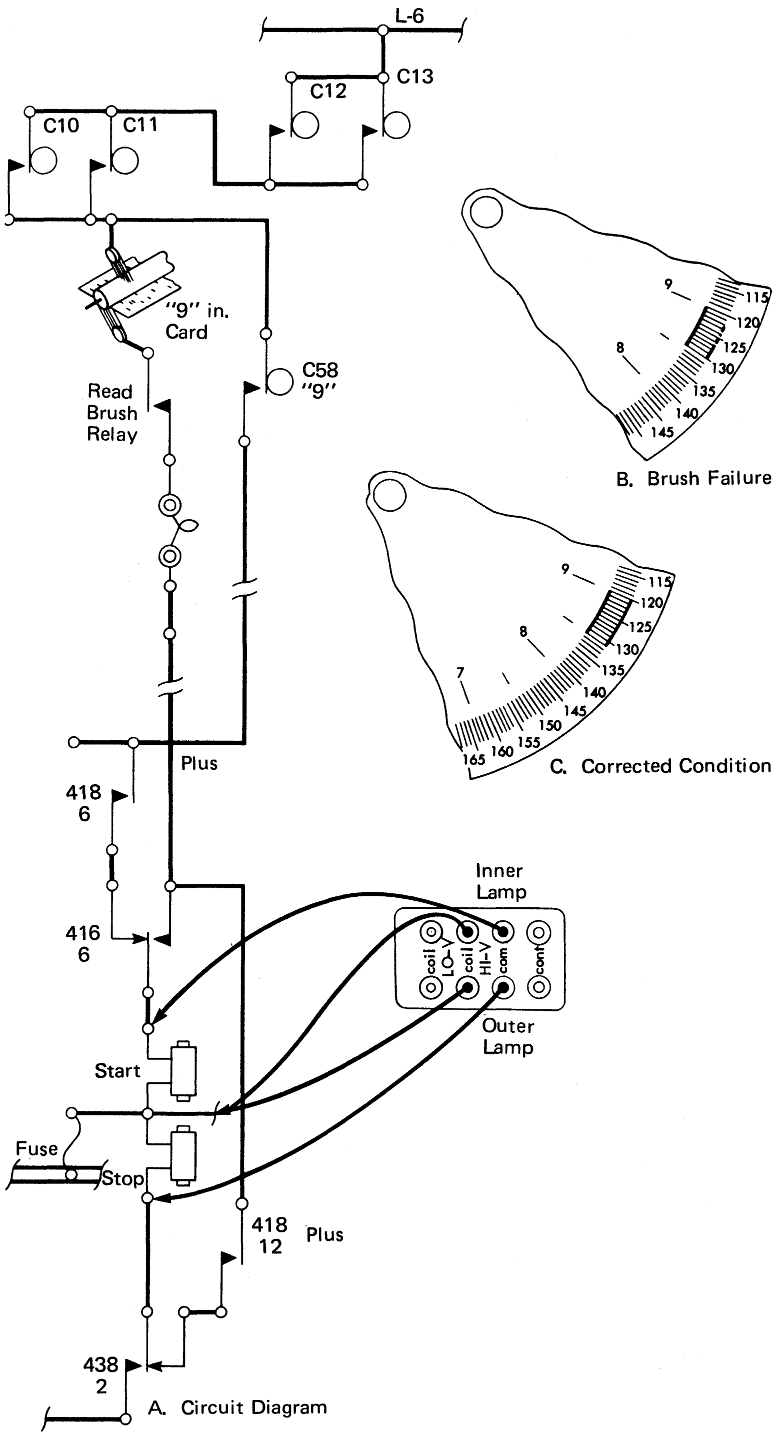


Figure 4-22. Checking Reading Brush Impulses

known, the time in milliseconds can be computed by the following formula:

$$\text{Pickup time in ms} = \frac{\text{degrees lag x ms/sec}}{\text{machine cycle/min x } 360^{\circ}\text{/cycles}}$$

or

$$\frac{\text{degrees lag x 1000}}{\text{machine cycles/min x 6}}$$

Example: A relay contact closes 5 degrees after the relay is impulsed. The delay is computed as follows:

$$\frac{\text{5 degrees x 1000}}{\text{200 cycles/min x 6}} = 4.17 \text{ milliseconds}$$

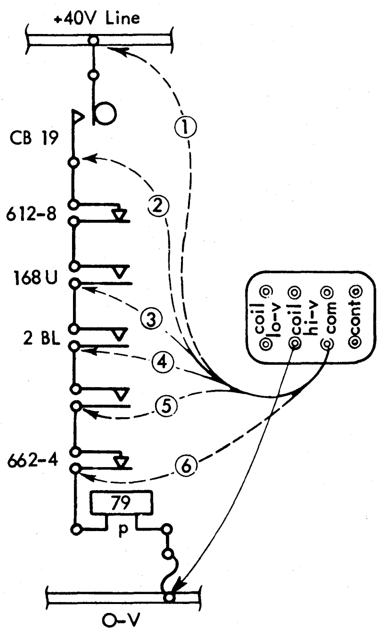


Figure 4-23. Checking Continuity 0V Common

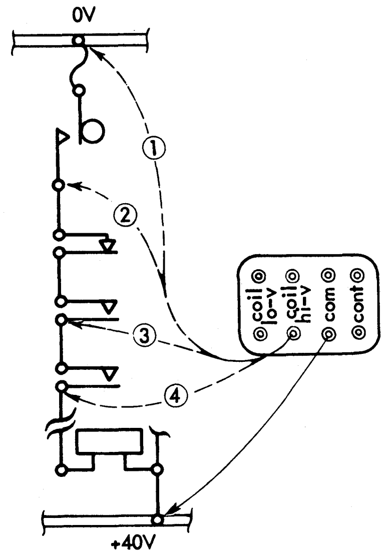


Figure 4-24. Checking Continuity +40V Common

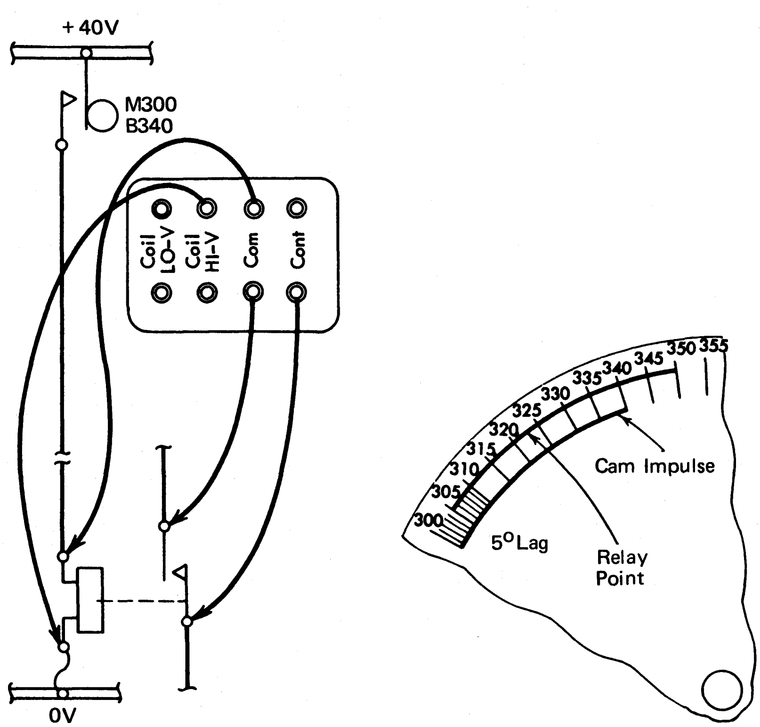
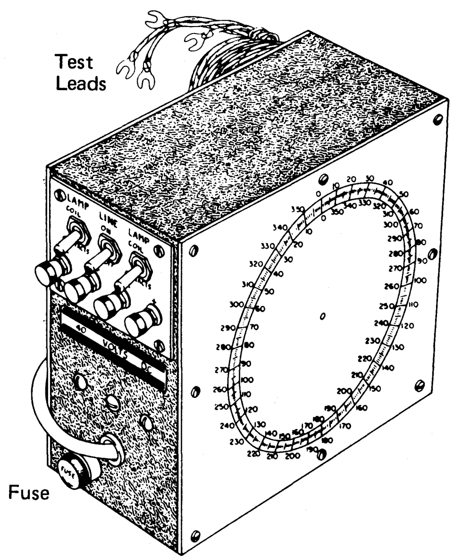


Figure 4-25. Checking Relay Pick Time

PORTABLE DYNAMIC TIMER

A portable dynamic timer kit can be used on some of the older types of IBM machines. This kit contains the dynamic timer (Figure 4-26) and the necessary mechanical coupling devices (Figure 4-28). The circuits and operation (Figure 4-27) are essentially the same as for the built-in dynamic timer with a portable power



Front View

Figure 4-26. Portable Dynamic Timer

pack. One difference is that the selection of coil or contact operation is made by a toggle switch instead of by plugging. Power is supplied by a power cord with alligator clips that may be attached to any convenient

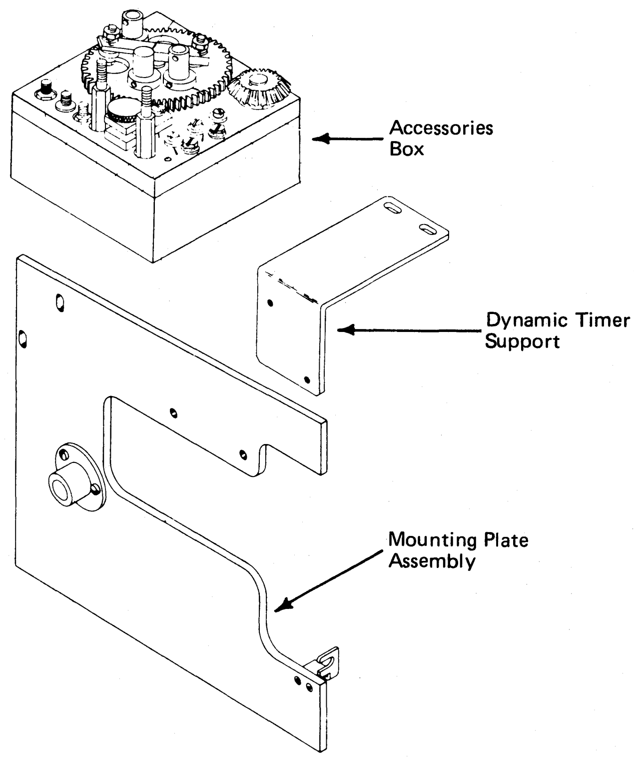


Figure 4-28. Portable Dynamic Timer Coupling Adapters

binding posts to obtain 40-48 volts dc from the machine.

The portable timer has low usage. Refer to the instructions and instructional drawings included with each kit for the information needed for mounting.

As a precautionary measure, the pointer disk should be rotated by hand prior to mounting on the machine.

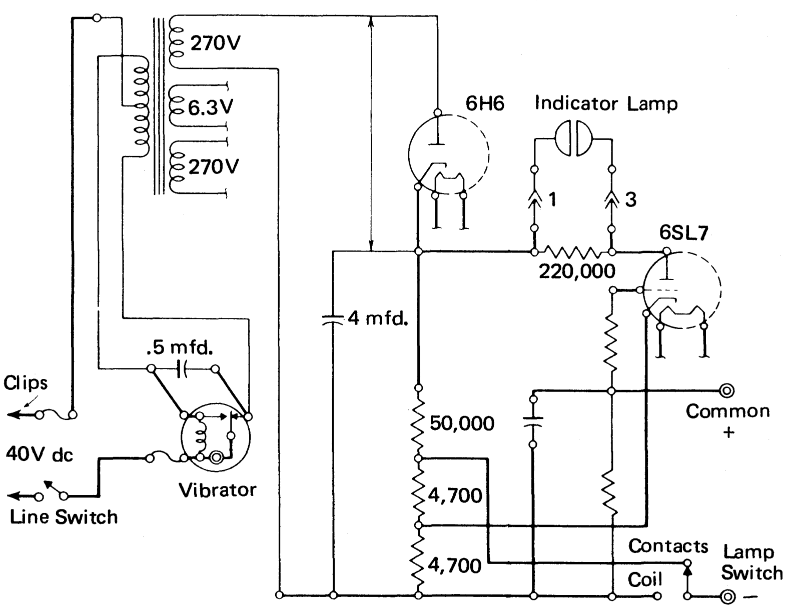


Figure 4-27. Portable Dynamic Timer Circuit Schematic

If any binds or interference with its rotation is detected, corrective measures should be taken before proceeding.

OSCILLOSCOPES

General Information

An oscilloscope is simply an ac voltmeter that also displays the waveform of the measured voltage. It has been used in laboratories and in industry for many years to study the magnitudes of currents and voltages in connection with transient and cyclic phenomena. With the rise of television and electronic calculators, its use has spread rapidly to various types of maintenance work.

When synchronized, the oscilloscope combines some of the advantages of the voltmeter and the dynamic timer and gives a graphic presentation of voltage magnitudes at any point of machine index.

An oscilloscope consists chiefly of a cathode-ray tube and the necessary electronic circuits needed to permit the cathode-ray tube to perform a particular function. Where the volt-ohmmeter employs a scale and pointer, the cathode-ray oscilloscope uses a beam of electrons. This beam originates from the cathode at the rear of the cathode-ray tube and is focused to form a point of light where the beam strikes the fluorescent screen.

The electron beam passes between two pairs of deflection plates, and a voltage impressed on the deflection plates moves the electron beam from its position in the center of the luminescent screen. A voltage connected to the horizontal deflection plates moves the spot of light horizontally, while a voltage impressed on the vertical plates deflects it vertically. The volt-ohmmeter has mechanical inertia and cannot follow instantaneous changes of voltage. The electron beam has virtually no inertia and can follow extremely rapid variations of voltage.

All scopes consist of four major components: the cathode-ray tube, the two deflection amplifiers, and the time base generator. (See block diagram in Figure 4-29.)

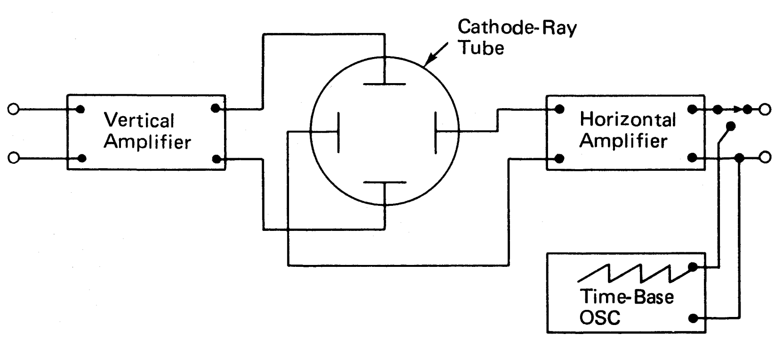


Figure 4-29. Oscilloscope Block Diagram

The amplifiers are required to improve the sensitivity of the cathode-ray tube, and the time-base generator enables the tube to display the signals as a function of time. The internal circuits of the amplifiers and the oscillator vary greatly, depending on the type of work for which the scope is intended. All cathode-ray tubes are essentially the same, varying only in size and voltage applied therefore, only one discussion is needed to illustrate operational fundamentals.

Cathode-Ray Tube

The heart of the oscilloscope is the cathode-ray tube, because it is upon the face of this tube that the pattern of the voltages under test is observed. The cathode-ray tube is a long glass envelope shaped as in Figure 4-30. At the small end of the tube is the cathode, a small button of material that emits electrons freely when heated indirectly by the filament.

A grid, which is negative with respect to the cathode, controls the intensity (brilliance) of the spot. A system of electrodes (anodes) that are positive with respect to the cathode forms the electrons into a narrow beam and accelerates and directs them to the screen of fluorescent material covering the large end of the tube. Where the beam of electrons strikes the screen, the fluorescent material glows, and a spot of visible light is produced. Focusing is accomplished by causing the electron beam to pass through a series of electrostatic fields of differing intensity.

An electron beam entering a field of rising potential is accelerated and concentrated in a manner comparable to the action of a converging lens on light rays. An electron beam entering a field of lowered potential tends to spread out. By properly arranging the sequence of fields, the electron beam can be focused the same as light rays are focused. The electron beam can be focused by passing through a decreasing and then an increasing electrostatic field so that a pin point of light is formed at the screen (Figure 4-31).

This tiny spot of light must be deflected from its normal position in the center of the screen if it is to

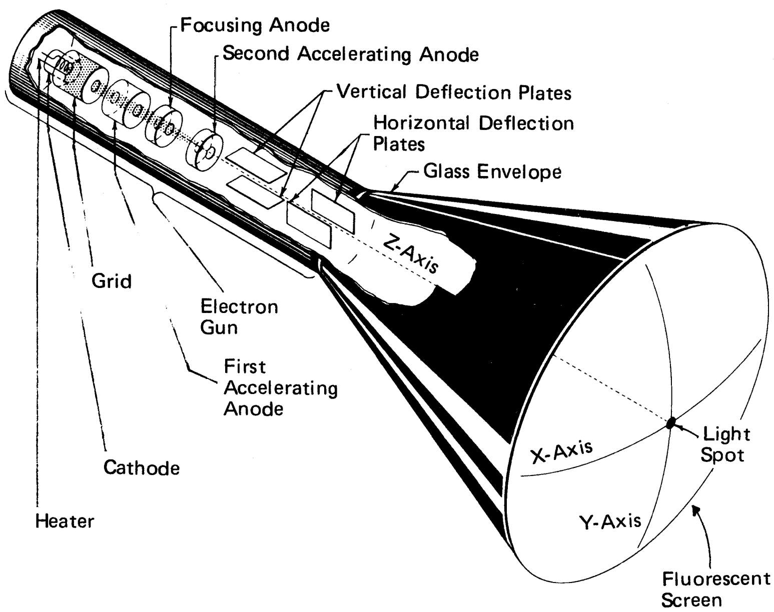


Figure 4-30. Cathode-Ray Tube

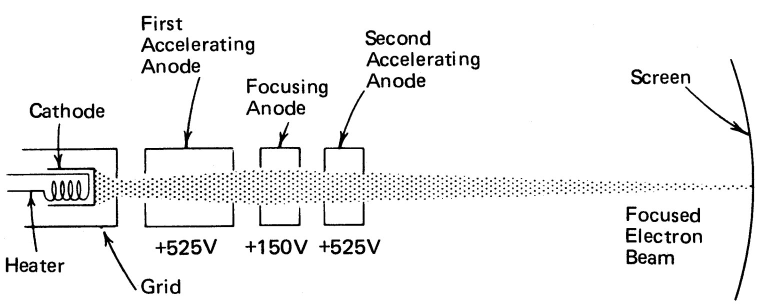


Figure 4-31. Electronic Focusing

impart any information. The spot is caused by a stream of electrons, which are negatively charged particles. These negative particles are attracted by positively charged objects and repelled by objects with a negative charge. This principle, called electrostatic deflection, is used in the cathode-ray tube to deflect the electron beam from its central position on the screen.

Two pairs of deflection plates allow the electron beam to be deflected along two axis. The vertical deflection plates move the beam vertically on the face of the screen. The vertical direction is sometimes called the Y-axis. The horizontal deflection plates move the beam horizontally across the face of the screen, and this direction is sometimes called the X-axis. When different potentials are applied to the deflection plates, the electron beam is deflected so that the luminous spot can be moved to any position on the face of the tube.

As the electrons speed between the two pairs of plates, the electron beam is unaffected if no potential difference is applied to the plates. If the voltage on the upper plate is increased and the voltage on the lower plate is reduced, the electron beam moves upward (Figure 4-32). The deflection is proportional to the voltage difference of the plates; if 40 volts deflects the beam 1/2 inch, 80 volts would deflect it one inch. Therefore, measuring voltages is possible by calibrating the cathode-ray screen and applying voltages to the vertical deflection plates.

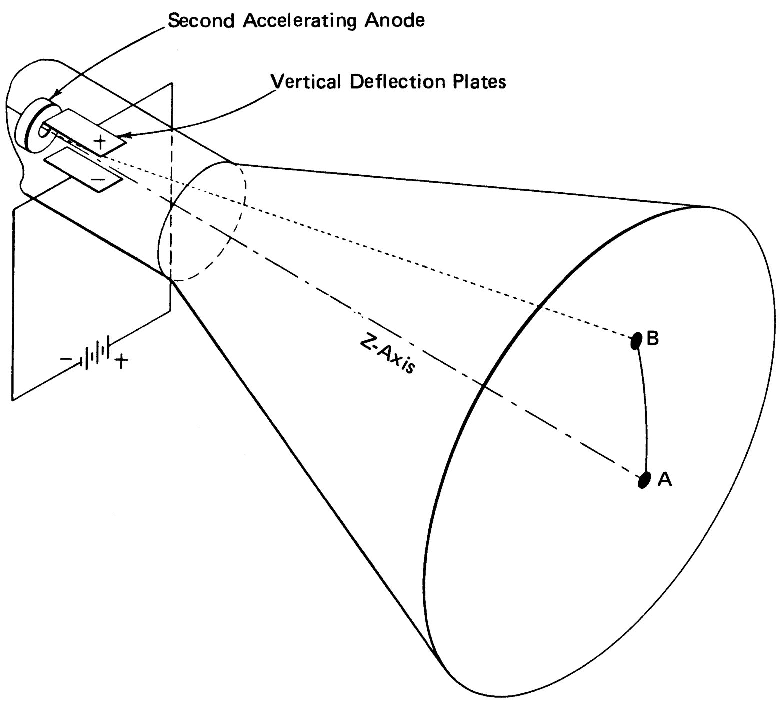


Figure 4-32. Vertical Deflection

Basic Circuit

The cathode-ray tube is, by itself, an insensitive device. A potential of about 100 volts is needed to deflect the electron beam one inch on the face of the tube. So that the cathode-ray tube can indicate signals of relatively small potential amplifiers are used in the circuits to the deflection plates.

To show graphically the relation between a voltage and time, a device for generating a time base is necessary. The time-base generator provides a voltage that deflects the fluorescent spot across the screen of the tube from left to right at a steady rate. The voltage required to deflect the spot must increase at a steady rate in respect to time.

A simple circuit for the time-base oscillator is shown in Figure 4-33A. Capacitor C is charged slowly through the resistor R. The voltage across the capacitor increases as time passes. When the voltage across the capacitor reaches the ionization potential of the gas in the cold-cathode diode, the gas ionizes, and a low resistance path is provided through which the capacitor discharges almost instantaneously. The gas de-ionizes and the capacitor again starts to charge. The voltage across the capacitor takes the form shown in Figure 4-33B and is called a saw-tooth wave. The frequency may be varied by changing the values of R and C. On the screen (Figure 4-33C), the spot of light moves from point A to point B as the voltage rises, returning to point A when the gas tube ionizes. If no signal voltage is applied to the vertical deflection plates, the trace is a horizontal line as shown in Figure 4-33C.

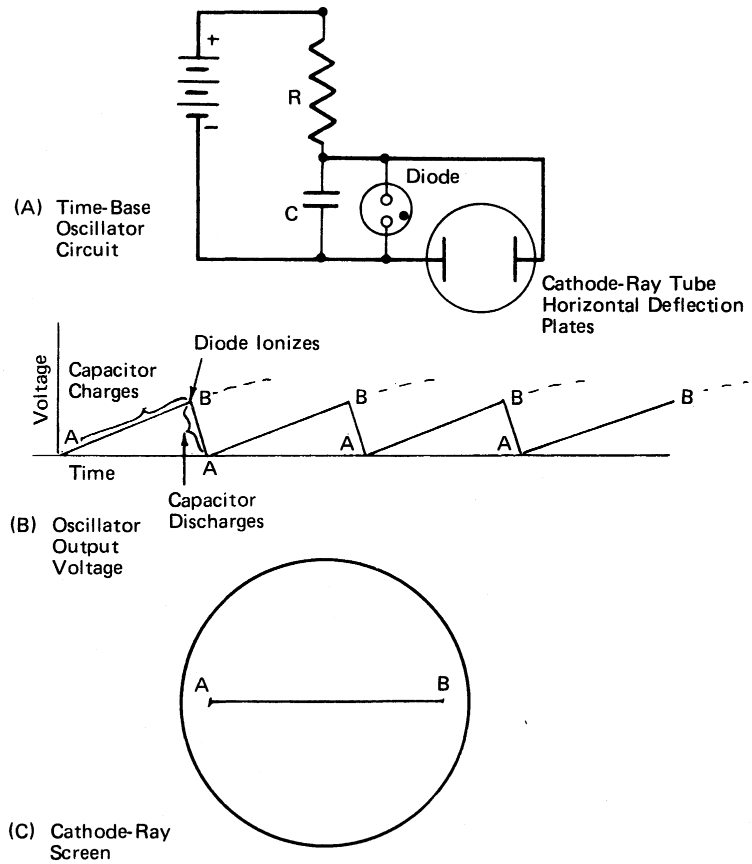
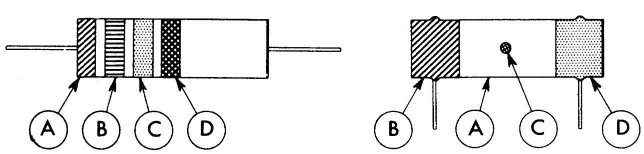


Figure 4-33. Time Base Oscillator

RMA COLOR CODES

Resistors

The Radio Manufacturers' Association (RMA), the American War Standard (AWS) and the Joint Army-Navy (JAN) specifications for color coding fixed composition resistors (Figure 5-1) are identical. On axial lead composition resistors, four bands of color starting from the end give the resistance value. Radial lead resistors have their values given by color placed on the body, end, and dot, with the fourth color on the other end. In Figure 5-1C, band A indicates the first significan figure in ohms, band B indicates the second significant figure, band C indicates the decimal multiplier, and band D, if present, indicates tolerance in percent of nominal resistance. For example, if a resistor has a code of green, black, yellow, and gold, it indicates that the nominal value is 500,000 ohms, ±5%. This resistor, therefore, lies between 475,000 and 525,000 ohms.



Resistance in Ohms

Color A	First Signif-cant Figure	Color B	Second Signif-cant Figure	Color C	Decimal Multiplier	Color D	Resistive Toler-ance
Black	0	Black	0	Black	....	None	±20%
Brown	1	Brown	1	Brown	10	Silver	±10%
Red	2	Red	2	Red	100	Gold	± 5%
Orange	3	Orange	3	Orange	1,000		
Yellow	4	Yellow	4	Yellow	10,000		
Green	5	Green	5	Green	100,000		
Blue	6	Blue	6	Blue	1,000,000		
Violet	7	Violet	7	Violet	10,000,000		
Gray	8	Gray	8	Gray			
White	9	White	9	White			

Figure 5-1. Resistor Color Codes

Capacitors

The RMA standard three-dot color code (Figure 5-2) shows the capacitance of fixed mica capacitors in much the same manner that resistance values are shown. In the left-hand diagram, dot A represents the first significant digit, dot B the second digit, and dot D the decimal multiplier. All the capacitance values are given in picofarads. For example, a capacitor with a color code of red, green and black represents a value of 250 picofarads.

The RMA standard six-color has the colors arranged in two rows, as in the right-hand diagram. The upper row indicates the first three significant digits of the capacitor at A, B, and C. The decimal multiplier is at D. Dot F gives the voltage rating, and dot E the tolerance.

If dot A is black, white or silver, dots B and C give the significant digits, and dot D the decimal multiplier.

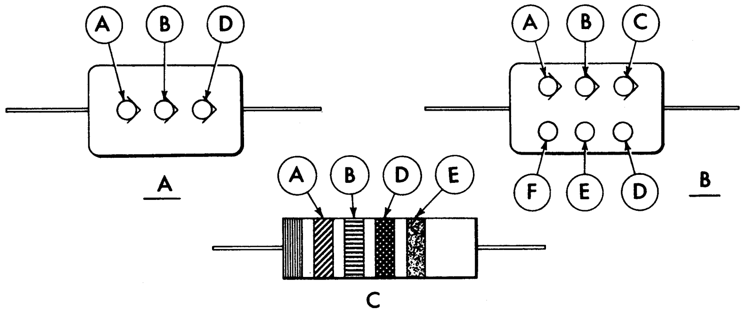
Ceramic capacitors are marked as shown in Figure 5-2.

CAPACITOR SERVICING

Capacitors are made in many shapes and sizes from the extremely small types used on printed circuit boards to large filter capacitors used in power supplies for smoothing out rectified dc. The electrolytic types are normally marked with an identifying mark to indicate the positive terminal. The exceptions to this are the capacitors used on ac as motor start capacitors. This type is specially made to perform its work on ac and is a non-polarized electrolytic capacitor.

Capacitors may be tested for shorts, and in some instances, depending on the size of the capacitor, for open circuit conditions by using the ohmmeter. The following procedure may be followed:

1. Remove the machine line plug from the socket.
2. *Discharge the power supply capacitors* by shorting across the terminals with a heavy screwdriver which has an *insulated* handle and an uninsulated blade. Maintain short for several seconds to ensure capacitor is completely discharged.
3. Disconnect one side of the capacitor to be tested (this must be done to prevent a false indication).
4. Plug red test lead into the positive hub on meter and connect the clip on the red lead to one lead or terminal on the capacitor (if electrolytic type connect to + terminal). Set ohmmeter to R x 100 range. Plug the black test lead into the common hub of meter.
5. Touch the clip end of the black lead to the other terminal on the capacitor. The meter pointer should go upscale and, then as the capacitor charges, drop back to a fairly low reading. The capacity of the condenser determines how far and how quickly the pointer drops back. Small capacitors may give only a faint indication on the meter, large capacitors may



Capacitance in Picofarads

Color A	First Significant Figure	Color B	Second Significant Figure	Color C	Third Significant Figure
Black	0	Black	0	Black	0
Brown	1	Brown	1	Brown	1
Red	2	Red	2	Red	2
Orange	3	Orange	3	Orange	3
Yellow	4	Yellow	4	Yellow	4
Green	5	Green	5	Green	5
Blue	6	Blue	6	Blue	6
Violet	7	Violet	7	Violet	7
Gray	8	Gray	8	Gray	8
White	9	White	9	White	9

Color D	Decimal Multiplier	Color E	Tolerance	Color F	dc Test Voltage
Black	. . . .	Black	20%	Black	. . . .
Brown	10	Brown	1%	Brown	100
Red	100	Red	2%	Red	200
Orange	1,000			Orange	300
Yellow	10,000			Yellow	400
Green	100,000	Green	5%	Green	500
Blue	1,000,000			Blue	600
Violet	10,000,000			Violet	700
Gray	. . . .			Gray	800
White	. . . .	White	10%	White	900
Gold	0.1	Gold	5%	Gold	1000
Silver	0.01	Silver	10%	Silver	2000
No Color	. . . .	No Color	20%	No Color	500

Figure 5-2. Capacitor Color Codes

take several seconds for the pointer to fall back to a relatively low reading. For capacitors below .5 mfd down to about .01 mfd the R x 1000 range should be used to be able to see a deflection of the meter pointer. A capacitor which causes the meter to read full scale is shorted and should be replaced. Capacitors (except those in the value of about .01 mfd or less) which do not cause the meter pointer to deflect even slightly are probably open and should be replaced. Substitution of a suspected capacitor with one known to be satisfactory is the only sure way to determine that a given condenser is good or bad.

ELECTROLYTIC CAPACITORS

Electrolytic capacitors are manufactured with a safety blowout plug designed to relieve gas pressure in the container. If the safety blowout plug fails to operate, the increasing pressure causes the capacitor to explode. This could result in serious injury to anyone in the immediate vicinity.

The following rules should be adhered to for maximum safety while working in the vicinity of or after installing an electrolytic capacitor in a machine:

1. The dc electrolytic capacitors must be connected properly with reference to polarity to prevent possible explosion and to assure proper machine operation. Most electrolytic capacitors are identified by a red dot or a plus sign near the positive terminal.
2. After installing any electrolytic capacitor, be sure the capacitor is shielded by replacing the machine covers before turning the power on. This can prevent possible injury if the capacitor should explode.
3. Whenever possible, covers should be left installed over capacitor areas when the machine is on.
4. Caution should be observed when working with tools in the power area.

SELENIUM RECTIFIERS

Dry metallic rectifiers have several advantages over vacuum-tube diodes when used to change ac line voltages to the dc potential required for IBM machines. They do not require a time delay for the cathode to heat, they can handle heavy current overloads, their life is much longer than that of a vacuum tube, and they can supply much higher currents than a vacuum-tube power supply occupying the same space.

When vacuum-tube rectifiers age, the dc output decreases, and a time may come when the output is sufficiently low to cause an occasional failure in machine operation. The metallic-rectifier output decreases so slowly that under normal conditions the rectifier far outlasts the life of the machine.

The selenium dry disk rectifier is assembled from aluminum or steel disks coated on one side with a thin layer of selenium. Over this thin coating is sprayed a layer of metallic alloy that makes even contact with the selenium. Between the selenium and the alloy a barrier layer is formed, which has the unique property of offering a low resistance to electrons flowing from alloy to selenium but a high resistance to electron flow in the opposite direction. The selenium cell, therefore, acts in the same manner as a vacuum diode, with the alloy acting as a cathode and the selenium serving as an anode.

Each selenium cell is capable of withstanding a back voltage of 26 volts. If higher voltage is to be rectified, the cells are connected in series. Seven such cells would be required to withstand the 161-volt peak voltage of nominal 110 volts ac, but more are used to give a safety factor.

The selenium rectifier is represented by the symbol shown in Figure 5-3. Note the direction of high resistance to electron flow. In some applications individual rectifier assemblies may be used to function as a polarity trap or filter to prevent back circuits.

See Figure 5-5 for illustrations of rectifiers used as diodes and the markings used to designate polarity.

As shown in Figure 5-3 one terminal has been marked either by a dot, red mark, red stripe, or a plus (+). This terminal on metallic rectifiers is referred to as the "positive terminal." This is an industry standard and is used only to indicate the positive dc voltage terminal when the component is used as a dc rectifier. It must be remembered, however, that this terminal is still the cathode when referring to the diode's actual construction.

A half-wave metallic rectifier circuit is illustrated in Figure 5-3. It is often desirable to use selenium rectifiers to accomplish full-wave rectification. The bridge circuit in Figure 5-4 is most commonly used. The terminals marked ac are daubed with yellow paint to indicate that they are connected to alternating current.

The electrolytic filter capacitors are connected in the manner indicated, with the red positive terminal connected to the positive terminal of the rectifier.

The selenium rectifier withstands high-current overloads, but voltage overloads puncture the barrier layer. When the barrier layer has been punctured, a pungent odor is evident. *Avoid breathing fumes as much as possible.* If the overload is slight, the selenium heals the puncture, but if a severe overload has occurred, the entire rectifier must be replaced. Selenium rectifiers which have been removed from a machine can constitute a serious safety hazard if the following precautions are

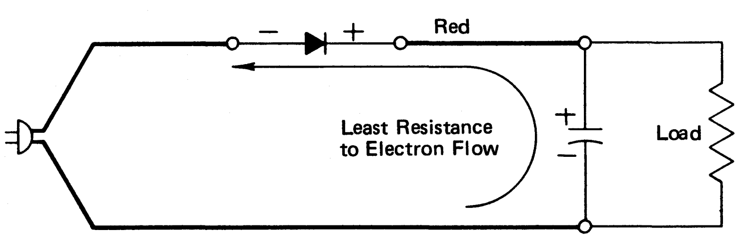


Figure 5-3. Half-Wave Metallic Rectifier Circuit

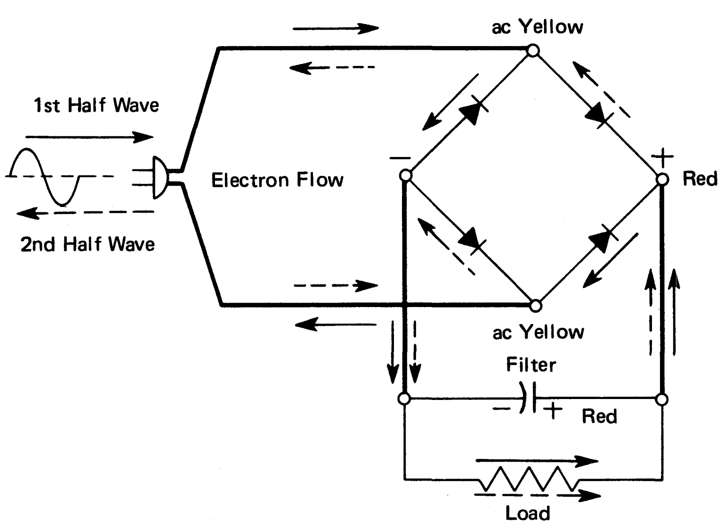


Figure 5-4. Full-Wave Metallic Rectifier Circuit

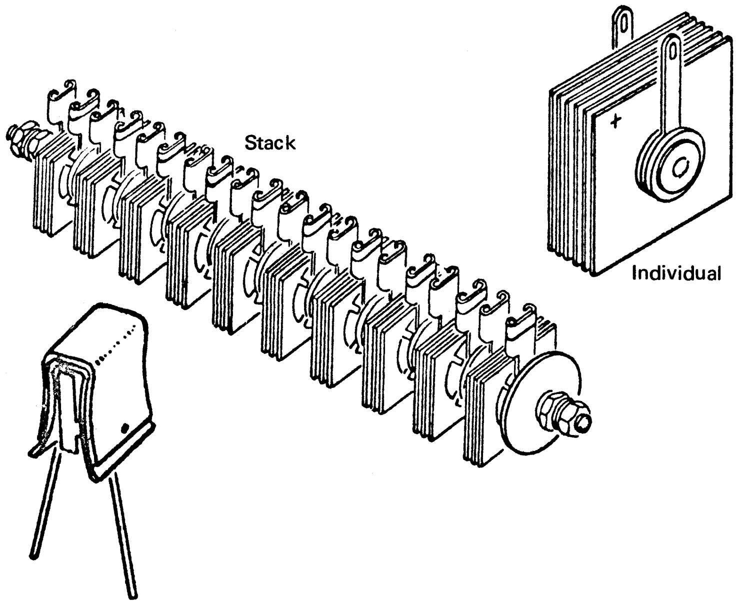


Figure 5-5. Rectifiers

not observed: Do not discard rectifier in customer's office; wrap in paper and return to the branch office for proper disposal. Wash hands thoroughly before smoking or eating.

SILICON RECTIFIERS

Silicon is also used as a rectifier in IBM equipment and has replaced selenium in many applications. Silicon not only has greater current carrying capacity than selenium (750 amps per square inch as compared to .016 amps per square inch for selenium), but silicon rectifiers also are much smaller physically than selenium rectifiers for the same current output. Figure 5-6 shows the comparative size of selenium and silicon rectifiers. Both are 500 mA units. Silicon crystals are produced by a "pulling" process. This is a process where a seed of pure silicon is dipped into a molten silicon and through rotation and withdrawals the crystal is formed.

When the crystal has been formed into the proper type and has the desired characteristics the crystal is cut into thin slices and finally into wafers of the desired size and thickness. These wafers are called "dice."

The wafers are subjected to other processes including sorting to eliminate the wafers not meeting specifications, and grading. The next process is alloying, which is the joining of metal to the crystal. The alloying is done at high temperatures and provides the junction needed for rectifying action. The alloyed wafers are brazed to a base and then hermetically sealed. Figure 5-7 is a cross section of a typical silicon rectifier. Silicon rectifiers come in many sizes and shapes. Figure 5-8 illustrates a few of the many types currently in use.

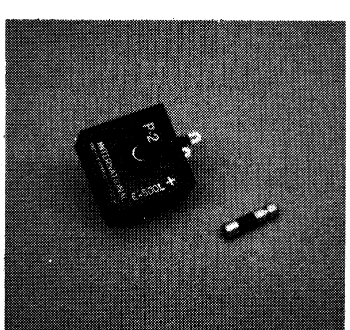


Figure 5-6. Relationship of Selenium to Silicon Rectifiers

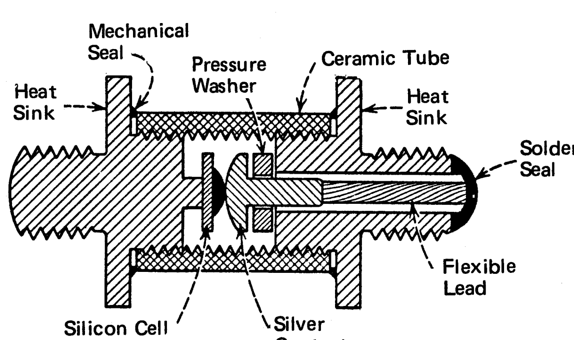


Figure 5-7. Silicon Rectifier-Cross Section

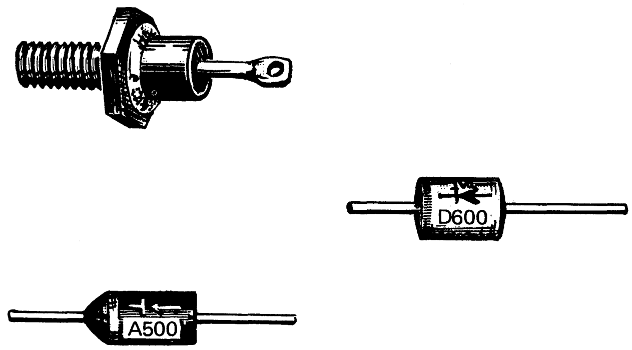


Figure 5-8. Types of Silicon Rectifiers

GERMANIUM CRYSTAL DIODES

In the early days of radio development, radio receiving sets used a detector made by clamping a small piece of metallic crystal in a small cup or receptacle. A flexible wire called a "cat whisker" was held in light contact with a sensitive spot on the crystal. This arrangement permitted electrons to flow easily from the cat whisker, which was made of a metal having free electrons, to the crystal, but electrons were impeded in the reverse direction because the crystal had very few free electrons. Thus, rectification, or detection, of the incoming radio frequency voltage was accomplished.

The development of the vacuum-tube diode made crystal detectors obsolete in commercial radio sets; however, because the crystal-diode rectifier is superior in certain respects to the vacuum-tube diode, especially in high-frequency circuits, considerable development has been made on this device.

The most widely used substance for crystal diodes is crystalline germanium. A germanium crystal (Figures 5-9 and 5-10) is pressed into a holder and the exposed surface is then ground and polished to a bright finish. The crystal is assembled in its cartridge with a cat whisker of platinum or tungsten pressing lightly on the germanium surface. A high current is sent through the assembly momentarily to heat the cat whisker, and a weld is formed between the whisker and the crystal. The welded unit is mechanically stable, and does not require further adjustment. A germanium diode is inherently a rugged and reliable device.

There are several unique properties that should be considered when working with these devices:

1. The resistance is non-linear; that is, the resistance changes with voltage applied. Usually, the resistance decreases for an increasing voltage.
2. The resistance at a given voltage is inversely proportional to temperature.
3. The properties of the germanium are affected by moisture. IBM goes to great lengths to ensure that only diodes mounted in moisture resistant cases are used where this factor is important.
4. Guard against twisting or bending which could result in damage to the diode.
5. The life of a diode cannot be determined by testing, because the most common break occurs at the connection between the whisker and the crystal. A diode may be tested and operate satisfactorily one

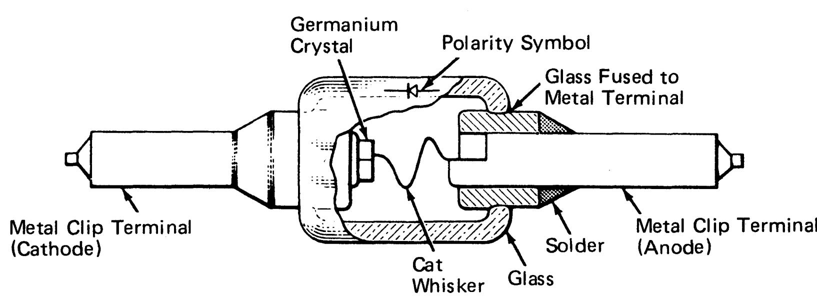


Figure 5-9. Glass Enclosed Germanium Diode

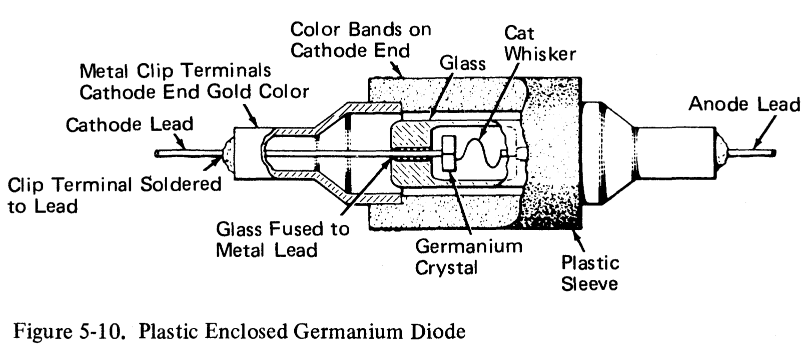


Figure 5-10. Plastic Enclosed Germanium Diode

minute, but it may become defective the next. Only after a satisfactory period of operation may a diode be considered stable.

6. A high temperature in an area around a diode can cause unsatisfactory results. Do not mount the diodes in a tight, solid group. Leave some space for air circulation around each diode.

Semiconductor diodes used in many IBM machines have characteristics which limit their use to specific circuits. Substitution should not be made unless it is certain that the replacement diode has the same overall characteristics as the one presently in the circuit. Replacement with diodes other than direct replacement can lead to difficult and hard to diagnose machine problems.

Note: When semiconductor diodes have to be soldered into circuits or on to SMS cards, it is important that a heat sink, part 460846, or a pair of long nose pliers, be used on the diode lead being soldered. Excess heat can cause a diode to change characteristics or breakdown and cause subsequent machine failures.

Vendors encapsulate diodes and identify the type by color code or some other means. When color coding is used, color bands are closest to the cathode terminal. Generally speaking, the cathode end is marked. For example, in Figure 5-9 the arrowhead of the diode symbol indicates the direction of conventional current flow.

JUMPER WIRE RESISTANCE

Metal contacts, exposed to the air, tend to exidize or tarnish. The oxide film formed on the contacts generally increases the resistance of the contact. Thus, wire plug connectors and jumper wire connections may indicate resistance values higher than the allowable values when an IBM or Simpson meter is used to measure these resistances.

Because the ohmmeter employs a low voltage and a low current, the tarnish film appears as a high resistance. However, this resistance may have no detrimental effect on machine operation if the tarnish films are punctured immediately after the machine voltage is applied. The passage of current through the high resistance film causes enough heat to produce a metal bridge through the puncture. The properties of such bridges depend upon the magnitude of the current that produces them.

The resistance measured after passage of relatively high current is frequently lower than it would be if the load resistance is large and limits the current to a few milliamperes. This contact resistance can be further created or eliminate; by slightly flexing the wire near the plug connection. The resistance may also fluctuate due to normal machine or room vibration. However, no failures resulting from this condition occur at voltages well below specified machine voltages.

Example: A meter reading indicates 300,000 ohms or infinity in a single contact or a series of contacts before voltage is applied. This is reduced to 0.5 ohms or less immediately after the machine voltage is applied. Conclusion: The effective dc resistance in the circuit is less than one ohm, which has no detrimental effect.

To evaluate the apparent resistance properly and to determine its possible effect on a particular circuit, a measurement can be made of the voltage drop in the wire connector or jumper connection with standard field equipment. The circuit shown in Figure 5-11 indicates the method of connecting the meter (use the Simpson meter only, 10-volt scale) and a 250-ohm resistor to simulate a load comparable to a relay coil or counter magnet.

When electronic circuits are involved, a significant test of the circuit resistance may be made by using the Simpson meter on the 10-volt scale and a 7500-ohm resistor. Such a resistor on 45 volts limits the current to a 6 milliamperes and simulates the current impulse that controls the grid in an electronic circuit.

Make all the connections shown in Figure 5-11 with the mainline switch turned off. Set the Simpson meter on the 50-volt scale and turn on the mainline switch.

With a cable wire, jumper wire, or series of jumpers connected in the test circuit, the voltage drop should not exceed 0.1 volt per jumper connector, or 1.5 volts aggregate for 30 jumpers. (This value is discernible on 10-volt dc scale.) Set the meter back to 50-volt scale before removing any connections.

Note: This procedure must be followed to protect the meter from higher potential when the 10-volt scale is used.

To simulate this resistance phenomenon under machine vibrating conditions, cables, and jumpers should be flexed; note any voltage drop. The meter must be returned to 50-volt scale for this test because a circuit may be opened accidentally and expose the meter coil to higher potential.

Where a circuit failure cannot be isolated to any definite source such as points, cam contacts, etc. or where extreme resistances are noted in the process of ringing circuits with a meter, the amount of voltage drop in a circuit must be ascertained before concluding that an indicated resistance condition is a contributing factor to the machine malfunction.

Where the voltage drop is in excess of the amount already mentioned, the wire plug connector or jumper should be replaced. If an excessive voltage drop occurs in a series of jumpers, the faulty jumper is to be determined and removed through the process of elimination.

Where this current test indicates that voltage drop, above the specification, is prevalent in various strings of

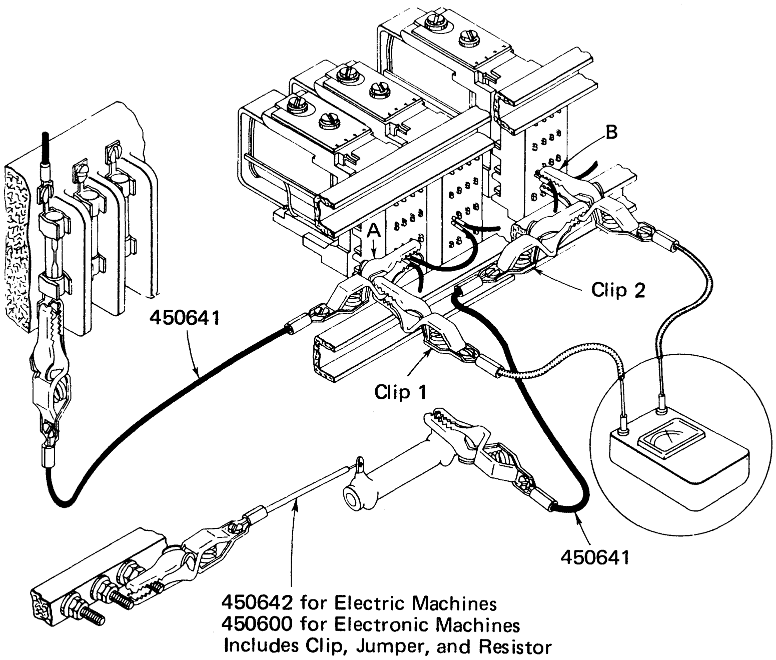


Figure 5-11. Connections for Measuring Contact Resistance

jumpers, notify the Field Engineering Technical Operations Department at the controlling plant for the machine involved.

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