Trouble Shooting Section

OF THE

NATIONAL SERVICE MANUAL

OF

Starting—Lighting—Ignition

—EDITED BY—

JAMES ROLAND WRIGHT

Director of the Engineering Division

NATIONAL AUTOMOTIVE SERVICE

DETROIT - - - SAN FRANCISCO

Concerning the Use of Instruments

Electrical testing can only be successfully accomplished if reliable instruments are used. It is essential that to make ordinary tests the shop should be equipped with

1. Ammeter.
2. Voltmeter fitted with several scales, particularly .3, 3 and 30 volt instrument.
3. A 110 volt test line.

Both for ignition and starting testing an accurate ammeter is very valuable and shunts should be available so that it may be used to measure the heavy current consumed by the starter while on test.

Every shop should be equipped with a 110 volt test line as the lamp and test points are perhaps the most convenient and most widely used instruments in the shop. The test points are nothing more than sharpened copper prods inserted in insulated handles and connected to a flexible lead. The points are connected across the 110 volt line with a lamp in series. The lamp serves to limit the current flow and is usually of 25 to 40 watts. It also serves as an indicator and checks shorted and open circuits by lighting or remaining unlighted when the test points are applied to the terminals of the circuit. Before testing, the lamp itself should be tested by touching the two test points together. If it does not light the lamp should be replaced.

The Service Man will find a test bench practically indispensable. It allows performance tests to be run on ignition coils, distributors, starters and generators, and provides a convenient mounting for the units being tested. Through the use of flexible leads and definitely arranged switchboard circuits, it obviates the annoyance of wiring the units being tested.

BATTERY

The battery is so important a unit of the electrical equipment of the automobile that it deserves particular attention. It may be discharged or destroyed through failure of any of the electrical units, and will then cause the failure of the entire electrical system. For this reason the battery is the proper place to begin testing.

Battery failure may be caused by age since the demand on the battery is strenuous and its average life when used for starting and lighting is only fifteen months to two years. A defective starter or generator will cause rapid discharge or result in a constantly undercharged battery which will affect the condition of the plates and cause the battery to break down.

CAUSES OF DISCHARGE:

1. Unusual Operating Conditions.

Driving car at night or on short trips with constant use of the starter. For directions in changing the charging rate, see page on particular car in the NATIONAL MANUAL. In regulating the output a test ammeter should be inserted in the line at the generator terminal. The dash ammeter is not accurate enough for this work, since it does not indicate the current taken by the ignition.

2. Shorts or Grounds in the Lighting or Ignition Circuit.

Check for grounds by noting the dash ammeter with all lights off and the engine stopped. Pointer should indicate 0. A discharge indicates ground which locate as directed in "Lighting Circuit" section.

3. Defective Starter.

Starter may draw excessive current. Check starting circuit as directed in section on "Starting."

4. Defective Generator.

If generator does not charge connect a test ammeter in the generator circuit at the generator terminal and check output against the figures given on the car data sheets in the NATIONAL MANUAL, by operating the generator at various speeds.

On cars using relay, battery may be discharging through the generator windings at low speeds, if the relay contacts do not open. Note ammeter reading at low speed (below 6 miles an hour) with lights off. Reading should not be greater than 1 to 2 amperes. If reading is greater check relay as directed in "Generator" section.

5. Too Many Accessories.

The addition of spot lamps, signal lamps, cigar lighters, and wind-shield wipers may cause a discharge rate higher than the charging rate of the generator. Correct by increasing the charging rate.

6. Internal Defects.

Cracked or leaky battery jars or internal short circuits will cause battery to discharge. If the battery plates are sulpbated, battery will not hold charge. Open and inspect battery.

BATTERY TESTS:

1. Hydrometer Test.

All hydrometer tests should be made with a battery solution temperature as nearly 70° F. as possible since the figures given are standard at this point. Check hydrometer reading against following table.

1275 to 1300—Fully charged cell.
1200 to 1225—Practically discharged cell.
1150—Discharged cell—may be sulphated. Should be immediately charged.

To obtain correct hydrometer reading when battery solution temperature varies from 70° F. use following table:

When solution is	50° F.	subtract	8	points	from	hydrometer	reading.		
" " "	55° F.	"	6	"	"	"	"		
" " "	60° F.	"	4	"	"	"	"		
" " "	65° F.	"	2	"	"	"	"		
" " "	75° F.	add	2	"	"	"	"		
" " "	80° F.	"	4	"	"	"	"		
" " "	85° F.	"	6	"	"	"	"		
" " "	90° F.	"	8	"	"	"	"		
" " "	95° F.	"	10	"	"	"	"		
" " "	100° F.	"	12	"	"	"	"		
" " "	105° F.	"	14	"	"	"	"		

The battery solution temperature should never exceed 105° F.

A discharged battery where cells vary by less than 50 points is probably O. K. On a charged battery variations in cell readings should not be great. If there is a considerable variation or if the readings vary by more than 50 points on a discharged battery examine for internal short circuit, defective plates, cracked jars or doped electrolyte. Do not add acid or quick charging dope to the solution. If this has already been done, hydrometer reading will not be correct as a reading of 1300 might be secured from a totally discharged battery. In such cases battery must be completely charged and solution adjusted by adding distilled water until the specific gravity is brought down to 1275-1300.

2. Voltmeter Test.

If the electrolyte level is below top of plates where it cannot be reached by hydrometer, or if battery is suspected to be defective, a voltmeter test should also be made.

Turn on lights or connect resistance across the battery so that discharge current is approximately 5-10 amperes. Connect voltmeter across cell terminals. If cell is in perfect condition readings should be

2.1 to 2.2 volts—Fully charged cell.
1.8 volts—Practically discharged cell.

A cell giving a reading that varies by more than .1 volt from the others is probably defective and should be examined and given a Cadmium Test.

In general the voltage of a cell that is in order will not fall more than .1 volt, when beginning to discharge at the 5 ampere rate. A greater drop indicates a discharged cell, while a rapid drop or reversed reading indicates a cell that is out of order.

3. Cadmium Test.

The Cadmium Test can only be made while the battery is being charged or discharged and will check internal trouble in the cells. If test is made while the battery is on charge this should be done at the completion of the charge with the charging current at the finish rate.

If test is made while the battery is on discharge this should be done when the discharge is practically completed at the 5 ampere rate.

If no readings are secured in the Cadmium Test an internal short circuit probably exists.

Fasten a stick of cadmium to the side of a prod. Attach prod lead to the negative (—) terminal of a special voltmeter which is calibrated to read —.2 to +3 volts and fasten the lead from the other prod to the plus (+) terminal of the voltmeter. Insert the cadmium stick into the battery solution, being careful not to touch the plates. Touch the other prod to the negative (—) and positive (+) terminal posts of the cell, and check the voltmeter reading with the following tables:

a. Table for Battery on Charge

Positive (+) Prod.	Voltmeter Reading	Indication
On (+) post of cell.	2.35-2.45 volts	Positive plates O. K. and fully charged.
On (+) post of cell.	Under 2.34	Positive plates probably defective
On (—) post of cell.	—.1 to —.2 volts	Negative plates O. K. and fully charged.
On (—) post of cell.	Less than —.1 or positive	Negative plates probably defective

If the cadmium test indicates that the plates are fully charged, the specific gravity of the solution should be 1275 to 1300. If it differs from this the solution should be adjusted to give this figure.

b. Table for Battery on Discharge

Positive (+) Prod.	Voltmeter Reading	Indication
On (+) post of cell.	2.05 volts	Positive plates O. K.
On (+) post of cell.	Less than 2. volts	Positive plates probably defective
On (—) post of cell.	.25 volts	Negative plates O. K.
On (—) post of cell.	More than .25 volts	Negative plates probably defective

In order to check the capacity of the battery, multiply the number of hours over which the 5 ampere rate was secured by the discharge current. The resulting capacity in ampere hours should be compared with the data given on that particular battery in the NATIONAL MANUAL.

4. High Amperage Test.

Before sending the battery out of the shop, it is advisable to give it the high amperage test which is made for the purpose of checking the condition of the battery plates and separators, and determining whether the battery will hold the charge and perform satisfactorily when installed on the car.

Connect a resistance across the battery terminals and take voltage readings across each cell while current is flowing. The resistance unit should allow approximately 25-30 amperes for each positive (+) plate of the cell or 150-200 amperes for an ordinary 13 plate battery. (A 13 plate battery has 6 positive (+) plates and 7 negative (—) plates.)

The readings of the cells should not vary by more than .1 volt. If one cell differs from the others by a greater amount it should be closely examined. The voltage of a fully charged battery should not fall below 1.7 volts.

Feel the cell connectors after the current has been discharging. Poorly burnt connections will be hot to touch.

BATTERY IGNITION

The ignition circuit consists of the battery, ammeter, ignition switch, coil, breaker contacts, condenser, distributor, spark plugs and the wires used to connect the low and high tension lines.

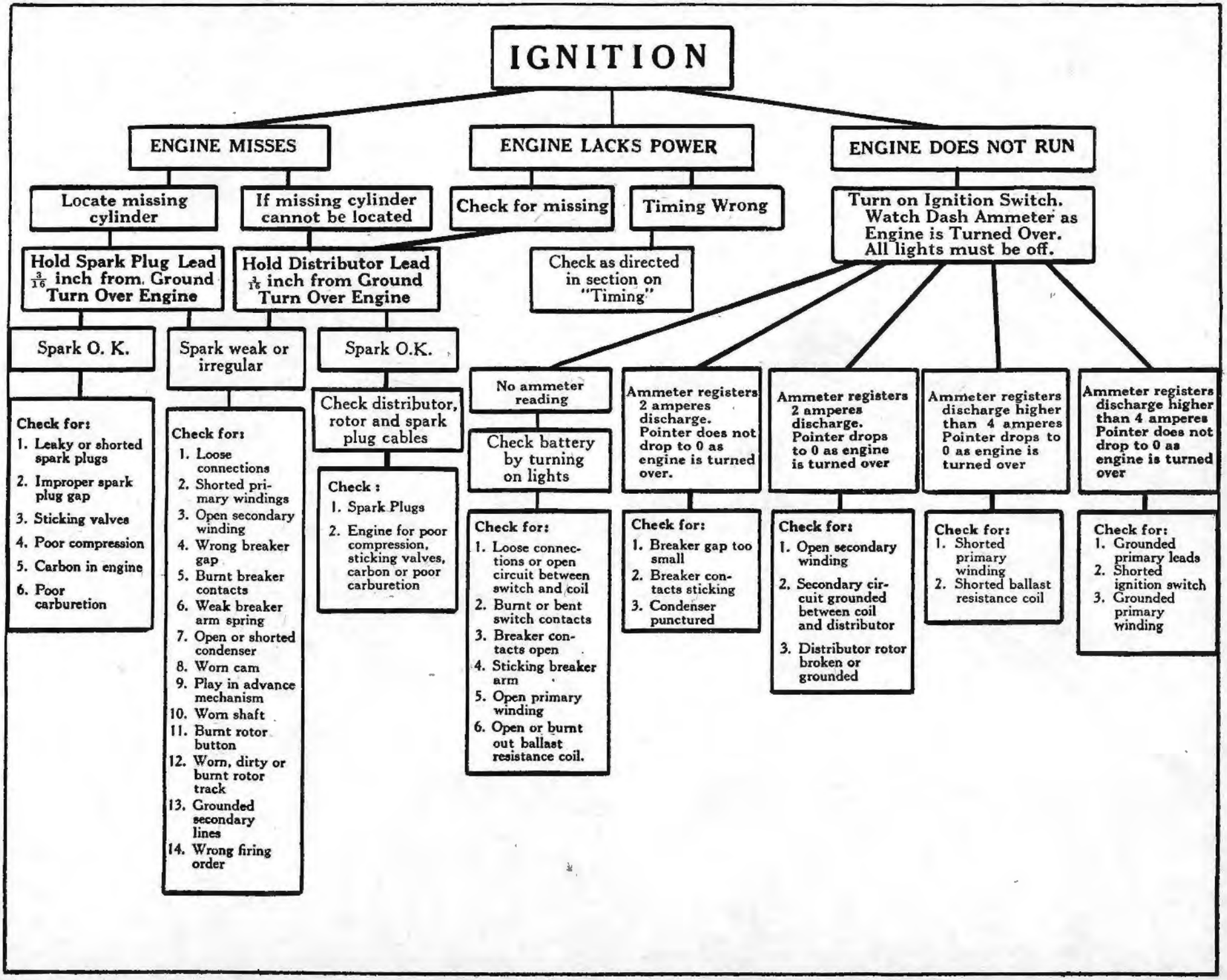
Ignition trouble consists of: (1) Missing caused by mechanical trouble or weak spark; (2) loss of power and poor acceleration caused by faulty timing; (3) complete failure of the ignition system preventing the engine from running.

If engine misses, locate missing cylinder by running engiue on two cylinders alternating until missing cylinder is found. Check condition of spark by holding the spark plug lead 3/16 inch from ground. The spark should jump regularly as the engine is turned over. If it does ignition is O. K. Then check engine for fouled or cracked spark plugs, incorrect spark plug gap setting, weak compression caused by sticking valves or worn cylinders and pre-ignition caused by carbon deposits. If spark is weak or jumps irregularly test ignition system as directed in following table.

If missing cylinder cannot be located, test spark by holding high tension lead from coil to distributor about 3/16 inch from engine block while cranking engine. If spark tests O. K. check distributor head, rotor button and spark plug cables.

Causes of Engine Missiug.

1. **Loose connections in the ignition circuit.** Check the connections at ammeter, ignition switch, coil and breaker. See that condenser pigtail connection is tight.
2. **Short circuited primary or open circuited secondary in the ignition coil** Test on the bench if spark is weak and no other cause can be discovered.
3. **Wrong breaker contact gap.** Check and adjust as directed on car data sheets in the NATIONAL MANUAL. If breaker gap is too small en-



gine will miss at low speeds. If too large it will cause missing at high speeds.

4. **Burnt breaker contacts.** Resurface contacts or replace as directed in section on "Distributors."
5. **Weak breaker arm spring.** If weak the spring will not close the contacts at high speeds. Check tension with a small spring balance and replace breaker mechanism if found defective.
6. **Defective condenser.** A leaky condenser will cause missing. An open or short circuited condenser will cause complete failure of the ignition system. Test as directed in section on "Condensers."
7. **Worn cam.** A worn cam may cause irregular firing and missing at high speeds. Check and replace.
8. **Wear in the distributor shaft.** Check for wobbling. If shaft is worn replace it.
9. **Play in advance mechanism.** Causes irregular firing.
10. **Defective distributor rotor.** If bent or burnt it should be replaced.
11. **Glazed or burnt rotor track or bent contacts.** Clean as directed in section on "Distributors."
12. **Defective insulation in high tension leads.** Examine for chafed or burnt insulation permitting current leaks to ground. Replace the defective leads with high tension cable.
13. **Wrong secondary connections.** Check firing order as given in the NATIONAL MANUAL.

If engine lacks power, check timing as directed in section on "Timing."

If engine will not run, test spark by turning on ignition switch and watching ammeter as engine is turned over. The dash ammeter should register 2-4 amperes with the engine stopped and all lights off. The current flow may reach 4-6 amperes momentarily but should cut down within a few seconds due to the heating up of the ballast resistor. If the breaker arm is on the high point of the cam no discharge will be shown until the engine is turned over. On systems using the open circuit principle no discharge will be shown until the contacts are closed by the breaker arm reaching the high point of the cam.

Check ammeter against following table as engine is turned over.

1. **No ammeter reading.** Primary connections are loose. Primary winding or ballast resistor is open. Breaker contacts are defective, breaker arm stuck or spring weak or broken. Check battery. If lights burn battery is O. K. Touch primary lead at coil to ground momentarily. If flash is secured ignition switch and primary lead are O. K. Test coil and breaker as directed in following sections.
2. **Ammeter reading 2 amperes steady.** POINTER DOES NOT SWING BACK TO 0 AS ENGINE IS TURNED OVER. Breaker contacts are shorted or condenser is punctured. Examine and test as directed in following sections.
3. **Ammeter reading higher than 4 amperes.** POINTER PERIODICALLY SWINGS TO 0 AS ENGINE IS TURNED OVER. Primary winding or ballast resistor is shorted. Test on the bench as directed under "Ignition Coil."
4. **Ammeter reading higher than 4 amperes.** POINTER REMAINS STEADY—DOES NOT SWING PERIODICALLY. Primary leads or primary winding are grounded. Examine leads and test coil.

IGNITION COIL.

The internal circuits of the ignition coils differ with the different electrical manufacturers and can be checked by referring to the car diagrams in the NATIONAL MANUAL. In general the secondary winding is connected to the primary winding or is grounded to the coil shell. The condenser may be enclosed in the coil shell. Test as follows:

For Open Circuit. Test primary winding with a test lamp placing one test lead on each of the primary terminals. The lamp should light. If it does not the primary is open. Test secondary in the same way. Due to high resistance the lamp will not light. Small sparks should be visible when the circuit is broken.

For Short Circuit. Test primary winding for short circuit by connecting the coil in series with an ammeter to a six volt battery. Excessive current flow indicates short circuits in the primary. See that current flow is not caused by shorted ballast resistor. Test resistance unit with the lamp and test points. It should never be connected across the battery. Short circuits in the secondary can only be checked by noting the spark while running a performance test on the bench. A weak spark then indicates defective secondary winding.

For Ground. Test for ground by placing one test lead on the primary terminal and the other on the coil base. The lamp should not light. If it does the primary winding is grounded. If the condenser is in the coil shell, a punctured condenser will also cause the lamp to light.

Final Service Test. Connect the coil to a breaker setting the gap as given on the particular system in the NATIONAL MANUAL and connect secondary circuit to an air gap of approximately 3/8 inch between needle points. Connect a condenser known to be O. K. across the breaker contacts. If the condenser is in the coil check by alternately using one coudenser and the other.

Operate the coil for at least an hour allowing it to become thoroughly heated. Check the current consumption and the condition of the spark throughout this time. They should not vary. If spark is O. K. when test condenser is used but is faulty when coil is run on its own condenser, the condenser or coil must be replaced. If spark is faulty under all circumstances secondary circuit is defective and coil must be replaced.

CONDENSER.

The simplest method of testing the condenser is to substitute a condenser known to be perfect and check coil operation. In making this test the suspected condenser should be disconnected from the circuit.

Condenser tests should be made as follows:

For Short Circuits. Test with lamp and test points. Disconnect condenser or insulate breaker contacts by placing a piece of cardboard between them. Then place one test point on each of the condenser leads. The lamp should not light. If it does the condenser is shorted.

For Open Circuits. Place one test point on condenser terminal and touch other test point to the other condenser terminal. If condenser is perfect small sparks will be visible when the circuit is broken. If this test is made with alternating current the sparks will not be visible every time the circuit is broken.

For Grounds. Disconnect condenser leads and place one test point on condenser case and touch other test point to condenser lead. The lamp should not light. If it does the condenser is grounded.

Capacity Test. Connect the condenser to the center poles of a D. P. D. T. switch and connect it in series with a voltmeter to a 110 volt D. C. line. Connections must be made so as to reverse the direction of current flow every time the switch is thrown. Cheek the voltmeter reading when the switch is thrown and compare this reading with the figures obtained by previous tests with a perfect condenser. **This test can not be made with A. C. current.**

DISTRIBUTOR.

See that distributor head is clean and free from oil. The rotor track should be smooth and glazed. Wipe out distributor head with vaseline or heavy grease removing all excess and polishing rotor track with a soft clean cloth. See that rotor button is making firm contact and that the carbon brush is free to move in its holder. On distributors using the jump-spark principle see that contacts are not burnt or out of line and that rotor button rotates freely.

BREAKER.

Breaker contacts are usually made of tungsten. The surface of the contacts should be gray, flat and smooth. Badly burnt or blue contacts may be caused by a defective condenser. Check operation of breaker as follows:

Wrong Contact Gap. Check contact gap opening with figures given on the car data sheet in the NATIONAL MANUAL. **These figures are recommended by the manufacturers and should be closely followed.** To set gap place breaker arm on high point of the cam and set movable contact to give proper opening. This distance should be set with a feeler gauge.

Burnt Contacts. If contacts are not parallel or are burnt resurface on an oilstone or with a fine flat contact file. If they are badly burnt or pitted they should be replaced. Check contact opening after resurfacing contacts.

Weak Breaker Arm Spring. See that breaker arm spring has sufficient tension to close contacts quickly. The spring tension should be approximately 15-20 ounces. It may be tested with a small spring scale by lifting the breaker arm from the cam and noting the force required at the instant the contacts separate.

Worn Cam. Check cam for irregularities in wear by checking contact opening on each high point of the cam. If the opening is not uniform the cam should be replaced.

Defective Advance Mechanism. Make certain that manual advance lever is connected to the breaker mechanism and correctly working. Check for play or lost motion caused by wear. If automatic advance is used see that advance mechanism operates freely with no great amount of lost motion.

Worn Distributor Shaft. Check distributor shaft for wobbling caused by insufficient lubrication and consequent wear. If there is excessive play the shaft or distributor housing must be replaced.

Grounded Contact. Test insulated contact for short to ground with the test lamp. Disconnect coil lead and insulate contacts by placing a piece of cardboard between them. Then place one test point on the insulated contact and touch the other test point to the breaker frame. The lamp should not light. If it does the insulated contact is grounded and must be repaired.

TIMING.

Manufacturers issue special instructions on timing. **These are given on the car data sheets in the NATIONAL MANUAL and should be closely followed.**

Causes lack of power, sluggish acceleration and overheating of the engine.

Late Timing. Cheek automatic advance mechanism for binding subshaft or sticking weights. Check manual advance rod for positive connection to breaker housing. On systems using movable cam for timing check cam for slipping. Check rotor and see that pin holding distributor rotor is not bent.

Causes backfiring in starting, knocking when rapidly accelerated and lack of power.

Early Timing. Check automatic advance mechanism for weak or broken springs. Check manual advance rod for positive connection. Check cylinders for carbon deposits causing pre-ignition.

To check timing proceed as follows:

Single Contact Systems. Insert a six or twelve volt lamp in the primary circuit at the breaker or connect the lamp across the breaker contacts. The lamp will go out when the contacts open. If connected across the contacts the lamp will light when the contacts open. Check position of engine with data given on particular car in NATIONAL MANUAL.

Where double contact system is used they must be synchronized so that both contacts open at the same instant. Check as in the single contact system.

If breakers are connected in parallel in the primary circuit connect the test lamps across the breaker contacts. The lamps should light at the same instant.

Double Contact Systems. If breakers control separate primary circuits connect lamps in circuit. The lamps should go out at the same instant. If connected across breaker contacts lamps should light at the same instant.

If contacts do not separate at the same instant adjust by loosening one breaker mounting plate and shifting until both breaker arms are on the high point of the cam. Check position of engine when contacts separate with data given in the NATIONAL MANUAL.

Systems Using Two Contacts Opening Alternately.

ON 90° ENGINES. Test as directed for single contact systems. Contacts open at intervals of 45°. Check by flywheel markings or by marking firing intervals of 45° on a scale which will fit within the distributor housing. Check rotation of distributor shaft between contact openings by noting position of the pin or a mark made on the cam.

This type of ignition is used on some of the new straight eight engines.

ON 60° ENGINES. Test as directed in previous paragraph. Breaker contacts separate at intervals of 30 and 60° corresponding to periods of 60 and 120° of crankshaft rotation.

MAGNETO IGNITION

Magneto ignition systems are of two types. Straight magneto ignition consists of a high tension magneto with ground switch to control circuit. Dual or duplex systems use high tension magneto with battery attachment for starting. Battery circuit has separate coil and breaker and uses magneto distributor and spark plugs or may nse magneto windings to generate secondary current.

If engine fires irregularly, locate missing cylinder by shorting out two cylinders at one time and running engine on remaining cylinders. If missing cylinder is located check condition of spark by holding spark plug lead ¼ inch from cylinder block while turning over engine. If spark jumps regularly and is blue in color ignition system is O.K. and trouble is caused by condition of engine. Check spark plug for leak, fouled contacts or gap set too wide. If gap is incorrectly set spark may jump at safety gap in magneto, causing engine to miss.

Check for:—

DEFECTIVE DISTRIBUTOR BRUSHES AND ROTOR TRACK. Check carbon brushes for proper contact and wipe off rotor track with heavy grease, polishing with clean cloth.

If Magneto Spark Weak, Causing Engine to Miss.

BURNT CONTACTS. Resurface with worn No. 00 sandpaper or flat contact file, as magneto contacts are of platinum. Set for proper opening in accordance with figures given on particular system in the NATIONAL MANUAL. If gap is too wide engine will miss at high speeds. If breaker gap is too small engine will miss at low speeds.

DEFECTIVE CONDENSER. If breaker contacts are badly burnt or pitted examine condenser for loose connections or open circuit. Check by connecting test condenser across contacts and noting condition of spark. If spark is O.K. magneto condenser must be repaired or replaced.

WEAK MAGNETS. Weak magnets will cause missing at low speeds or while pulling heavy load and cause hard starting. They are caused by constant use or removal from the magneto without the protection of a keeper. Check by rotating magneto by hand, noting force required to turn armature over point of maximum inductance. If no point of distinct resistance is felt or if resistance is less than that of a perfect magneto, recharge magnets on regular magnet recharger. Recharge magnet with same poles as originally charged, placing north pole of magnet on south pole of charger. Use compass to check this condition. Allow magnet to remain on charger for several seconds, tapping magnet lightly to assist process. Place a keeper or flat bar of iron across magnet poles before removing from charger and do not remove keeper until magnet is in contact with pole piece of magneto. This is important to retain the magnetism. In replacing magnets make certain that all magnets have like poles together. Check with compass. A reversed magnet will cause weak spark. RECHARGING FORD MAGNETS. Magnets on Ford magneto can be recharged without removing from car. Remove floor boards and disconnect lead from magneto terminal on flywheel housing. Place compass over flywheel, slightly behind terminal post and 1 inch to left. Then crank engine until north pole of compass points directly forward toward front of car. Connect two six volt batteries in series, connecting positive lead to magneto terminal. Then flash negative lead to engine block or flywheel case several times to insure proper magnetizing of the coils.

WEAR IN MAGNETO BEARINGS. Check magneto for wear in the bearings or excessive end play, permitting increased air gap between armature core and pole pieces. This

will reduce intensity of magnetic flux and cause weak primary current.

DEFECTIVE WINDINGS. Shorted primary and shorted or open secondary windings may cause weak spark. Disassemble magneto and test as directed below.

DEFECTIVE COLLECTOR RING OR BRUSH. Examine high tension brush and ground brush for proper contact. Check collector ring for punctured insulation, permitting current leak to ground, as directed below.

If engine stops suddenly or fails to start disconnect switch lead at magneto and crank engine. If engine fires switch lead or switch is grounded and must be repaired. If engine does not fire check spark by holding spark plug lead ¼ inch from ground while cranking engine. If spark jumps satisfactorily, ignition system is O. K. If no spark is visible check secondary circuit by removing high tension lead to distributor from terminal on distributor face and holding near ground. If spark is O.K. check distributor brush for proper contact, rotor track for burnt or pitted surface and spark plug leads for grounds. If no spark is found check trouble from following table.

BREAKER CONTACTS BURNT OR OPEN. Check breaker contacts for correct setting and proper condition. Resurface contacts and set gap as directed in NATIONAL MANUAL.

If No Spark at Secondary Terminal.

PUNCTURED CONDENSER. Disconnect condenser and crank engine. If system operates condenser is shorted and must be replaced. Do not continue to run without condenser or contacts will be burnt. On systems with condenser incorporated in armature assembly condenser lead is soldered to primary.

DEFECTIVE BRUSHES. Check primary contact at breaker and examine ground brush for proper contact. Check high tension brush and examine collector ring for punctured insulation, permitting internal short circuit of secondary current. Test by removing high tension brush, inserting small screw driver in opening, providing gap of ⅛ inch to ground. Rotate magneto. If no spark jumps gap, collector ring is shorted or primary or secondary windings are open or shorted.

DEFECTIVE WINDINGS. Test primary winding after removing armature from magneto with lamp and test points connected to a six volt battery. Disconnect primary lead where grounded to core. Then touch one test point to each primary lead. The lamp should light. If it does not the primary is grounded. Touch one test point to primary lead and other to armature core. The lamp should not light. If it does the primary or condenser is grounded. Disconnect condenser lead and test separately. Test secondary winding with test leads connected to voltmeter in series with battery. Touch one test lead to secondary terminal and touch other to armature core. If reading is indicated on voltmeter scale secondary is grounded. Secondary leads must not be touching the armature core in making this test.

If engine does not stop when ignition switch is opened, switch or line from switch to magneto is open. Stop engine by short circuiting from switch terminal on magneto to ground. Check line for breaks or loose connections and examine switch for proper contact of switch arm.

LIGHTING CIRCUIT

The lighting circuit consists of the battery, ammeter, lighting switch, circuit breaker or fuses where used, the lamps, horn and other appliances, and the lines used in connecting them. Lighting circuit troubles are as follows:

Check fuses on lighting switch or in fuse block on dash. Do not replace blown fuses until lighting circuit has been tested for shorts and grounds as directed in sections following on "Lines and Switches." Check circuit for open connections examining lines at ammeter, lighting switch and junction block where used. Check for defective switch as directed in section following on "Switches."

Lighting Circuit Dead.

Circuit Breaker Operating.

Check lines for shorts or grounds as directed in section on "Lines."

Check for loose connections at ammeter, lighting switch, junction block and lighting socket. Test battery with hydrometer as directed in "Battery" section. Check for broken wires in lighting lines. Check fuse clips for positive contact.

Lights Dim or Flickering.

Disassemble switch and examine switch contacts. If burnt resurface and reshape to insure firm contact.

Lights Flare Up and Burn Out.

Check charging circuit for loose connections causing high generator voltage as directed in section on "Generators."

Fuses Blow Irregularly

If fuses blow or circuit breaker operates irregularly and lighting lines check O. K. look for an intermittent ground caused by vibration. Check lines for chafed insulation.

Test lighting circuit as follows:

1. **LINES.** Test lighting lines with a lamp and test points first disconnecting car lamps to prevent their burning out. Turn the lighting switch to the "Off" position.

Place one test point on the line terminal being tested and touch the other to the car frame. The lamp should not light. If it does the line is grounded and must be repaired or replaced. Test lighting sockets by disconnect-

For Grounds.

BATTERY

CAUSES OF DISCHARGE

Unusual Driving Conditions

Change charging rate
See directions in section on "Generators"

Too Many Accessories

Change charging rate
See directions in section on "Generators"

Shorts or Grounds in Lines

Test with lamp and test points as directed in section on Lines under "Lighting"

Defective Starter

Check for:

1. Grounded starter cable
2. Grounded or shorted starter.

Test as directed in section on "Starters"

Defective Generator

Check for:

1. Discharge through generator windings
2. Low charging rate.

Test as directed in section on "Generators"

Defective Battery

Check for:

1. Sulphated plates
2. Cracked jars
3. Internal short circuit.

Test as directed in section on "Batteries"

LIGHTING

Lighting Circuit Dead

Check for:

1. Blown fuses. Check lines for shorts or grounds. If lines test O.K. look for intermittant ground caused by vibration.
2. Open connections.
3. Defective switch. Check as directed in section on "Switches"

Circuit Breaker Operating

Check for:

Shorts or grounds in lines. Test as directed in "Lines" in section on "Lighting"

Lights dim or flickering

Check for:

1. Discharged battery. Test with hydrometer.
2. Loose connections
3. Loose fuse clips. Check for firm contact.

Lights flare up and burn out

Check for:

1. Loose connections in charging circuit. Examine connections at relay, ammeter, switch and battery for loose connections causing high voltage
2. Grounded third brush arm
3. Defective regulator. Test as directed in section on "Relay-Regulators"

ing lighting line and placing one test point on insulated contact and touch other point to frame after removing the bulb. The lamp should not light. If it does the socket is defective and must be replaced.

For Open Circuit. Place one test point on each end of the lighting line. The lamp should light. If it does not the line is broken and must be repaired or replaced.

2. **SWITCHES.** Test switch with lamp and test points to make certain that contacts are O. K. and that switch is correctly assembled. In testing switch remove fuse if still O. K.

Switch Circuits. Place one test point on battery terminal of the switch and touch other test point to switch terminals noting when lamp lights. The lamp will light when switch contacts close the circuit. Note position of lever and check circuits completed through switch with diagram given on the car data sheet in the NATIONAL MANUAL. If lamp does not light when test point is touched to proper terminal as indicated by switch lever position, disassemble switch and examine.

Switch Contacts. Clean switch contacts and make certain that they make firm contact with the switch spider or arm.

Dimmer Resistance. If head lamps burn bright in both "Bright" and "Dim" positions dimmer resistance is shorted and must be replaced. If head lamps burn in "Bright" position but are dead in "Dim" position dimmer resistance is open, being disconnected or burned out. Examine and replace.

3. **CIRCUIT BREAKER.** Circuit breakers when used are mounted on the back of the switch or on the dash. Vibrating circuit breakers limit the current flow and produce a perceptible noise attracting attention to the system. Test circuit breaker by connecting it to a six volt battery in series with an ammeter. The circuit breaker should open the circuit at 25-30 amperes and continue with a current flow of 10-15 amperes. Test vibrating circuit breakers with a lamp and test points.

For Open Circuits. Place one test point on each of the circuit breaker terminals. The lamp should light. If it does not the coil is open and the circuit breaker is defective. It must be replaced.

For Short Circuits. Place one test point on the circuit breaker terminal and touch the other to the frame. The lamp should not light. If it does the winding is shorted to ground and must be repaired or replaced.

Adjust Delco vibrating circuit breakers in accordance with the following instructions:

1. **Circuit Breaker Cuts Out With Greater Current Flow Than 30 Amperes.** Decrease length of plunger spring by cutting off a piece about 1/16 inch in length or file off end of plunger slightly.

2. **Circuit Breaker Cuts Out With Current Flow of Less Than 25 Amperes.** Increase spring tension by stretching it slightly or increase air gap between plunger and frame. The normal air gap should be .019-.025 inch.

3. **Current Flow Greater Than 15 Amperes With Circuit Breaker Operating.** Decrease air gap slightly by bending frame nearer to plunger disk.

Lockout circuit breakers may be used to protect the horn, handy lamp and accessory circuits. Test with lamp and test points as follows:

Open Circuited Series Winding. (HEAVY WINDING.) Place one test point on the battery terminal of the circuit breaker and other test point to either of terminals to which lamps are connected. The lamp should light. If it does not the heavy winding is open or the contacts are defective. With the test points in place separate the contacts. The lamp should glow dimly. If it does not the fine winding is open. It must be repaired or the circuit breaker replaced.

Open Circuited Shunt Winding. (FINE WINDING.)

In reassembling lighting circuits see that all connections are clean and tight and that lights are correctly wired. Test by placing switch in all positions and noting lamps lighted. Connect accessories to the terminal on junction block to which generator and ammeter leads are connected. If junction block is not used connect to switch side of ammeter or to battery terminal on switch. If connected to horn terminal on switch accessories will be protected by horn fuse where used.

After assembly test electrical system for leaks or shorts to ground by disconnecting battery ground cable and connecting voltmeter between battery and ground. With all lights off and engine stopped the voltmeter reading should be 0. A reading indicates grounds. In making this test all switches must be in the "Off" position. A closed switch will give a voltmeter reading even though no current is flowing in the line.

GENERATOR

Generating circuit consists of generator, relay or relay-regulator, ammeter, battery and lines used to connect these units. In normal operation generator begins to charge at 6-10 miles per hour and reaches its maximum at 25-30 miles per hour. If generator fails to charge battery satisfactorily check performance by watching dash ammeter while slowly speeding up engine. Check generator performance with following table:

Ammeter Does Not Indicate Charge or Discharge.

GENERATING CIRCUIT IS OPEN. Check for loose connections and broken lines.

DEFECTIVE RELAY. Check by bridging relay contacts by connecting short wire across relay terminals. If generator indicates charge, relay is defective or generator voltage is low. Test as directed below.

DEFECTIVE AMMETER. Check by turning on lights with engine stopped. Ammeter should indicate 5-10 amperes discharge. If no discharge is shown check connections between ammeter and battery and ammeter and lighting switch. If connections are O. K. ammeter is defective and must be replaced.

DEFECTIVE GENERATOR. Give performance test as directed below.

Ammeter Indicates Discharge.

REVERSED BATTERY OR AMMETER CONNECTIONS. Check by turning on lights with engine stopped. If ammeter indicates charge battery has been installed in reverse position or ammeter reversed. Check battery connections. If reversed change connections. If O. K. change ammeter connections. In generators using relay control, reversed battery may permit generator to build up with opposite polarity causing battery discharge or faulty relay operation. Change residual magnetism of generator by bridging relay contacts with wire for several seconds with the engine stopped.

DEFECTIVE GENERATOR. Battery discharging through generator windings. Check generator for shorts or grounds by Motoring Test as directed below.

Ammeter Indicates Charge at Slow Speeds or for Short Interval Then Indicates Discharge.

DEFECTIVE RELAY-REGULATOR. Check regulator for open resistance coil.

DEFECTIVE THERMOSTAT. Examine thermostat closely for bent arm or burnt out resistance. If defective, thermostat must be replaced.

Low Charging Rate. (Does Not Approach Maximum.)

LOOSE CONNECTIONS. Check generating circuit for loose connections at relay, ammeter, switch, aud battery.

DEFECTIVE GENERATOR. Check for internal defects by performance test.

High Charging Rate. (Exceeds Maximum or Does Not Decrease After Peak Speed Is Reached.)

DEFECTIVE RELAY-REGULATOR. Test relay-regulator as directed in section on "Relay-Regulators."

GROUNDED THIRD BRUSH ARM. On third brush systems where field is connected to ungrounded main brush, grounded third brush causes generator to operate as a straight shunt machine. Test as directed in section on "Starter and Generator Internal Testing."

Test defective units of generating circuit as follows:

1. RELAYS.

Check relay operation by connecting voltmeter between generator terminal and ground or across generator terminals in a two wire system. Slowly speed up generator and note terminal voltage when relay contacts close. The voltage will drop slightly at this point. Check with data given for particular car in the NATIONAL MANUAL. See that relay contact gap is correctly set. Check air gap between relay armature and coil core for correct clearance. This is important since the armature will stick if allowed to touch the core and will not open the relay contacts. Correct figures for contact gap and air gap are given on each car data sheet in the NATIONAL MANUAL. If relay closes normally but generator does not charge, series coil is open. If relay contacts do not close but generator charges when contacts are closed by hand, shunt coil is open or shorted. Test relay series coil (coarse winding) and shunt coil (fine winding) for open and shorts as follows:

Series Coil.

Test with lamp and test points. Place one test point on generator terminal and one on battery terminal of relay. Close relay contacts. The lamp should light. If it does not series coil is open. Repair or replace relay.

Shunt Coil.

Test for open circuit with lamp and test points. Place one test point on generator terminal of relay and touch other point to relay base. The lamp should light. If it does not shunt coil is open or series coil is open where shunt winding is connected to series winding at relay contact.

Test for short circuit by connecting six volt battery across shunt winding. Check magnetism by raising relay armature with the hand. There should be considerable attraction between the core and armature. If little or no magnetism exists the shunt winding is shorted.

Relay Contacts.

Check condition of relay contacts. Burnt contacts may be caused by poor adjustment, improper relay setting allowing contacts to separate while carrying heavy current or reversed battery causing relay armature to flutter with constant breaking of circuit. Resurface coutacts with worn No. 00 sand paper and adjust contact opening.

2. RELAY-REGULATORS.

Generators using straight shunt field use regulators to control the current output The relay and regulator are incorporated in one unit but usually have independent windings. Check relay of relay-regulator as directed in paragraph above. Regulators either cut a fixed resistance into shunt field circuit or vibrate and so limit the field current. Examine regulator resistance for open circuit caused by high generator voltage burning out resistance. Check condition of regulator contacts. High generator voltage or improper regulator setting will cause burnt contacts. Resurface with worn No. 00 sandpaper and adjust contact opening. To set regulator, operate geuerator with ammeter in circuit at generator terminal and voltmeter connected between generator and ground Increase or decrease regulator armature spring tension until generator performance agrees wth performance table given on car data sheet in the NATIONAL MANUAL.

3. THERMOSTATS.

Thermostat may be connected in shunt field circuit and is mounted in the brush rigging. Thermostat contacts open at 165-195° F. cutting resistance in the field circuit. Examine thermostat for burnt out resistance unit or bent arm preventing correct operation. If thermostat is defective replace it.

4. GENERATOR.

Check generator by running performance test. If performance test is run on the bench more accurate results will

GENERATOR

RUN ENGINE FASTER THAN 10 M. P. H. WITH ALL LIGHTS OFF

DASH AMMETER INDICATES DISCHARGE

Check for:

1. Ground in line between relay and ammeter
2. Reversed battery
3. Reversed ammeter polarity

Check Generator for:

1. Ground between relay terminal and main brush
2. Open field or blown field fuse
3. Grounded field coils
4. Shorted field coils
5. Grounded brush arm
6. Open or shorted armature coils
7. Broken or slipping drive

DASH AMMETER REGISTERS 0 OR 2 AMPERE IGNITION DISCHARGE

Bridge relay terminals with short wire

READING UNCHANGED

Check for:

1. Open connections at relay, ammeter or switch
2. Broken line between generator and switch

Check Generator for:

1. Open brush connections
2. Sticking brush arms
3. Shorted armature coils
4. Dirty or burnt commutator
5. High mica

GENERATOR CHARGES O. K.

Check Relay for:

1. Contact setting wrong
2. Burnt contacts
3. Open series coil
4. Open shunt coil

Check Generator for:

1. Wrong brushes
2. Oily brushes
3. Loose connections in armature or field

CHARGING RATE BELOW NORMAL

Check for:

1. High ignition current caused by shorted primary or ballast resistance coil
2. Loose connections in generating line
3. Shorts in line between generator and ammeter
4. Burnt or badly adjusted relay contacts
5. Regulator or thermostat contacts open or burnt

Check Generator for:

1. Slipping drive
2. Loose brush or field connections
3. Reversed field coil
4. Resistance in field circuit
5. Grounded or shorted field coil
6. Wrong third brush
7. Dirty, oily or burnt commutator
8. High mica
9. High resistance main brushes
10. Open armature coils
11. Third brush in retarded position

CHARGING RATE ABOVE NORMAL

Check for:

1. Grounds in line between ammeter and battery
2. Regulator contacts sticking. Resistance coil shorted

Check Generator for:

1. Grounded third brush arm
2. Wrong brushes
3. Low resistance third brush
4. Third brush arm advanced too far

be obtained. Connect ammeter in generating circuit at generator terminal and connect voltmeter between terminal and ground or across generator terminals. A test ammeter must be used since the dash ammeter does not register current taken by ignition and is not accurate enough for this work. The generator when run on test must always be connected to the battery since the regulating action of the third brush depends on this. If run on open circuit the generator voltage increases until the windings burn out. Run generator at various speeds and record ammeter and voltmeter readings. Check results with test data given for each car in the NATIONAL MANUAL.

Performance Test.

DEFECTIVE DRIVE. Examine for slipping belt, sheared key or sticking or worn rollers in overrunning clutch where used. Disassemble clutch and clean with gasoline. Repack with vaseline or medium heavy grease.

Generator Dead. (No Terminal Voltage or Amperage.)

OPEN FIELD OR REVERSED FIELD CONNECTIONS. Examine field connections at third brush and main brush or ground and check fuse clips for positive connection. Test field coils for proper polarity as directed in section on "Fields" under "Starter and Generator Internal Testing."

BLOWN FUSE OR BURNT OUT FIELD. Check field fuse or field winding where no fuse is used for damage caused by high generator voltage or shorts permitting high current flow.

WEAK RESIDUAL MAGNETISM. Bridge relay contacts momentarily by touching short wire from relay terminal to generator terminal. Current flow should not be greater than 2.5-5 amperes.

SHORTED FIELD COILS. Examine field for short circuits or grounds. If shorted field will draw excessive current. Test as directed in section on "Fields" under "Starter and Generator Internal Testing."

DEFECTIVE COMMUTATOR. Examine commutator for burnt or oily surface or high mica, as directed in section on "Commutators" under "Starter and General Internal Testing."

OPEN BRUSH CONNECTIONS. Check generator for internal open circuits at brushes and generator terminal. Check pigtail connections on brushes for positive connection.

SHORTED GENERATING CIRCUIT. Short circuits in generating line may prevent generator building up. Check line for discharge with engine stopped. Disassemble generator and examine.

OPEN CIRCUITED OR SHORTED ARMATURE COILS. Cause low charging rate or complete failure of generator. Disassemble generator and test armature as directed in section on "Armatures" under "Starter and Generator Internal Testing."

SLIPPING DRIVE. Check generator for loose belt or defective overrunning clutch. Belt should be tight enough so that generator does not move when ignition switch is turned on or relay contacts are closed. If too tight belt will crowd bearings causing wear and heating of the shaft and armature.

REVERSED FIELD COIL. Causes weak field magnetism. Test with compass to check polarity as directed in section on "Fields" under "Starter and Generator Internal Testing."

RESISTANCE IN FIELD CIRCUIT. Check field circuit for loose connections, defective or wrong third brush, defective or loose field fuse clips, defective regulator or thermostat contacts permitting resistance unit to remain in field circuit.

Generator Voltage Low. (May Not Close Relay Contacts. Will Not Charge Battery.)

DEFECTIVE COMMUTATOR. Examine commutator for dirty, oily or burnt surface or high mica as directed in section on "Commutators" under "Starter and Generator Internal Testing."

DEFECTIVE BRUSHES. Examine for excessive sparking and heat caused by poor contact, improper setting, wrong brushes or weak brush spring tension. Check brush mountings for shorts.

OPEN OR SHORTED ARMATURE COILS. Loose connections, thrown solder, open or shorted coils will cause low charging rate and excessive heat in the generator. Disassemble generator and examine carefully. Test armature as directed in section on "Armatures," under "Starter and Generator Internal Testing."

High Generator Voltage. (Overcharges Battery or Burns Out Lights.)

LOOSE CONNECTIONS. Check generating circuit for loose connections in third brush systems causing high voltage. Examine connections at relay, ammeter, switch and battery. If defective, clean connections and tighten.

GROUNDED THIRD BRUSH. Grounds in field circuit or third brush mounting arm may cause failure of regulating action and permit high generator voltage.

SHORTED RESISTANCE UNITS. Check regulator where used for sticking contacts or shorted resistance coil. Examine thermostat for bent arm.

MOTORING TEST. Check generator by running as a motor on the bench. Connect generator to six volt battery through ammeter. Armature should revolve slowly and evenly in same direction as when driven on car. Check current consumption with table given on car data sheet in the NATIONAL MANUAL. If generator performance is not satisfactory check by following table.

Current Flow Is Intermittant or Armature Rotates Unevenly.

OPEN OR SHORTED ARMATURE COILS. Disassemble generator and test armature as directed in section on "Armature" under "Starter and Generator Internal Testing."

EXCESSIVE FRICTION. Test generator for tight bearings, bent shaft, or rubbing pole pieces.

Armature Does Not Rotate.

WRONG BRUSH POSITION. Check brush mounting plate for correct position. Brushes are set at factory in correct position and should not be moved except to correct unauthorized tampering. Disconnect field lead. Loosen holding screws and shift brush mounting plate until generator ceases to rotate in either direction. Then turn plate against direction of rotation slightly and tighten mounting screws.

If above tests indicate that the generator is defective, disassemble it and check as directed under "Starter and Generator Internal Testing" section.

MOTOR-GENERATORS

Motor-generators are built with a single winding on armature and operate as both motor and generator or have two windings on armature and field, making motor and generator electrically separate although built as one unit. Machines using single winding are permanently connected to engine crankshaft through gears or chain drive. Current regulation when operating as a generator is by reverse series field or third brush system. Check motor-generators of this type for motoring and generating troubles as listed separately in sections on "Starters" and "Generators."

If motor-generator has two armature windings as used in Delco machines and connection to engine is through overrunning clutch and pinion shifted by the motoring action of the generating unit, check for special troubles in following table. Check for general motor and generator troubles from tables given in sections on "Starters" and "Generators."

GENERATING CIRCUIT NOT BROKEN. Check generator switch incorporated in starting mechanism or motor brush lifting mechanism and make certain that generating line is broken when motor brushes are in contact with the commutator. Adjust switch blades or sand down generator brush in types where brush is lifted from commutator, until this result is obtained.

Motor-Generator Cranks Engine Slowly.

MOTOR OVERRUNNING CLUTCH SLIPPING. Motor-generator revolves without cranking engine, or cranks slowly. Disassemble clutch and examine. If gummed or sticking clean and repack with pure vaseline. If worn replace cam, rollers or plungers.

DEFECTIVE MOTOR. Examine motor carefully for defective commutator, brushes and shorted or grounded motor field and armature coils. Test as directed in section on "Starters."

GENERATOR LINES OPEN. Check line between generator armature and switch. With ignition switch turned on, disconnect lead at motor-generator and flash to ground. If no spark is visible generator line is open. Examine connections at switch and repair or replace line.

Generator Unit Does Not Motor and Mesh Starter Pinion.

GENERATOR FIELD LINE OPEN. Check generator field connection to ignition coil or switch. Disconnect field lead at generator terminal and flash to ground. If no spark results, field lead is open. Examine connection at switch and replace line.

TIGHT BEARINGS. Check motor-generator for tight bearings, bent shaft, or striking pole pieces preventing armature from turning. Rotate armature by hand, noting force required.

Operates As Motor Before Pinion Gears Mesh.

DEFECTIVE MOTOR SWITCH. Check motor switch and shifting mechanism for broken connections, lost motion, or bent shifting lever. In system using brush lifting mechanism as switch check for long brushes touching commutator when switch is open. Repair by replacing brushes or sanding down to remedy condition.

GENERATOR OVERRUNNING CLUTCH SLIPPING. Examine generator overrunning clutch for slipping caused by wear or gumming of roller. Disassemble clutch and clean with gasoline, repacking with pure vaseline, or if worn replace cam, roller and plunger.

Motor-Generator Does Not Generate or Charging Rate Below Normal.

DEFECTIVE GENERATOR SWITCH. Check switch to make certain that generator circuit is completed after cranking operation has been finished. If switch sticks generator voltage will increase, causing damage to windings.

DEFECTIVE GENERATOR. Check generator for defective commutator or windings or shorted or open field coils and armature windings, as directed in section on "Generators."

STARTER

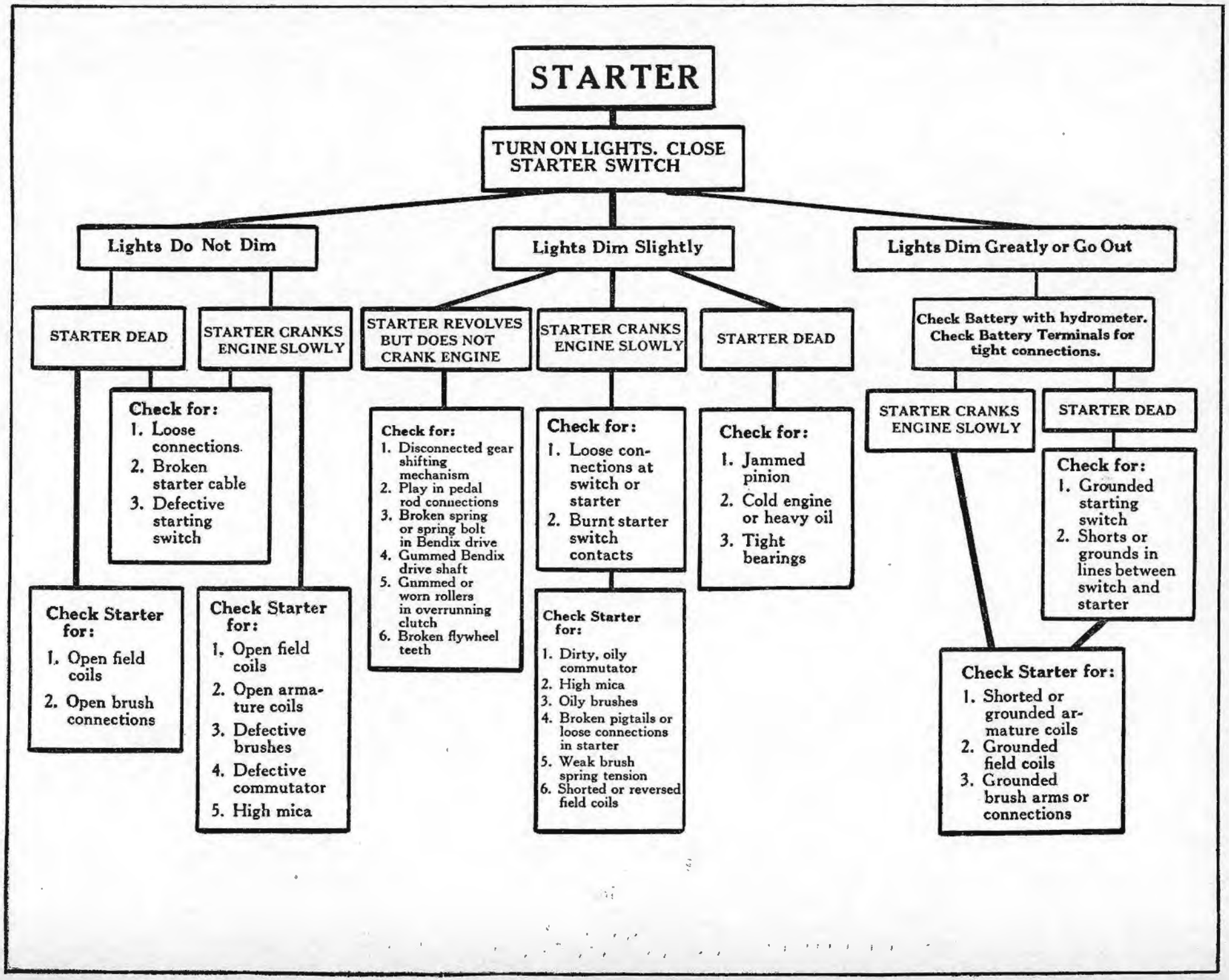
The starting circuit consists of the battery, starting switch, starting motor and the heavy cable used to connect these units. In normal operation when the starting button is pressed with the lights turned on the lights should dim slightly. Test starting circuit and starter by turning lighting switch to "Bright" position and noting lights when the starter switch is closed. Check with following table:

1. HEAD LIGHTS DO NOT DIM PERCEPTIBLY.

Starter Dead.

Check for broken starter cable, loose connections or defective starting switch, as directed in following section.

Check starter for internal open circuits in field, armature or brush connections.



Starter Engages With Flywheel.

Check for loose connections and defective starting switch.

Check starter for defective commutator or high mica or sticking brush arms.

Check for open field or armature coils.

2. HEAD LAMPS DIM SLIGHTLY BUT STARTER DOES NOT OPERATE SATISFACTORILY.

Starter Dead.

Check for jammed pinion. Release by placing car in gear and rocking back and forth.

Check engine for heavy oil or tight bearings by cranking engine by hand.

Examine flywheel for broken teeth.

Starter Revolves but Does Not Crank Engine.

Check systems using overrunning clutch for worn or gummed rollers. Disassemble clutch, clean with gasoline and repack with vaseline or medium heavy grease.

Check Bendix drive for broken spring or spring bolt or dirty or gummed Bendix drive shaft. Disassemble and clean with gasoline.

Check manual gear shift for broken or disconnected starting pedal or play in shifting rod.

Starter Cranks Engine Slowly.

Check for loose connections at battery, starting switch, and starter terminal.

Check starting switch for burnt or defective contacts as follows:

Test with voltmeter placing test points connected to voltmeter on each starting switch terminal. Voltmeter reading will indicate full battery voltage with the switch open but should drop to 0 when the switch is closed. A reading with switch closed indicates defective or burnt switch contacts. Disassemble switch and clean contacts. Check for proper contact with switch arm.

Examine starter for defective commutator—oily, dirty, burnt or high mica, as directed in section on "Commutators" under "Starter and Generator Internal Testing."

Check for oily, soft or defective brushes or weak brush spring tension.

Check starter for shorted or reversed field coils as directed in section on "Starter and Generator Internal Testing."

3. LIGHTS DIM GREATLY OR GO OUT.

Starter Dead.

If lights dim greatly check for discharged battery, grounded field coils or shorted or grounded armature coils as directed in sections on "Battery" and "Starter and Generator Internal Testing."

If lights go out check for loose connections or open circuits at battery terminal, starter switch or starter terminal as directed in following paragraph.

Starter Cranks Engine Slowly.

Check for damp, grounded or shorted field or armature coils or grounded brushes as directed in section on "Starter and Generator Internal Testing."

GENERAL TESTING OF STARTING UNITS

For Defective Battery Terminals, or Connections.

Check connections by connecting test points to voltmeter and placing one test point on either side of connection to be tested. In testing battery terminals place one test point on battery post and other on starter cable. Close starter switch. No reading should be indicated on the voltmeter. A reading indicates poor connections which should be cleaned and tightened.

For Defective Starter.

Operate starter on bench to check performance with data given on particular car in NATIONAL MANUAL. Mount starter rigidly on bench and connect to fully charged six volt battery with No. 00 stranded starting cable through a regular starting switch. Connect six volt voltmeter across starter terminals. Connect ammeter in circuit making certain that proper size shunt is used. (Current on lock torque tests may be 750 amperes). Run No Load, Lock torque and Load Tests to check starter.

No Load Test.

Close starting switch allowing starter to revolve freely. Check current consumption and speed and compare with data given for particular starter on car data sheet in the NATIONAL MANUAL. If starter is mounted on a test bench the speed can be accurately determined. Otherwise a tachometer or speed counter should be used. If the starter does not perform in accordance with test specifications, disassemble and examine. Tight bearings or worn bearings or bent shaft causing armature to rub pole pieces will cause higher current consumption and lower speed.

Lock Torque Test.

Fasten a brake arm of wood or metal rigidly to armature shaft so that armature can only revolve by turning brake. Make brake arm one foot in length from center of shaft to outer end and fasten a spring balance to end or rest on scale capable of reading equivalent of lock torque in pounds. (Starter lock torque 8-12 pound feet. With starters using reduction gears lock torque may be as high as 70 pound feet.) Close starter switch and note scale reading. Reading in pounds will give lock torque of starter in pound feet. Compare figure and ammeter and voltmeter readings with figures given on car data sheet in NATIONAL MANUAL. If starter does not develop full lock torque examine for internal defects as directed in section on "Starter and Generator Internal Testing."

Fasten brake arm to armature shaft so that starter can revolve and friction between brake arm and armature shaft can be varied. Make bearing surface of brake arm in two pieces straddling shaft and held by bolts and thumb nuts. Vary pressure on shaft by tightening or loosening nuts. Close

Load Test. starter switch and operate starter with various loads noting scale reading, current consumption and voltage. Compare figures obtained with table given on car data sheet in the NATIONAL MANUAL. Starter should operate closely in accordance with these figures. If considerable variation is noticed, disassemble starter and examine.

If bench test on starter indicates that starter is defective and examination does not locate trouble, the starter should be disassembled and the brushes, commutator, field coils and armature coils tested separately as directed in section on "Starter and Generator Internal Testing."

STARTER AND GENERATOR INTERNAL TESTING

FIELD COILS. Check as follows:—

Check field with compass. Connect field terminals to six volt battery, using resistance with starter fields. With small current flowing in field coils, hold a compass near frame opposite center of pole piece. Note which end of compass needle is attracted toward pole. Adjacent poles should attract opposite ends of compass needle, poles being alternately north and south around frame. If adjacent poles attract same end of compass needle, field coil connections are reversed or compass needle is demagnetized. Check compass for demagnetized needle by observing action when not near field poles. If field coil is reversed, interchange field connections or replace with correctly wound coil.

For Reversed Coils.

Disconnect all brush and ground connections in the field circuit. Make certain that field leads do not touch frame. Test field with lamp and test points, placing one point on field terminal and other on frame. The lamp should not light. If it does field is grounded. Disconnect leads between coils and test separately for grounded coil. Defective coil must be reinsulated or replaced.

For Grounded Coils.

Test with lamp and test points. Disconnect field connections or insulate third brush from commutator with slip of cardboard. Place one test point on lead at each end of field circuit. The lamp should light. If it does not field circuit is open. Check connections between coils and test each coil with lamp and test points to locate defective coil. Repair if caused by open connection or replace coil if defective.

For Open Circuited Field.

Check each generator coil separately by connecting across six volt battery with ammeter in circuit. Check ammeter reading and compare with current drawn by other coils. Coils should draw approximately same current. Coil drawing considerable excess is shorted and must be repaired or replaced.

For Short Circuits.

Starter coils are of low resistance and cannot be tested in this way. Examine starter coils for melted insulation or burnt winding caused by short circuit.

Check for shorts between motor and generator field windings with lamp and test points. Place one test point on motor field terminal and other on generator terminal. The lamp should not light. If it does windings are shorted. This will cause low cranking speed and excessive current consumption. Examine windings and repair shorts.

Motor-Generator Tests. For Shorted Fields.

ARMATURES.

Examine armature carefully for thrown coils, thrown solder, or loose connections. Examine for damage caused by bent shaft or loose pole pieces resulting in armature striking pole piece. If armature heats excessively check relay for sticking contacts and test armature for shorted coils.

Test armature as follows:

Test with lamp and test points. Place one test point on commutator and other on armature shaft. The lamp should not light. If it does commutator bars or armature coils are grounded. Examine commutator and test armature coils for shorts probably causing the ground.

For Grounds.

BAR TO BAR TEST. Mount armature on bench. Connect in circuit with resistance and six volt battery through contacts or brushes resting on commutator at points diametrically opposite (180° apart) for two pole generators and at right angles (90° apart) for four pole machines. Adjust resistance so that approximately ten amperes flow through armature coils. Rotate generator slowly, taking readings between each two commutator bars with test points connected to three volt voltmeter. (Number commutator bars 1, 2, 3, 4, etc., and take readings between 1 and 2, 2 and 3, 3 and 4, etc.) These readings should approximately agree around armature. If one reading is appreciably higher than others, armature coil is open. Examine coil connection at commutator slot and repair or replace coil. In testing four pole machines, readings will increase in places diametrically opposite, due to jumpers used in making connections. The readings will then regularly decrease.

For Open Circuited Armature Coils.

GROWLER TEST. Mount armature on growler connected to 110 volt A.C. line. The same growler can not be used to test both starter and generator armatures unless a special machine is employed having coil wound in two sections which may be connected in parallel or series, as desired, or some other method of securing different coil ratio necessary in

testing both types of armatures is used. Slowly rotate armature on growler, keeping a thin strip of steel or hacksaw blade laid lengthwise on uppermost armature segment. If armature coils are shorted local currents are set up, causing steel strip to be attracted perceptibly to armature core. Short circuit is either in coil or commutator. Examine commutator for shorts caused by foreign matter in slots or shorted coil connections. Repair or replace defective coil.

For Short Circuited Armature Coils.

VOLTMETER TEST. If growler test does not locate suspected shorts in armature coils repeat "Bar to Bar" test, using .3 volt scale of voltmeter. This test must not be made until all open circuits in armature coils have been eliminated. An open circuit will cause damage to voltmeter. Voltmeter readings will be approximately the same around armature. If reading drops to 0 armature coil is shorted and must be repaired. In taking readings care must be used to keep test points on adjacent commutator bars.

Motor-Generator Test.

On motor-generators using two armature windings test for short circuits between windings with lamp and test points. Place one test point on motor commutator and other on generator commutator. The lamp should not light. If lamp lights, windings are shorted. Test each winding and replace armature if the short cannot be located and repaired.

COMMUTATORS.

Commutator is checked for shorts and grounds in testing armature coils. Commutator should be dark brown, clean and smooth. If oily, clean with gasoline, wiping dry before operating machine. If commutator is rough, smooth with No. 00 sandpaper. Do not use emery cloth. If badly burnt or with high mica turn down commutator and undercut mica on generator commutators. Starter commutators are not undercut. Hard brushes are used which keep mica worn away.

Turning Down Commutator.

Turn down commutator in a lathe. Run lathe at high speed and take a fine cut. Do not use dull cutting tool or mica insulation will be injured or copper will be turned over between bars, shorting coils.

Undercutting Commutators.

Cut out mica between bars on generator commutators to a depth of 1/32 in. Use a special undercutting tool or a hacksaw blade ground to fit between the bars. The mica must be cut evenly across so that a rectangular slot is left between the commutator bars. After cutting mica bevel the edge of the commutator bars with a flat file to remove all burrs.

BRUSHES.

Examine brushes for correct performance. If defective, brushes will affect charging rate or cause excessive sparking, resulting in burnt commutator or overheated commutator or armature coils.

Check brushes for following troubles:

Brushes Spark or Overheat in Service.

IMPROPER MOUNTING. Brushes should make snug fit in holders, but should be free to move. Test for binding or for sticking brush arms on systems using rigid mounting with swinging brush arm.

LOOSE CONNECTIONS. Check brushes mounted in box type holders for positive connection of braided "pigtail" to brush and holder. If broken, current flows through sliding contact between brush and holder, cutting down output through high resistance of connection.

WRONG BRUSHES. Brushes recommended by manufacturer should be used for particular machine. Improper brushes may affect charging rate and cause damage to commutator. If third brush is not of proper resistance field current will not be correct, causing unsatisfactory generator performance.

BRUSHES NOT PROPERLY SEATED. Check brushes for proper bearing surface on commutator. Brushes must bear on commutator across entire face. Sand brushes in by slipping strip of sandpaper wider than brush between brush and commutator, wrapping sandpaper around commutator so that brush face will have correct curvature. If all brushes need sanding in glue strip of sandpaper to face of commutator and rotate armature. Blow out all carbon dust before operating machine.

IMPROPER SPRING TENSION. Check position of brush spring. It should bear straight down on brush. Test spring tension by lifting spring from brush with small spring balance. Note reading when spring leaves brush. If brush is rigidly mounted to brush arm note brush arm spring tension in same way. Set spring tension to figure recommended for particular brushes and machine. If spring tension is too light brushes will spark, resulting in burnt commutator. If spring tension is too heavy brushes will wear rapidly, cutting commutator and overheating in service.

GROUNDED BRUSH ARMS OR HOLDERS. Check insulated brush holders or arms for shorts to ground. Disconnect all leads from brush holder and insulate brush from commutator with slip of cardboard. Then test with lamp and test points, placing one test point on brush holder and other on frame. The lamp should not light. If it does, the brush holder or arm is grounded and must be repaired.

SHAFT BENT OR COMMUTATOR NOT ROUND. Check commutator to see if out-of-round. Check armature shaft for wear, allowing wobbling while rotating. If commutator is not round brushes will be thrown off at high speeds, causing fluctuations in charging current. Repair by truing commutator in lathe.

NATIONAL SERVICE MANUAL

STARTING—LIGHTING—IGNITION

— EDITED BY —

JAMES ROLAND WRIGHT
Director Engineering Division

NATIONAL AUTOMOTIVE SERVICE
DETROIT - - - SAN FRANCISCO

NATIONAL AUTOMOTIVE SERVICE
San Francisco, California, U. S. A.

A PERPETUAL MAINTENANCE DATA SERVICE

The National Service Manual of Starting, Lighting and Ignition is being published to meet the need for complete and authoritative electrical equipment data in the servicing of automobiles.

The Manual contains (1) the wiring diagrams of all American automobiles built since 1915; (2) the explanations of these diagrams; (3) complete information and necessary instructions for the care, adjustment, "trouble shooting" and repair of the equipment.

By means of LOOSE LEAF SUPPLEMENTS the Manual is always UP TO DATE, and Manual owners are kept constantly apace with the new systems, devices and different types of equipment continually being installed on new car models. Supplements are furnished at a very nominal cost and notification is made when they are ready for distribution.

Grateful appreciation is acknowledged for the hearty co-operation and assistance accorded us by the Automobile and Equipment manufacturers, without which this valuable data could not be released.