R E P O R T   R E S U M E S

ED 021 099 VT 005 682

AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XXVIII, I--CATERPILLAR STARTING (PONEY) ENGINE (PART II), II--UNDERSTANDING MORE ABOUT STARTING DEVICES.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

REPORT NUMBER AM-1-28 PUB DATE 5 OCT 66

EDRS PRICE MF-$0.25 HC-$1.04 24P.

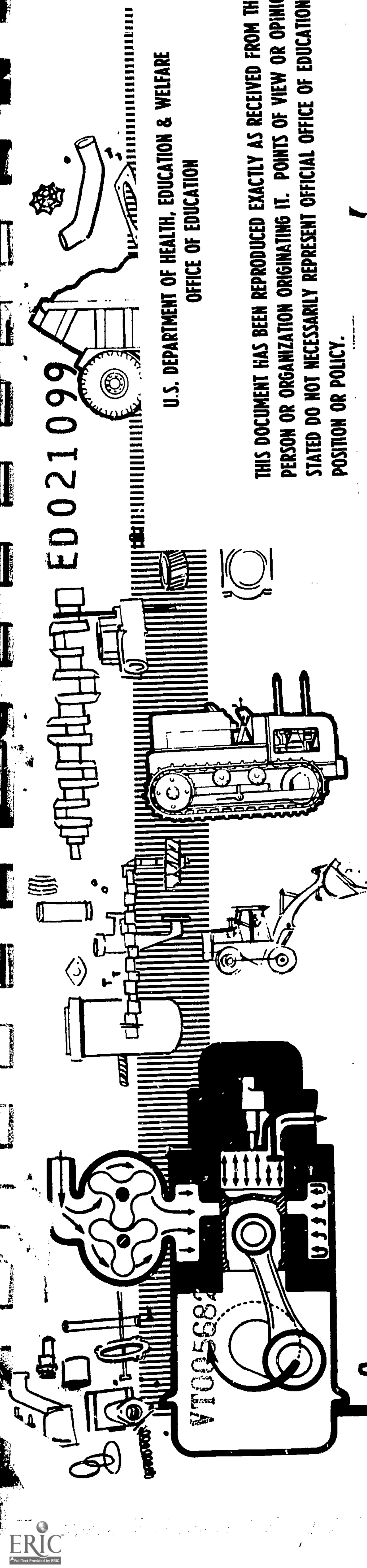
DESCRIPTORS- *STUDY GUIDES, *TEACHING GUIDES, *TRADE AND INDUSTRIAL EDUCATION, *AUTO MECHANICS (OCCUPATION), *DIESEL ENGINES, ADULT VOCATIONAL EDUCATION, TRANSPARENCIES, PROGRAMED MATERIALS, INDIVIDUAL INSTRUCTION, INSTRUCTIONAL FILMS, PROGRAMED INSTRUCTION, MOTOR VEHICLES, EQUIPMENT MAINTENANCE,

THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF DIESEL ENGINE STARTING ENGINES. TOPICS ARE (1) STARTING ENGINE MAGNETO (WICO), (2) MAGNETO MAINTENANCE, (3) SPARK PLUGS, (4) GENERAL DESCRIPTION (STARTING DEVICES), (5) OPERATING (STARTING DEVICES), (6) LUBRICATION (STARTING DEVICES), (7) PERIODIC CHECKS AND ADJUSTMENTS, AND (8) CRANKING MOTOR DRIVE CHECKS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "CATERPILLAR DIESEL STARTING ENGINE" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILALBE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

ED021099

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.



STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL 1 MAINTENANCE

I - CATERPILLAR STARTING (PONEY) ENGINE (PART II)
II - UNDERSTANDING MORE ABOUT STARTING DEVICES

UNIT XXVIII

Part I

SECTION A	STARTING ENGINE MAGNETO (WICO)
SECTION B	MAGNETO MAINTENANCE
SECTION C	SPARK PLUGS

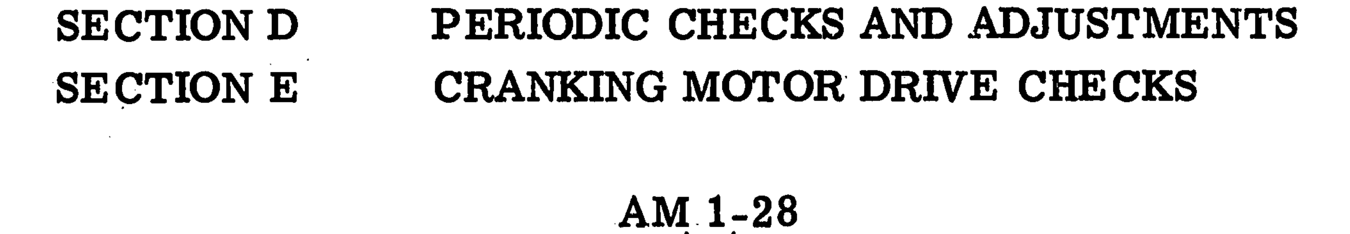
Part II

SECTION A	GENERAL DESCRIPTION
SECTION B	OPERATION
SECTION C	LUBRICATION
SECTION D	PERIODIC CHECKS AND ADJUSTMENTS
SECTION E	CRANKING MOTOR DRIVE CHECKS

AM 1-28
10/5/66

Human Engineering Institute

Minn. State Dept. of Ed.
Vocational Education



HUMAN ENGINEERING INSTITUTE

This unit is divided into two parts. The first part continues with the discussion of the Caterpillar starting (poney) engine. The second part is a brief presentation of starting devices other than poney engines.

I - CATERPILLAR STARTING (PONEY) ENGINE (PART II)

SECTION A -- STARTING ENGINE MAGNETO (WICO)

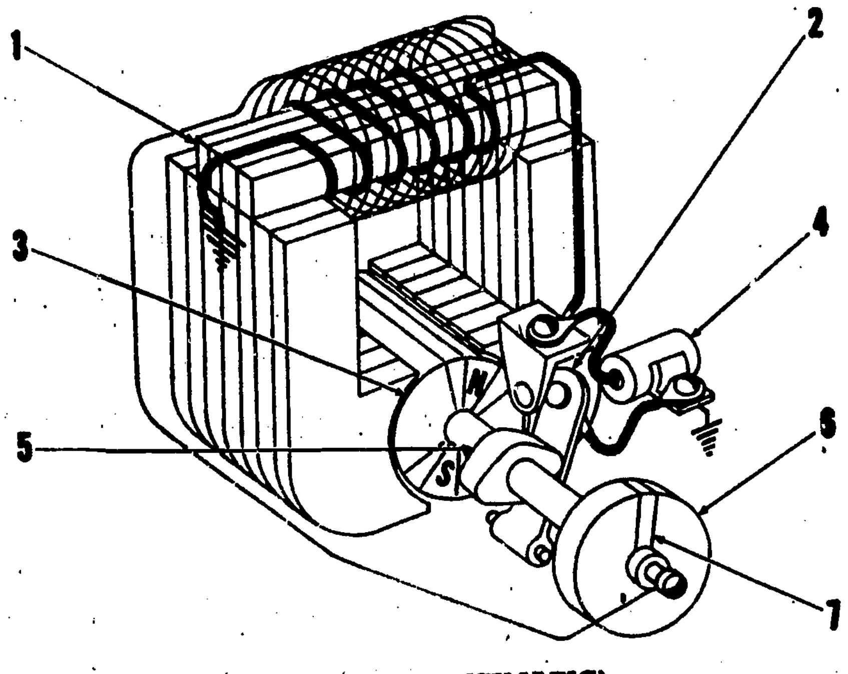
Spark-ignited engines require a source of electricity that can be interrupted to produce "sparks" at proper times, to ignite air fuel mixtures in the engine cylinders.

A magneto is a self-contained alternating current generator that can produce the electric source (and interrupt it at the proper time) necessary for spark ignited engines.

Operation -- It is assumed that the reader has some knowledge of basic magnetism and electricity.

The basic components of a magneto are shown in Figure 1.

TRANSFORMER (1) has a heavy primary coil with relatively few windings, when compared with the number of fine wire windings in the secondary coil that is wound around the primary in the same direction.



MAGNETO (SCHEMATIC)
1-Transformer. 2-Contact breaker. 3-Rotor. 4-Condenser. 5-Cam. 6-Distributor. 7-Contact.

Fig. 1 Magneto (schematic).

CONTACT BREAKER (2) is actuated by cam (5) on the rotor shaft.

ROTOR (3) contains a permanent magnet.

CONDENSER (4) is shunted across the contact breaker (2).

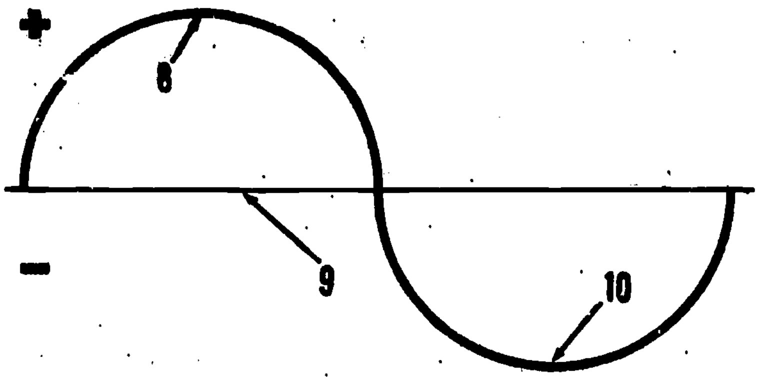
DISTRIBUTOR (6) contains contact (7) and is driven by the rotor shaft.

All magneto components are in a housing that has a removable distributor cap.

One end of the primary wire (of transformer (1)) is grounded on the transformer core. The other end of the primary coil wire is joined by one end of the secondary coil wire and is grounded through contact breaker (2). The other end of the secondary coil wire connects to the distributor (6).

When rotor (3) is turning, the north pole of the rotor magnet comes under the core of transformer (1). Magnetic flux takes the easy route from the magnetic north to the magnetic south by passing through the laminated metal core of the transformer. This turning rotor induces more flux (in the core) until the magnetic north is completely under the core and flux is at its greatest strength. As the rotor continues to turn, the magnetic north moves out from under the core and flux diminishes until there is no magnetic flux in transformer core (1). The rotor continues turning and the magnetic north comes under the opposite side of the transformer core. Now the magnetic flux must change its direction through the transformer core. Flux builds up and diminishes as previously explained but in the opposite direction. This change in flux direction is repeated each rotor revolution.

Magnetic flux passing through the core also surrounds the coil wire of transformer (10) and creates electricity in the wires. With no interruptions, the electricity (voltage) would build up positive (+) (8), diminish to nothing (9), change directions, build up negative (-) (10) and diminish to nothing every complete revolution of rotor (3). See Figure 2. In an electric generator this is known as an alternating current cycle.



8-Voltage build up positive. 9-No voltage. 10-Voltage build up negative.

Fig. 2 Alternating current cycle (one rotor revolution).

In a magneto an interruption in the alternating current cycle occurs when rotor (3) has turned in transformer (1) to a position where primary coil voltage build-up (11) is high. At this instant, cam (5) opens contact breaker (2) and the current cycle is interrupted. The magnetic flux (around the primary coil wires) suddenly collapses. This quick collapse is magnified by the vast number of fine wires in the secondary coil, and the voltage in the secondary coil is now thousands of times greater than the voltage was at the instant contact breaker (2) opened.

The instant that very high voltage builds up in the secondary coil, distributor (6) is in a position where contact (7) completes an electrical circuit (through a brush in the distributor cap and through a lead wire) to the spark plug in the engine cylinder. This high voltage now discharges (sparks) across the gap of the spark plug electrodes, completing the ignition to that engine cylinder.

The function of condenser (4) is to prevent damaging arcs from jumping across contact breaker (2) as it opens. The condenser collects the rush of electrical energy that would normally discharge across the contact as it opens. When the contact breaker opens wider, the electrical energy absorbed by the condenser discharges back into the primary coil, thus adding to the voltage build-up in the secondary coil.

Both the primary and secondary coil wires of transformer (1) are wound in the same direction. One end of each coil is joined and grounded through contact breaker (2). The primary coil wires become additional wires in the secondary coil when contact breaker (2) is open. In this way, a little more boost in voltage is picked up in the secondary coil as magnetic flux collapses.

When the rpm of the magneto increases, the spark at the spark plug electrodes intensifies. An impulse coupling can be employed (on the drive end) to increase rotor rpm momentarily when the engine is being cranked. The trip arm, that actuates the impulse, will disengage when the engine driving the magneto starts to operate.

SECTION B -- MAGNETO MAINTENANCE

VOLTAGE LEAKS -- When the high voltage discharge from the magneto secondary can find an easier route to ground, a path to ground is usually established and it is likely that the spark will continue to take this new route to ground.

High voltage can leak to ground in various places. Some of the places where spark leakage occurs can be corrected easily. Replace lead wires that are either broken or have damaged insulation.

Replace spark plugs that have eroded electrodes, or if the spark plugs appear serviceable, remove the corrosion and reset the electrode gap. Make certain the spark plugs are clean and dry.

Clean the oxidation from the inside of the magneto. Make certain all wires in the magneto are in serviceable condition. Tighten all screw connections.

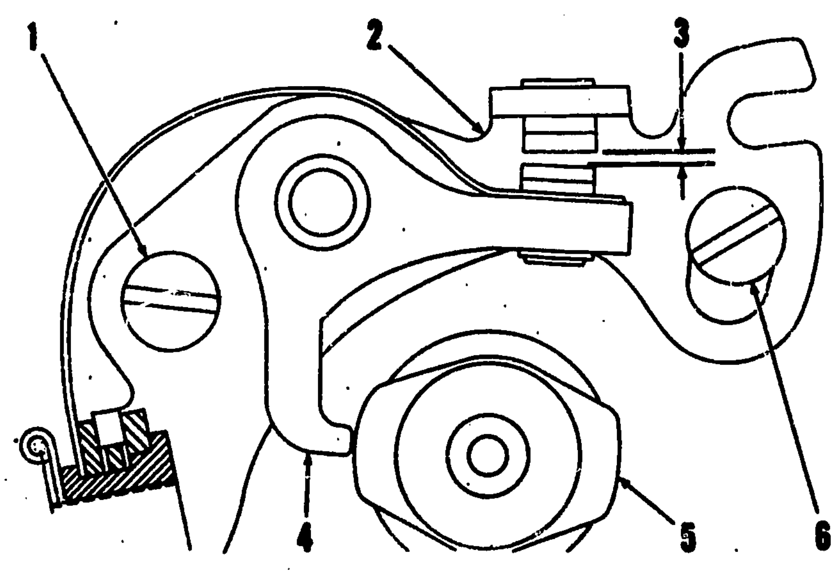
Most surface leaks are easily located at points where high voltage sparks have left burning effects on plastic or insulation.

INTERNAL OXIDATION -- When oxidation is observed in a magneto there usually is some cause for the condition. Some common causes could be sparks across a loose or broken connection, carbon paths in the magneto, brushes that are broken or are sticking in the distributor cap or a break in the exterior of the secondary voltage circuit. After the cause for oxidation has been determined, disassemble the magneto and individually clean each part that is serviceable. When reassembling a magneto, always install gaskets, seals, washers, a new contact breaker and a new condenser.

Parts substitution can sometimes be used to determine the faulty component in a magneto (process of elimination).

MAGNETO ADJUSTMENT -- The contact assembly gap is the only adjustment in the magneto. See Figure 3. One part of the contact assembly is a fiber pivot block (4) (sometimes called rubbing block) and the other part is an adjustable contact (2). When a magneto is operating, high portions on rotor cam (5) (high point of cam) rub against the fiber pivot block. When the fiber wears, contact gap (3) becomes less and it is necessary to adjust the gap.

NOTE: When the magneto switch is off, the magneto is grounded and cannot produce sparks.



1–Screw. 2–Adjustable contact. 3–Contact gap. 4–Fiber pivot block. 5–Rotor cam. 6–Screw.

Fig. 3 Contact assembly.

SECTION C -- SPARK PLUGS

A spark plug must operate in combustion temperatures as high as 4000 F, at 1000 to 2000 sparks per minute, and withstand pressure as high as 800 pounds per square inch. After several hundred hours of operation, the spark plug gap widens and the electrodes become rounded due to the combined action of intense heat, pressure, corrosion gases within the combustion chamber, and spark erosion. See Figure 4. The plug insulator also becomes covered with carbon and lead deposits.

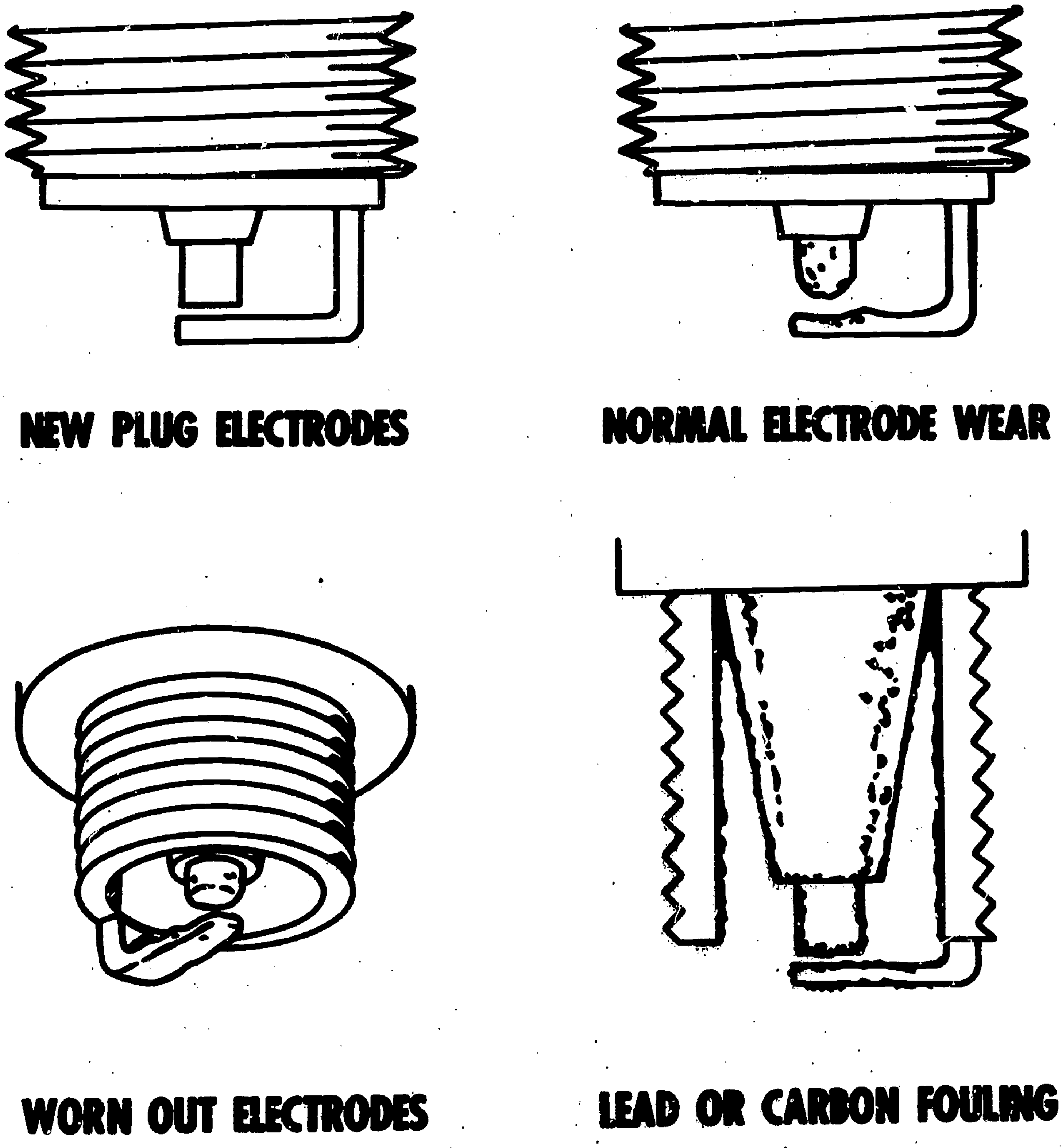
The correct spacing of the spark plug gap is important because it influences the entire range of engine performance: starting, idling, acceleration, power and top speed. Uniformity of all spark plug gaps is extremely important for smooth engine operation. Always check the plug gap on new spark plugs against specifications, before installing them.

The effect of insufficient spark plug gap is engine misfire at idling speed and uneven power at all speed. Carburator adjustments will also be more critical. The effect of gaps wider than specified is hard starting and the tendency of the engine to misfire at high speeds.

Spark plug electrodes should be filed flat because current is emitted from a sharp corner much more easily than from a blunt surface. If this maintenance is neglected, up to 30% more voltage is required to fire the spark plug.

To obtain efficient spark plug performance, plugs should be washed, cleaned, filed, inspected and regapped at regular intervals. Spark plugs should be replaced in sets. If any questions exist in your mind about the condition of the spark plugs you take from an engine, suggest they be replaced with new plugs. The quick starting and added performance from new plugs, and the savings in greater fuel economy, will shortly repay the cost of the new plugs. Use the specifications, and cross-reference table if necessary, for proper spark plug selection. Torque the plugs to specifications to insure proper heat transfer and use a thread lubricant.

ERIC



<u>Fig. 4</u> Analysis of spark plug wear.

II -- UNDERSTANDING MORE ABOUT STARTING DEVICES

SECTION A -- GENERAL DESCRIPTION

Most cranking motors used on CATERPILLAR engines are not cranking motors, but are gasoline driven starting engines. This section will cover the three types of cranking motor drives, the DYER DRIVE, the SPRAG OVERRUNNING CLUTCH DRIVE and the BENDIX FRICTION CLUTCH DRIVE, used on diesel engines.

The cranking motors (Figures 5, 6, &7) are specially designed heavy duty electric motors made for the specific purpose of cranking internal combustion engines at speeds sufficient to permit their starting.

Figure 5 illustrates a cranking motor with a Dyer Drive. Figure 6 illustrates a cranking motor with a Bendix Friction Clutch Drive. Figure 7 illustrates a cranking motor with a heavy duty Sprag Overrunning Clutch Drive.

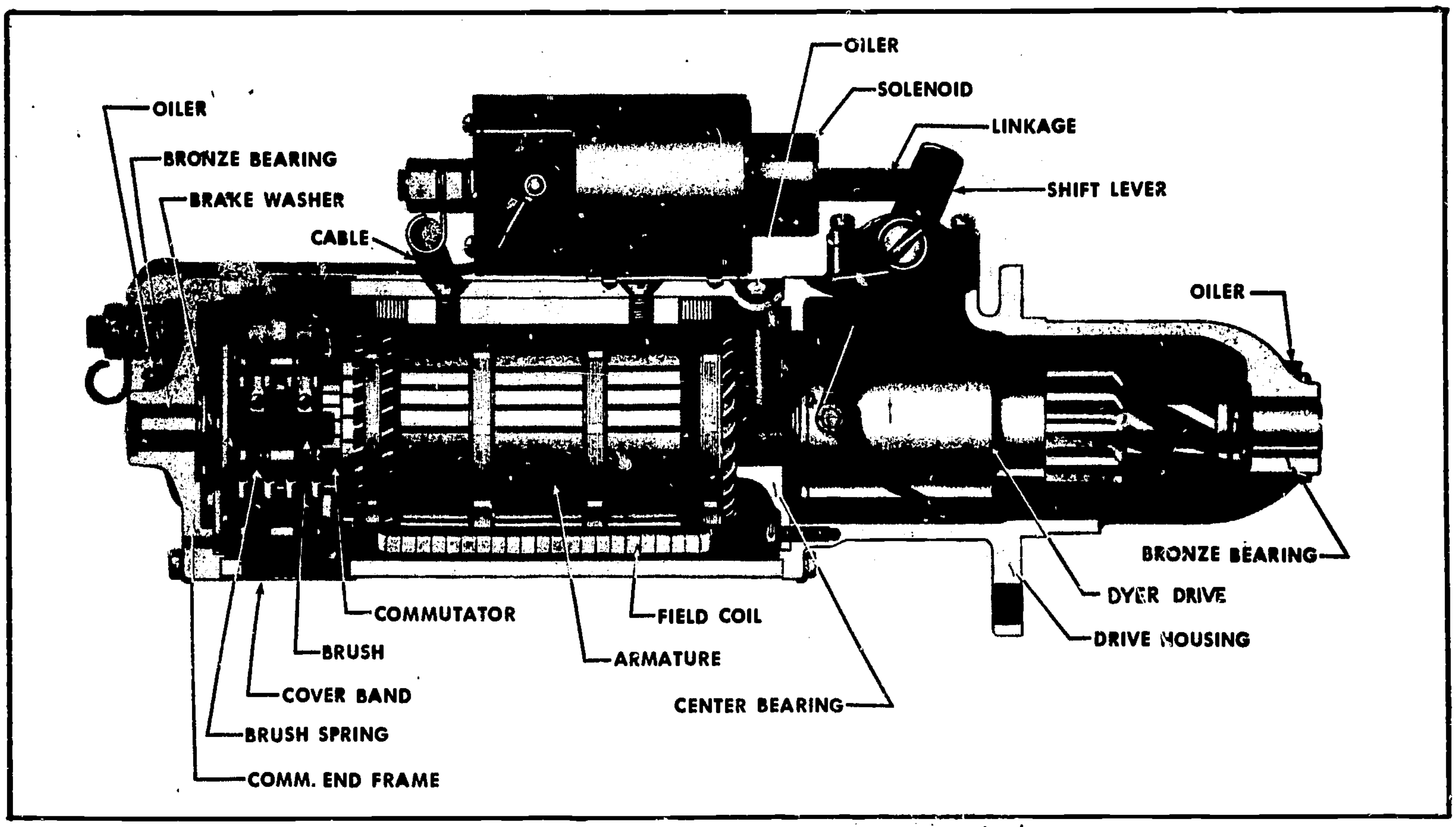


Fig. 5 Cutaway view of a Dyer Cranking Motor.

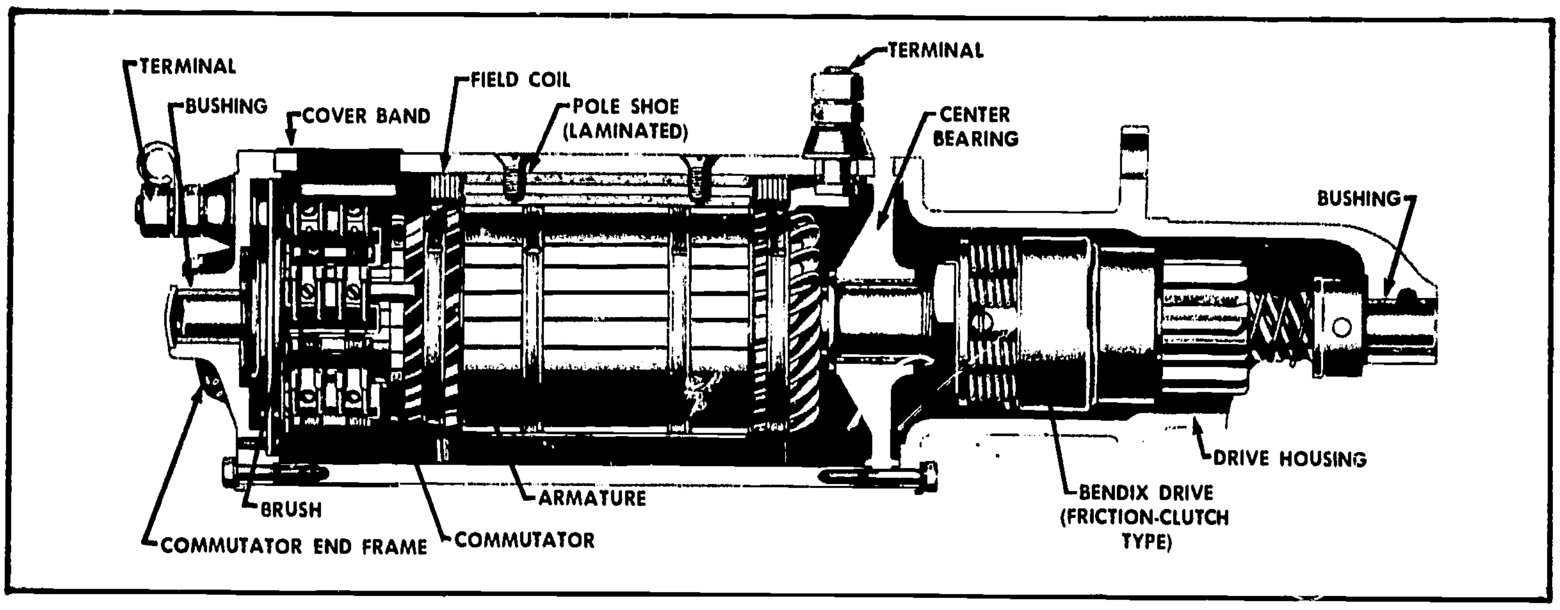


Fig. 6 Cutaway view of a Bendix Cranking Motor.

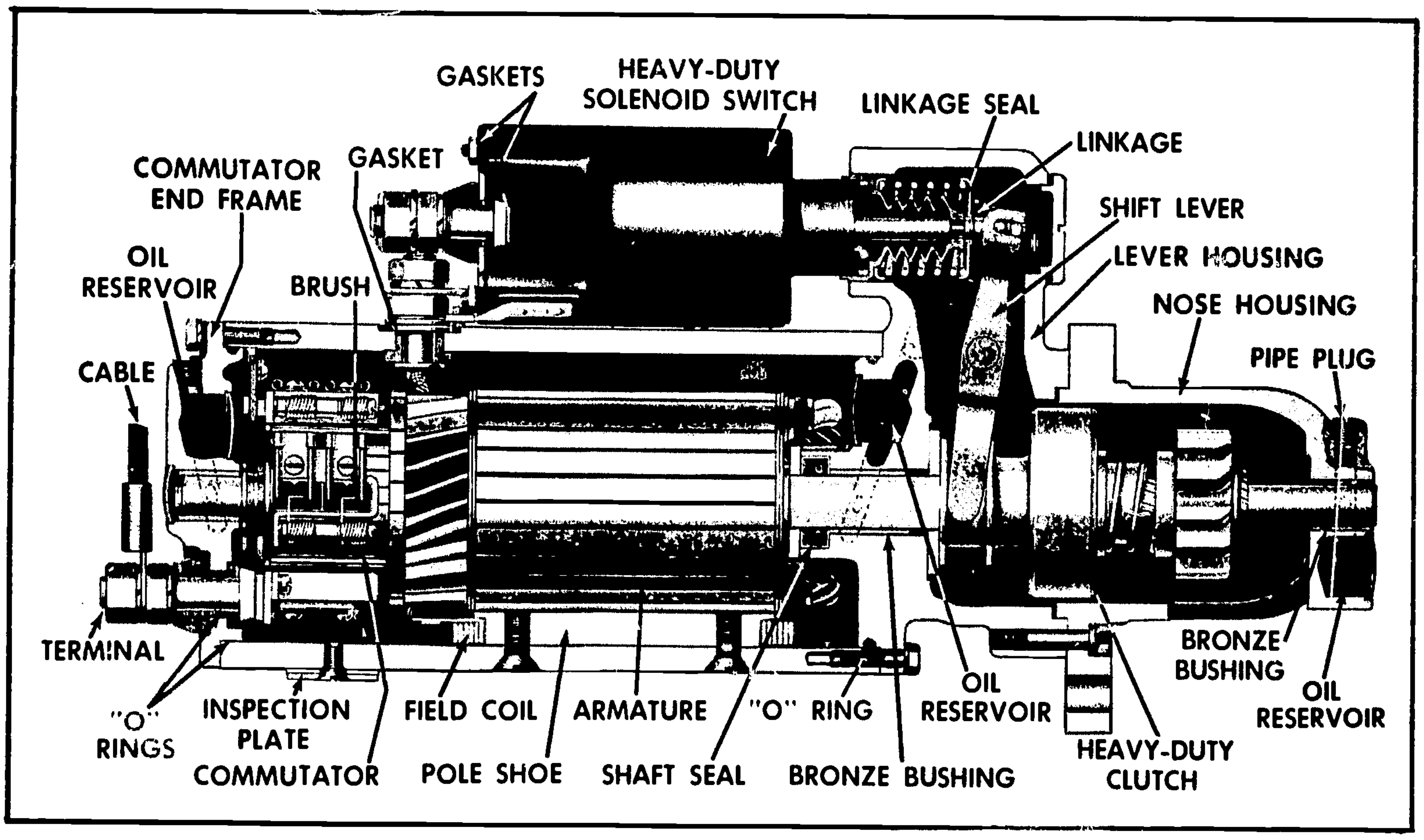


Fig. 7 Cutaway view of a heavy duty Sprag Clutch Cranking Motor.

They are equipped with bronze bushings in the end frame, lever housing and drive housing. Lubrication is provided through hinged cap or slotted plug, wick type oilers. The enclosed shift lever type starter (Figure 7) is equipped with the O-rings to prevent the entry of dirt and moisture into the assembly. The oil seal between the shaft and level housing and the boot over the solenoid plunger prevent the entry of oil into the starter mainframe and solenoid case. This allows the starter to be used on wet flywheel housings.

Usually, a heavy duty solenoid switch is mounted on the cranking motor field frame. In some installations a remote mounted magnetic switch is used.

SECTION B -- OPERATION

There are two windings in the solenoid, a pull-in winding and a hold-in winding. When the circuit between the battery and the solenoid windings is closed, by means of a remote control switch, the current flowing through the coils produces a magnetic field which pulls the plunger inward. Movement of the plunger shifts the drive pinion in the drive mechanism into mesh with the flywheel ring gear and closes the main switch contacts, connecting the cranking motor and the battery. Cranking then takes place. Closing the main switch shorts out the pull-in winding, since the winding is connected across the main contacts. The magnetism produced by the hole-in winding is sufficient to keep the plunger in, and shorting out the pull-in winding reduces drain on the battery.

NOTE: Where a magnetic switch is used, it performs the same function as the solenoid.

When the engine starts, the drive pinion is thrown back out of mesh so that the excessive speed will not be transmitted to the armature.

In the heavy duty Sprag clutch drive, the collar and shell assembly has straight splines to match the armature splines and the pinion slides on a spiral spline. As the shift level (Figure 7) is actuated, the pinion slides into mesh with the ring gear. The rotary motion between the pinion and ring gear, provided by the spiral spline, normally relieves tooth abutment on the first attempt. A protective sleeve or shoulder on the spiral spline acts as a pinion stop when extreme tooth abutment occurs. This limits clutch travel, preventing the switch contacts in the solenoid from closing. Therefore, the armature cannot rotate before the pinion is engaged. Spinning and subsequent damage is eliminated.

NOTE: The Sprag Clutch should NOT be cleaned in any degreasing tank or with grease dissolving solvents, since these would dissolve the lubricant in the clutch mechanism. The clutch can be wiped with a clean cloth.

Check the shop manual for special lubrication procedure to be followed. The best assurance of getting maximum service from cranking motors with minimum trouble is to follow a regular inspection and maintenance procedure. Lubrication where required, inspection of the brushes, commutator and drive arrangement are essentials in the inspection procedure.

SECTION C -- LUBRICATION

Bearings provided with hinge cap or reservoir type oilers should have 8 to 10 drops of light engine oil at the interval specified on the lubrication chart. On some models, oil wicks protected by set screws are used to lubricate the center and drive end bushings. The wicks are saturated with oil before assembly, and should be saturated again whenever the cranking motor is taken off the engine or disassembled. Some cranking motors are equipped with oilless bearings (bushings) and have no lubrication openings.

These should be supplied with a few drops of light engine oil at any time the cranking motor is disassembled for repair or service.

Avoid excessive lubrication, since it might cause lubricant to be forced out into the commutator where it would gum and cause poor commutation, with a resulting decrease in cranking motor performance. NEVER LUBRICATE THE COMMUTATOR and do not attempt to lubricate the cranking motor while it is being operated. Keep lubricant clean and in closed containers.

SECTION D -- PERIODIC CHECKS AND ADJUSTMENTS

At periodic intervals, the cranking motor should be inspected to determine its condition. The frequency with which this should be done will be determined by the type of service in which it is used. Frequent starts, excessively long cranking periods caused by hard starting engine conditions, excessively dirty or moist operating conditions, heavy vibration, all will make it necessary that the inspection checks be made at more frequent intervals. Generally speaking, inspection and maintenance checks should be made at approximately 500 hour intervals. However, where special operating conditions such as outlined above exist, inspection at more frequent intervals may be required.

Cranking motor action is indicative, to some extent, of the cranking motor condition. Thus, a cranking motor that responds normally when the cranking motor switch is closed is usually considered to be in good condition.

The Bendix Drive Assembly is used on air starting systems, gasoline engine starters and electric starting motors. It provides an automatic means of engaging the drive pinion with the engine flywheel ring gear for cranking the engine and for disengaging the drive pinion from the flywheel ring gear after the engine starts.

ERIC

When the starter (whether it be gasoline, air or electric), is not operating, the pinion gear is in the position shown in Figure 8, demeshed from the engine flywheel ring gear. As soon as the starter is actuated, the rotor or armature begins to rotate, picking up speed rapidly. The shaft assembly picks up speed with the rotor inasmuch as it is driven through the drive spring. However, the drive pinion, being a loose fit on the shaft assembly, does not pick up speed instantly. The result is that the shaft assembly turns within the pinion, forcing the pinion endwise along ths shaft and into mesh with the flywheel ring gear. As the drive pinion reaches the pinion stop on the end of the shaft assembly, it can move out no further and it must then rotate with the shaft assembly and starter drive shaft so that the engine flywheel is turned and the engine is cranked. The drive spring compresses slightly to take up the shock of engagement.

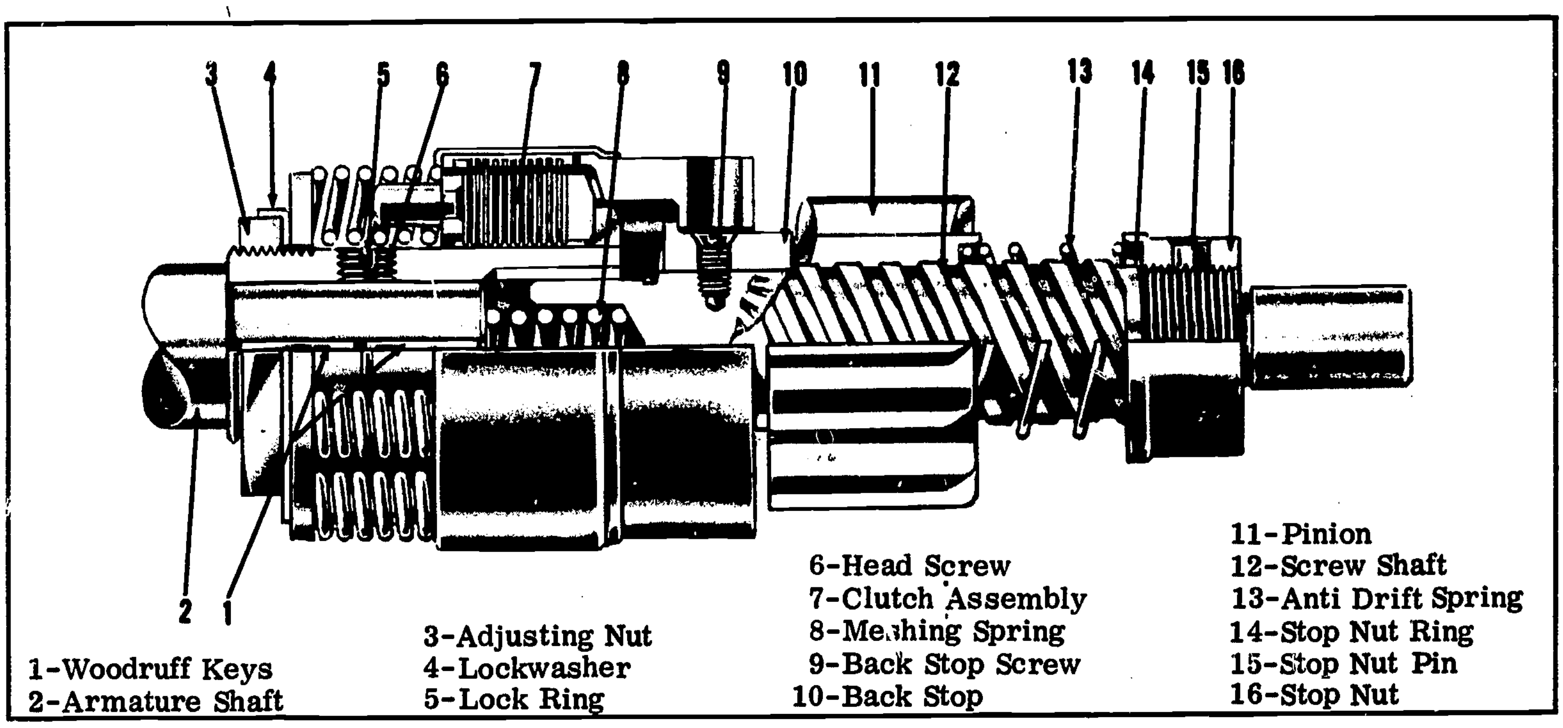


Fig. 8 Cutaway view of a Bendix Drive Assembly.

After the engine has started, the flywheel spins the drive pinion more rapidly than the rotor and shaft assembly are turning, with the result that the pinion is backed out of mesh with the flywheel ring gear. A small anti-drift spring between the drive pinion and the pinion stop prevents the pinion from drifting into mesh when the engine is running.

SECTION E -- CRANKING MOTOR DRIVE CHECKS

DYER DRIVE CHECK - There is one check on the Dyer Drive mechanism which should be made while the cranking motor is off the engine. This is the pinion travel against the spring with the motor in cranking position. Disconnect the lead between the solenoid and cranking motor and connect a battery of the correct (specified) voltage to the two small solenoid terminals (or to the small terminal and the solenoid base if there is but one small terminal). If the plunger does not pull in, move it in by hand so the shift lever is in the cranking position. Battery current will then maintain it in the operating position so that the pinion travel can be checked. It should be possible to push the pinion back against spring pressure 1/8 to 3/16 inch, as shown in Figure 9. Adjustment is made by turning the stud in the solenoid plunger in or out as required. A half turn of the stud allows 1/16 inch pinion travel adjustment.

BENDIX DRIVE CHECK - Hold the drive in your hands with the fingers extending over the front end of the clutch and squeeze it. By doing this, the meshing spring (Item 8, Figure 8) should be compressed inside the clutch housing. If the spring cannot be compressed, sufficient wear or damage has occurred to render the clutch inoperative and the clutch assembly should be replaced.

NOTE: Compress the meshing spring before removing the drive from the rotor or armature shaft. It is possible for the meshing spring to fall out once the drive assembly is removed. When this happens the check cannot be made.

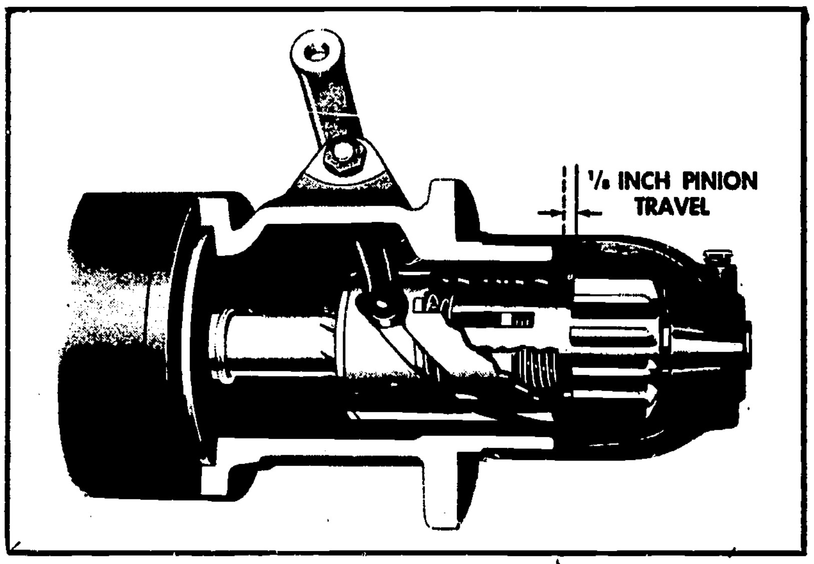


Fig. 9 Dyer drive pinion travel.

SPRAG CLUTCH CHECK - To check the pinion clearance, connect a battery from the solenoid switch terminal to the motor frame. If the solenoid does not operate, use a 12 volt battery. Also to prevent motoring, connect a heavy jumper lead from the solenoid terminal to the motor frame. See Figure 10.

With the solenoid energized and the clutch shifted toward the pinion, push the pinion back toward the commutator end as far as possible to take up any slack movement, then check the clearance between the pinion and housing. The clearance should be 23/64". The clearance is adjusted by removing the plug on the lever housing and turning the nut on the plunger rod inside the housing. Turn the nut clockwise to decrease the clearance and counterclockwise to increase the clearance. See Figure 11.

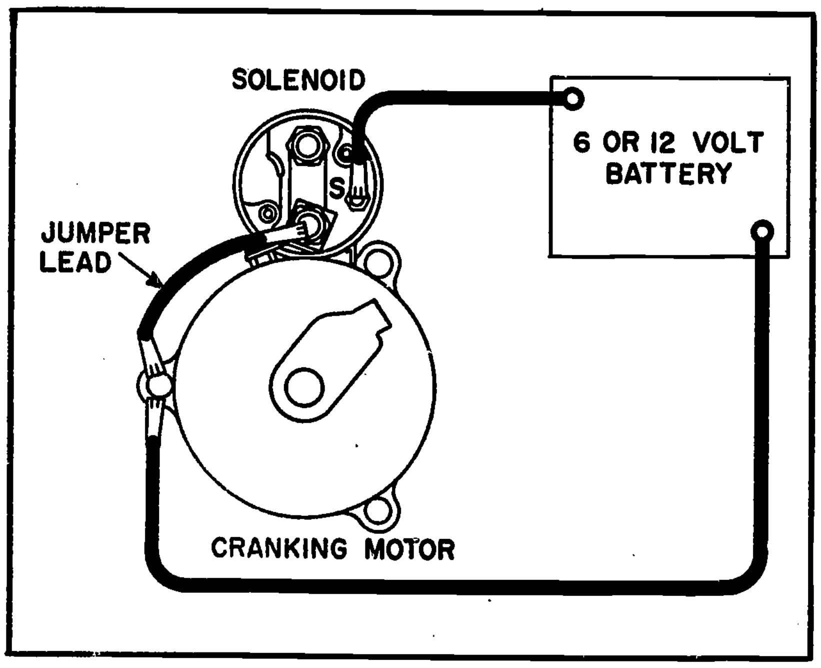


Fig. 10 Circuit for checking Sprag clutch pinion travel.

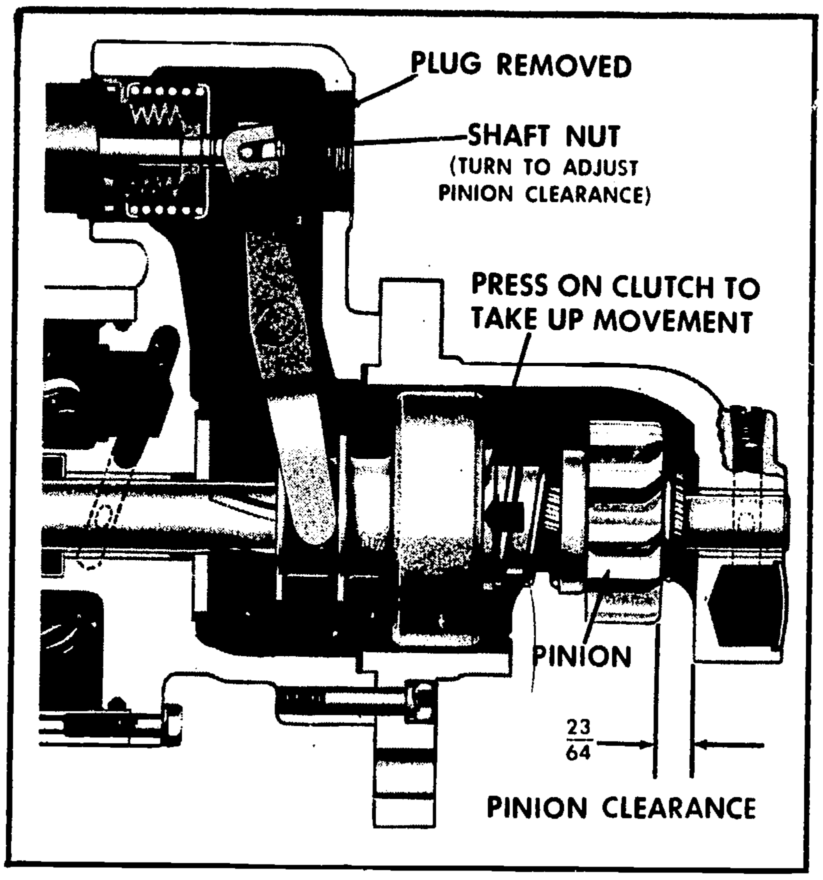
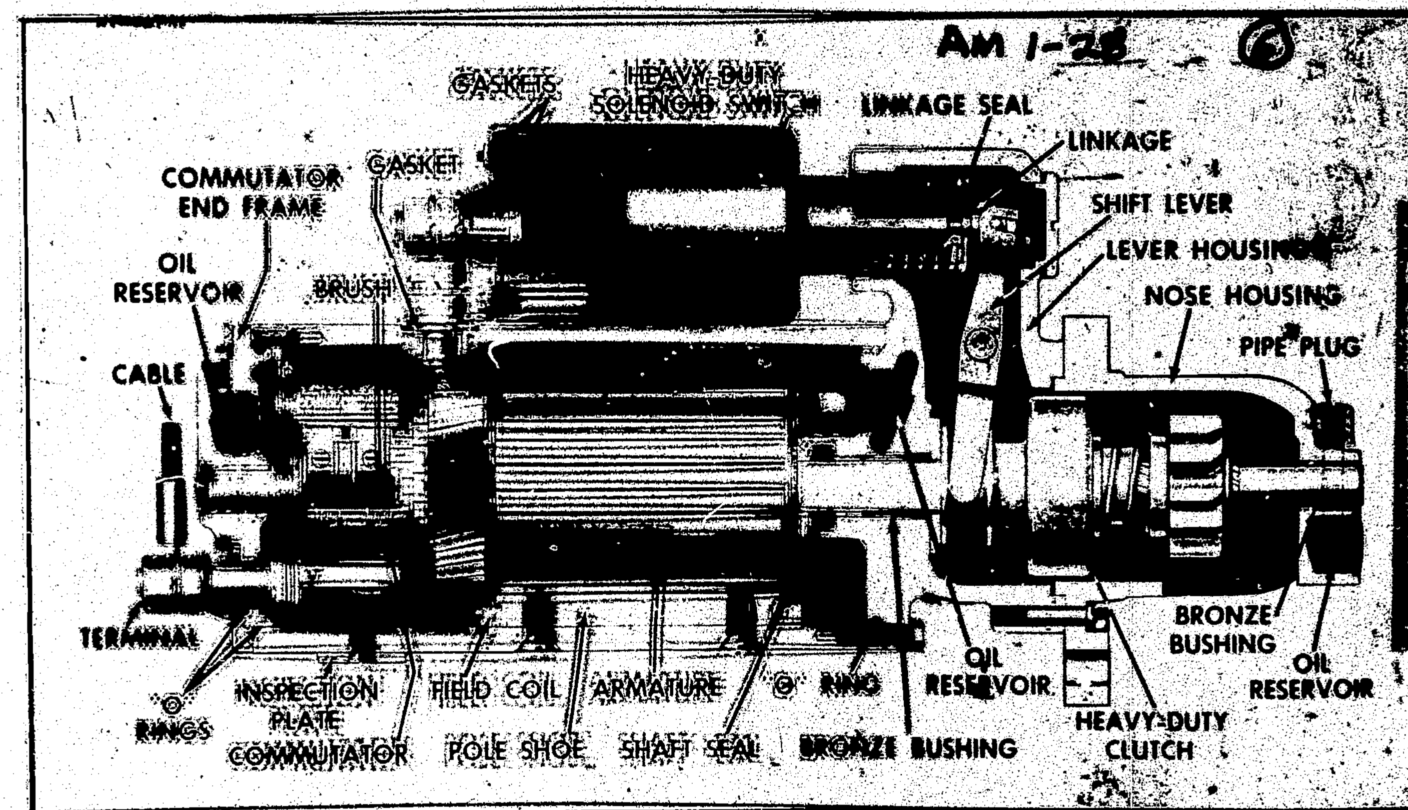


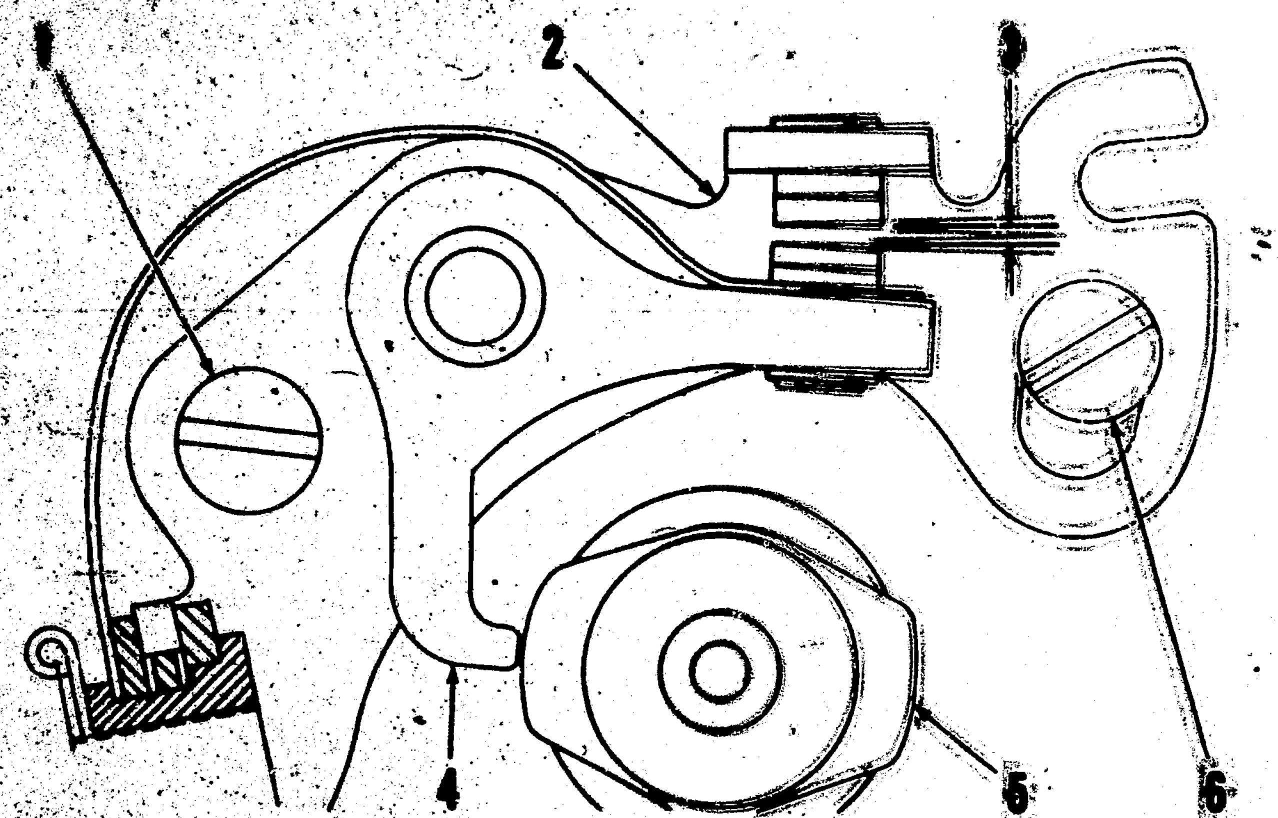
Fig. 11 Sprag clutch pinion travel.



– Cutaway View of Heavy Duty Sprag Clutch Cranking Motor

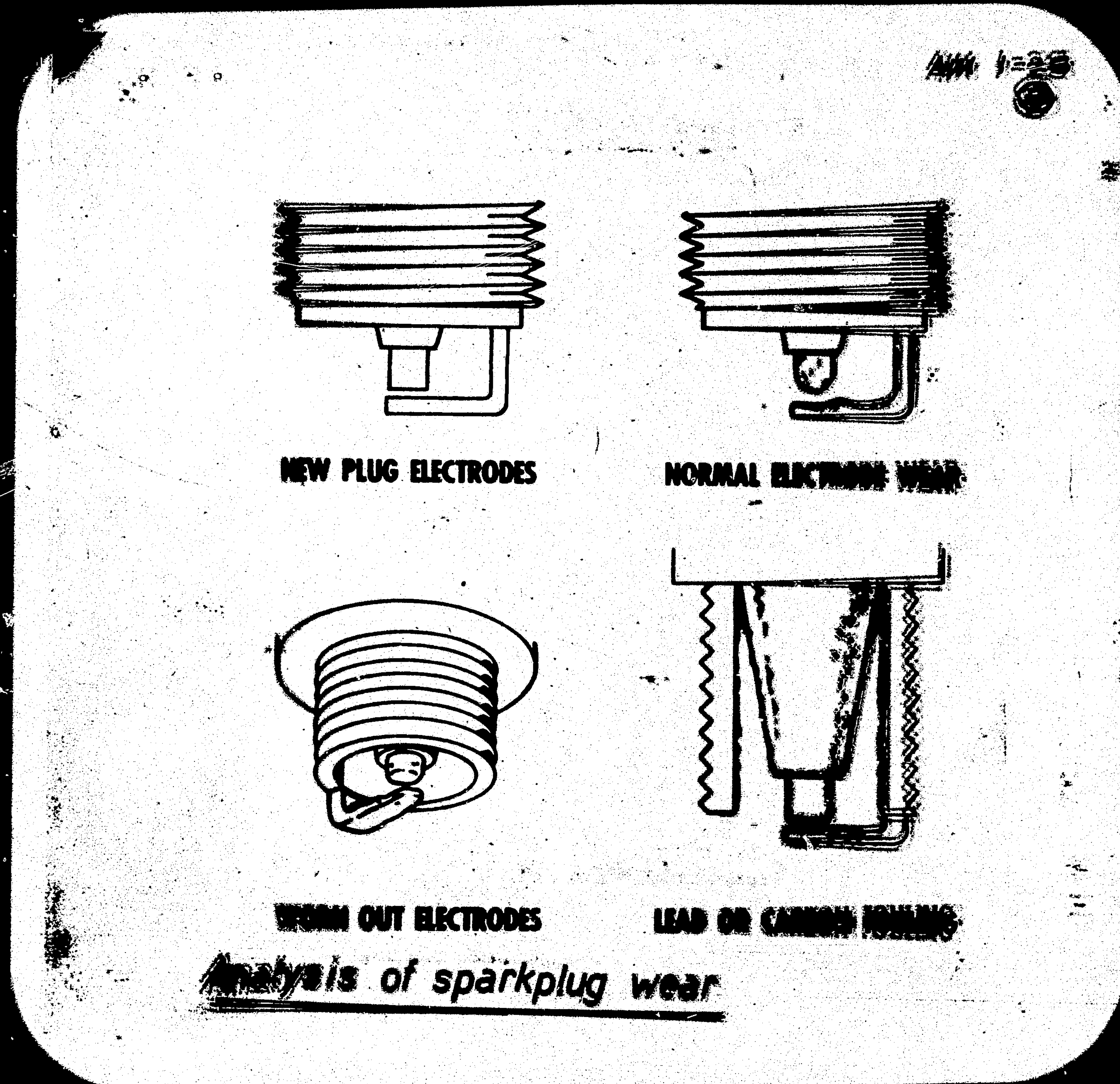
HUMAN
ENGINEERING
INSTITUTE

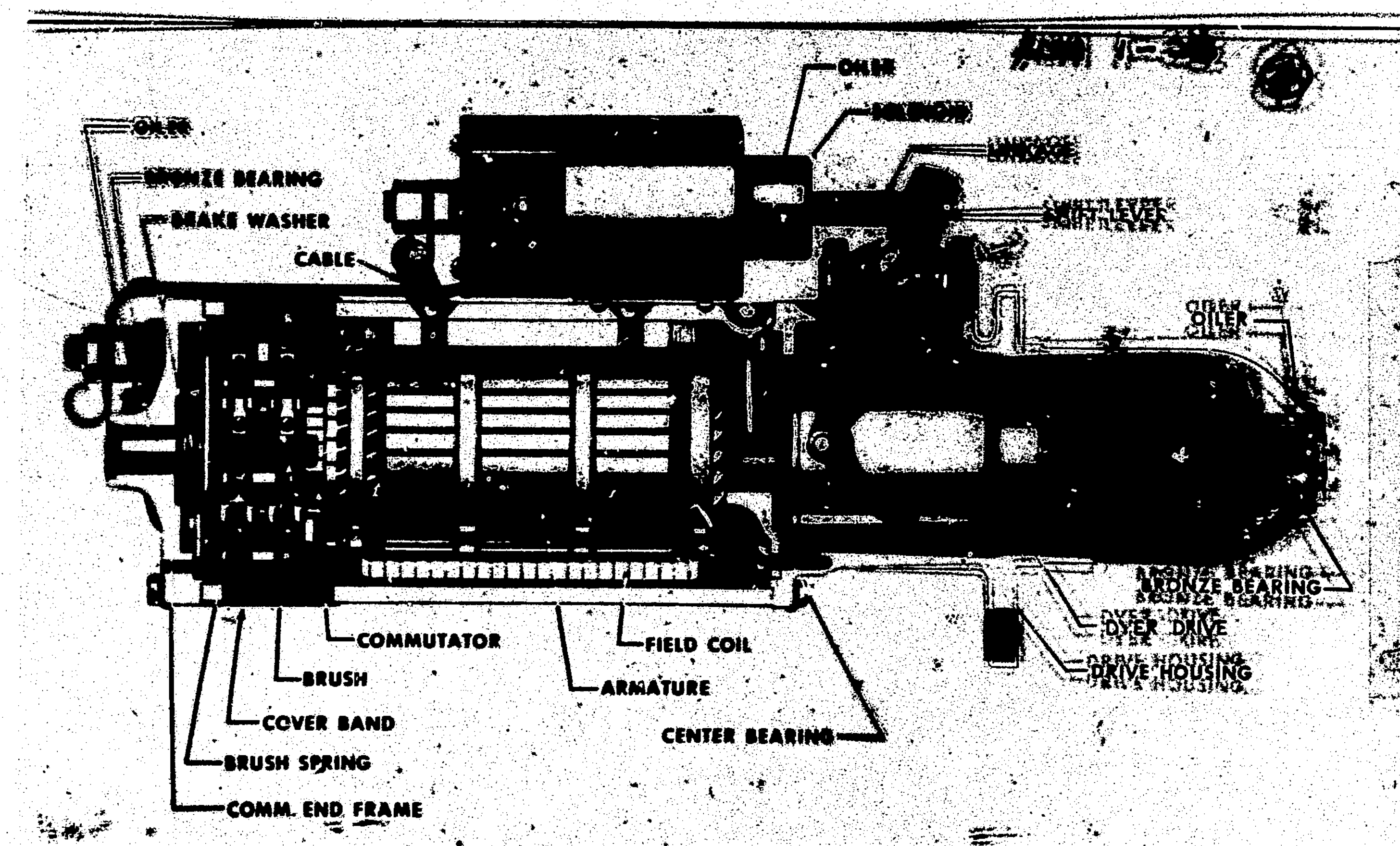
AM 1-28



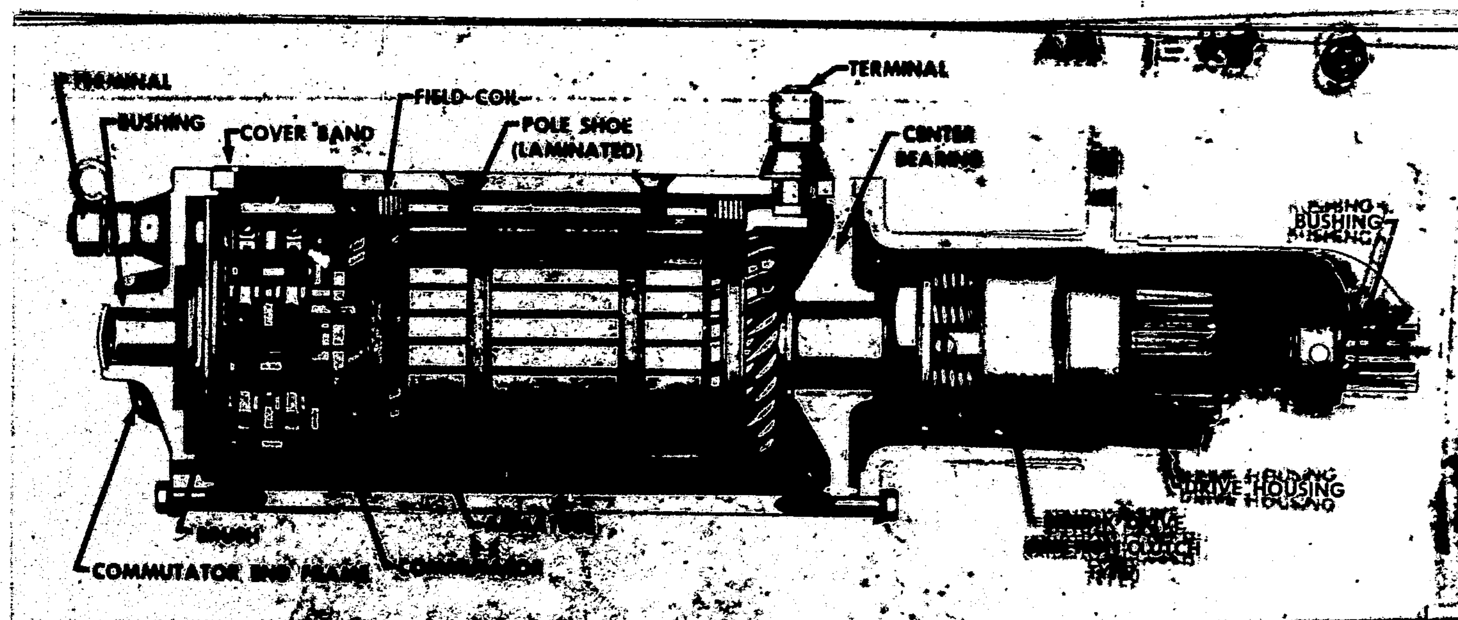
1–Screw. 2–Adjustable contact. 3–Contact gap. 4–Fiber pivot block. 5–Rotor cam. 6–Screw.

Contact assembly.


NEW PLUG ELECTRODES
NORMAL
OUT ELECTRODES
of sparkplug wear



Cutaway View of Dyer Drive Cranking Motor



Cutaway View of Bendix Drive Cranking Motor

INSTRUCTOR'S GUIDE

Title of Unit: I - Caterpillar Starting (Poney) Engine (Part II) AM 1-28
II - Understanding More About Starting Devices 10/5/66

OBJECTIVES:

1. To discuss more in detail the components of the Caterpillar starting engine.
2. To present some basic electrical concepts to the student.
3. To discuss starting devices used other than a poney engine. This was covered briefly in a prior unit but this unit covers more of the electrical aspects involved with starting devices.

LEARNING AIDS suggested:

Vu-Graph Cells:

AM 1-28 (1) (Magneto Schematic)
(2) (Contact Assembly)
(3) (Analysis of Spark Plug Wear)
(4) (Cutaway View of a Dyer Drive Cranking Motor)
(5) (Cutaway View of a Bendix Drive Cranking Motor)
(6) (Cutaway View of a Heavy Duty Sprag Clutch Cranking Motor)

MODELS:

Any components of starting devices that can easily be brought into class will be helpful for demonstration and explanation.

FILM STRIP:

NOTE to Instructor: The following film strip probably is available from your nearest Caterpillar distributor:
Film number - 363B (Alternator Charging System)
Caterpillar Tractor Co. - Peoria, Ill.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. Why is an alternating current generator required for the operation of the Cat Starting engine?
2. What is the purpose of the contact breaker on the magneto?
3. What is the purpose of the condenser?

4. Why is it necessary for the spark plug to withstand extreme pressures and temperatures?
5. What is the effect of insufficient spark plug gap?
6. What is the effect of too much spark plug gap?
7. Why is it important to torque spark plugs when installing them?
8. What are the motor drive checks described for the three different types discussed in this Unit?