air gap and contact adjustments have been made, the armatures should be checked to see if they float. This means that with the spiral armature springs removed from their hangers, you should see daylight between the contacts and between the magnet core and bottom of armature. If an armature does not float the contacts will snap closed, giving an "oil can" effect, which is much too violent an action for the contacts.

A suitable tool for floating armatures may easily be made by machining a pair of glass pliers by drilling holes in the jaws so the holes fit over the rivets on the armature. It may then be used to bend the back end of the armature up or down, Fig. 57, until daylight can be seen at the places mentioned.

Regulator Armature Springs—Whenever these springs are removed, care must be exercised to see that they get back on their correct spring hangers. These springs, particularly on Auto-Lite regulators, very often do not have the same tension values, which can easily be determined by counting the number of spirals each one has. If springs are not installed on the proper hangers, the regulator will not function properly.

Auto-Lite Rectifiers—On some of the newer high output Auto-Lite regulators, a rectifier, Fig. 58, has been added to the field circuit. These rectifiers make an alternate, low resistance path for the field current to continue when the regulator contacts open. This limits the build-up of voltage across the contacts and reduces the arc when the contacts separate, making for much longer contact life.

Two types of rectifiers have been used: copper sulphide and selenium. Both are connected between the field and armature terminals but the connections are made at different points as it is necessary to connect a resistance in series with the copper sulphide type in order to obtain best overall performance.

Since the rectifier is connected from the armature terminal to ground (through the regulator contacts) it is imperative that it has the correct polarity. For positive ground systems, the rectifier eyelet must be on the field terminal. If the system is negative grounded, the rectifier eyelet must be on the armature terminal, Fig. 58. If installed incorrectly, the wrong polarity would make the regulator inoperative.

STARTING MOTORS

When trouble develops in the starting motor circuit, and the starter cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble lies in the battery, in the starter, in the wiring between them, or elsewhere. Many conditions besides defects in the starter itself can result in poor cranking performance.

To make a quick check of the starter system, turn on the headlights. They should burn with normal brilliance. If they do not, the battery may be run down and it should be checked with a hydrometer.

If the battery is in a charged condition so that the lights burn brightly, operate the starting motor. Any one of three things will happen to the lights: (1) They will go out, (2) dim considerably or (3) stay bright without any cranking action taking place.

If Lights Go Out—If the lights go out as the starter switch is closed, it indicates that there is a poor connection between the battery and starting motor. This poor connection will most often be found at the battery terminals. Correction is made by removing the cable clamps from the terminals, cleaning the terminals and clamps, replacing the clamps and tightening them securely. A coating of corrosion inhibitor (vaseline will do) may be applied to the clamps and terminals to retard the formation of corrosion.

If Lights Dim—If the lights dim considerably as the starter switch is closed and the starter operates slowly or not at all, the battery may be run down, or there may be some mechanical condition in the engine or starting motor that is throwing a heavy burden on the starting motor. This imposes a high discharge rate on the battery which causes noticeable dimming of the lights.

Check the battery with a hydrometer. If it is charged, the trouble probably lies in either the engine or starting motor itself. In the engine, tight bearings or pistons or heavy oil place an added burden on the starting motor. Low temperatures also hamper starting motor performance since it thickens engine oil and makes the engine considerably harder to crank and start. Also, a battery is less efficient at low temperatures.

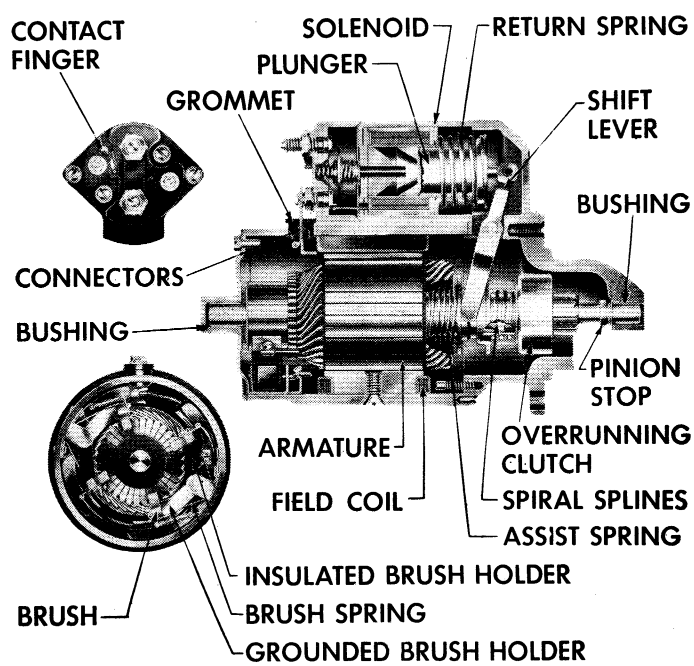

Fig. 1 Sectional view of starter with overrunning clutch drive

In the starting motor, a bent armature, loose pole shoe screws or worn bearings, any of which may allow the armature to drag, will reduce cranking performance and increase current draw.

In addition, more serious internal damage is sometimes found. Thrown armature windings or commutator bars, which sometimes occur on over-running clutch drive starting motors, Fig. 1, are usually caused by excessive over-running after starting. This is the result of such conditions as the driver keeping the starting switch closed too long after the engine has started, the driver opening the throttle too wide in starting, or improper carburetor fast idle adjustment. Any of these subject the over-running clutch to extra strains so it tends to seize, spinning the armature at high speed with resulting armature damage.

On Bendix drive starting motors, Figs. 2 and 3, broken Bendix housings and wrapped up Bendix springs may result if the driver closes the starting switch during engine rockback after the engine starts and stops again.

Another cause may be engine backfire during cranking which may result, among other things, from ignition timing being too far advanced.

To avoid such failures, the driver should pause a few seconds after a false start to make sure the engine has come completely to rest before another start is attempted. In addition, the ignition timing should be reset if engine backfiring has caused the trouble.

Lights Stay Bright, No Cranking Action This condition indicates an open circuit at some point, either in the starter itself, the starter switch or control circuit. If the car is equipped with a solenoid starting switch, the solenoid control circuit can be eliminated momentarily by placing a heavy jumper lead across the solenoid main terminals to see if the starter will operate. This connects the starter directly to the battery and, if it operates, it indicates that the control circuit is not functioning normally. The wiring and control units must be checked to locate the trouble.

If the starter does not operate with the jumper attached, it will probably have to be removed from the engine so it can be examined in detail.

Checking Circuit With Voltmeter

Excessive resistance in the circuit between the battery and starter will reduce cranking performance. The resistance can be checked by using a voltmeter to measure voltage drop in the circuits while the starter is operated. There are three checks to be made:

1. Voltage drop between car frame and grounded battery terminal post (not cable clamp), Fig. 4.
2. Voltage drop between car frame and starting motor field frame, Fig. 5.
3. Voltage drop between insulated battery terminal post and starting motor terminal stud (or the battery terminal stud of the solenoid), Fig. 6.

Each of these should show no more than one-tenth (0.1) volt drop when the starting motor is cranking the engine. Do not use the starter for more than 30 seconds at a time to avoid over-heating it.

If excessive voltage drop is found in any of these circuits, make correction by disconnecting the cables, cleaning the connections carefully, and then reconnecting the cables firmly in place. A coating of vaseline on the battery cables and terminal clamps will retard corrosion.

NOTE—On some cars, extra long battery cables may be required due to the location of the battery and starter. This may result in somewhat higher voltage drop than the above recommended 0.1 volt. The only means of determining the normal voltage drop in such cases is to check several of these vehicles. Then when the voltage drop is well above the normal figure for all cars checked, abnormal resistance will be indicated and correction can be made as already explained.

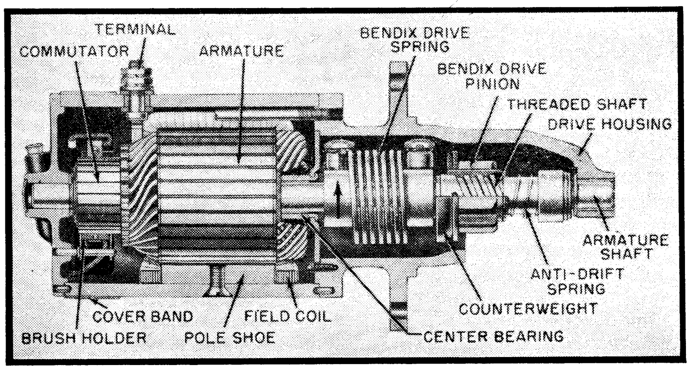

Fig. 2 Starter equipped with standard Bendix Drive

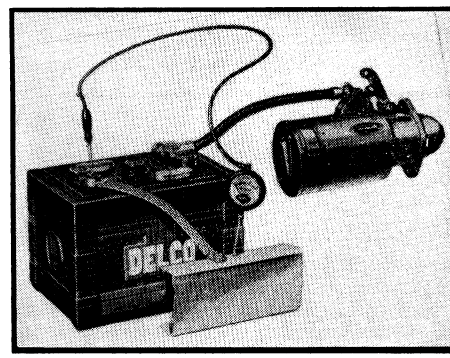

Fig. 4 Checking voltage drop between vehicle frame and grounded battery terminal post

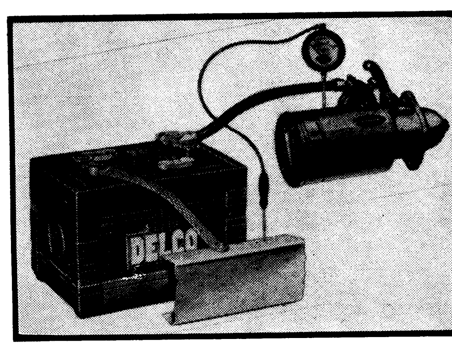

Fig. 5 Checking voltage drop between vehicle frame and starter motor field frame

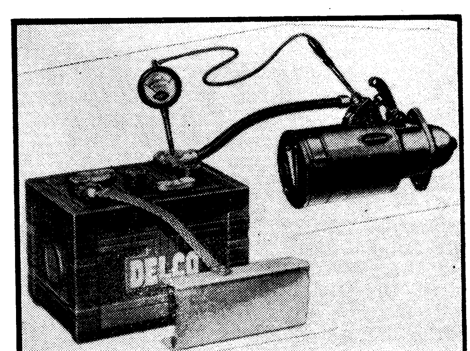

Fig. 6 Checking voltage drop between insulated battery terminal post and starting motor terminal stud (or battery terminal on solenoid, if so equipped)

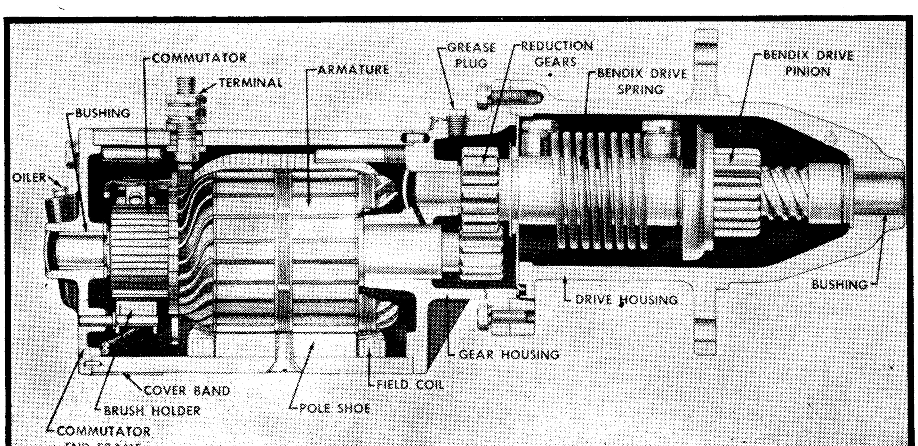

Fig. 3 Standard Bendix Drive starter with gear reduction to give extra cranking torque

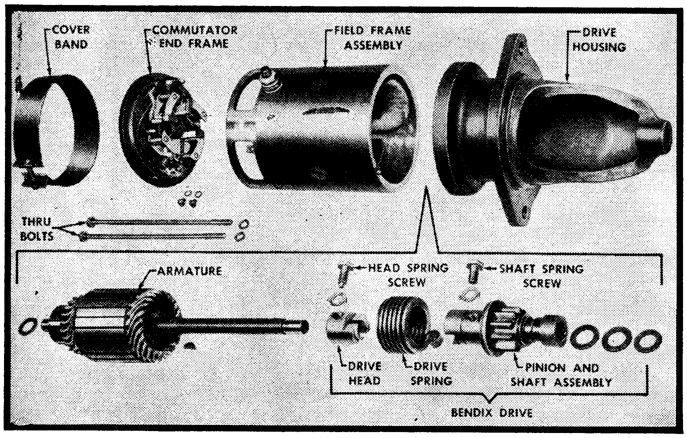

Fig. 7 Exploded view of starting motor with a standard Bendix Drive

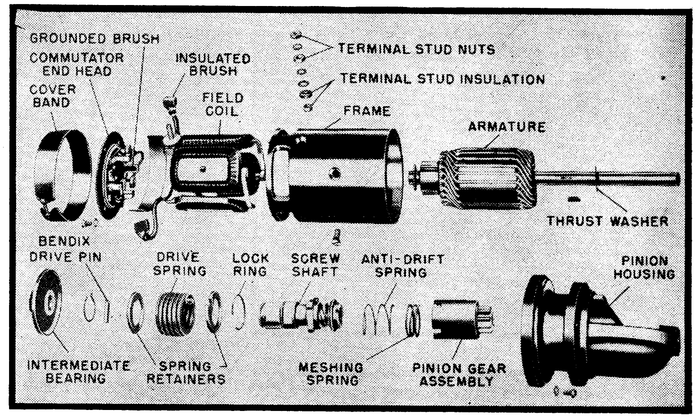

Fig. 8 Exploded view of starting motor with barrel type Bendix Drive

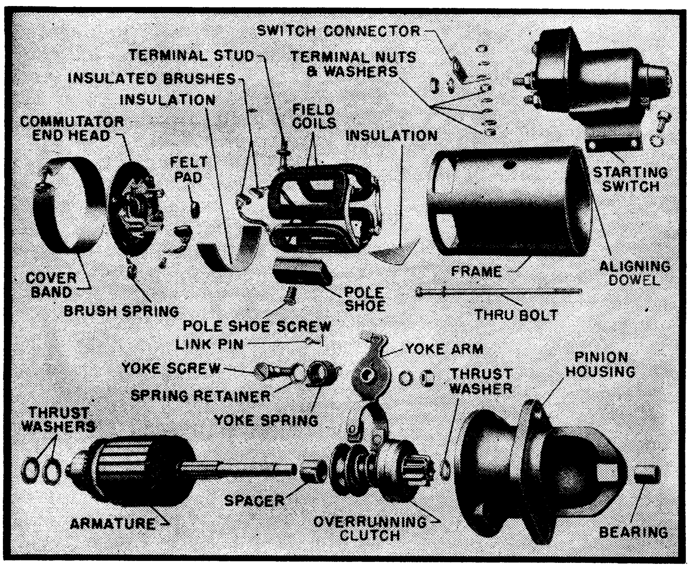

Fig. 9 Exploded view of starting motor with solenoid-operated overrunning clutch drive

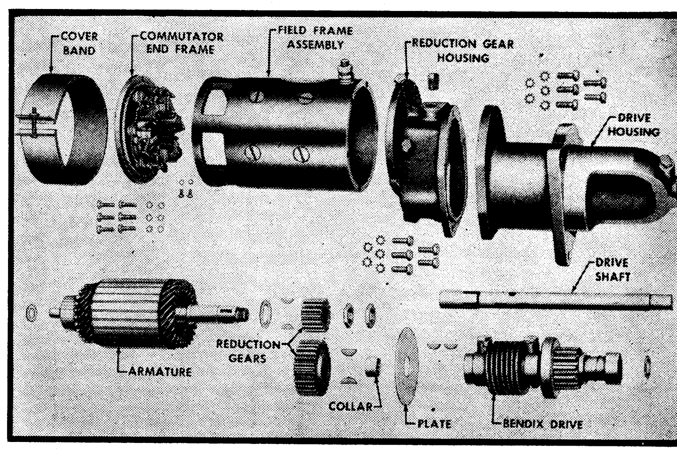

Fig. 10 Exploded view of gear reduction starting motor with standard Bendix Drive

STARTING MOTOR SERVICE

To obtain full performance data on a starting motor or to determine the cause of abnormal operations, the starting motor should be submitted to a noload and torque test. These tests are best performed on a starter bench tester with the starter mounted on it.

From a practical standpoint, however, a simple torque test may be made quickly with the starter in the car. Make sure the battery is fully charged and that the starter circuit wires and terminals are in good condition. Then operate the starter to see if the engine turns over normally. If it does not, the torque developed is below standard and the starter should be removed for further checking.

Removing Starter from Engine

The general procedure for removing a starter from the engine is as follows: Disconnect the leads from the starter. (When the switch is mounted on the motor, the battery lead should be covered with friction tape or a short piece of hose to prevent it from short-circuiting against any metal surface.) Disconnect any pedal linkage directly connected to the starting motor or yoke. Then take out the mounting bolts and lift the starter from the engine.

Disassembling Starting Motor

The disassembly procedure to be followed will vary according to the type and construction of the starting motor. Normally, disassembly should proceed only so far as it is necessary to make repair or replacement of defective parts. For example, the field coils should be checked for opens or grounds and if found to be in normal condition, they should not be removed from the field frame. (See Figs. 7, 8, 9 and 10.)

1. If the brush holders are of the box type, lift the spring with a hook made of stiff wire and take the brushes out of the holders. On swinging type brushes, disconnect the field coil lead from the insulated brush and slightly tighten the screw to keep the brush in place.
2. Before disassembling commutator end heads that are fastened by a number of screws into the end of the field frame, scratch a mark on the frame and head so that they can be reassembled in their original position. This is not necessary on motors using through bolts to hold the heads and having a dowel pin to locate the commutator end head position.
3. Take out the through bolts or commutator end head and drive end housing attaching screws. If necessary, tap the commutator end head lightly with a rubber or plastic hammer and remove the head.
4. Lift off the drive end head (or pinion housing) and the armature. On types having an intermediate bearing, the armature will remain in the pinion housing. On most motors, this bearing assembly is a press fit in the pinion housing and can be forced out with an arbor press bearing on the drive end of the shaft. A few types of motors use a screw or a lock ring to hold the intermediate bearing in place.

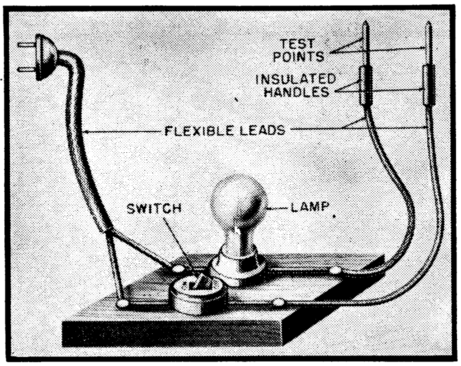

Fig. 12 A simple tester for use in making continuity and ground tests on armature and field windings

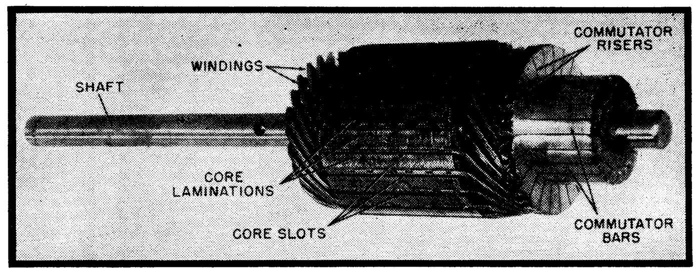

Fig. 11 Typical starting motor armature

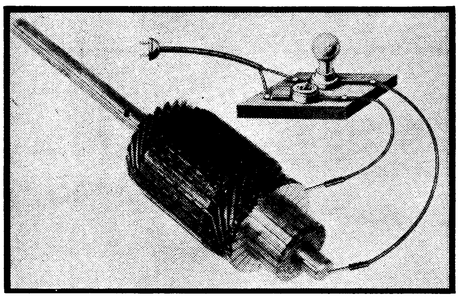

Fig. 13 Checking armature for grounds. If lamp lights, armature is grounded and should be replaced

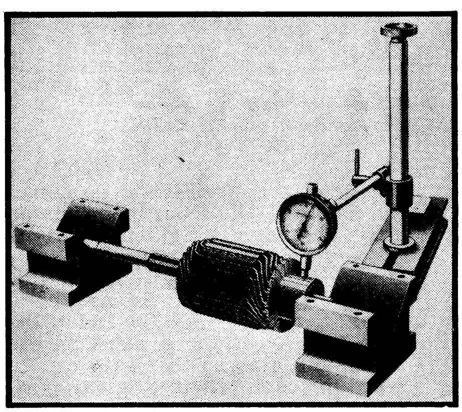

Fig. 14 Measuring commutator runout with dial indicator. Mount shaft in V blocks and rotate commutator. If runout exceeds .003", commutator should be turned in a lathe to make it concentric

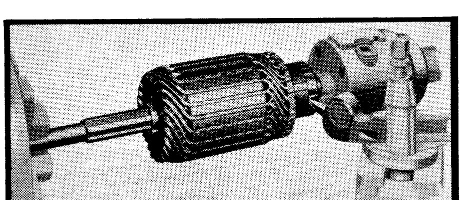

Fig. 15 Turning commutator in a lathe. Take light cuts until no worn or bad spots appear. Then remove burrs with 00 sandpaper

These must be removed before pressing the armature out of the pinion housing. Gear reduction motors require the removal of the intermediate housing screws to complete their disassembly.

Armature Inspection & Service

1. Visually inspect the armature, Fig. 11, for mechanical defects such as a worn or bent shaft, worn commutator, scored core laminations, and to see that all windings are properly in place in the core slots.
2. Inspect for evidence of excessively high speeds which would throw the windings outward at the ends and may even cause them to leave the core slots.
3. Inspect to see that all windings are properly staked and soldered to the commutator. Resolder if necessary, being careful not to short between coils and commutator bars.
4. With test clips or points such as are illustrated in Fig. 12, test the armature for grounds by touching the shaft with one point and the commutator with the other, Fig. 13. Do not touch the test points to the bearing or brush surfaces as an arc would burn the smooth finish. If the lamp lights, the armature is grounded and should be replaced.
5. Clean the commutator with 00 sandpaper and remove all dirt from between the bars.
6. Place the armature shaft bearing surfaces on V blocks, Fig. 14, and mount a dial indicator against the commutator as shown.
7. Turn the armature slowly and read the total runout as indicated on the dial gauge. If runout exceeds .003", the commutator should be turned down with a lathe to make it concentric.
8. Mount the armature in the lathe by the shaft bearing surfaces (not shaft centers), Fig. 15, and take light cuts until the commutator is completely cleaned up. Remove all burrs with 00 sandpaper. This trueing up of the commutator should also be done if it is rough, burned or if the mica extends above the surface of the copper. Recheck runout after turning the commutator.
9. Undercut the mica $\frac{1}{64}$" measured depth, Fig. 16. This cut should be exactly centered on the mica and the cutting tool used should be .002" wider than the mica. The undercut should be clean and square.
10. If the burrs on the copper after undercutting are not large they can be left on the commutator to help seat the brushes after assembly. However, be sure to remove the burrs with 00 sandpaper before completing the overhaul.
11. Place the armature on an open core transformer, otherwise known as a growler, Fig. 17, and hold a hacksaw blade on the core as shown. Rotate the armature slowly and if the armature is shorted the hacksaw blade will become magnetized and vibrate.
12. If a short is present, inspect the commutator risers and bars for copper chips or solder that may be shorting between the bars. If shorts cannot be found, replace the armature.

Frame & Field Service

1. Clean the frame and field with a cloth dampened in cleaning solvent but do not soak insulation or brushes.
2. Inspect for faulty insulation and stripped threads.
3. With a test lamp, check for grounds by touching the terminal stud with one test point and an unpainted spot on the frame with the other test point, Fig. 18. Be sure brushes or leads are not in contact with the frame. If the lamp lights, there is a ground in the field circuit.
4. If a ground is present, remove the terminal stud nuts and if the stud is removable, press it out of the frame. Then recheck the field coils for grounds as before.
5. If the terminal stud is soldered to the field coils or if the field coils are grounded, remove the pole shoe screws and take the coils out of the frame. It is good practice to mark one end of the frame and also the shoes before disassembly so that they can be installed in their original position.
6. Replace any faulty or damaged parts, making sure all connections are tightly clinched and soldered to be sure that no high resistance connections are present.
7. When installing field coils and shoes, the tools shown in Fig. 19 or their equivalent should be used to insure a tight installation of the coils and shoes.
8. Be sure the pole shoes are installed in the same location and direction as they were originally. On some motors, the shoes are bored after assembly and when they are inter-

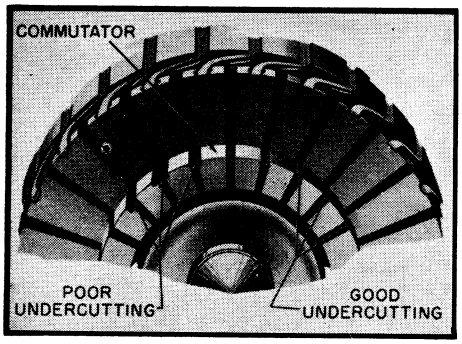

Fig. 16 Good undercutting should be .002" wider than the mica, 1/64" deep and exactly centered so that there are no burrs on the mica

changed they may interfere with the armature. On other motors, the two tips of the shoes are not alike. However, on this type, the long tip is always the trailing edge.

9. If the brushes are oil soaked or are worn to less than ½ their original length they should be replaced.
10. To remove the brushes, unsolder and unclinch the lead from the field coil or connector.
11. Insert the new brush lead to its full depth and insert the equalizer lead (if used).
12. Clinch tightly and solder to make a low resistance connection. Do not use acid for soldering flux as it will damage the insulation. Use a rosin or alcohol solution.

Commutator End Head Service

1. Clean the commutator end head, being careful not to soak the brushes in solvent.
2. Inspect for a cracked, bent or distorted head and replace if these conditions are present.
3. Place the armature in a padded vise and install the commutator end head on the end of the armature shaft.

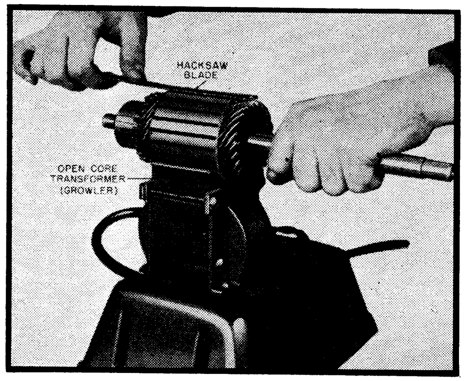

Fig. 17 This illustrates the use of an open core transformer (growler) and a steel strip to test the armature for shorts. Turn armature slowly and if a short is present the steel strip will vibrate rapidly

4. Do not clamp the armature tightly as this distorts the laminated core.
5. Feel the fit of the bearing on the shaft. If side play is excessive, the bearing or shaft is worn and should be replaced. Where the bearing is replaceable, it should be pressed into place with the correct arbor, as the arbor determines the inside diameter of the bearing. If the bearing is not removable, replace the complete head.
6. With the head mounted on the armature, install a spare brush in one of the holders.
7. Inspect to make sure the brush is parallel to the commutator segments and that it moves freely in the holder.
8. To align the brush it is necessary to install a new arm on swinging type holders, or to replace the complete head or brush plate if the brush holders are of the box type.
9. Measure the brush spring tension with a spring scale hooked under the brush spring, Fig. 20, or brush screw, Fig. 21, near the end. Pull the scale on a line parallel to the edge of the brush and take the reading just as the spring leaves the brush, Fig. 20, or just as the brush leaves the commutator, Fig. 21.
10. Adjust the tension by bending the brush spring at the point where it is clamped by the brush holder.
11. Repeat this brush alignment, movement and tension inspection for all brushes.
12. Be sure to remove the brushes from the holders before taking the head off the armature as they may become chipped or cracked if they are allowed to snap off the commutator.
13. If the brush leads are broken or frayed or if the brushes are oil soaked, chipped, cracked or worn less than ½ their original length, the brushes should be replaced.
14. Brushes that are soldered to the field coils or connectors should be replaced as outlined under Frame and Field Service. Brushes that have the ground terminal riveted under the brush holder should have the lead unsoldered and the terminal unclamped.
15. Insert the lead to its full length in the terminal and clamp tightly. Solder it to make a strong and electrically tight connection, using a high temperature solder and a rosin flux. Do not use acid.

Drive End Head Service

1. Thoroughly clean the head or pinion housing and inspect for cracks.
2. Try the fit of the armature shaft in the bearing and replace the bearing

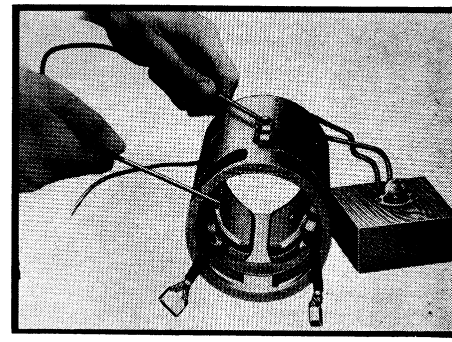

Fig. 18 Testing field coils for grounds. A six-volt test lamp is shown but the test lamp illustrated in Fig. 12 may also be used. If a ground is present the lamp will light

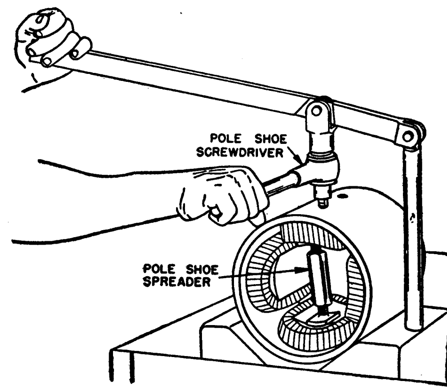

Fig. 19 Recommended equipment for installing field coils and pole shoes

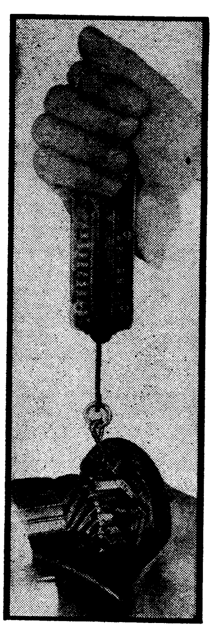

Fig. 20 Measuring brush spring tension on units with box type holders. Hook scale under brush spring and pull parallel to sides of brush. Place a strip of paper between brush and commutator. While holding a slight tension on the paper, take scale reading just as paper can be slipped from under brush

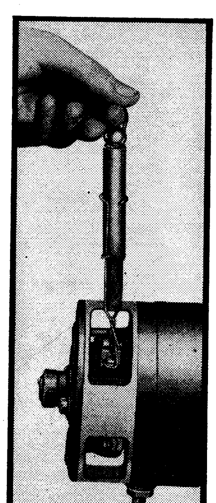

Fig. 21 Measuring brush spring tension on units with swinging type holders. Hook scale under brush screw tight against brush and pull parallel to sides of brush. Use paper as in Fig. 20

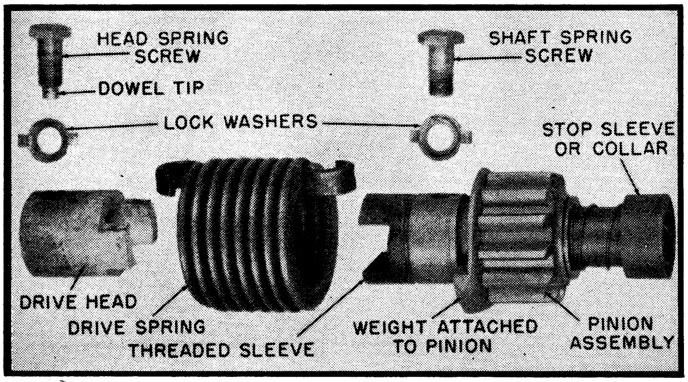

Fig. 22 Layout of standard Bendix Drive parts

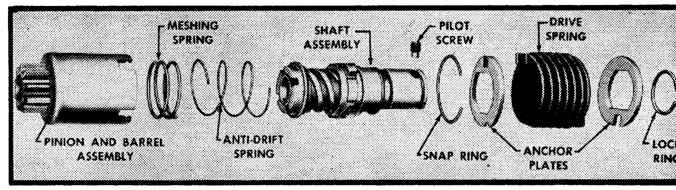

Fig. 23 Layout of barrel type Bendix Drive parts

if the side play is excessive.

3. When installing a new bearing, be sure to support the housing so that it does not twist or damage the bearing.
4. Install a new bearing, using the correct arbor, as it is designed to give the proper inside diameter of the bearing without the necessity of reaming or scraping.
5. Soak the bearing in SAE 10 engine oil and remove the excess oil from the housing or head.

STARTER DRIVE SERVICE

Overrunning Clutch Drive

It is recommended that clutch type drives be cleaned and inspected as a unit and no attempt made at disassembly or adjustment. This type of drive should be returned to the factory for any repairs or adjustments as the clutch is set at the factory to a pre-determined value according to the installation on which the drive is used.

Clean the outside of the drive with a brush or cloth dampened in cleaning solvent. Do not soak the drive in any fluid as the clutch mechanism cannot be relubricated. Inspect for wear and make sure the clutch slides easily on the armature shaft. Replace the drive if the pinion is worn badly or if the internal splines are damaged.

Place the drive on the armature shaft and turn the pinion. The clutch should release and the pinion turn smoothly though not necessarily freely. Reverse the direction of rotation. The clutch should immediately lock and unlock each time the direction of pinion rotation is changed. If the clutch action is sluggish or restricted, replace the drive assembly.

Before assembling the drive on the armature shaft, lubricate the shaft sparingly with SAE 10 engine oil.

Standard Bendix Drive

This type of drive, Fig. 22, is detached from the armature shaft by removing the head spring screw. Unscrewing the shaft spring screw permits separation of the drive spring from the drive pinion and shaft assembly.

Clean the parts with kerosene. Inspect each part for wear or distortion and replace any part that is not in good condition.

Assemble the drive, using new spring lockwashers and install the washers with the turned up lip hooked in the drive spring loop.

After installing the drive on the armature shaft, these lockwashers should have the lip bent tightly against a flat side of the screw head to prevent any possibility of becoming loose.

When assembling the drive do not force the parts together as they are designed for free movement and any restriction may cause failure of the drive to function. Locate the cause of the restriction and correct it before completion of the assembly.

Lubricate the armature shaft and screw threads sparingly with SAE 10 engine oil. Install the drive on the armature shaft, making sure it slides easily without restriction. Be sure the keys are in place (where used) and tighten the spring screws so that the head spring screw enters the hole in the shaft. Clinch the lockwashers or install any pins or lock rings used on some types and inspect the installation to be sure the drive is ready for service.

Push the pinion assembly to compress the drive spring. The screw shaft should move freely on the armature shaft without restriction and should return to its original position when released. The longitudinal movement should be ¼″ to 5/16″, depending upon the type of drive. If there is too little movement or if there is restriction, the drive may not mesh properly when using the starting motor. These adjustments are outlined further on.

Barrel Type Bendix Drive

This type of drive, Fig. 23, can be removed from the armature shaft by pushing in the outer anchor plate so that the pilot screw (or pin) can be removed. The drive itself can be disassembled as shown in Fig. 23 by slipping off the anchor plates and drive spring. Then remove the snap ring from the inside of the barrel and separate the pinion and barrel assembly from the shaft.

When assembling, the meshing spring must be in the pinion and barrel. The lugs on the shaft will easily slip into the barrel slots if the anti-drift spring is correctly positioned and the lugs or slots are not burred. Do not use force. Install the snap ring in the barrel by inserting one end in the groove. Then feed it around, forcing the ring out with a screwdriver until it seats securely in the depth of the groove.

Be sure there is unrestricted travel of the pinion and barrel in either direction on the screw shaft. In the full meshed position, it should automatically index and rethread itself (with a click) to all three screw shaft threads upon slightly reversed rotation of the barrel. If this does not occur, check the meshing spring.

The screw shaft assembly must be serviced as a complete unit with the exception of the anti-drift spring. To remove this spring, hook a finger under the spring, pull the spring back and allow the end coil to slip over the shoulder of the stop nut. Then carefully remove the spring.

Before installing, always test the anti-drift spring for distortion by dropping it into the pinion barrel. Try both ends of the spring. If it falls into the barrel freely, it is satisfactory to use again. If either end binds in the barrel, discard the spring and use a new one.

To install the anti-drift spring, hook the end coil over the stop nut and thread the spring on the screw shaft with a rotary movement until it abutts the control nut. Then bring the outer end of the spring over the stop nut shoulder. Screw the control nut a half turn forward on the screw shaft, making sure that the end coil of the spring does not project beyond the control nut or stop nut shoulder.

Installation—Do not force the drive onto the armature shaft by striking the end of the pinion or barrel as this may damage the threads on the drive shaft. The drive should slide on the shaft and over the key easily. If binding occurs, locate

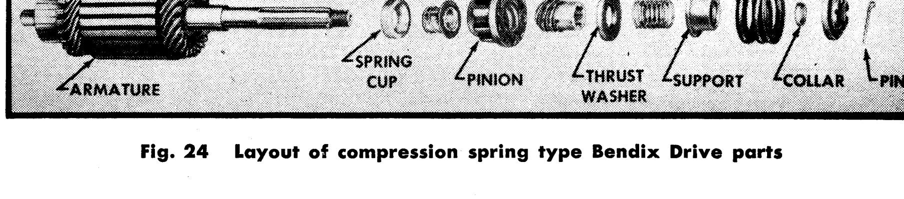

Fig. 24 Layout of compression spring type Bendix Drive parts

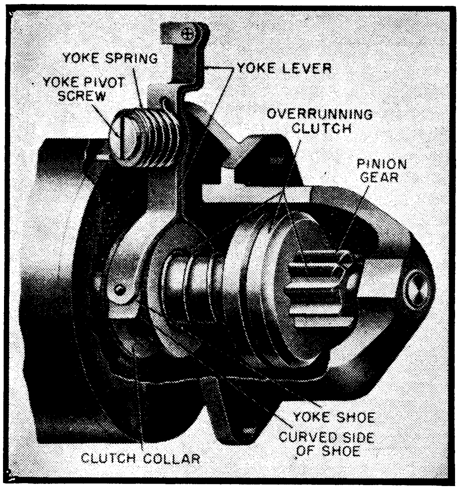

Fig. 25 Assembly of overrunning clutch and yoke shifting lever. Make sure curved sides of yoke shoes are toward gear end of clutch. Reversed yoke shoes can cause improper meshing of pinion

the cause and correct it.

Check for free movement of the pinion and barrel assembly on the screw shaft. If binding occurs, look for a bent armature shaft or for burrs, scoring or excessive lubricant on the portion of the shaft on which the pinion rides. Examine the triple threads for burrs, dirt or excessive lubricant and check the anti-drift spring for distortion as previously explained.

NOTE—The triple threads on the screw shaft can be cleaned without removing the drive from the starter by rotating the pinion barrel to its full meshed position. Then compress the drive spring and wipe the exposed threads with a cloth wet with kerosene. If the dirt is thick or gummy, apply kerosene (not gasoline) to the threads with a small brush. Tilt the starter so that some kerosene will run under the pinion barrel. Work the barrel back and forth several times and rewipe the threads. Never dip or wash the entire drive in any cleaning fluid as it will wash out the lubricant originally placed under the screw shaft.

Compression Spring Type Bendix Drive

This type of drive, Fig. 24, is removed from the armature shaft simply by removing the cotter pin, unscrewing the nut and removing the parts in the order shown. Observe carefully the relationship of the parts when removing them so they can be reinstalled in the same manner.

When installing the anti-drift spring sleeve, compress the anti-drift spring beyond the end of the sleeve, thus eliminating the possibility of the end spring coil slipping between this piece and the pinion spring cup while the nut is tightened. Tighten the nut firmly, thereby drawing the anti-drift spring sleeve and spring cup tight against the shaft shoulder. To do this, the armature must be held in a vise with soft jaws. Avoid burring or jamming the commutator.

ASSEMBLING STARTER

Soak bronze bearings and felts in SAE 10 engine oil and apply a light film of oil to the shaft bearing surfaces. Remove the excess oil as too much lubrication may deposit on the brushes, commutator, fields or armature, impairing their operation and possibly causing failure.

On gear reduction motors, add $\frac{1}{2}$ ounce of high temperature, non-fibre gear grease to the gear chamber.

When assembling the yoke on overrunning clutch type motors, be sure the yoke shoes are installed with the curved edge toward the pinion end of the clutch, Fig. 25.

Install the switch and its linkage, making sure all linkage operates freely and the clutch shifts to its full mesh position. Also make sure the armature turns easily with only the brush drag restricting its movement.

When assembling the commutator end head on some motors, it is possible to have the head rotated from its correct position. This changes the brush position and on some types causes the motor to turn in the wrong direction. On other types the motor may not operate in either direction. The safest way of insuring against this difficulty is to mark the head and frame before disassembling so that they can be installed in their original position.

Bendix Drive Motors—Check the clearance between the Bendix drive stop and the inside of the pinion housing as shown in Fig. 26. Measure the clearance with a feeler gauge and if it is not $\frac{1}{16}$″ first make sure the motor and drive are correctly assembled. Then install thrust washers just inside either the intermediate bearing (if used) or the commutator as required to establish this clearance. This affects the end play which should be checked at the same time.

Measure the clearance between the drive stop and housing as described above with the armature pressed to its

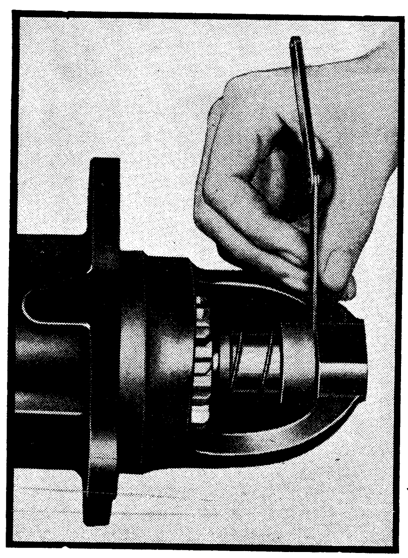

Fig. 26 Measuring Bendix Drive stop clearance which must be 1/16″. Do not compress Bendix spring as this will give an incorrect reading

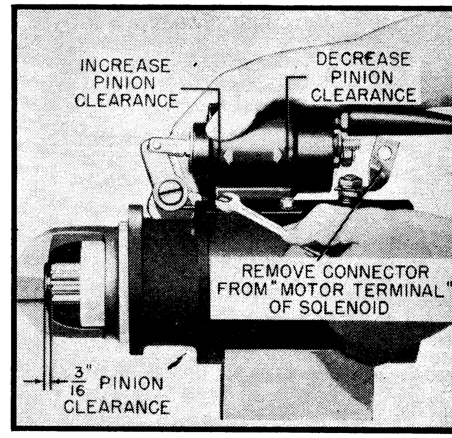

Fig. 27 Adjusting pinion clearance on overrunning clutch motor equipped with solenoid having a non-adjustable plunger stud

two extreme positions. The end play will be the difference between the two readings and should be at least .005″. Do not compress the Bendix spring when measuring clearance.

If the end play is less than .005″, inspect for improper assembly and make sure all washers are in their correct location. If end play is excessive it can be reduced by installing thrust washers just inside the intermediate bearing (if used) or commutator end head. When installing washers, be sure that the brushes are centered on the commutator and the pinion "at rest" or demeshed position is correct (this adjustment is given later on).

Overruning Clutch Motors—Thrust the armature toward the commutator end and measure the clearance between the shoulder on the shaft and the drive end thrust washer. This clearance is the same as the end play which should be .005″ to .030″ and is adjusted by installing thrust washers on the shaft just inside the commutator end head. These washers may be steel, fibre or leather and should be placed with the hardest material next to the head.

Install the switch on the motor. Connect the yoke linkage to the plunger screw on solenoid-operated clutches but do not install the lock pin. Shift the pinion into full mesh position by pressing on the solenoid core on electrically-operated shifts, or by pressing the yoke lever on manually-operated shifts.

Measure the clearance between the outer edge of the pinion to the thrust washer just inside the drive end bearing, Fig. 27. If the clearance is more or less than $\frac{3}{16}$″, adjust as follows:

For manually-operated clutch motors, adjust by screwing the switch plunger in or out as required.

On solenoid-operated clutch motors not having an adjustable plunger stud, Fig. 27, loosen the switch mounting screws and shift the switch forward or backward as required to establish the $\frac{3}{16}$″ clearance.

On solenoid-operated clutch motors equipped with an adjustable plunger stud, Fig. 28, turn the plunger stud in or

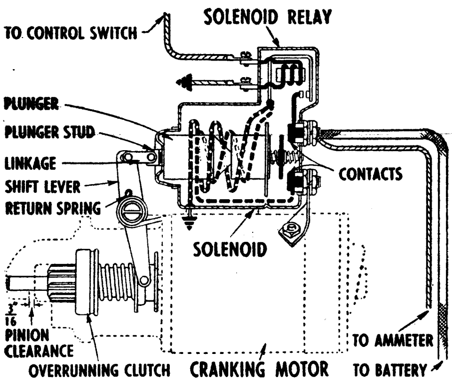

Fig. 28 Overrunning clutch motor equipped with adjustable plunger stud for adjusting pinion clearance (see Fig. 27)

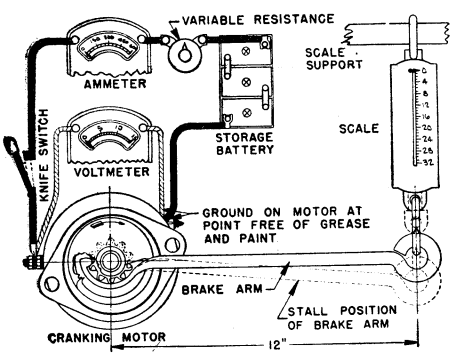

Fig. 29 Diagram of a starting motor torque tester

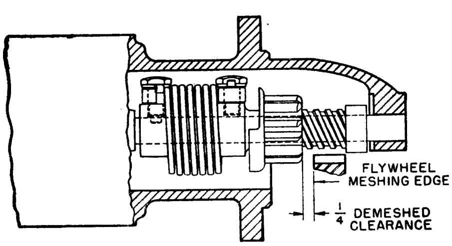

Fig. 30 Typical standard and "F" outboard Bendix Drives. Both types are similar but the "F" type Bendix spring is designed with the first coil on each end wound to a reduced diameter

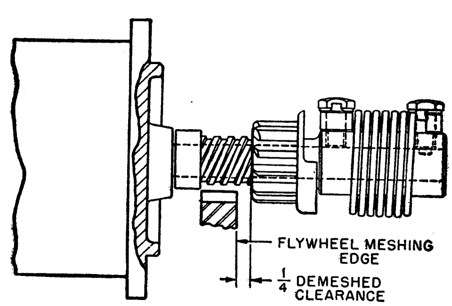

Fig. 31 Typical standard and "F" inboard Bendix Drive

out as required to establish the $\frac{3}{16}''$ clearance.

CAUTION—Failure to establish this clearance may result in a broken drive housing.

STARTING MOTOR TESTS

On most motors the terminal stud is accessible and the motor can be connected for test without the switch in the circuit. However, on motors with manually-shifted clutch, the switch should be removed before making electrical tests.

Connect the motor terminal and frame to a battery of the correct voltage and operate on "no-load" for two or three minutes to seat the brushes. Stop the motor and remove the burrs from the commutator with 00 sandpaper. Then blow out all dust with clean compressed air. If the motor will not operate, check the internal connections for shorts or binding.

To obtain full perforance data on a starting motor according to the manufacturer's specifications, certain equipment is required in addition to the specifications, which may be found at the beginning of this chapter. There are a number of reputable manufacturers of test equipment and each one furnishes complete instructions for its use. Two tests are required to obtain full performance data, namely, no load test and torque test.

In the no load test, the starting motor is connected in series with a battery of the correct voltage and an ammeter capable of reading several hundred amperes. An RPM indicator (tachometer) should also be used to measure the armature revolutions per minute.

The torque test requires such equipment as illustrated in Fig. 29. The starting motor is mounted securely and the brake arm hooked to the drive pinion. Then when the specified voltage is applied, the torque can be computed from the reading on the scale. If the brake arm is one foot long as shown, the torque will be indicated directly on the scale in pounds feet. A high-current carrying variable resistance should be used so that the specified voltage can be applied.

Many torque testers indicate the developed pounds feet of torque on a dial. The specifications are normally given at low voltages so that the torque and ammeter readings obtained will be within the range of the testing equipment available in the field.

Interpreting Results of Tests

Rated torque, current draw and no load speed indicates normal operation of the starting motor.

Low free speed and high current draw with low developed torque may result from: (a) Tight, dirty or worn bearings, bent armature shaft or loose field pole screws which would allow the armature to drag. (b) Shorter armature. (c) A grounded armature or field.

Failure to operate with high current may result from: (a) A direct ground in the switch, terminal or fields. (b) Frozen shaft bearings which prevent the armature from turning.

Failure to operate with no current draw may be caused by: (a) Open field circuit. (b) Open armature coils. (c) Broken or weakened brush springs, worn brushes, high mica on commutator or other causes which would prevent good contact between brushes and commutator.

Low no-load speed with low torque and low current draw indicates: (a) An open field winding. (b) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under *Failure to Operate With No Current Draw.*

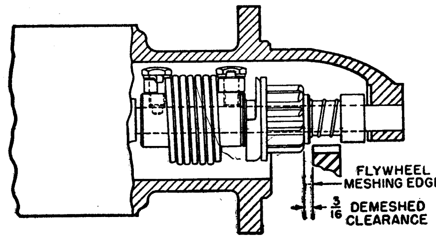

Fig. 32 Typical "CD" outboard Bendix Drive. This is similar to the standard type but the "CD" has an anti-drift spring

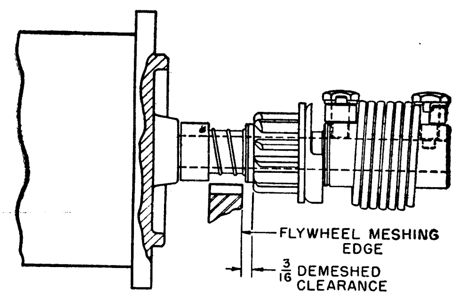

Fig. 33 Typical "CD" inboard Bendix Drive

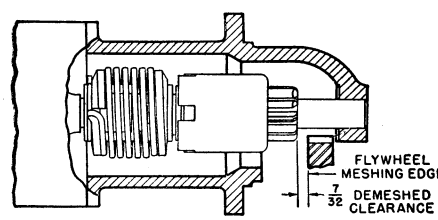

Fig. 34 Typical barrel type outboard Bendix Drive

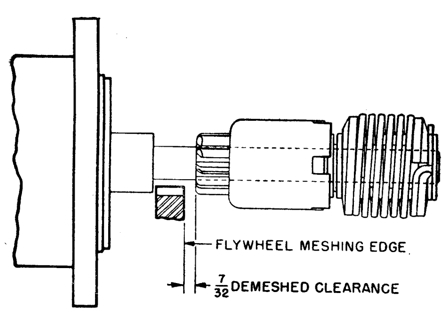

Fig. 35 Typical barrel type inboard Bendix Drive

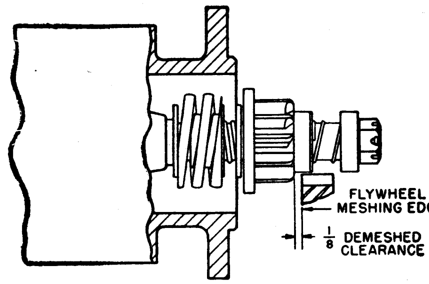

Fig. 36 Typical compression spring type outboard Bendix Drive

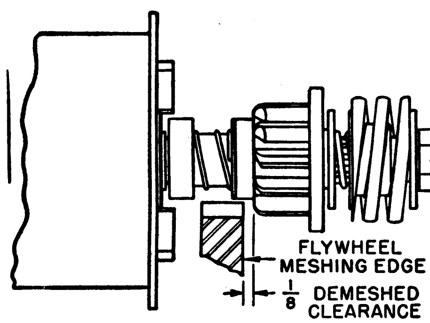

Fig. 37 Typical compression spring type inboard Bendix Drive

High free speed with low developed torque and high current draw indicates shorted field coils. There is no easy way to detect shorted fields, since the field resistance is already low. If shorted fields are suspected, replace them and check for improvement in performance.

Installation of Starter

Install the cover band on the motor. Clean the mounting faces of the motor and flywheel housing to secure a good ground contact. Install the motor on the engine. Connect the leads and pedal linkage, making sure the linkage operates freely and that it returns to the "at rest" position when pressure is released. Check the motor for proper performance while cranking the engine.

Checking Demeshed Pinion Clearance

With the starting motor on the engine the demeshed position of its pinion should be the dimension shown in the accompanying illustrations. If the demeshed clearance is not as indicated, it is usually due to an installation error. Locate the cause and correct it before placing the motor in service.

The dimensions should be checked from the full demeshed position, that is, when the pinion is resting on the heel of the screw shaft threads. This applies to standard, barrel and "F" types of Bendix drives. (Standard and "F" type drives are similar but the "F" type Bendix spring is designed with the first coil on each end wound to a reduced diameter. Likewise, the "CD" type of Bendix drive differs from the standard type in that it has an anti-drift spring.)

In checking "CD" and compression spring types, rotate the pinion slightly forward until its face abutts the pinion washer or bushing, whichever is used.

If the demeshed position of the pinion is not as shown in Figs. 30 to 37, incorrect meshing with the flywheel will be the result.

Overmeshing permits the pinion counterweight on standard, "F" and "CD" type drives to contact the meshing face of the flywheel, thereby pushing the counterweight off the pinion.

A comparable circumstance in the case of barrel type drives would result in noisy operation and, in extreme cases, failure to crank the engine would occur.

Insufficient lengthwise meshing of the pinion with the flywheel reduces the tooth area of contact when cranking, thus placing undue strain on the gear teeth.

STARTING SWITCHES

STARTING motor controls may vary from a simple switch on the toe-board or starting motor frame, to the series-parallel switch which breaks parallel connections between two batteries and connects them in series when operated so that a higher voltage is applied to the starting motor. Controls considered herein are (1) Vacuum switches, (2) Magnetic switches, (3) Solenoid Switch with Relay, and (4) Series-Parallel Switch.

VACUUM SWITCH

The vacuum switch, Fig. 1, is mounted on or connected with the intake manifold, and is linked by a rod or rods to the throttle or accelerator pedal. The vacuum switch may be used in starting motor solenoid or magnetic switch circuits to protect the starting motor from accidental operation when the engine is running. When the throttle is opened for initial engine starting, the linkage to the vacuum switch causes the vacuum switch contacts to close, completing the starting motor control circuit, so that the starting motor operates and the engine starts. After the engine has started, vacuum develops in the intake manifold, and this causes the vacuum switch contacts to open and latch. This opens the control circuit so that the starting motor stops operating.

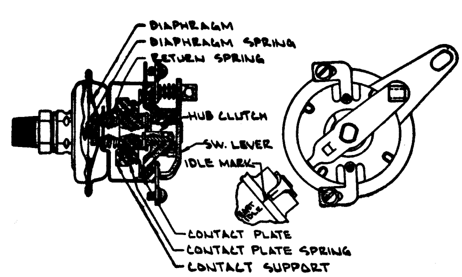

Fig. 1 A typical starting motor control vacuum switch. Switch is adjusted with engine idling so marks on pointer and housing align

The vacuum switch may be tested on the vehicle by starting the engine, disconnecting the leads from the two switch terminals, and connecting a test lamp to these terminals. The lamp should not light as the engine is operated from idle to high speed. Stop the engine with the throttle held half open. After the engine comes to rest, slowly release the throttle. The test lamp should not light. Slowly open the throttle. The lamp should light as the throttle is partly opened. Failure to operate in this manner requires replacement of the switch.

MAGNETIC SWITCH

The magnetic switch, Fig. 2, is a solenoid which consists of a plunger and one or two windings so placed and related that, when the windings are magnetically energized, the plunger is sucked into the windings. This motion forces a contact disc across a pair of contacts, so that the battery becomes directly connected to the starting motor. Little attention ordinarily need be given the magnetic switch, except an occasional check to see that the connections and mountings are tight. Many magnetic switches have a small metal cap on one end which may be unscrewed so that the switch contacts can be closed by hand in case the switch does not operate properly.

The magnetic switch may be tested by applying varying voltage to the terminals (from a battery and variable resistance or a generator driven by a variable speed motor) to determine the voltage required to operate it. Usually, the switch is assembled by crimping, welding, or brazing parts together, so that it cannot be repaired if it is found to be defective. Consequently, the switch is serviced by complete replacement.

SOLENOID SWITCH WITH RELAY

The solenoid switch with relay, Fig. 3, is a solenoid of somewhat more powerful construction than the magnetic switch,

STARTING SWITCHES

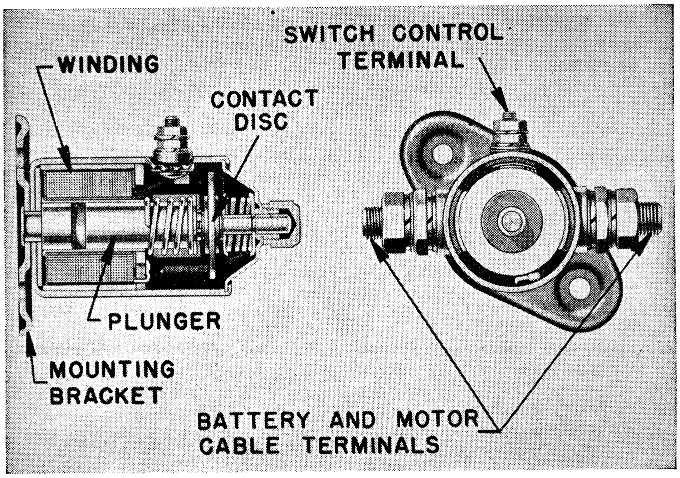

Fig. 2 Sectional view of a magnetic switch

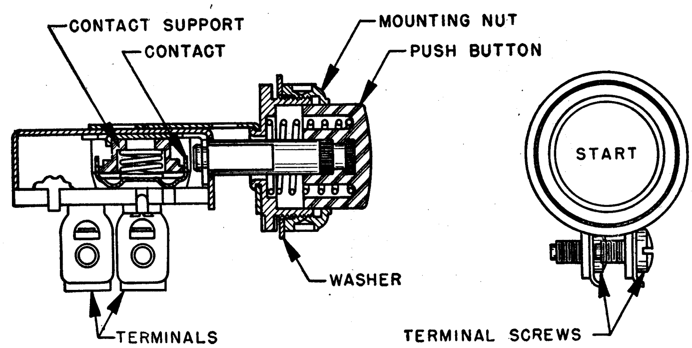

Fig. 4 Dash push button of the type which may be used with solenoid or magnetic switch

since it must not only close the circuit between the battery and the starting motor, but it must also operate a shift lever which shifts the starting motor drive pinion into mesh with the engine flywheel teeth. The relay, which mounts on the solenoid, is energized by the operation of the starting motor control device—either a dash push button, Fig. 4, or an accelerator-linked vacuum switch. When the relay is energized, its points close, so that the solenoid windings become directly connected to the battery. The solenoid becomes energized, pulling in its plunger, so that the drive pinion meshes with the engine flywheel teeth. As the plunger completes its travel, it closes the solenoid switch, directly connecting the starting motor to the battery.

It is possible partly to disassemble the solenoid so that the plunger may be removed and the plunger and plunger chamber cleaned of any grease, dirt, or corrosion which would tend to make the solenoid action sluggish. The contacts and contact disc may be removed so that the contact surfaces can be cleaned by wire brushing or some similar method. The solenoid relay points or air gap, and closing voltage may be checked, and adjustment made as necessary, Fig. 5.

On Auto-Lite solenoid relays, the contact point opening should have .025 to .035 inch gap. Adjustment is made by raising or lowering the upper armature stop. The relay points should close at 3.5 to 4.5 volts on 6-volt units and 7.0 to 9.0 volts on 12-volt units. The relay points should open at 1.5 to 2.5 volts on 6-volt units and 3.0 to 5.0 volts on 12-volt units. The closing and opening voltages may be checked by connecting the relay terminals to a voltmeter and a source of variable voltage (battery and variable resistance or a generator driven by a variable speed motor). Adjust the closing voltage by varying the armature spring tension. Increasing the tension increases the closing voltage. Decreasing the spring tension lowers the closing voltage.

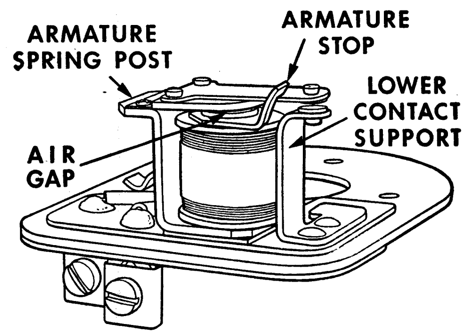

Fig. 5 Adjustment of solenoid relay

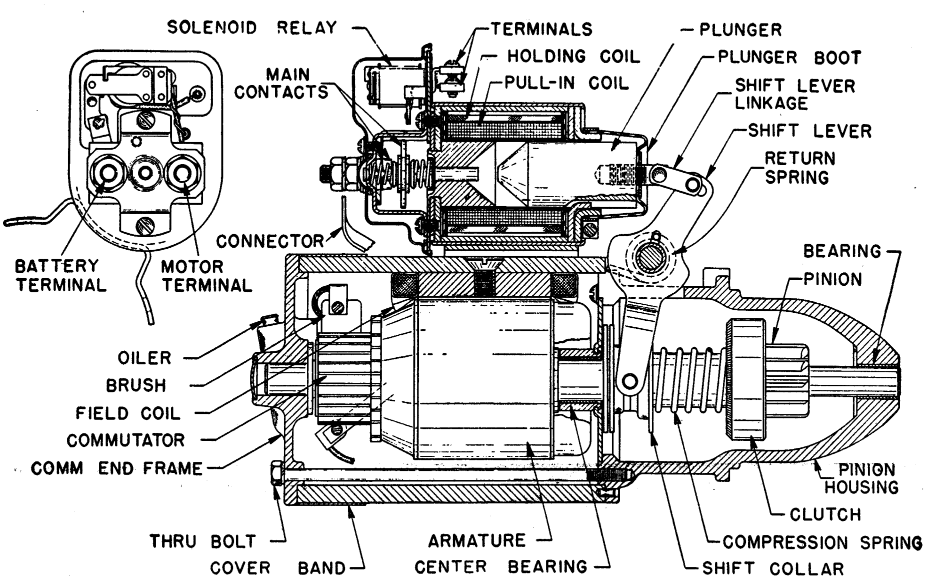

Fig. 3 Sectional view of solenoid with relay on starting motor

On late type Delco-Remy solenoid relays check the point opening and closing voltage. In addition, earlier type solenoid relays, which have the armature mounted to the relay frame by two screws, should have the air gap checked. Air gap is checked by loosening the two armature attaching screws and raising or lowering the armature as required. On all solenoid relays, the point opening is adjusted by bending the upper armature stop. The closing voltage is adjusted by changing the armature spring tension. Increasing the tension increases the relay closing voltage, while reducing the tension lowers the relay closing voltage.

The solenoid may be connected to a source of variable voltage and a voltmeter so that the operating voltage may be checked. Be sure that the plunger is free to move without any restriction or binding, before making this check. The current draw of the shunt or hold-in winding, and the series or pull-in winding of the solenoid may be checked at the specified voltage.

SERIES-PARALLEL SWITCH

The series-parallel switch, Fig. 6, is designed to be used with solenoid-operated starting motors, and permits the use of a 24-volt starting motor with a 12-volt system, or a 12-volt motor with a 16-volt system. Such a combination is desirable when conventional lighting, generating and accessory equipment is to be used in connection with a higher voltage starting motor. Such a starting motor is required on Diesel and heavy-

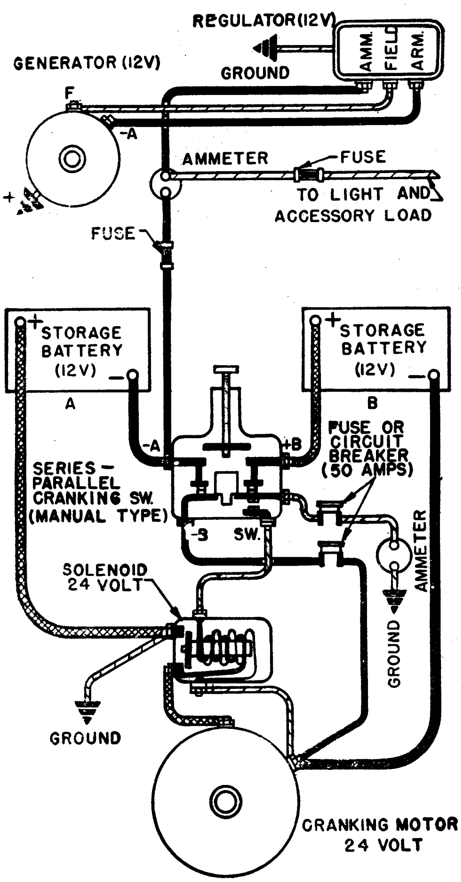

Fig. 7 Circuit diagram of series-parallel system with batteries connected in parallel through the series-parallel switch. Negative or insulated side of system shown in black. Current delivered by generator splits at "A" terminal of switch, half going into battery "A" and the other half going into battery "B" through the switch. Fuses may be incorporated in the series-parallel switch or they may be installed in the external circuit as shown

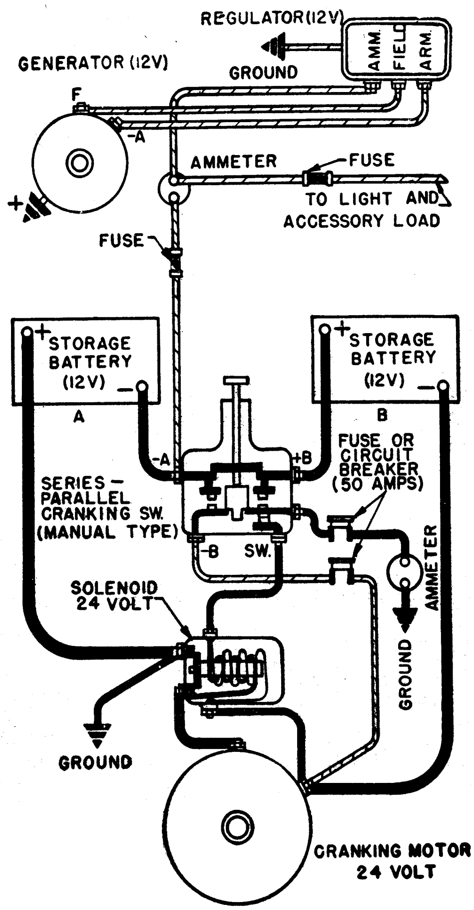

Fig. 8 Circuit diagram of series-parallel system with batteries connected in series through the series-parallel switch. Switch has been operated to cause starting motor to crank engine. Series connections are made through heavy contacts in switch and through heavy contacts in solenoid. Parallel connections in switch have been broken

duty gas engines, where the cranking requirements are severe.

The series-parallel switch consists of a push button and rod which, when depressed, forces a contact disc against a pair of heavy contacts. At the same time a small floating plunger is actuated which opens contact points to break the parallel connections between the batteries, and then closes another set of contact points to ground the starting motor solenoid so it operates and completes the series connections to the starting motor.

The series-parallel switch may be completely disassembled and reassembled, so that contacts may be cleaned or replaced as necessary. The diagrams, Figs. 7 and 8, and the exploded views, Figs. 9 and 10, of the series-parallel switch may be followed as a guide to the proper disassembly-assembly procedure.

The first step of disassembly is to remove the cover and the contact and terminal stud plate. This is done by unscrewing and removing the nuts and washers from the two main terminal studs and the SW terminals. The "B—" and ground terminals may be unscrewed from the switch cover. The cover, insulating plate, and gasket will now lift off the housing. The housing assembly may be disassembled by pulling the cotter key, unscrewing the slotted nut, and removing the contact disc, washers and spring. If the hex nut which is a part of the push button assembly is now unscrewed from the housing, the push button assembly, push rod, spring and sleeve, may be removed. The triggers and spring which, acting on the push rod, produce the quick-break action, may be removed by lifting out the springs and pushing out the trigger pins. The contact and terminal stud plate may be further disassembled by unscrewing nuts, and removing washers, terminal studs, insulators and supporting plate from the contact plate. Contact blades, with pins and hinge springs, are removed by pushing down on blades at hinge end and sliding from vee slots in support. Assembly is the reverse of the above. Apply a small amount of high melting point grease to the push rod and push button assembly on reassembly. Use Permatex to seal the sleeve and gasket under the push button assembly hex nut. The terminal studs should be re-

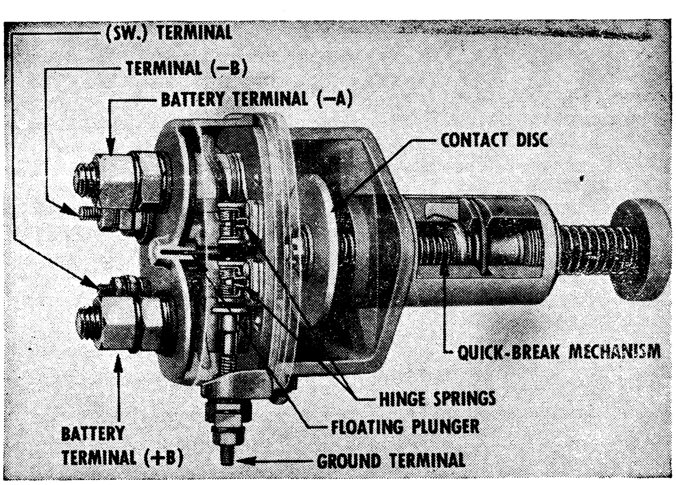

Fig. 6 Phantom view of series-parallel switch

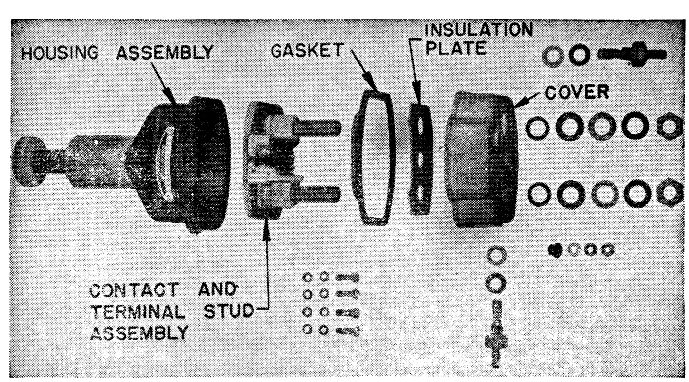

Fig. 9 Exploded view of series-parallel switch

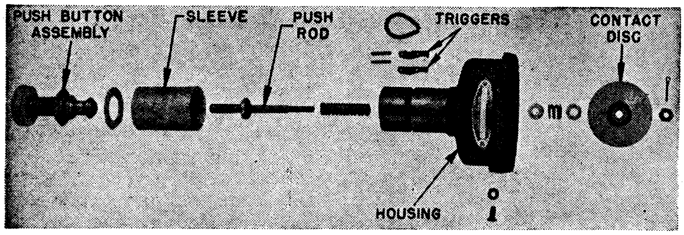

Fig. 10 Exploded view of series-parallel switch housing

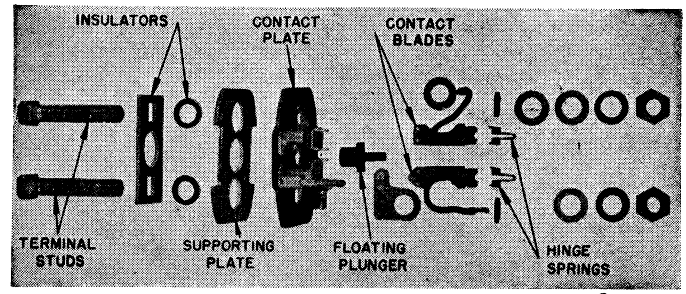

Fig. 11 Exploded view of contact and terminal stud assembly

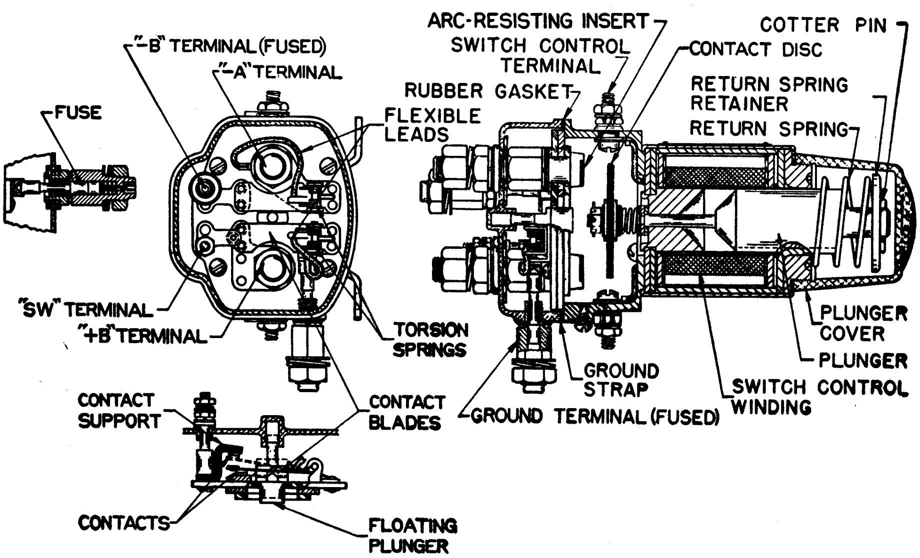

Fig. 12 Solenoid operated series-parallel switch. This switch is similar to the manually operated type except that it is operated by a solenoid controlled by a push button

assembled to the contact plate so that the heavy tungsten inserts on the stud heads will be located as near the centerline of the switch as possible. This will permit the maximum area of contact between the tungsten inserts and the contact disc when the switch is operated.

Since series-parallel switches are used on applications where heavy-duty starting motors and higher voltage batteries are installed, it is extremely important to avoid grounding any terminal on the starting motor or switch while the battery or batteries are connected. Due to the low resistance of the circuits, any ground would permit such a high current to flow that fuses would be blown and serious damage might result to the equipment. For this reason, it is strongly recommended that all exposed terminals be protected with friction tape and shellac, rubber tape, or rubber boots. In addition, care should be used to make sure that all leads and terminal clips are adequate to withstand the high current and mechanical shock and vibration on the installation.

DASH GAUGES

CONSTANT VOLTAGE DASH GAUGES

First introduced on some 1957 vehicles, the constant voltage system incorporates a voltage regulator as well as "senders" that are different from those used in previous systems, Fig. 1A. The new system can easily be tested with a voltmeter having a range up to 15 volts and with a fuel-gauge sending unit.

Responsible for the greater ease of testing is the greater simplicity of the new system. Essentially, it consists, in addition to the new-type senders, of a voltage regulator which changes the variable input from the car battery and charging system to a constant output of the gauges. When the ignition is turned on, the regulator current flows through a heating coil which encircles a bimetallic arm. Resulting heat causes the arm to bend and separate the contacts. Repeated making and breaking of the circuit supplies current at a pulsating 5 volt pressure to the gauges.

Senders for the fuel and oil-pressure gauges are rheostats. In the fuel-tank unit, the sliding contact brings full resistance into the circuit when the tank is empty and only a small amount of current flows through the dash-gauge heating coil. The bimetallic arm deflects the gauge pointer to "Empty." As the tank fills, the float arm moves the contact, decreasing resistance. As more current flows to the dash unit heating coil the pointer deflects toward "Full."

In the oil line, a contact, attached to the diaphragm, moves as pressure increases or decreases, varying the resistance in the circuit, and deflecting the gauge needle accordingly.

The sender for the temperature gauge contains an element in which resistance to the flow of electrical current increases with cold. As the engine warms up, resistance falls and the fuller flow of current to the gauge moves the pointer toward "Hot."

Trouble Shooting

When trouble develops, you can quickly put your finger on the cause through the use of the voltmeter and the fuel-gauge sending unit already mentioned. The latter should have a short ground lead and clip.

A word of caution about grounding: When testing or making replacement of a unit under the dash, be careful not to ground the wires to the gauges, sending units or regulator. A full flow of current through the regulator to ground will burn out this unit.

All the trouble that can develop in a constant-voltage gauge system falls into the following four distinct classes: 1. All gauges read too high; 2. All gauges read at high limit; 3. All gauges read too low; 4. One gauge is inaccurate or erratic.

When All Gauges Read Too High

When all gauges read too high, you will usually find that the voltage regulator is not properly grounded. To be sure, make a quick check with a jumper connected from the regulator case to the sheet metal of the instrument panel. Clean the mounting area to provide a good ground.