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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT XIX, LEARNING ABOUT CRANKING MOTORS.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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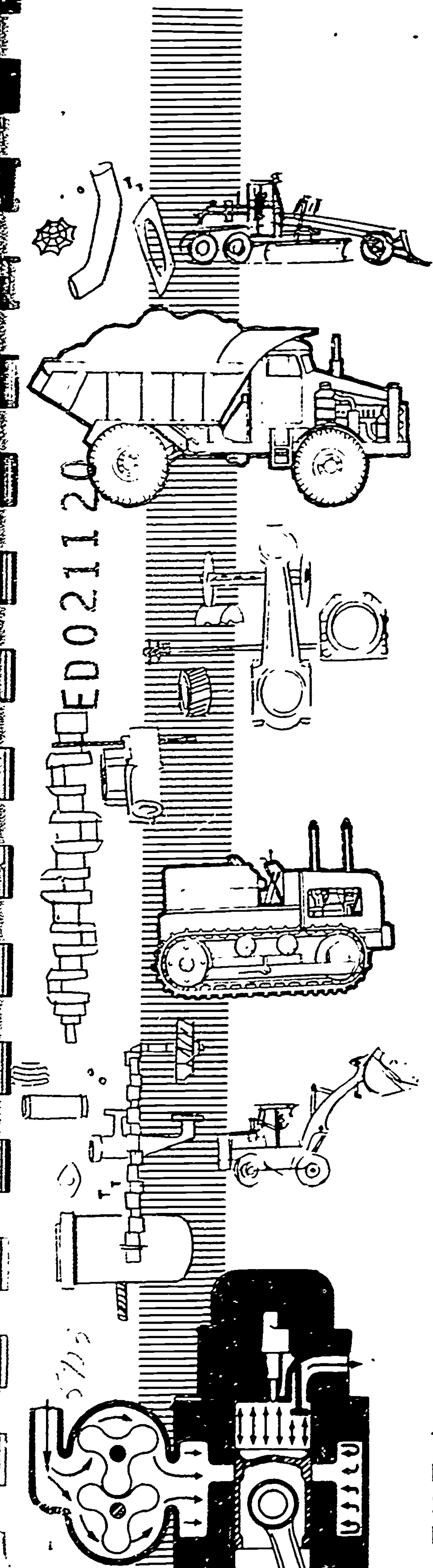
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATING PRINCIPLES OF CRANKING MOTORS USED ON DIESEL POWERED EQUIPMENT. TOPICS ARE (1) CRANKING MOTORS, (2) MOTOR PINCIPLES, (3) CRANKING MOTOR CIRCUITS, (4) TYPES OF CRANKING MOTOR DRIVES, AND (5) CRANKING MOTOR SOLENOID CIRCUITS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "LEARNING ABOUT CRANKING MOTORS" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, 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)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL MAINTENANCE 2

LEARNING ABOUT CRANKING MOTORS

UNIT XIX

SECTION A CRANKING MOTORS

SECTION B MOTOR PRINCIPLES

SECTION C CRANKING MOTOR CIRCUITS

SECTION D TYPES OF CRANKING MOTOR DRIVES

SECTION E CRANKING MOTOR SOLENOID CIRCUITS

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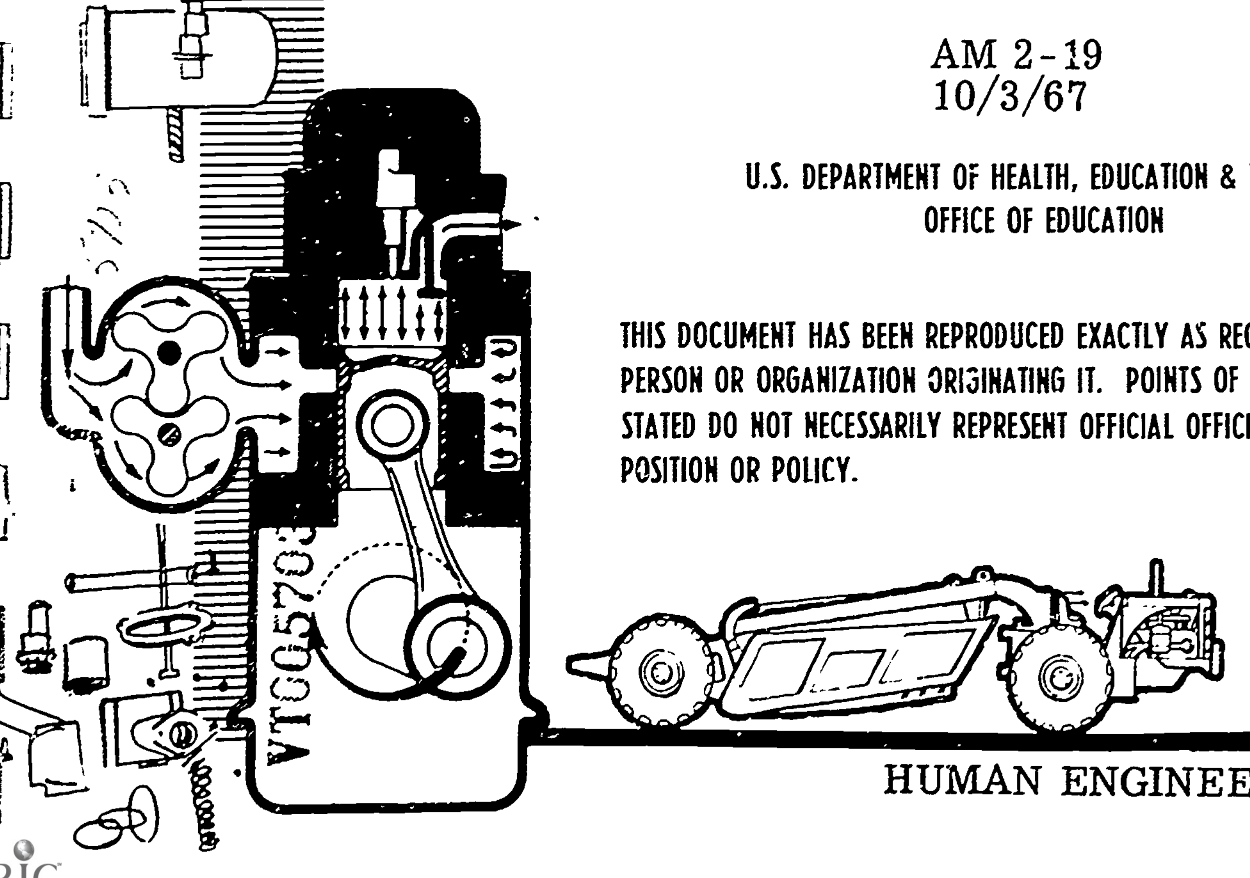


HUMAN ENGINEERING INSTITUTE

SECTION A -- CRANKING MOTORS

All cranking motors consist basically of the drive mechanism, frame, field windings, armature and brushes. The armature is supported by bearings to permit it to rotate freely. All current that passes through the field coils also travels through the armature. One type of cranking motor is known as a SERIES wound motor and is capable of developing great torque (twisting force).

On cranking motors where high voltage is required, auxiliary shunt-connected coils are added to the circuit to slow down the top free-running speed which would otherwise be destructive to the motor. As current enters the motor, it passes through the field windings, creating a magnetic field. Then it travels into the brushes, which ride on the commutator, and through the armature windings, thus creating a second magnetic field. The two strong magnetic fields oppose each other in such a way that the armature is forced to rotate.

Some types of cranking motors incorporate a magnetically-operated switch which closes and opens the circuit between the battery and the cranking motor. Other motors, designed with an overrunning clutch or a Dyer drive, have a solenoid type magnetic switch which not only closes the circuit between the battery and cranking motor (causing the armature to rotate), but also shifts the cranking motor pinion into mesh with the teeth on the flywheel ring gear of the engine. When the pinion drive becomes engaged with the teeth of the ring gear, cranking of the engine takes place.

Some cranking circuits have a RELAY in conjunction with the solenoid switch. The relay type solenoid requires less current to operate in the control circuit, thus allowing the use of lighter switches and smaller wire. It is actuated, when connected to the battery, by closing the cranking motor control circuit. Energizing the relay winding closes the relay contact points and connects the solenoid directly to the battery. This causes the solenoid to operate, shifting the drive pinion into mesh and closing the cranking motor circuit.

The cranking motor is a special type of electric motor, designed to operate under great overload and to produce high horsepower for its size. It can do this, however, only for short periods of time, since the high current used creates considerable heat. If the cranking motor operation is continued for any length of time, the accumulated heat will cause serious damage. For this reason, the cranking motor must NEVER be used for more than THIRTY SECONDS AT ANY ONE TIME, and cranking should not be repeated without a pause of at least two minutes to permit the heat to escape.

The DRIVE MECHANISM is a vital part of the cranking motor, since it is through the drive that power is transmitted to the engine, cranking it as the cranking motor armature rotates. The drive mechanism has two functions. First, it transmits the cranking torque (twisting force) to the engine flywheel when the cranking motor is operated, and disconnects the cranking motor from the flywheel ring gear after the engine has been started. Secondly, it provides a gear reduction between the cranking motor and the engine so there will be sufficient torque to turn the engine over at cranking speed.

There are approximately 15 to 20 teeth on the flywheel for every tooth on the drive pinion, which means the cranking motor armature will rotate approximately 15 to 20 times for every engine revolution. Thus, to turn the engine over at 100 rpm, the cranking motor armature must rotate at 1500 to 2000 rpm. If the cranking motor drive pinion remains in mesh with the flywheel ring gear at engine speeds above 1000 rpm, and if the pinion transmits its rotation to the cranking motor armature, the armature will be spun at very high speeds. Such speeds will cause the armature windings to be thrown from the armature slots, and the segments will be thrown from the commutator. To avoid such a condition, the cranking motor drive must disengage the pinion from the flywheel ring gear as soon as the engine begins to operate.

Several types of drive mechanisms have been developed for use with cranking motors. Each provides a means of engaging the drive pinion with the engine flywheel for cranking, and for disengaging the drive pinion from the flywheel ring gear when the engine starts.

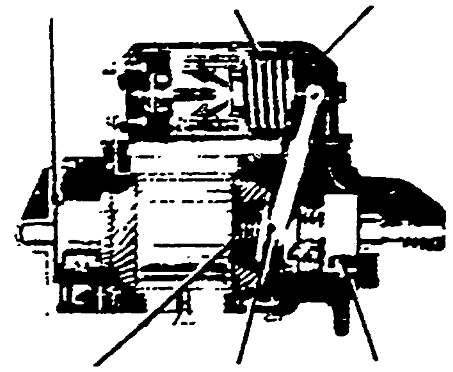


Fig. 1 Enclosed shift lever

Many cranking motors are now located under the engine, where they are subject to road splash, slush and mud. To prevent the entrance of moisture and other foreign material detrimental to the operation of electrical equipment, the enclosed shift lever type was produced. See Figure 1. The drive housing is extended to enclose the entire shift lever mechanism and the solenoid plunger, and protects them from icing and freezing.

SECTION B -- MOTOR PRINCIPLES

Magnetically, the cranking motor is made up of two parts, the ARMATURE and the FIELD WINDING ASSEMBLY. The armature contains a number of low resistance CONDUCTORS placed in the insulated slots of a laminated soft iron core which is assembled onto an armature shaft. The COMMUTATOR is made up of a number of copper segments assembled together and insulated from each other and from the armature shaft. The conductors are connected to each other and to the commutator in such a way that current flows through all of the armature conductors when brushes are placed on the commutator and a source of current is connected to the brushes. This creates magnetic fields around each conductor. Current also flows through the field windings, creating a powerful magnetic field.

Illustrated in Figure 2 is the relationship between the magnetic field of a permanent magnet, the field of a single conductor through which current flows, and the direction of the resulting force exerted on the conductor. Magnetic lines of force pass from the north to the south pole, as indicated by the arrows. The flow of current through the conductor is in the direction shown.

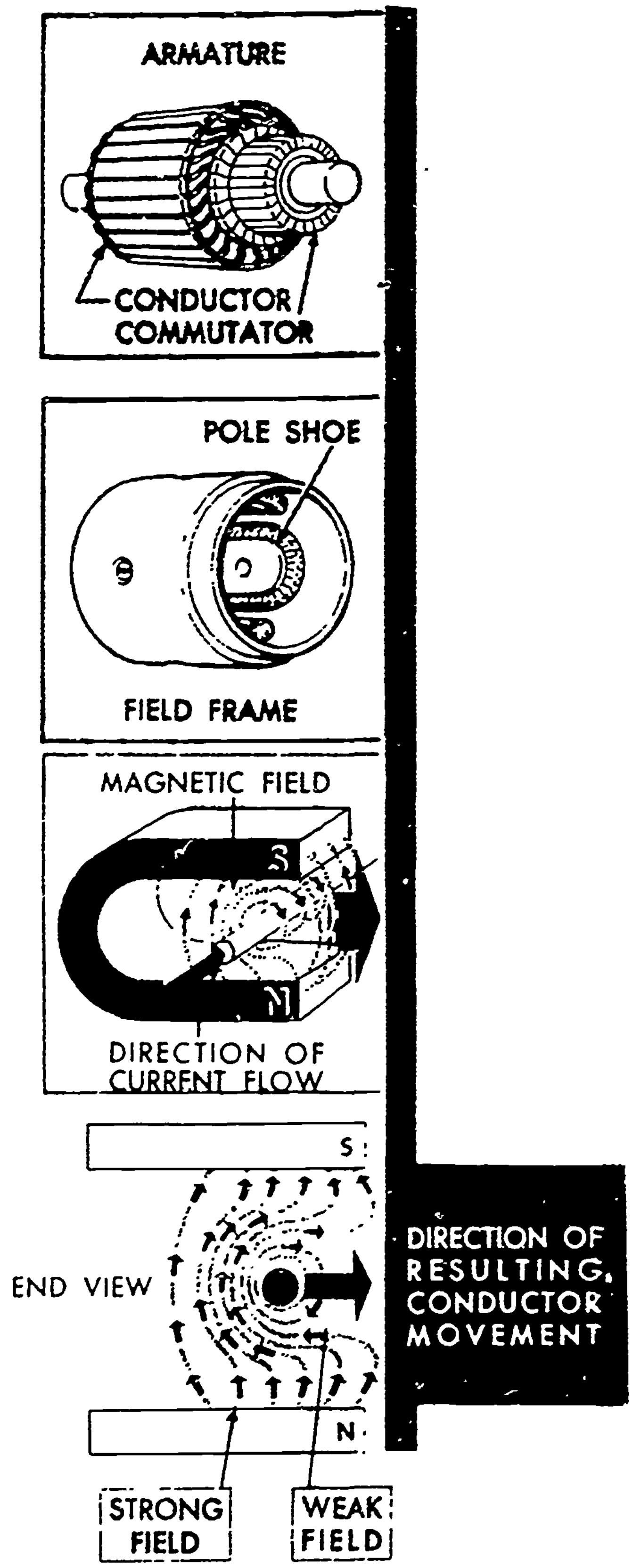


Fig. 2 Motor principles

Using the right hand rule for determining the direction of lines of force around a straight conductor, it can be seen that when the direction of current through the conductor is as shown in Figure 2, (away from the viewer), the magnetic lines of force around the conductor will be in a clockwise direction indicated by the circular arrows around the conductor). Looking at the end of the conductor, it will be noted that to the right of the conductor, the magnetic field from the permanent magnet and the circular magnetic field around the conductor oppose each other. To the left of the conductor, they are in the same direction and the field is strengthened.

When a current-carrying conductor is located in a magnetic field, the normal field of force is distorted, creating a strong field on one side of the conductor and a weak field on the opposite side. The conductor will be forced to move in the direction of the weak field. In this instance, therefore, it will be pushed to the right. The more current flowing through the conductor, the stronger the force exerted on it will be.

Application of this principle is illustrated in Figure 3, showing a simple electric motor with a one-turn armature. The magnetic field is created by current flowing through the field coil windings which are assembled around the two poles. Using the right hand rule for coils, you can see that the direction of the current tends to increase the magnetic field between the two poles. The U-shaped armature winding placed between the two poles is connected to a two segment commutator.

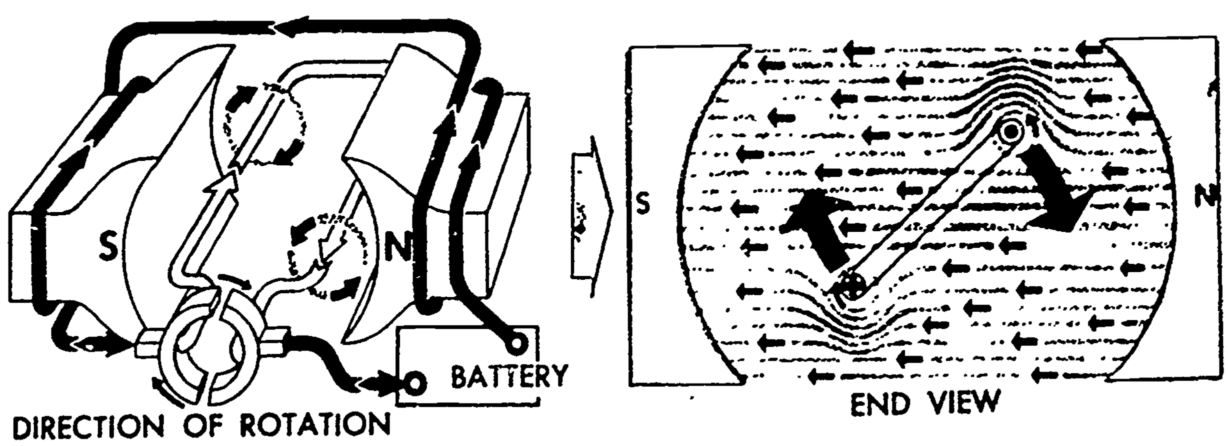


Fig. 3 Motor principles

In the position shown in Figure 3, current from the battery first flows into, and around, the right hand field coil. It then crosses over to the left hand field coil and flows through it, coming out through the brush of the left hand commutator segment. From this commutator segment, the current enters the armature winding at the side nearest the south pole, flows through the winding, and leaves the right hand commutator at the side nearest the north pole.

From the right hand segment, the current returns to the battery through the right hand brush. The magnetic fields around the conductor will be in the directions shown by the circular arrows. The left hand side of the armature winding will be pushed upward while the right hand side will be pushed downward, causing clockwise rotation.

Since the armature winding and commutator are assembled together, movement of the winding causes the commutator to turn also. By the time the left hand side of the winding has swung around toward the north pole, the commutator segments will have reversed their connections with respect to the brushes. Current will then flow through the winding in a direction opposite that shown in Figure 3; but since the winding has turned 180 degrees, the force exerted on it still will tend to rotate it in a clockwise direction.

The static neutral point is always halfway between the pole shoes. It is the point where the direction of current must be changed to maintain a turning force in the same direction. This is true whether the motor has two, four or six poles. However, when current flows through the armature windings and creates another magnetic field, the normal field between the pole shoes is distorted. Since lines of force may be assumed not to cross each other, the neutral point is therefore shifted.

Motor brushes usually are located back of the static neutral point (against the direction of rotation) to prevent excessive arcing and to obtain more efficient operation. See Figure 4.

The type motor illustrated in Figure 3 is what is known as a SERIES WOUND MOTOR. Armature windings and field coil windings are connected in series so that the current which flows through one winding will flow through the other. The current flowing through the field winding produces a powerful magnetic field between the poles. In the complete assembly, the field frame into which the pole pieces are assembled forms the return magnetic circuit for the magnetic lines of force. See Figure 5.

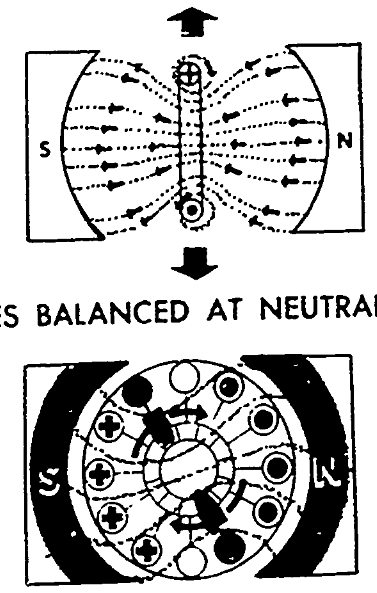


Fig. 4 Motor principles

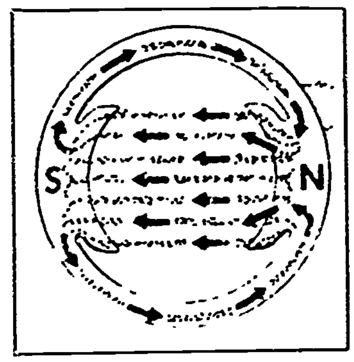


Fig. 5 Magnetic circuit

SECTION C -- CRANKING MOTOR CIRCUITS

In most cranking motors, the field windings and the armature are connected in such a way that all current entering the cranking motor passes through both the field windings and the armature. In other words, the field coils and the armature are connected in series. Most cranking motor conductors are made of heavy copper ribbons which have a very low resistance and thus permit a high current flow. The more current flowing, the higher the power developed by the cranking motor will be.

Some cranking motors have four pole shoes and are therefore called four pole units. Four pole units have only two field windings. This provides four pole action with only two field coils, thus keeping the resistance low. In Figure 6, notice the path of the current through the cranking motor. Following the right hand rule for coils, the poles with the field coil windings have a north polarity at the face of the pole shoes. Lines of force pass through the armature, enter the pole shoes without windings, pass through the frame, and then move back to the original pole shoe with windings to complete the magnetic circuit.

There are as many lines of force entering the south pole shoe as there are leaving the north pole, making the magnetic strength the same for both poles.

In all cranking motors, the adjacent pole shoes must be of opposite polarity. In a four pole unit, the sequence around the frame is north-south, north-south. A compass may be used at the pole faces to check this condition, making sure the field coils are properly connected before the unit is assembled. See Figure 7.

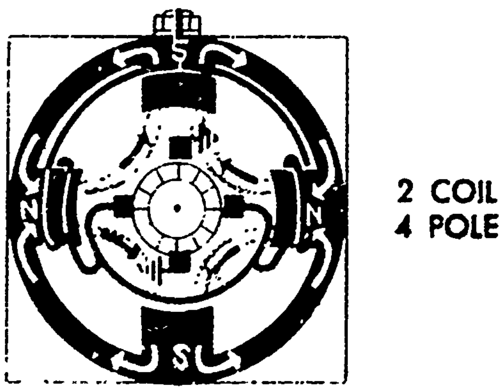


Fig. 6 Motor circuits

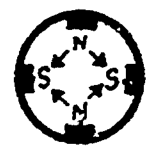


Fig. 7 Motor circuits

Some cranking motors have four poles, four field windings, and four brushes. Here, the field windings are paired off so that half the current flows through one set of field windings to one of the insulated brushes, while the other half of the current flows through the other set of field windings to the other insulated brush. With four field coil windings of low resistance, it is possible to create more ampere turns and stronger magnetic fields, thus producing cranking motors with greater torque or cranking ability. In Figure 8, by tracing the current flow from the terminal, you can see that the poles alternate south-north, south-north, providing four magnetic paths through the armature core.

On other types of cranking motors, all brushes are insulated. Half the brushes are connected to the cranking motor terminal and the other half are connected to one end of the field coils. (The opposite ends of the field coils are connected to ground in this type of circuit.) For applications where a completely insulated cranking motor is required, the two field leads are connected to a second insulated terminal in the field frame. Such motors are used with series-parallel circuits and with marine applications where ground returns are not available. A variation of this design has four field windings connected in series so that all current must flow through each field winding. See Figure 9.

Fig. 8 Motor circuits

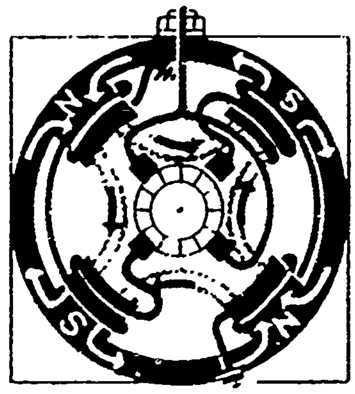


Fig. 9 Motor circuits

Another cranking motor designed for heavy duty service uses six poles and six brushes. Here the current is split in three ways, one third flowing through each pair of field windings to one of the insulated brushes. Increasing the number of circuits through the cranking motor helps to keep the resistance low so that a high current can flow and a high horsepower can be developed. See Figure 10.

As a rule, all the insulated brushes are connected together by means of jumper leads or bars, so that the voltage is equalized at all brushes. Without these equalizing bars, there may be conditions which would cause arcing and burning of commutator bars, eventually insulating the

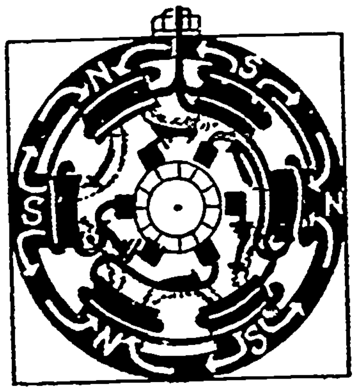


Fig. 10 Motor circuits

brush contact from the commutator surface, thereby preventing cranking. See Figure 11(a).

High voltage motors with a straight series circuit would reach an extremely high top free speed if not controlled. Even on some 12 volt, four pole motors, high free speed is a factor. Therefore, a SHUNT connected coil is used for the purpose of limiting the top free speed. Some motors use one or more shunt coils; see Figure 11(b).

The magnetic strength of the shunt coil remains constant and does not vary with speed. The speed of the armature, revolving through this strong magnetic field, creates a greater counter-voltage which limits the amount of current flow and, consequently, the top speed. During cranking of the engine the shunt coil, with many turns of comparatively small wire, creates a magnetic force similar to the force provided by each of the series coils. Normal cranking performance is therefore provided with less current draw and a safe top free speed. See Figure 11(c).

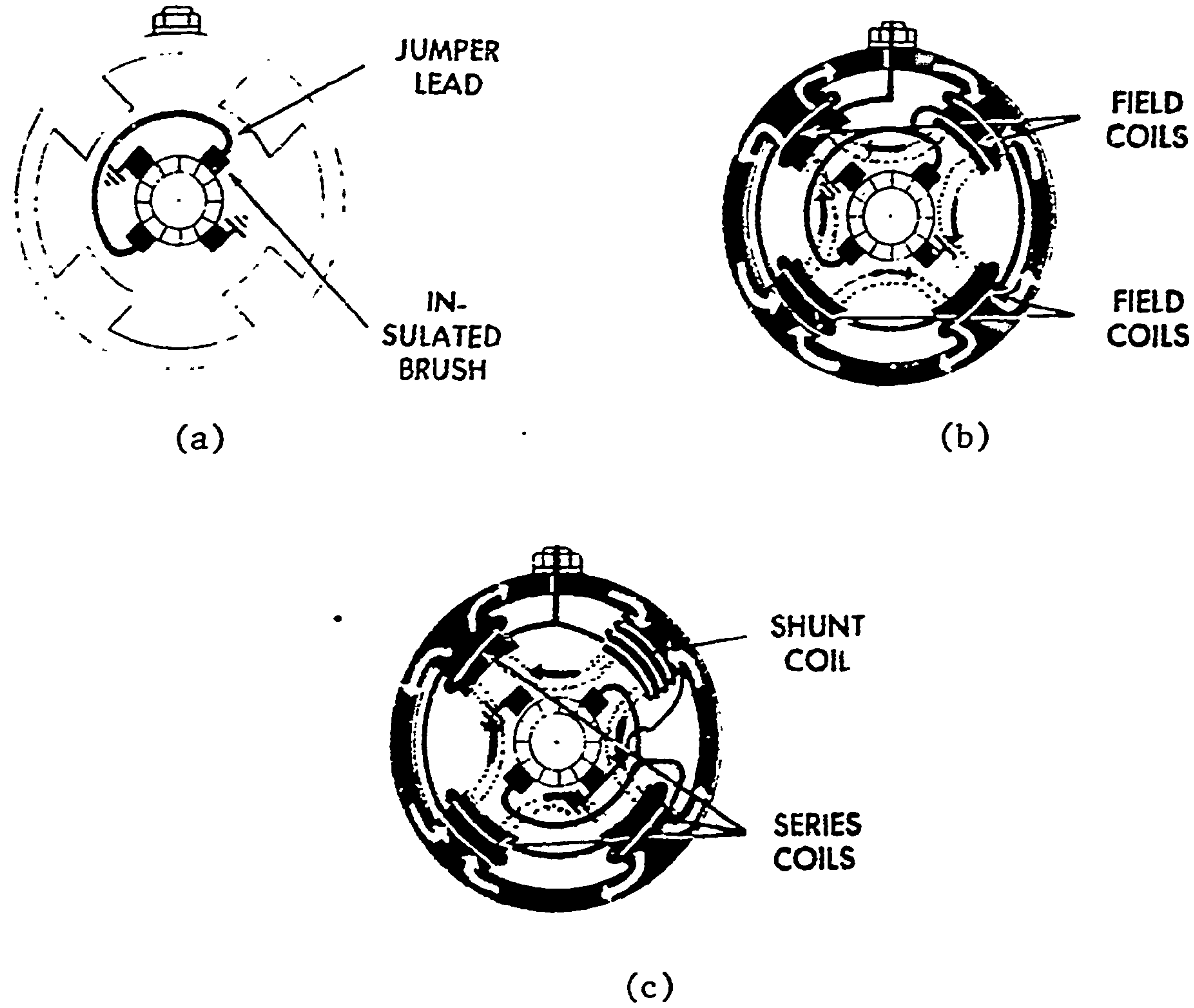


Fig. 11 Motor circuits

The pole shoes of most cranking motors have a longer tip on one side of the pole shoe. When installed, the long tip of the pole shoe should point in the direction of the armature rotation. In this position, a better magnetic field is obtained and an increase in performance will be noted. See Figure 12.

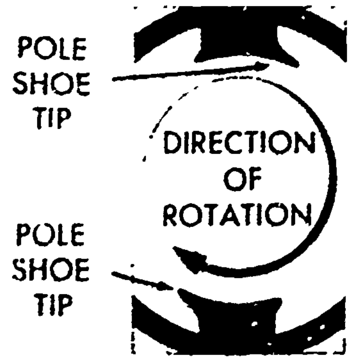


Fig. 12 Pole shoe details

SECTION D -- TYPES OF CRANKING MOTOR DRIVES

BENDIX DRIVES depend on inertia to provide meshing of the drive pinion with the engine flywheel ring gear. The Bendix drive consists of a drive pinion, sleeve, spring and spring fastening screws.

The drive pinion is normally unbalanced by a counterbalance on one side. It has screw threads on its inner bore.

The Bendix sleeve, which is hollow, has screw threads cut on its outer diameter which match the screw threads of the pinion. The sleeve fits loosely on the armature shaft, and is connected through the Bendix drive spring to the Bendix drive head, which is keyed to the armature shaft. Thus, the Bendix sleeve is free to turn on the armature shaft within the limits permitted by the flexing of the spring. Both inboard and outboard types of drives are available in right hand and left hand rotations.

The three stages of Bendix drive operation are:

1. When the cranking motor switch is closed, the armature begins to revolve. This rotation is transmitted through the drive head and the spring to the sleeve, so that all these parts pick up speed with the armature. The pinion, however, being loosely fitted on the sleeve screw thread, does not pick up speed along with the sleeve. In other words, the increased inertia of the drive pinion, due to the effect of the counterbalance, prevents it from rotating. The result is that the sleeve rotates within the pinion. This forces the drive pinion endwise along the armature shaft so that it goes into mesh with the flywheel teeth.

2. As soon as the pinion reaches the pinion stop, it begins to rotate along with the sleeve and armature. This rotation is transmitted to the flywheel. The Bendix spring takes up the shock of the meshing.

3. When the engine begins to operate, the pinion spins at a higher speed than the cranking motor armature. This causes the pinion to rotate relative to the sleeve, and the pinion is driven back, out of mesh with the flywheel teeth. Thus, the Bendix drive automatically meshes the pinion with the teeth of the flywheel ring gear to provide cranking, and automatically de-meshes the pinion from the flywheel ring gear as soon as the engine begins to operate. See Figure 13.

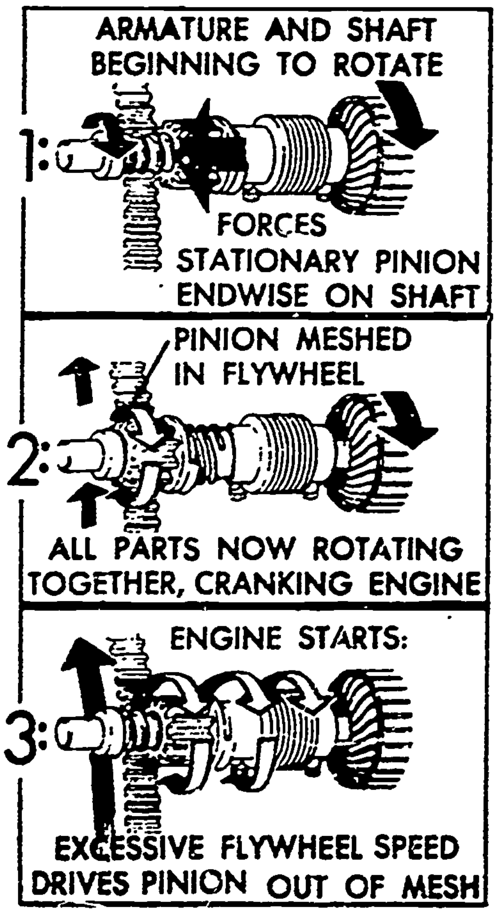


Fig. 13 Bendix drive operation

BARREL TYPE BENDIX DRIVES have the same function as the original Bendix drive, but the pinion and barrel assembly operate with a nut on the screw shaft. The pinion, operating directly on the armature shaft, allows the use of a smaller gear, which increases the cranking ratio and provides more torque (twisting force). See Figure 14.

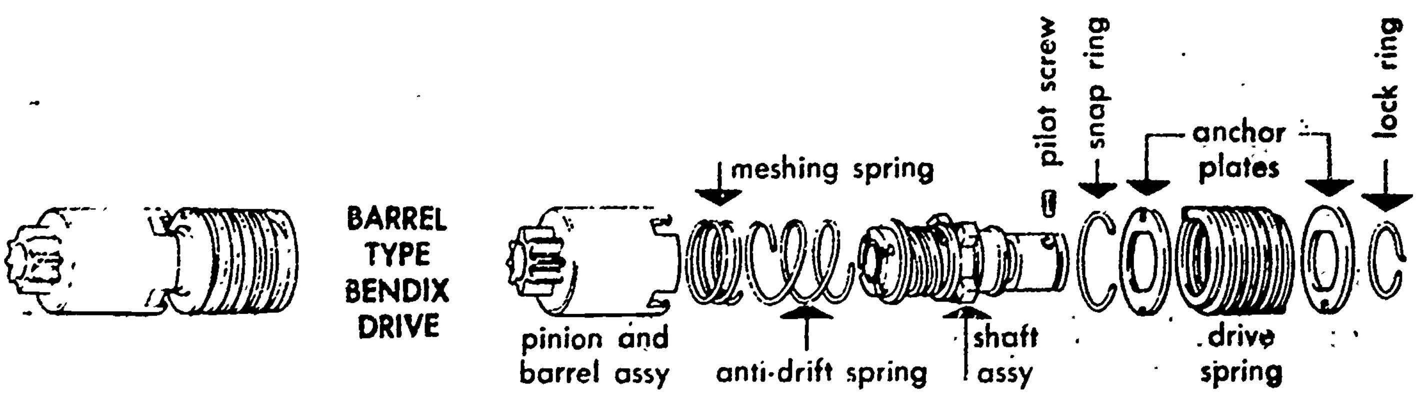
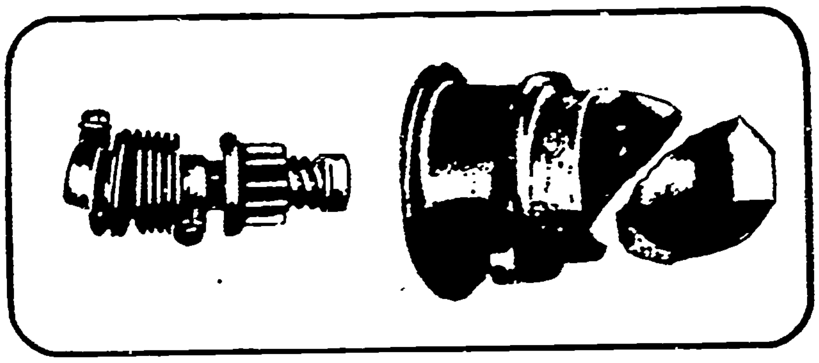


Fig. 14 Barrel type Bendix

Certain precautions must be taken when operating a Bendix type cranking motor. If the engine backfires when the pinion is in mesh with the engine flywheel ring gear, and the cranking motor is operating, a terrific stress is placed on the parts. The cranking motor and the ring gear try to spin the pinion, but in opposite directions. This meeting of opposing forces sometimes breaks or "wraps up" the Bendix spring. Engine ignition timing or diesel engine injector timing should be checked and corrected to overcome this condition. See Figure 15.



STARTING CAUTION

1. **PRESS** starter button firmly.
2. **DO NOT** re-press button until engine comes to **COMPLETE REST** (approx. 5 seconds) if not started on first attempt.

SERIOUS DAMAGE to cranking motor may result if above rules are not followed.

Fig. 15 Damaged Bendix

Damage also may occur when the engine starts, throws the Bendix drive pinion out of mesh with the engine flywheel teeth, and then stops. When the engine is coming to rest, it often rocks back, or rotates in the reverse direction for part of a revolution. If the operator attempts to re-engage the drive pinion at the instant the engine is rocking back, serious damage to the equipment will result. Like a backfire condition, it may break the drive housing or "wrap up" the Bendix spring. The operator should always be careful not to re-engage the cranking motor drive too soon after an incompleted start. It is advisable to wait at least five seconds between attempts to crank.

Burred teeth on the flywheel ring gear are an indication of an attempted engagement while the engine is running. Burred teeth should be relieved so that full engagement of the pinion will be possible. If the pinion does not make a full engagement and travel to the pinion stop, a screw-jack force is applied to the commutator end frame, and the commutator end frame may be broken.

Another Bendix drive, of the barrel type, is known as the "folo-thru". It has a detent pin which locks the drive in the cranking position and prevents disengagement on false starts. This pin is thrown out by centrifugal force when the engine starts and the pinion is disengaged. The screw shaft is in two pieces, connected by a Dentil Clutch, which acts as a safety factor to prevent overspeeding of the cranking motor armature. If the engine drives the pinion faster than the free speed of the armature, the pinion and barrel assembly will overrun the armature shaft.

Some heavy-duty cranking motors use a friction-clutch type Bendix drive. This type of drive functions in much the same manner as other Bendix drives. However, instead of a drive spring, it uses a series of spring-loaded clutch plates, which slip momentarily during engagement to relieve shock. See Figure 16.

OVERRUNNING CLUTCH TYPE DRIVE -- Positive meshing and demeshing of the drive pinion with the flywheel ring gear teeth is secured with the OVERRUNNING CLUTCH. The overrunning clutch uses a shift lever to actuate the drive pinion. The pinion, together with the overrunning clutch mechanism, is moved endwise along the armature shaft and into, or out of, mesh with the flywheel ring gear teeth.

The shift lever may be either manual, or operated by means of a solenoid. When the cranking cycle begins, the clutch assembly is forced along the armature shaft by the shift lever, so that the pinion meshes with the

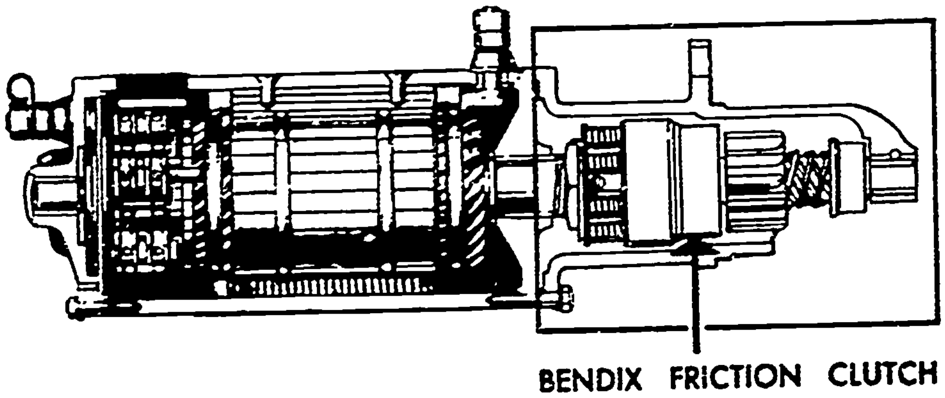


Fig. 16 Bendix friction clutch

flywheel ring gear teeth. After the pinion and flywheel teeth have made butt engagement, the pinion becomes spring loaded because the shift lever movement continues to compress the clutch spring. After the cranking motor switch is closed, and the armature begins to turn, the pinion rotates only the width of one-half of a tooth before alignment takes place, and the pinion drops into mesh.

The overrunning clutch transmits cranking torque from the cranking motor armature to the engine flywheel. It allows the drive pinion to rotate freely with respect to the remainder of the clutch assembly and the armature when the engine begins to operate. This feature prevents the armature from being driven at excessive speed by the engine. See Figure 17.

THE FOUR ROLL CLUTCH -- This overrunning clutch consists of a shell and sleeve assembly, which is splined internally to match splines on the armature shaft. Some units have straight splines while others are spiral splined. The pinion and collar assembly fits within the shell. Notches are cut in the shell and a hardened steel roller is assembled into each notch. The notches taper inward slightly, with adequate room for the rollers in this position (shown at the bottom of Figure 17).

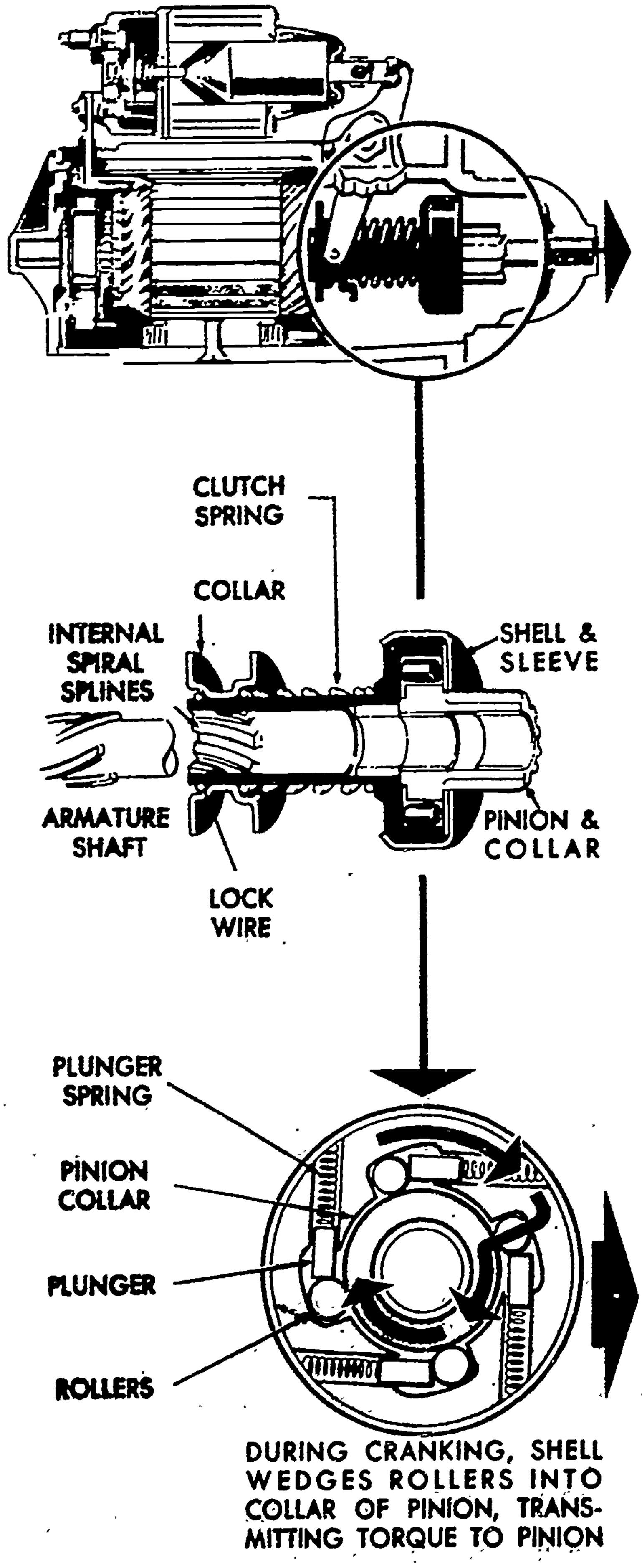


Fig. 17 Overrunning clutch

The pinion collar can rotate freely in the direction which tends to move the rollers against the springs. However, when the pinion is meshed with the flywheel ring gear teeth and the armature begins to rotate, the shell rotates in the cranking direction (clockwise, viewing the drive end at the bottom of Figure 17). The rollers tend to rotate between the shell and collar, and are forced tightly into the smaller part of the notches. When the rollers jam between the collar and the shell, they force the pinion to rotate with the shell. Torque is thus transmitted from the shell to the pinion, causing the engine to be cranked.

When the engine begins to operate, it tends to drive the pinion faster than the armature rotates. This action returns the rollers back to the position shown in Figure 18. The pinion, consequently, can rotate freely with respect to the shell.

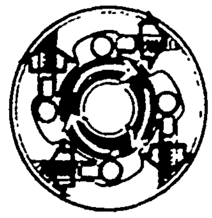


Fig. 18 Overrunning clutch

As soon as the engine begins to operate, the cranking motor pedal or switch should be released. Otherwise, the drive pinion remains in mesh and continues to overrun the armature. This overrunning clutch can withstand this condition for brief periods. However, if the overrunning effect is continued for too long a time, overheating occurs, melting the lubricant in the clutch. Ultimately, the clutch will seize, and then spin the armature at high speed.

A similar effect will result if the operator opens the throttle too wide during initial starting. Either condition puts an excessive strain on the overrunning clutch which may cause it to seize.

Both the armature and the clutch may be damaged by excessive overrunning. Evidences of such abuse are galling of the clutch bearings under the drive pinion and bluing, or deposits of bearing material, on the armature shaft from the heat developed.

The overrunning clutch must never be cleaned by any high temperature or grease-removing methods because this removes the lubricant originally packed in the clutch and causes rapid clutch failure. You should clean the clutch with a brush dipped in olium or other neutral spirits, or by some other acceptable and approved method.

On many solenoid switch operated cranking motors, the linkage between the shift lever and solenoid plunger must be adjusted so that there is clearance between the pinion and the housing, in the operating position. This clearance should be checked in accordance with recommended specifications, using battery current to hold the plunger in the bottomed position. Disconnect the solenoid-to-cranking motor lead, so that the motor will not operate. Close the solenoid circuit, and push the plunger in by hand. Battery current will hold the plunger in while the pinion clearance is checked. See Figure 19.

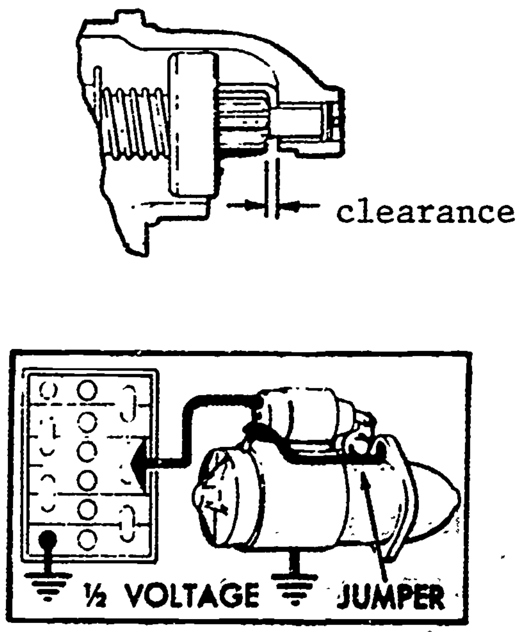


Fig. 19 Pinion clearance

EXTRUDED FRAME TYPE CRANKING MOTORS do not permit the solenoid and motor terminals to be disconnected from each other. To check these units for pinion clearance, a heavy jumper lead is connected between the motor terminal and motor ground, and one-half of the system voltage is applied to the solenoid to prevent rotation of the armature. See Figure 19.

Clutch shells of smaller diameter were introduced with the enclosed shift lever motors. Mechanical strength is maintained in the smaller unit by using accordion type roller springs, instead of the coil spring and plunger construction. See Figure 20.

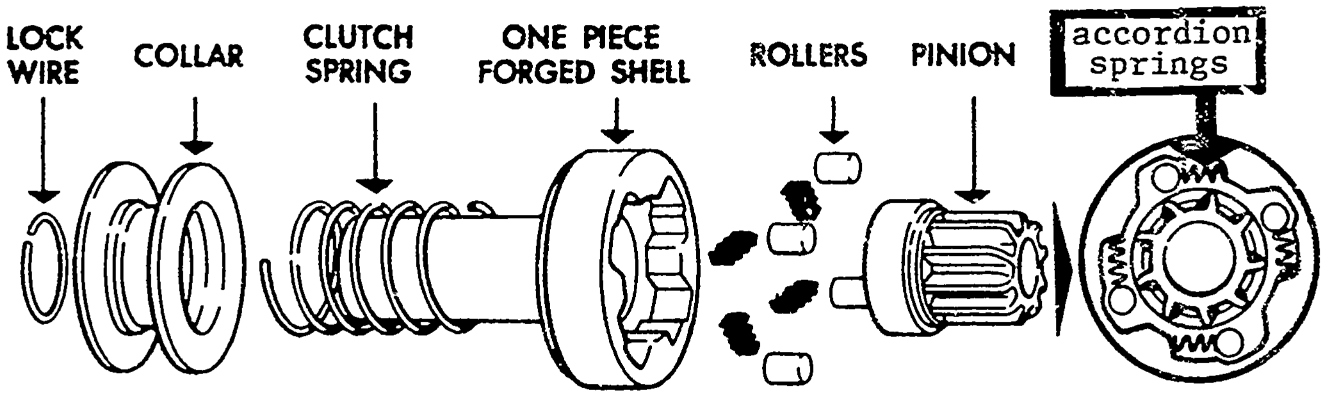


Fig. 20 Overrunning clutch

SIX ROLL CLUTCH -- A larger SIX ROLL CLUTCH was designed for more powerful cranking motors and, with a few exceptions, functions the same as the four roll clutch. An involute spline is used on the armature shaft to provide many driving teeth for heavier cranking loads. The drive pinion is a separate part, mounted on the spline shaft and collar assembly, with the clutch spring located between the clutch shell and the pinion. See Figure 21. On butt tooth engagement, the clutch spring is compressed and only the light weight of the pinion has to be moved forward when alignment takes place. This is a big advantage where higher voltages are used.

SPRAG CLUTCH -- A heavy duty SPRAG CLUTCH has been designed to replace the heavy duty six roll clutch and in some applications which use the Dyer and Bendix clutch type drives. The sprag clutch pinion operates on a spiral splined sleeve, making it possible to mesh with the flywheel ring gear more frequently even with butt tooth engagements. See Figure 22. Many small sprags replace the rolls of four role and six role clutches.

The sprags distribute the load or stress around the points on a shell of uniform cross-section. Much higher cranking loads can be carried with this construction. See Figure 23.

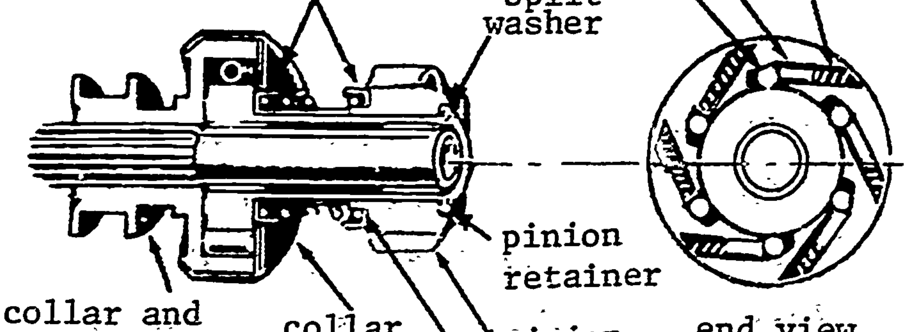


Fig. 21 Six roll clutch unit

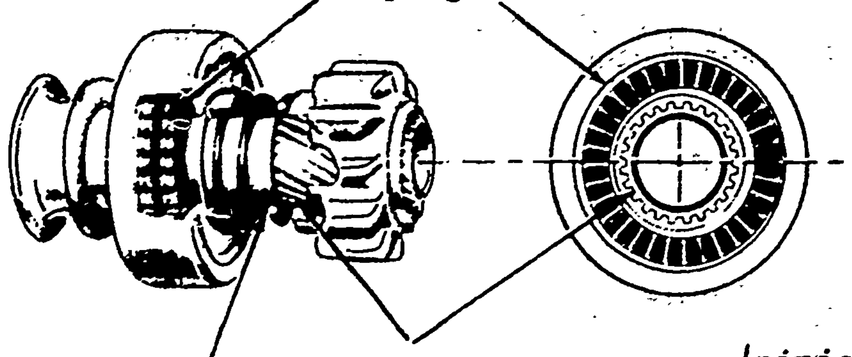


Fig. 22 Sprag clutch unit

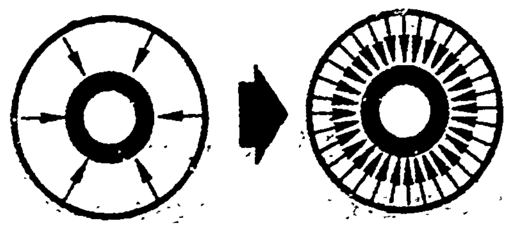


Fig. 23 Sprag clutch

DYER SHIFT DRIVE -- The Dyer drive is a special type of drive mechanism that provides positive meshing of the drive pinion with the flywheel before the cranking motor switch is closed and before the armature begins to rotate. This action eliminates both the clashing of pinion teeth with flywheel teeth, and the possibility of broken or burred teeth on either the engine flywheel or the drive pinion.

The Dyer drive is used on heavy duty applications where it is important that the pinion be engaged before rotation begins. Engaging the pinion while in motion would be impossible, because of the high horsepower developed and the acceleration of the armature when the cranking circuit is completed.

The Dyer drive mechanism consists of thrust washers, a shift sleeve, pinion guide, pinion spring, pinion, pinion stop and cotter pin. The pinion guide is a snug fit in the spiral splines of the armature shaft, while the pinion (which has internal splines matching the armature splines) fits loosely on the armature shaft splines. See Figure 24.

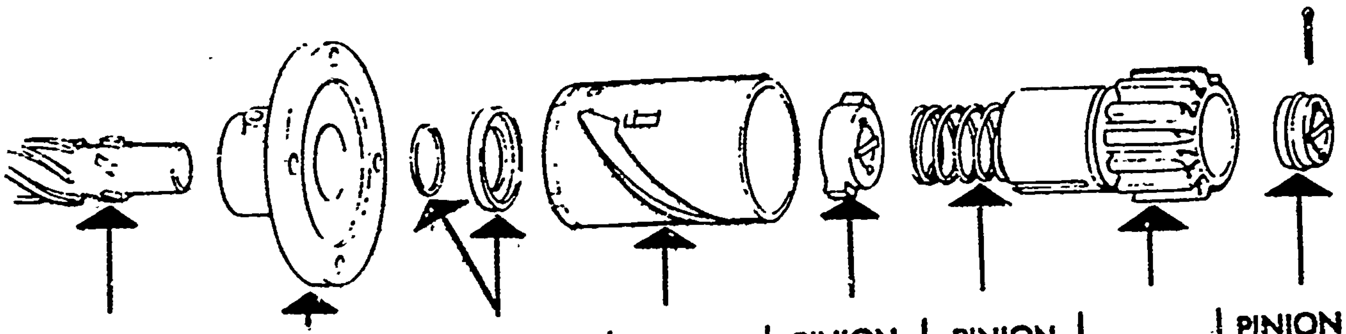


Fig. 24 Dyer drive

In the position shown in Figure 25, the drive assembly is at rest. The drive pinion is retained in this position by the pinion guide, which drops into milled slots (or notches) in the armature shaft splines. The pinion can be released from this position only by movement of the pinion guide, through operation of the shift lever .

DYER DRIVE OPERATION -- Movement of the shift lever causes the shift sleeve, the pinion guide, the pinion spring and the pinion to be moved endwise along the armature shaft so that the pinion meshes with the flywheel teeth, (provided the teeth align properly). Further movement of the shift lever closes the cranking motor switch, and cranking takes place. If the teeth are not aligned and meshing cannot take place at once, the pinion is rotated against the flywheel teeth until alignment occurs and meshing is accomplished. The pinion rotates because it is a loose fit on the armature shaft splines, while the pinion guide is a tight fit. The continued forward movement of the pinion guide causes it to rotate as it follows the spiral splines of the shaft. This rotation is transmitted, by means of two lugs on the pinion guide, to the pinion. The pinion rotates without any forward movement until alignment of the teeth takes place, then it is thrust forward into mesh.

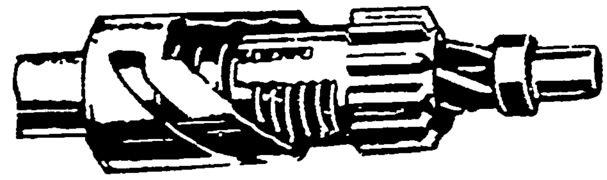


Fig. 25 Dyer drive at rest

The three stages of Dyer drive operation are as follows:

1. The pinion stop limits forward movement of the pinion. As the shift lever completes its travel, it closes the cranking motor switch which is linked mechanically with the shift lever. See Figure 26(a).

2. The motor armature then begins to rotate. The shift sleeve is carried back to its original position, rotating back out of the way. The instant the engine begins to operate, it attempts to drive the pinion faster than the armature is turning, with the result that the pinion and pinion guide are spun back out of mesh with the flywheel teeth.

3. The pinion guide drops into the milled section of the shaft splines, locking the pinion in the out-of-mesh position; see Figure 26(b) and (c).

It is impossible to start another cranking cycle without completely releasing the shift lever. The lever must drop all the way back to the at-rest position. With pedal operated shift levers, it takes a few seconds to perform this operation. Solenoid operated shift levers return to the starting position faster. On any automatic disengaging type of cranking motor drive, it is always good policy to wait five seconds after

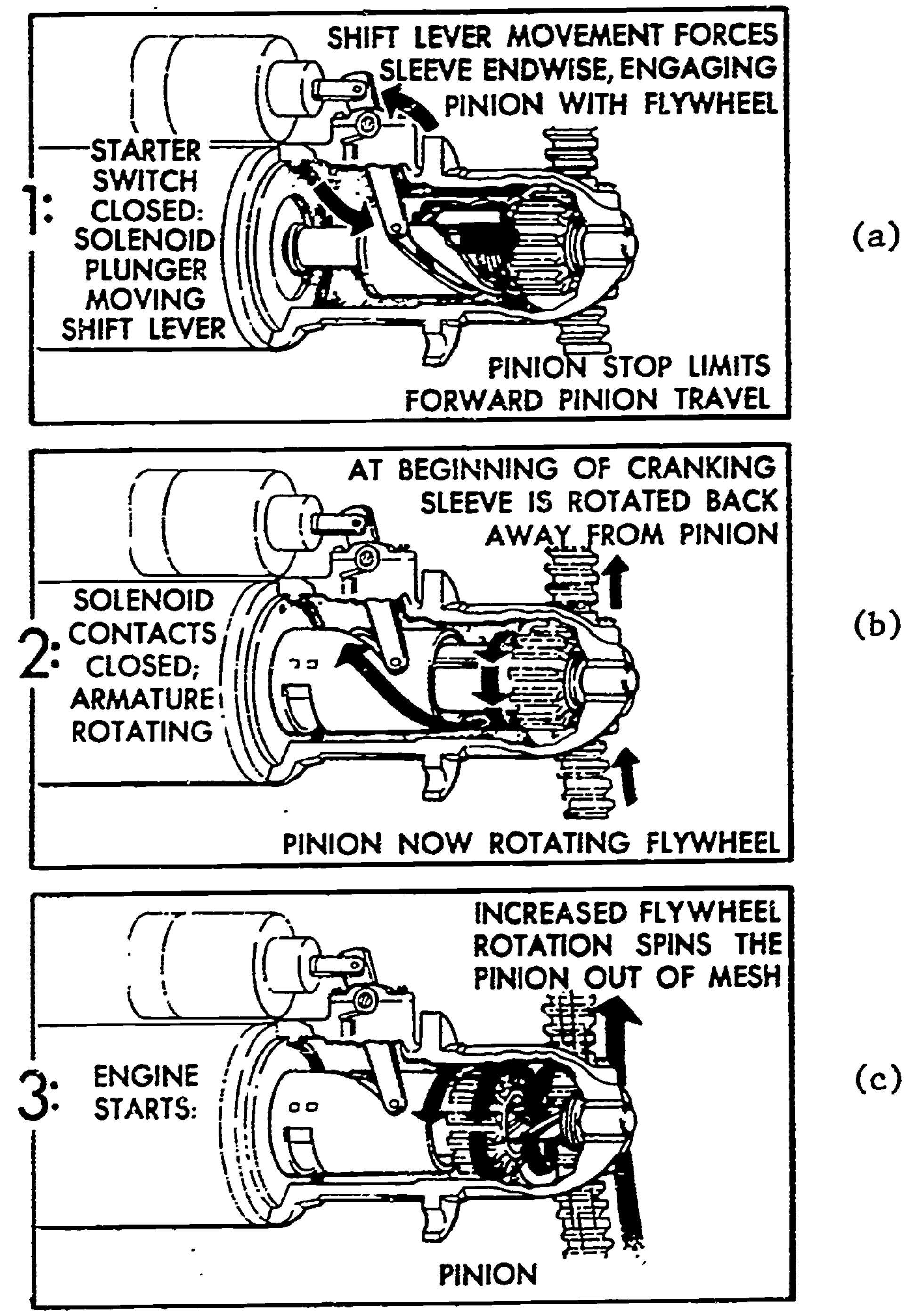


Fig. 26 Dyer drive operation

a false start, before attempting another start. During this time, the engine will be at complete rest. Then, when the cranking motor shift lever is again operated, it picks up the shift sleeve and moves it (shift sleeve), the pinion guide, the spring, and the pinion along the shaft into the meshing position.

On solenoid operated cranking motors, the solenoid should never be replaced without checking the free travel of the pinion when it is in the cranking position. This usually means that the cranking motor must be removed from the engine for this service operation.

Loose solenoid mounting screws or worn linkage parts will also change the amount of free travel, and cause improper engagement. This adjustment can be checked easily on the solenoid controlled types by disconnecting the lead from the solenoid to the cranking motor, and using the battery current through the solenoid to hold the shift lever in the forward position.

Since disconnecting the motor lead opens the pull-in coil of the solenoid, it will be necessary to assist the movement of the plunger by hand. Make sure the plunger reaches its extreme travel position, and closes the switch contacts. The cranking motor armature will not revolve when the motor lead is disconnected.

The pinion travel can be checked by pushing the pinion back against the spring pressure with a scale (steel rule) and measuring the relative movement between the pinion and the casting. See Figure 27. When the shift lever is in the extreme forward (engaged) position, and the switch contacts in the solenoid are closed, there should be at least from 3/16 to 1/4 inch of travel by the pinion against the pinion spring pressure, in the out-of-mesh direction. It is very important that this adjustment be maintained in service.

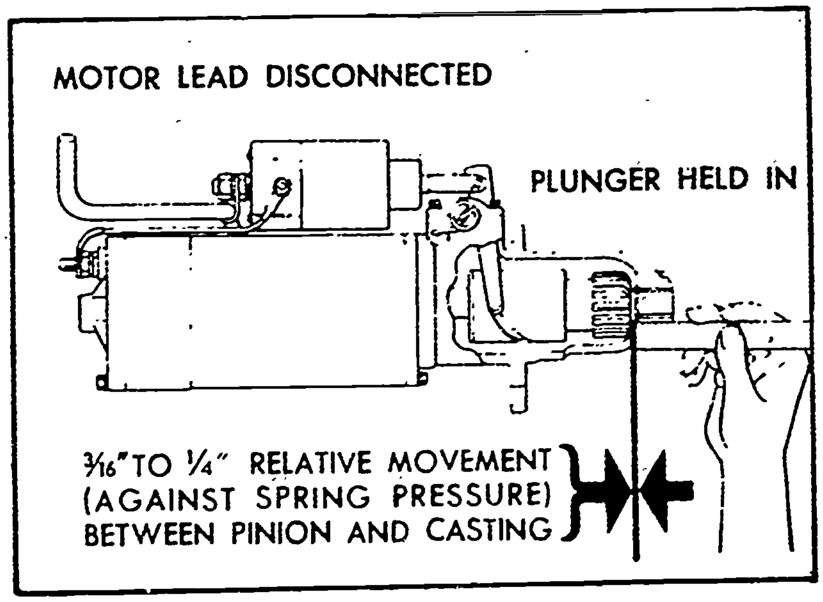


Fig. 27 Checking pinion clearance

The adjustment can be changed by turning the plunger stud in or out of the solenoid plunger, as necessary. One-half turn of the stud will change the adjustment by 1/16 of an inch. The moving parts on this type of drive may be lubricated to prevent excessive wear. Periodic inspection should be made, however, to see that dirt accumulation does not pack in behind the drive and prevent normal operation.

SECTION E -- CRANKING MOTOR SOLENOID CIRCUITS

The solenoid switch on a cranking motor not only closes the circuit between the battery and the cranking motor, but also shifts the cranking motor pinion into mesh with the engine flywheel ring gear. This is accomplished by means of a linkage between the solenoid plunger and the shift lever on the cranking motor. Solenoids are energized directly from the battery through a starter switch, or in conjunction with a solenoid relay.

When the circuit is completed to the solenoid, current from the battery flows through two separate windings, designated as the pull-in and the hold-in windings, (Figure 28). These windings produce a combined magnetic field which pulls in the plunger so that the drive pinion is shifted into mesh and the main contacts in the solenoid switch are closed.

The two windings have different size wire but contain approximately the same number of turns. The heavy pull-in winding is required to complete the plunger movement. When the air gap is decreased, the hold-in winding is sufficient to retain the plunger in position. Closing the main switch contacts connects the battery directly to the cranking motor, and at the same time, partially shorts out the pull-in winding, since it is connected across the main contacts (Figure 28(b)). The heavy current draw through the pull-in winding occurs only during the movement of the plunger and will not register on an ammeter.

When the control circuit is broken after the engine is started, current no longer reaches the hold-in winding from this source. However, there

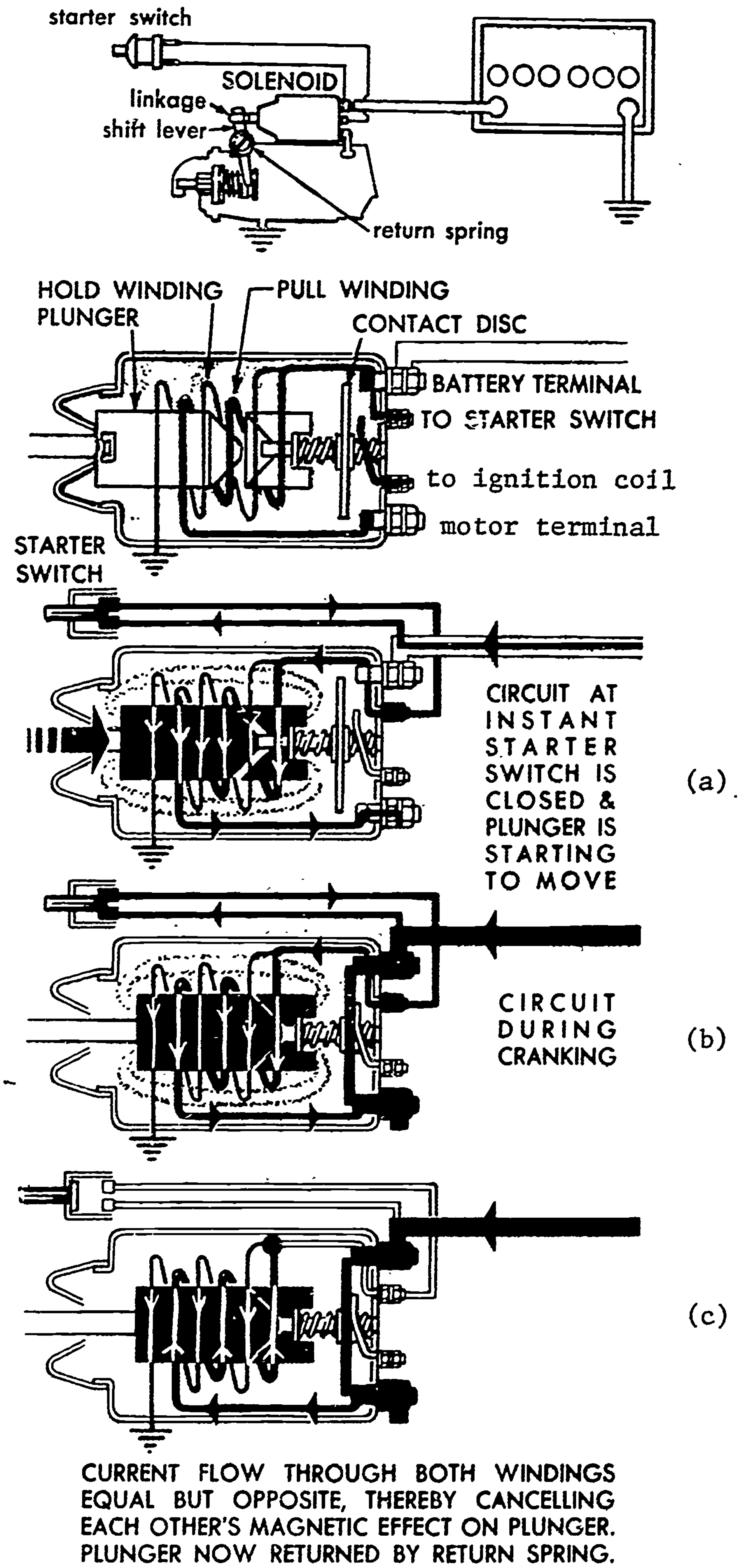


Fig. 28 Solenoid operation

is a current flow from the battery, through the main switch contacts, through the pull-in winding (in a reverse direction), and then through the hold-in winding to ground. See Figure 28(c).

With the same number of turns in each of the two windings, and the same amount of current flowing through both, the magnetic forces created are opposed and will counteract each other. The tension of the return spring then causes the plunger to return to the at-rest position, and breaks the cranking motor circuit.

As few as 15 shorted turns in the pull-in winding will result in less magnetic force available to oppose the magnetic field of the hold-in winding, and the switch contacts will remain closed. Continued cranking after the control circuit is broken indicates either shorted turns in the pull-in coil, or out-of-line mounting of the solenoid, which causes binding of the plunger.

Either low system voltage, or an open circuit in the hold-in winding will cause an oscillating action of the plunger. The pull-in winding has sufficient magnetic strength to close the main contacts. But when they are closed, the pull-in winding is shorted out. Under these conditions, there is no magnetic force to keep the contacts closed. Whenever chattering of the switch occurs, you should check for a complete circuit in the hold-in winding, as well as the condition of the battery.

Solenoids used with the Dyer drive cranking motors have a replaceable contact disc which is adjustable. See Figure 29. The location of the disc, when assembled, should be 1 1/32 inches below the edge of the housing, with the plunger in a retracted position. See Figure 30. This position is important to assure proper pressure between the contact disc and the terminal contacts while cranking.

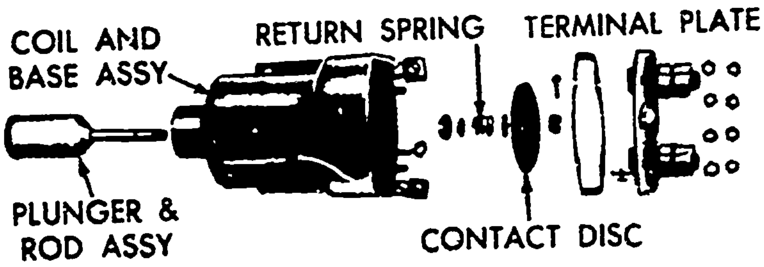


Fig. 29 Solenoid disassembly

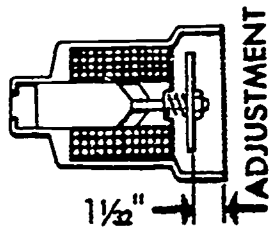


Fig. 30 Contact disc adjustment

Since the Dyer drive is designed to engage the pinion with the flywheel ring gear before the cranking circuit is completed, the pinion travel adjustment is very important. (This adjustment was covered under the subject of Dyer drives.)

The pulling power of a solenoid multiplies at an increasing rate as the air gap of the plunger is reduced. Locating the pinion adjustment at the high limit on either the clutch or Dyer type motors will, in effect, reduce the air gap and will create a more powerful magnetic force. Never replace a solenoid on a motor without checking pinion clearance. Satisfactory performance depends upon this adjustment.

0

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10/23/67

LEARNING ABOUT CRANKING MOTORS

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A — 1

Check to see that timer and index are OFF.

1

In this film we will discuss cranking motors, their design and operation, and the different types of drives used.

Basically, cranking motors consist of a drive mechanism, frame, field winding, armature and brushes. All current that passes through the field coils also travels through the armature winding. This type of cranking motor is known as a ______ motor and is capable of developing great torque (twisting force).

A. shunt wound — 2
B. compound wound (series-shunt) — 2
C. series wound — 3

1-1

2

No, you are incorrect. In the type of motor just described, the method of current travel through the field winding and then the armature winding makes it a SERIES wound motor (one continuous path).

Press A — 3

1-2

3

OK.

On cranking motors where high voltage is required, auxiliary shunt-connected coils are added to the circuit to slow down the top free running speed, which would otherwise be destructive to the motor. As current enters the motor it has a parallel path -- one part going to the shunt winding and the other part going to the series winding of the remaining coils and on to the armature winding.

The SERIES-SHUNT motor is sometimes referred to as a ______ motor.

A. reaction type — 4
B. impulse type — 4
C. compound wound — 5

1-3

4

No, you are incorrect. The SERIES-SHUNT wound motor is often referred to as a COMPOUND WOUND motor.

Reaction is a process that takes place between two or more magnetic fields during cranking.

Press A — 5

1-4

5

OK.

Compound wound is the term sometimes used to describe a SERIES-SHUNT wound motor.

Some types of cranking motors incorporate a ___(1)___ operated switch which closes and opens the circuit between the battery and the cranking motor. Other motors, designed with an overrunning clutch or a Dyer drive have a ___(2)___ switch.

A. (1) mechanically (2) magnetically operated — 6
B. (1) magnetically (2) solenoid type magnetic — 7
C. (1) magnetically (2) mechanically operated — 6

1-5

6

No, you are incorrect. Some types of cranking motors incorporate a magnetically operated switch; other motors, designed with an overrunning clutch or a Dyer drive, have a solenoid type magnetic switch.

Press A — 7

1-6

7

OK.

A solenoid type magnetic switch not only closes the circuit between the battery and cranking motor (causing the armature to rotate) but it also shifts the pinion gear into mesh with the teeth on the flywheel ring gear of the engine. When the pinion gear drive becomes engaged with the flywheel ring, ______.

A. cranking of the engine takes place — 8
B. the circuit is closed between the battery and motor — 8
C. the solenoid holds the drive pinion in place until the circuit is broken — 8
D. All of the above are correct — 9

1-7

8

No, you are not completely correct. All of the statements are true.

The pinion is engaged as a result of the solenoid action. The circuit is closed and the motor starts turning, but not before the drive gear is engaged. The drive gear is held in the engaged position with the flywheel ring gear until the circuit is broken. The overrunning clutch prevents the armature from being driven at excessively high speeds.

Press A —9 1-8

9

OK.

The cranking motor is a special type of electric motor, designed to operate under great overload and to produce high horsepower for its size. It can do this for only short periods of time, since high current must be used. High current creates ______________.

A. considerable heat —11
B. high battery discharge rate —10
C. a great overload on the electrical system —10

1-9

10

No, you are incorrect. If cranking motor operation is continued for any length of time, the accumulation of heat will cause serious damage. For this reason, the cranking motor must never be used for more than THIRTY SECONDS AT ANY ONE TIME. Cranking should not be repeated without a pause of at least two minutes to permit the heat to escape.

Press A —11 1-10

11

OK. The drive mechanism is a vital part of the cranking motor, since it is through the drive that power is transmitted to the engine, cranking it as the motor armature rotates.

The drive mechanism has two functions. One is to transmit the cranking torque (twisting force) to the flywheel. The second is to provide a gear reduction between the cranking motor and the engine. There are approximately ____________ teeth on the flywheel for every tooth on the drive pinion.

A. 75 to 100 —12
B. 8 to 10 —12
C. 15 to 20 —13

1-11

12

No, you are incorrect.

There are approximately 15 to 20 teeth on the flywheel for every tooth on the drive pinion. This means that the cranking motor armature will rotate approximately 15 to 20 times for every engine revolution. Thus, to turn the engine over at 100 revolutions per minute, the cranking motor armature must rotate at 1500 to 2000 rpm.

Press A —13 1-12

13

OK.

If the cranking motor drive pinion remains in mesh (engaged) with the flywheel ring gear at engine speeds above 1000 rpm, and if the pinion transmits its rotation to the cranking motor armature, the armature will spin at very high speeds. Such speeds will cause ______________.

A. damage to the motor bearings in a short time —14
B. the starting motor to act as a generator and develop excessively high voltage —14
C. the armature windings to be thrown from their slots and the segments to be thrown from the commutator —15

1-13

14

No, you are incorrect.

The armature windings will be thrown from the armature slots, and the segments will be thrown from the commutator if the starting motor is subjected to excessively high speeds. To avoid such a condition, the cranking motor drive must disengage the pinion from the flywheel ring gear as soon as the engine begins to operate.

Press A —15 1-14

15

OK. Several types of drive mechanisms have been developed for use with cranking motors. Each provides a means for engaging the drive pinion with the engine flywheel for cranking, and for disengaging the drive pinion from the flywheel ring gear when the engine starts.

Drive mechanisms in use include several versions of the Bendix drive, the Dyer drive, the Sprag clutch drive and many versions of the overrunning clutch drive.

Press A —16 1-15

16

The overrunning clutch must never be cleaned by _________________________ methods, as this would remove the lubricant originally packed in the clutch and cause rapid failure.

A. high temperature or grease-removing — 18
B. cleaning solvent or disassembly XX

(Only the correct answer will move the film.)

2-16

X(C)—17

17

Since you have missed one or more questions in this section, you should have the opportunity to review. Read the information over carefully and take your time in selecting your answers.

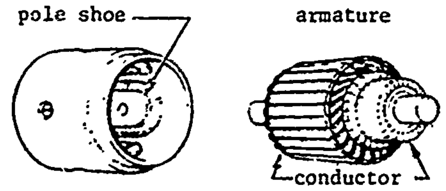
Press A — 1

1-17

18

OK. The overrunning clutch should never be cleaned by high temperature or grease-removing methods.

Magnetically, the cranking motor is made up of two parts, the ARMATURE and the FIELD WINDING ASSEMBLY.



2-18

Press A — 19

19

The armature contains a number of low resistance CONDUCTORS placed in the insulated slots of a laminated soft iron core, assembled onto the armature shaft. The commutator is made up of a number of copper segments assembled together, insulated from each other and from the armature shaft.

Press A — 20

2-19

20

The conductors are connected to each other (and to the commutator) in such a way that current flows through all of the armature conductors when brushes are placed on the commutator and a source of current is connected to the brushes. This creates magnetic fields around each conductor.

Current also flows through the field windings, creating _________________________.

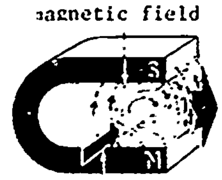
A. a distorted field — 21
B. an opposing force — 21
C. a powerful magnetic field — 22

2-20

21

No, you are incorrect. The current that flows in the field windings creates a powerful magnetic field.

Illustrated here is the relationship between the magnetic field of a permanent magnet, a single conductor through which current is flowing, and the direction of the force exerted on the conductor.



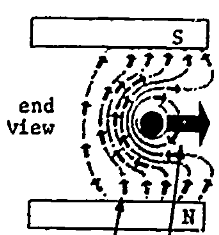
Press A — 22

2-21

22

OK.
Using the right hand rule, it can be seen that when the direction of current through a conductor is as shown, the magnetic lines of force around the conductor will be in a clockwise direction (as indicated by the arrows around the conductor).

It can also be seen that, to the right of the conductor, the magnetic fields oppose each other. To the left of the conductor they combine and the field is strengthened.



Press A — 23 2-22

23

When a current-carrying conductor is located in a magnetic field, the normal field of force is distorted. This creates a strong field on one side of the conductor and a weak field on the opposite side.

The conductor will be forced to move in the direction of the __________ field.

A. strong — 24
B. weak — 25

2-23

24

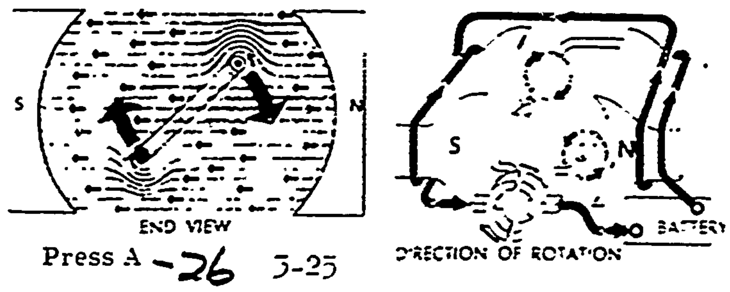
No, you are incorrect. A current-carrying conductor in a magnetic field will be forced to move in the direction of the weak field.

For another look at the illustration of this, press A. To advance to the next frame, press B. — 22 — 25

2-24

25

Application of the motor principle is illustrated here. The magnetic fields around the conductor are in the directions shown by the circular arrows. The left-hand side of the armature winding will be pushed upward, while the righthand side will be pushed downward. This imparts a clockwise rotation.



Press A — 26 3-25

X(C) — 25.1

25.1

OK. A current carrying conductor in a magnetic field will move in the direction of the weak field.

Let's have a quick review, since you have made an error on at least one question.

Press A — 15 3-25.1

26

Since the armature winding and the commutator are assembled together and must rotate together, movement of the armature causes the commutator to turn also. When the armature makes one-half a turn, current flows in the opposite direction in the winding.

Since the winding has turned 180 degrees, the force exerted on it tends to push it in a ____________.

A. counterclockwise direction — 27
B. clockwise direction — 28
C. direction opposite to the field of force — 27

3-26

27

No, you are incorrect. According to the illustration just shown, the lines of force created by the current flow cause the armature to rotate in a clockwise direction.

If you want another look at the illustration, press A. — 25

Press B to advance to the next frame. — 28

3-27

28

In most cranking motors, the field winding and the armature are connected in such a way that all current entering the cranking motor passes through both the field winding and the armature.

The field coils and the armature are connected in series. The conductors are made of heavy copper ribbon which have ____________, permitting a high current flow and a high torque (twisting force).

A. a very low resistance — 30
B. a very high resistance — 29
C. no resistance whatsoever — 29

3-28

29

No, you are incorrect. Cranking motor field coils and armature conductors are made of heavy copper ribbon, which has very low resistance. Low resistance conductors permit a high current to flow. The more current that flows, the higher is the torque developed by the cranking motor.

Press A — 30 3-29

30

OK. Some cranking motors have four pole shoes (called four pole units) but have only two field windings. This provides a four pole action with only two field coils, thus keeping the resistance low. There are as many lines of force entering the south pole shoes as there are leaving the north poles, making the magnetic strength the same for all poles.

This type of cranking motor has ____________ magnetic fields.

A. four — 32
B. eight — 31

3-30

31

No, you are incorrect. A four pole cranking motor has four magnetic fields, regardless of the number of field coils. It may have either two or four field coil windings.

Some cranking motors have four poles, four field windings and four brushes, but they still have only four magnetic fields.

Press A - 32

3-31

32

OK. A cranking motor with four poles will have four magnetic fields, whether it has two or four field coils. Another cranking motor (designed for heavy duty service) used six poles and six brushes. Here the current is split in three ways -- one third flowing through each pair of field windings to one of the insulated brushes. Increasing the number of circuits through the cranking motor helps to keep the ___(1)___ low so that a high current can flow and a ___(2)___ can be developed.

A. (1) heat (2) high voltage - 33
B. (1) voltage (2) reaction - 33
C. (1) resistance (2) high horsepower - 34

3-32

33

No, you are incorrect. Increasing the number of circuits through the cranking motor helps to keep the resistance low so that a high current can flow and a high horsepower can be developed.

Press A - 34

3-33

34

OK. As a rule, all insulated brushes are connected together by means of jumper leads or bars, so that the voltage is equalized at all brushes. Without these equalizing bars there may be conditions which will cause arcing and burning of the commutator bars, eventually insulating the brush contact from the commutator surface. This ________________.

A. discharges the battery by overloading - 35
B. causes the cranking motor to be overloaded - 35
C. prevents cranking - 36

3-34

35

No, you are incorrect. If some means of equalizing the voltage to all the brushes is not provided, there may be a condition which would cause arcing and burning of the commutator bars. This eventually would insulate the brush contact from the commutator surface and prevent cranking.

Press A - 36

3-35

36

OK. High voltage motors with a straight series circuit would reach an extremely high top free speed if not controlled.

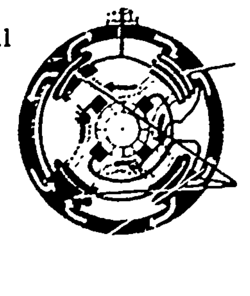
Even on some 12 volt, four pole motors, high free speed is a factor. Therefore, a ________________ is used, for the purpose of limiting the top free speed.

A. shunt connected coil - 38
B. speed limiting governor - 37
C. magnetic brake - 37

3-36

37

No, you are incorrect. A shunt connected coil is used for the purpose of limiting the top free speed. This feature was mentioned in the definition of the SERIES-SHUNT wound cranking motor, and will be covered in more detail later in this film.



Press A - 38

3-37

38

OK.

Some cranking motors use one or more shunt coils. The magnetic strength of the shunt coil remains constant and does not vary with speed. The speed of the armature (revolving through this strong magnetic field) creates a greater counter voltage, limiting the amount of current flow and consequently the ________________.

A. total voltage available - 39
B. total voltage drop - 39
C. top speed - 40

3-38

39

No, you are incorrect. The counter voltage limits the amount of current flow and the top speed.

Press A -40

3-39

40

OK.

During cranking of the engine, the shunt coil (with many turns of comparatively small wire) creates a magnetic field similar to the force provided by each of the series coils.

Normal cranking performance is therefore provided with less current draw and ____________________.

A. a safe top free speed -42
B. much less heat -41
C. a greater reaction between the armature winding and the field winding -41

3-40

41

No, you are incorrect. True, much less heat is developed (under normal operating conditions), but the correct answer is safe top free speed.

Press A -42

3-41

42

OK.

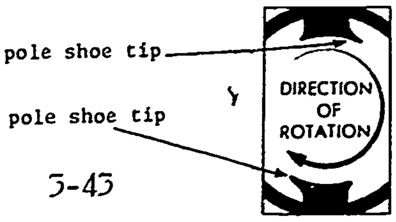
The pole shoes of most cranking motors have a longer tip on one side. When installed, the long tip of the pole shoe should point in ____________ ____________.

A. the direction opposite to the armature rotation -43
B. the same direction as armature rotation -44
C. It makes little or no difference as long as the polarity is correct. -43

3-42

43

No, you are incorrect. The extended tip of the pole shoe should point in the direction of armature rotation. In this position a better magnetic field and an increase in performance is obtained.



Press A -44

3-43

44

OK.

CRANKING MOTOR SOLENOID CIRCUITS -- The solenoid switch on a cranking motor not only closes the circuit between the battery and the cranking motor, but also shifts the cranking motor pinion into mesh with the engine flywheel ring gear.

Solenoids are energized directly from the battery through a starter switch or in conjunction with a solenoid relay.

Press A -46

X(C) -45

4-44

45

OK.

Since you have missed one or more of the questions in this section, we will have a brief review. Read the questions carefully; take your time in selecting your answers.

Press A -25

3-45

46

When the circuit is completed to the solenoid, current from the battery flows through two separate windings, designated as the pull-in and the ________ windings.

A. solenoid -47
B. motor -47
C. hold-in -48

4-46

47

No, you are incorrect. The two windings are the pull-in and the hold-in windings. These two windings produce a combined magnetic field which pulls in the plunger, so that the drive pinion is shifted into mesh, and the main contacts in the solenoid switch are closed.

Press A -48

4-47

48

OK. The two windings are made of different size wire, but contain approximately the same number of turns. The heavy pull-in winding is required to complete the plunger movement. When the air gap is decreased, the hold-in winding is sufficient to retain the plunger in position.

Closing the main contacts connects the battery directly to the ____________, and at the same time partially shorts out the pull-in winding, since it is connected across the main contacts.

A. solenoid terminal - 49
B. motor terminal - 50
C. battery terminal - 49

4-48

49

No, you are incorrect. The magnetic action of the pull-in winding closes the main contacts, connecting the battery and the cranking motor terminal.

Press A - 50

4-49

50

OK. The heavy current draw through the pull-in winding occurs only during the movement of the plunger, and will not register on an ammeter.

When the control circuit is broken after the engine is started, current no longer reaches the hold-in winding. However, there is a flow of current through the main switch contacts to the pull-in winding (in a reverse direction) and through the hold-in winding to ground. The magnetic forces created ____________ ____________.

A. are opposed and counteract each other - 52
B. work with the return spring to break the circuit - 51
C. have no effect on the return spring - 51

4-50

51

No, you are incorrect. The magnetic forces created are opposed and counteract each other. Tension of the return spring then causes the plunger to return to the at rest position and breaks the cranking motor circuit.

Press A - 52

4-51

52

OK. A few shorted turns in the pull-in winding will result in less magnetic force to oppose the magnetic field of the hold-in winding, and the switch contacts will ____________.

A. open and close rapidly - 53
B. remain closed - 54
C. fail to close - 53

4-52

53

No, you are incorrect. If as few as 15 turns of the pull-in winding are shorted, it will result in an insufficient amount of magnetic force to oppose the magnetic field of the hold-in winding. The switch contacts will remain closed. Possible damage to the cranking motor may result.

Press A - 54

4-53

54

OK. Continued cranking after the control circuit is broken indicates either shorted turns in the pull-in winding, OR an out-of-line mounting of the solenoid, which causes binding of the plunger.

Either low system voltage or an open circuit in the hold-in winding will cause an oscillating action of the plunger. The pull-in winding has sufficient magnetic strength to close the main contact. But when they are closed, the pull-in winding is shorted out. Under these conditions there is no magnetic force to keep the contacts closed. Whenever chattering of the switch occurs, check the condition of the battery and the hold-in winding.

4-54

Press A - 55

55

Solenoids used with DYER drive cranking motors have a replaceable contact disc, which is adjustable. The location of the disc when assembled is important, since it helps to assure proper pressure between the contact disc and the _______________ while cranking.

A. battery terminal —56
B. motor terminal —56
C. battery and motor terminal contacts —57

4-55

56

No, you are incorrect. The location of the disc used with DYER drive cranking motors is important, because it helps to assure proper pressure between the contact disc and the battery and motor terminal contacts while cranking.

Press A —57

4-56

57

OK. Since the DYER drive is designed to engage the pinion with the flywheel ring gear before the cranking circuit is completed, the pinion travel adjustment is very important.

Pinion travel adjustments should be made according to manufacturer's specifications. Always check alignment of the linkage on these units to _______________.

A. prevent excessive wear on the pinion and ring gear —58
B. prevent binding —59
C. insure proper engagement of the solenoid —58

4-57

58

No, you are incorrect. Always check alignment of the linkage between the solenoid and the pinion to prevent binding, which may result in damage to the cranking motor.

Press A —59

4-58

59

OK.

The pulling power of a solenoid multiplies at an increasing rate as the air gap of the plunger is reduced. Locating the pinion adjustment at the high limit (on either the clutch or DYER drive motors) will, in effect, reduce the air gap and result in powerful magnetic action.

A solenoid should not be replaced on a cranking motor without checking _______________. Satisfactory performance depends upon this adjustment.

A. air gap between the plunger and solenoid housing —60
B. air gap and pinion travel —60
C. pinion clearance —61

4-59

60

No, you are incorrect. A solenoid should not be replaced on a cranking motor without checking the pinion clearance. The solenoid may be operating properly, but if the pinion clearance is incorrect, it will cause the cranking motor to malfunction (operate improperly).

Press A —61

4-60

61

OK. Periodic checks of the cranking motor will go far toward eliminating unnecessary failures. Excessive start and stop operation, operation in dusty or very humid climates, or at sub-zero temperatures, all put an added strain on the equipment. Parts tend to wear more rapidly. Frequent checking of the cranking motor is desirable under such conditions. Press A —62

4-61

62

To prevent overheating, the cranking motor must not be operated for more than _______________ at a time without pausing a few minutes to allow it to cool off.

A. 60 seconds —63
B. 3 minutes —63
C. 30 seconds —64

4-62

63

No, you are incorrect. The cranking motor must not be operated for more than 30 seconds at a time without pausing a few minutes to allow it to cool off.

If the commutator is rough, worn, out-of-round, or has high insulation between the commutator segments, the armature must be removed from the cranking motor. The commutator should be turned down in a lathe, and the insulation undercut 1/32 of an inch.

Press A – 64

4-63

64

OK.

Thrown solder indicates that the cranking motor has been ___(1)___ due to excessively long cranking periods. Such abuse may cause open circuits to develop at the commutator riser bars, resulting in ___(2)___ commutator bars.

A. (1) overloaded (2) open circuited – 65

B. (1) overheated (2) burned – 66

C. (1) burned (2) shorted – 65

4-64

65

Not quite.

Overheating is the result of excessively long cranking periods. Burned commutator bars are usually caused by an open circuit at the commutator riser bars.

Press A – 66

4-65

66

OK. Each time an open circuited commutator bar passes under a brush, severe arcing occurs. The bar soon becomes burned. If the bars are not too badly burned, the armature may be repaired by ________________.

A. turning the commutator down and undercutting the insulation – 67

B. removing the carbon deposits and seating the brushes to make good contact with the commutator bars – 67

C. resoldering the leads in the commutator riser bars and then turning the commutator and undercutting the insulation – 68

4-66

67

No, you are incorrect. The armature may be repaired (if the bars are not too badly burned), by resoldering the leads in the riser bars and then turning the commutator down and undercutting the insulation.

Press A – 68

4-67

68

OK. Cranking motor brushes should make good, clean contact with the commutator. Brushes must have free movement to enable them to follow the commutator. Proper ________________ assures this.

A. spring tension – 70

B. seating area XX

X(C) – 69

(Only the correct answer will move the film.)

5-68

69

OK.

Since you have missed one or more questions in this section, let's have a quick review. Read the information carefully and take your time in selecting your answers.

Press A – 44

4-69

70

OK. The brush spring tension should never be below specified limits. Cranking motor brushes carry ___(1)___ current. Good contact between the brush and the commutator will reduce ___(2)___.

A. (1) low (2) voltage drop – 71

B. (1) high (2) resistance – 72

C. (1) low (2) amperage – 71

5-70

71

No, you are incorrect. Cranking motor brushes carry high current. Good contact between the brush and the commutator will reduce resistance. Most motor brush springs test above the specified tension. But since the cranking motor is used only intermittently, this is not objectionable.

New brushes should be installed if the old ones are worn too much to last until the next inspection or disassembly period. The brush seat may be improved by using a brush seating stone.

Press A -72

5-71

72

OK. At periodic intervals, the cranking motor should be removed from the vehicle and disassembled so that all parts can be cleaned and inspected. Defective parts should be repaired or replaced.

The frequency of this operation will depend on the type of equipment and operation. For average conditions the cranking motor should be disassembled once ________ ________ or about every 25,000 miles.

A. every two years -73
B. every eighteen months -73
C. a year - 74

5-72

73

No, you are incorrect. Most manufacturers recommend that the cranking motor be disassembled once a year or every 25,000 miles or equivalent time of operation.

Press A - 74

5-73

74

OK. The armature and field windings must not be cleaned with a grease dissolving solution or by any high temperature grease removing method, since this will damage the ________.

A. bearings - 75
B. insulation - 76
C. drive gear mechanism - 75

5-74

75

No, you are incorrect. The insulation may be damaged if the armature and field coil windings are cleaned in a grease dissolving solution or by a high temperature grease removing method.

Parts should be cleaned with a brush dipped in olium or other neutral spirits.

Press A - 76

5-75

76

OK.

If the cranking motor uses the Bendix type drive, the drive should be cleaned with kerosene and lubricated with a trace of light engine oil on the spiral sleeve. Avoid ________.

A. excessive oiling - 78
B. heavy (high temperature) grease - 78
C. light (low temperature) grease - 77
D. A and B above - 79

5-76

77

No, you are incorrect. The Bendix type drive should be cleaned with kerosene and lubricated with light engine oil on the spiral sleeve. Excessive oiling should be avoided. Never use a heavy (high temperature) grease.

Press A - 79

5-77

78

Your answer is incomplete.

The Bendix type drive should be cleaned with kerosene and lubricated with light engine oil on the spiral sleeve.

Avoid excessive oiling.

Never use a heavy (high temperature) grease.

Press A - 79

5-78

79

OK. The overrunning clutch type drive must never be cleaned by any high temperature or grease dissolving method, since this would (1), causing the clutch to fail quickly. The drive pinion of the overrunning clutch should turn freely in the overrunning direction and should not slip in the ______(2)______.

A. (1) cause the overruning clutch to run excessively (to coast) — 80
(2) disengaged position

B. (1) cause the overrunning clutch to bind — 80
(2) engaged direction

C. (1) remove the grease originally packed in the clutch — 81
(2) driving direction

5-79

80

No, you are incorrect. The overrunning clutch type drive must never be cleaned by a high temperature or grease dissolving method, since this would remove the grease originally packed in the clutch, causing it to fail quickly.

The drive pinion should turn freely in the overrunning direction, and should not slip in the driving direction.

Press A — 81

5-80

81

OK. As a final step in the periodic maintenance procedure, the cranking motor should be lubricated by adding a few drops of light engine oil to the visible hinge cap oilers.

The bearings in many cranking motors are of the oilless type. However, they do require oiling when the cranking motor is reassembled after the periodic disassembly.

Congratulations: you have successfully completed this film "Learning About Cranking Motors".

Press REWIND

X(C) -82

5-81

82

OK.

You have made an error on one or more questions in this section, so you should have the opportunity to review. Read the information carefully: take your time in selecting your answers.

Press A — 68

5-82

INSTRUCTOR'S GUIDE

Title of Unit: LEARNING ABOUT CRANKING MOTORS

AM 2-19
10/3/67

OBJECTIVES:

1. To introduce motor principles, motor circuits, and magnetic circuits and how they are related to each other.
2. To acquaint the student with the different types of cranking motor drives and some precautions to be observed with each.
3. To discuss the advantages of one type of drive over the other and to give a brief description of the solenoid circuit and its relation to the cranking circuit.

LEARNING AIDS: (suggested)

VISUAL AIDS: Delco-Remy Charts and Manuals 5133-C Cranking Motors and Series Parallel Switches

MODELS: Any Cranking Motors or components that could be brought into the class room for inspection, demonstration, and discussion would be helpful. Also, "on-vehicle" testing would be beneficial. Show the use of voltmeters, ammeters, and carbon pile or other variable load for testing cranking motors.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What is meant by the term series-wound motor?
2. How do shunt coils keep the free running speed down to a safe level?
3. Why do cranking motors use either a solenoid or other type of magnetically operated switch to close the circuit between the battery and cranking motor?
4. What are the four most commonly used drives?
5. What is another important function of the solenoid besides closing the circuit between the battery and the cranking motor?

QUESTIONS (continued)

6. Why is it important to observe the CAUTION and never operate a cranking motor more than THIRTY SECONDS AT ONE TIME?

7. Name the two functions of the drive mechanism.

8. Why is it important to have the drive mechanism de-meshed (disengaged) when the engine begins to operate?

9. How does the current flow in a cranking motor compare with the output of a generator or alternator?

10. The pole shoes of most cranking motors have a longer tip on one side than the other. Can you explain why?

11. Explain how the older type Bendix drive pinion was engaged with the flywheel ring gear. Name some improvements made in recent years.

12. Why is ignition timing or diesel engine injector timing so important when related to the cranking motor? (With Bendix drive.)

13. How are overrunning clutch drive mechanisms lubricated, and what precaution must be observed when cleaning this type of drive?

14. What is the advantage of using the Dyer shift drive over other types of drive on heavy duty equipment?

15. How many windings are in a cranking motor solenoid, and what is their function?