FAULTS AND HOW TO FIND THEM

BY

J. S. V. BICKFORD, B.A.

Faults and How to Find Them

MOTOR CAR FAILURES
AND THEIR REMEDIES
FULLY EXPLAINED.
(Second Edition, Revised and Enlarged)

With a list of One Hundred and Eighty Faults and their Symptoms and Remedies

BY

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PREFACE.

THE present little work has been prepared principally with a view to assisting the novice to locate those faults usually met with in automobiles.

Some years ago it occurred to the writer that it ought to be possible to devise a systematic method of examination which should find any given fault with a fair degree of certainty, and he then worked out such a system for use with a telephone receiver for trembler coil ignition. It was, however, found that this set of tables was far too complicated, and he decided then to prepare a set of tables which, as far as possible, should indicate a method of examination such as would be adopted by the expert. Few people will probably credit the difficulty of doing this. The expert is guided almost unconsciously by the previous behaviour of his car, and very likely hardly knows why he looks first at a certain point. In giving instructions to be followed by the novice, two contending factors had to be balanced. In the first place, the method given must not be so elaborate as to be hopelessly prolix; and, on the other hand, it would be to court certain failure if the novice were credited with the trained ears and eyes of the expert for the recognition of symptoms. Acting on these lines, an attempt was made to write the tables right off, and resulted in a bad headache and a hopeless failure.

The reason was that one was constantly forgetting at what stage of the examination one had arrived, and, of course, after one had hunted back through a page or so of type, one's thoughts were all to be collected again, so that after a few hours' trying the attempt was abandoned. The next method was to make out the tables as genealogical trees, which was more successful, as a glance showed the stage of the examination.

After this, the tables (thus prepared under the ruling idea of making the examination conform as closely as possible to the behaviour of the expert under similar circumstances) had to be tested for the various faults. As the writer had early come to the conclusion that it would be futile to hope to catch faults which had not been foreseen, he had now to prepare a list of every fault he could think of. This list was typed out and posted in a garage, and a prize offered to the men for any further faults. These were added to the list,

which the writer ventures to think is now fairly complete—an opinion supported by the fact that he does not remember coming across a single fault in the last year not on the list.

The tables were now checked over for every individual fault. This alone was a tedious business, for not only had a fault to be checked for each manifestation of itself—as, for instance, a badly adjusted trembler had to be checked both for misfiring and complete stoppage—but one of these manifestations had to be checked for all systems of ignition concerned, so that in some cases a single fault had to be checked over under two or even more forms for double and single-cylinder engines, and for trembler coil, high and low tension magneto, synchronised high tension, coil, and non-trembler coil ignitions. These lists had then to be copied out into table form, as here printed ; and, to avoid unavoidable errors of copying, the whole of the checking had to be gone through again from beginning to end. This work was carried out so that anyone employing the tables may reasonably hope that he will catch any one of these faults if it is present in his own engine.

A few extra faults, not of an obscure nature, were added afterwards as remedies could be suggested for them, such as a broken front wheel.

The index has been crossed as carefully as possible, and faults appear under several headings ; whilst the index has been checked both ways. That is to say, every entry in the index has been looked out to see if it is right, and every item in the list of faults has been looked up under most likely headings in the index to see if it appeared, and all omissions were put right.

In spite of such care, however, as the writer has been able to give to the work, he is fully prepared to find many errors and omissions for which he asks his readers' indulgence.

CAMBORNE, ENGLAND.

MAIN INDEX.—*If you know what the fault is*, and want the remedies or symptoms, refer at once to the main index at the beginning of the book.

THE TABLES.—*If you do not know the fault*, but only the symptoms, look up the tables Nos. 1 to 122. By a process of elimination they will lead you to the discovery of the fault.

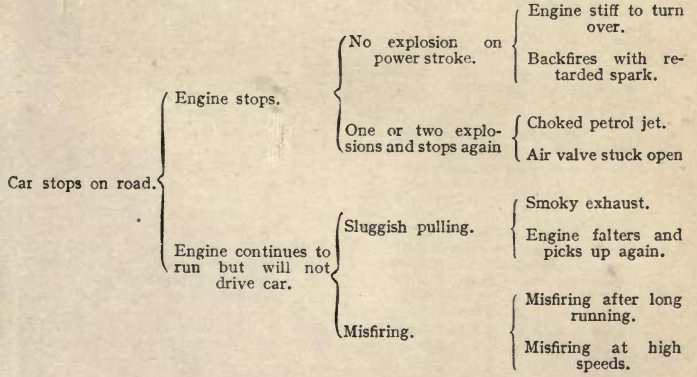
NOTES ON USE OF TABLES.—These (Nos. 296 to 299) will show you the quickest way of working through the tables when in search of a fault, and explain the system on which they have been compiled.

RUNNING COMMENTARY ON THE TABLES.—This gives supplementary and explanatory information, to which it may or may not be necessary to refer.

LIST OF FAULTS.—This is a complete list of the faults which can be discovered by the use of the tables, and gives the symptoms of each one and its remedy.

INDEX TO PRINCIPAL SYMPTOMS.—This will be found at the end of the book, and when the symptoms are very plain and unmistakable will refer you directly to the faults causing them, without the necessity of working through the tables.

NOTE.—The system on which the tables are compiled may be compared to that of a genealogical tree. It is designed so that the fault can be hunted down from stage to stage. The following gives an idea of the method—



MAIN INDEX.

TABLES.

NOTE.—*For instructions on use of these Tables see Nos.* 296-299. *A running commentary will be found at Nos.* 301-419, *giving further remarks on all paragraphs ma ked with asterisks.*

*1 CAR WITH MULTI-CYLINDER ENGINE : See No. 40.

*2 CAR WITH SINGLE-CYLINDER ENGINE.

(*a*) Engine will not start up : See No. 5.

(*b*) Engine runs, but the car will not move : See No. 4.

(*c*) Car runs badly, including all cases where the car will run at all under its own power : See No. 28.

(*d*) Car stops on the road : See No. 3.

3 CAR STOPS ON THE ROAD, including the case where the engine stops again after starting up.

(*a*) Engine stops as well as the car : See No. 5.

(*b*) Engine continues to run : See No. 4.

*4 CAR STOPS ON ROAD, ENGINE CONTINUES TO RUN : This indicates a mechanical failure. Note the point to which the motion of the engine is transmitted, then see the following points—

(*a*) Slipping clutch : Caution.—Where the clutch is slipping, the gears engaged, and the car stationary, be careful that the clutch does not seize suddenly, and cause an accident. See Nos. 1075 and 1076.

(*b*) Gears jumping out of mesh : Probably due to bent gear changing mechanism, some part unscrewed, or undue wear or lack of adjustment. See Nos. 1064-1065.

(*d*) Claw clutch of direct drive slipping out of mesh : Probably same cause as No. 4b, or worn teeth.

(*e*) Gear teeth broken or worn off : Usually produces violent grating and grinding noises.

(*f*) Gears will not engage, but grind when the change-speed lever is moved : Male clutch seized or stiff on the crankshaft spindle ; failure of lubrication of tail end of crankshaft spindle ; clutch fails to disengage. perhaps owing to bent clutch connections ; clutch pad (or brake) out of action if one is used ; faulty method of changing gears. See No. 1173.

(*g*) Engine runs, but has no power, and stops as soon as the gears are engaged and the clutch let in : Look out for wrong timing of ignition (see Nos. 117 and 118), crossed cables, broken valve springs, and then see "Faulty Running," No. 28 or 34.

(*h*) Engine runs apparently all right, but stops as soon as the clutch and gears are engaged, the car remaining immovable : Look for seized bearings, brake hard on, seized brake, or obstruction in gear teeth.

*5 CAR STOPS ON ROAD, ENGINE STOPS ALSO (from Nos. 2 and 3) : Where a trembler coil continues to buzz, see at once No. 108. Try the engine with the starting handle, noting—

Engine is stiff to turn over : See (*a*) below.
Engine backfires with retarded spark : See (*b*) below.
No compression : See (*c*) below.

(*a*) ENGINE IS STIFF TO TURN OVER : Have the clutch held or wedged out, and try again. If the engine is free now, it shows a seized bearing in the first motion-shaft of the gear box, a seized extension tit of the first motion-shaft (of direct drive), or an obstruction in the "constant mesh" gears, or the gears are engaged.

If the engine is still stiff : Indicates an obstruction or stiffness in the engine. Look for seized bearing ; seized piston ; mechanical breakage ; or lack of cylinder lubrication (not usual).

Engine stiff at certain points of each revolution (make sure you are not misled by compression) : Indicates bent connecting rod, bent crankshaft, bent camshaft, or bent half-time or pump gear spindle or magneto spindle (bent half-time gear spindle would cause much noise in running). Possibly also bent first motion-shaft of gear box (this would disappear on holding out the clutch).

(*b*) ENGINE BACKFIRES WITH RETARDED SPARK (make sure the spark *is* retarded) : Examine timing of spark (see No. 117) for slipped commutator wipe, key, driving gear, or chain. Make sure connection between commutator and spark lever is all right, and none of the connections slipped or bent. Try engine with spark switched off for pre-ignition (see index). Look for false contact in commutator. See No. 1139.

(*c*) No COMPRESSION : Examine valves for broken stems or springs, stickiness of stem so that valve does not close, broken cotter pin or washer, or obstruction

under the beat. Valve lifters, for unscrewed adjustment nuts preventing valves closing. Automatic inlet valve for loose nut, etc., or obstruction under the beat. If cause not found, listen for rush of air. An unusual cause of failure of compression is the blowing out of a piece from the piston head. All other sources of leakage, such as leaky valves or pistons are unlikely to stop the engine, but only to cause loss of power, for which see No. 28.

***6** ALL THIS IN ORDER: Try to start the engine in the usual way by merely turning the starting handle. Note the following points—

(*a*) Engine starts up: See No. 107.

(*b*) Engine gives one or two explosions, and stops again: Probably a choked carburetter jet; conceivably a broken valve spring or stem. See No. 107, and then No. 8.

(*c*) No explosion at all: See No. 7.

***7** NO EXPLOSION AT ALL on turning starting handle: Tickle carburetter and try again. Whilst tickling carburetter look for lack of petrol or stuck needle valve of float chamber, flooding (if obvious, by leaking of petrol), or cables off plugs. For causes of failure of petrol see No. 106*b*.

(*a*) One or two explosions: See No. 6*b*.

(*b*) Engine starts: See No. 107.

(*c*) Still no explosion at all: See No. 8.

***8** CARBURETTER TICKLED, engine will not start or give a single explosion: Try ventilating (see No. 1184), and if no good see *a*, *b*, or *c*.

(*a*) Magneto ignition: See No. 20.

(*b*) Non-trembler coil ignition: See No. 23.

(*c*) Trembler coil ignition: See No. 9.

(*d*) Bosch dual: See No. 123.

9 TREMBLER COIL IGNITION, engine will not start: Retard spark, switch on, and turn starting handle slowly. Note buzz of coil.

(*a*) No buzz: Place on contact, and see No. 13. (A buzz for a moment, and then stops, probably indicates battery run down, or possibly a weak commutator spring.)

(*b*) Coil buzzes: Use your ordinary experience as to whether to flood the carburetter, add petrol to the

cylinders, ventilate, etc. Lacking experience, proceed as below. Leave the commutator on contact, switch off, take high tension wire from plug, and see No. 10.

***10** TEST SPARK to the engine frame over ¼in. gap.

(*a*) No spark: See No. 12.

(*b*) Uncertain and intermittent spark: This should fire a charge now and then; if not, treat as no spark (No. 12). If it occasionally fires, see to faulty running (No. 28).

(*c*) Sparks steadily across ¼in. gap: See No. 11.

***11** TEST SPARK TO PLUG HEAD.

(*a*) No spark: Indicates plug points too wide.

(*b*) Good spark to plug head and cylinder frame: Examine the plug itself for sooting, oil, broken insulation, or points too close. In the rare case where the plug will spark with engine at rest, but not when it is turned over, fault should be sought in the commutator. When an engine has been running, and stops, and the plug is found wet, look out for water in the cylinder due to cracked jacket or leaky head (water joint). When an engine has been idle some time, moisture on the plug may be due to condensation, and heating the plug will put things right. See No. 76*a*. Spark found good see No. 106.

Before going further, make sure, if reasonably easy to do so, that the carburetter is not flooding. See No. 308.

***12** NO SPARK FROM HIGH TENSION LEAD (engine on contact from No. 10): Test spark into high tension lead at coil end, leaving the other end on its plug, or earthed.

(*a*) Good spark: Indicates leak in lead.

(*b*) No spark: Indicates broken-down coil, leak in high tension system of coil, or broken-down condenser (accompanied by sparking at the trembler points). An unlikely fault would be high tension lead broken out of sight, or the plug end dropped off its plug. In this case the coil would spark by separate wire to earth, or through a spanner or other metal tool to its own commutator connection. See No. 1117 to 1128.

***13** SINGLE-CYLINDER ENGINE will not run or give a single explosion; standing on contact, the coil does not buzz: Look for loose wires or terminals—battery, two connections; earth, one connection; switch, two or three con-

nections ; commutator, one or (where earthed) two connections ; and coil, two connections. Switch in spare accumulator if wired up. Test voltage of battery, which should be above 3.8. Adjust trembler points. Examine commutator for loose wipe ; weak wipe spring ; dirty wipe path ; and bad contact generally. Clean and adjust if necessary.

Make sure switch is not open : See No. 14.

***14** EXAMINE WITH VOLTMETER as under, first making quite sure that the battery shows a good voltage ; voltmeter should be one which will read as low as two volts : Test current from earth to the tail end of the trembler blade.

(*a*) Current flows : See No. 17.

(*b*) No current flows : See No. 15.

***15** TEST CURRENT from the coil positive terminal (not from the cable end) to earth.

(*a*) Current : Fault in coil between coil positive and the tail of the blade. Keep voltmeter on "earth," and touch in turn coil positive, coil positive small screw, trembler screw, and blade again. Fault between the points showing current and those showing no current, such, for instance, as insulated trembler points, points apart, etc. See No. 1119.

(*b*) No current : See No. 16.

16 TEST CURRENT Battery Positive Terminal to earth.

(*a*) Current : Fault between battery positive and coil positive. Hold one voltmeter terminal on earth, and touch in turn coil positive, switch terminals (if in this circuit), and battery positive again. Fault between points showing current and no current.

(*b*) No current : As the battery has been proved right, fault is between earth and battery. Locate by keeping voltmeter on battery positive, and touching earth, earth terminal, and battery negative (and switch terminals if in this circuit). Fault between current and no current.

17 SINGLE-CYLINDER TREMBLER COIL, no buzz on contact : Current flows from earth to the tail of the blade. Shows circuit in order from the tail of the blade through trembler points, coil positive, switch (if in this circuit), and battery to earth. See No. 18.

***18** TEST CURRENT from the tail of the blade to coil commutator terminal (not the cable end, but the binding screw).

(*a*) No current : Fault, therefore, between earth and coil commutator terminal through commutator. Test current from coil positive or battery positive (either of them will do) to earth (already proved), commutator spindle, commutator wiper, contact piece, commutator terminal, and coil commutator terminal again. Fault between current and no current.

(*b*) Good current : Shows circuit complete from coil commutator terminal through commutator earth and battery to tail of blade. See No. 19.

***19** TEST Coil Commutator Terminal to both trembler blade and trembler screw, with the blade depressed (out of contact with trembler point). Only one of these should show current when the blade is depressed.

(*a*) Both show current : Indicates a short circuit past the trembler points, probably a short-circuited condenser, or you have failed to separate the points.

(*b*) One only shows current : Indicates the trembler points are stuck together ; the armature out of adjustment, so that it fails to break contact of the blade ; that there is a break in the low tension winding of the coil, or in the connections from low tension winding to terminals. To prove this, move commutator off contact, and test with voltmeter from coil commutator terminal to earth. No current shows internal break in circuit.

***20** SINGLE-CYLINDER ENGINE, high tension magneto ignition will not start up, or give a single explosion : Look carefully to see whether a frayed end of the switch cable is making contact with magneto metal work. See switch open, and if in any doubt remove switch wire altogether and run without it. Examine all cables and binding screws for insulation by dirt, looseness, disconnection, or breakage, as under—

Separate coil type magneto.—Coil to magneto, tow tension cable, both ends ; coil earth, both ends ; coil to distributer cable, both ends.

Any high tension magneto.—Low tension winding to contact breaker, if by separate cable, as in some old machines ; distributer to plug, high tension cable ; plug.

Remove the plug, and examine it, and watch the spark whilst turning the engine by hand. Take care that plug binding screw is not in contact with metal of engine.

(*a*) Sparks apparently all right : See No. 106.

(*b*) No spark : See No. 21.

***21** No Spark from Sparking Plug: See switch open.

(*a*) Low tension magneto with separate coil: See No. 22.

(*b*) Self-contained high tension magneto: See No. 21*c*.

(*c*) Test spark to magneto frame, over one-sixteenth inch gap, with the cables off.

(*d*) Good spark: Shows defective plug or lead (where plug is found wet, see footnote 76*a*).

(*e*) No spark: Shows magneto fault. Clean and set contact breaker, making sure it makes and breaks correctly. Make quite sure switch is open (magnetos work with switch open, not closed, as in coil ignition). Take care that no frayed ends of the switch cable are short circuiting the magneto. To be quite sure of this, take off switch cable and try to start without it. If engine runs now it shows a short circuit in the switch cable somewhere. Run with it off if necessary; the only difference will be that you cannot stop engine on switch. Still no good: See No. 22*f*.

***22** Low Tension Magneto with Separate Coil: Test spark into high tension distributer lead from coil high tension terminal.

(*a*) Good spark: Shows leak in the high tension system (in case of sudden failure of multi-cylinder engine this is likely to be in the distributer or coil to distributer lead) or defective plug—broken, sooty, oily, wet (if wet see footnote 76*a*), or points too close.

(*b*) No spark: Shows fault in coil or magneto, or possibly distributer cable is off distributer terminal, or one of the connections is completely broken out of sight, in which case coil will spark to a separate earth wire, or to the coil earth wire, or plug points too far apart. Clean and set contact breaker, making sure it makes and breaks correctly. See No. 1175.

Take off switch wire. If coil sparks now shows a leak in switch or its cable, or switch closed. See No. 22*c*.

(*c*) Test current from switch terminal by voltmeter, or by tapping a wire from switch terminal on engine frame, when, as engine is turned, it should give faint irregular sparks. See No. 22*d* or 22*e*.

(*d*) Current: Shows coil fault, or insulated magneto coil wire or terminals or contact breaker cable if any. Examine coil earth and all terminals for loose wires or insulated terminals, not forgetting coil earth cable

at earth end. Try spare coil if available. Then, as last resource, on off chance of magneto fault, see No. 22*f*.

(*e*) No current: Shows a magneto fault. Examine all cables and binding screws for insulation by looseness, dirt, disconnection, or breakage, as under—

Separate coil type magneto.—Coil magneto low tension cable (both ends), coil earth (both ends), and coil distributer high tension cable (both ends),

Both self-contained and coil type magneto.—Low tension to contact breaker if by cable (as in some old machines), distributer high tension to plug high tension, and plugs. See No. 22*f*.

In all but simple and obvious faults send the magneto to its own makers rather than tinker with it yourself and rather than allow anyone else to do so.

(*f*) Magneto examination: Take off switch wire if not already done. Clean low tension collecting brush and slip ring. See that spring of same is bearing properly, and try forcing it into contact by hand. Clean off any water from magneto. Clean oil off brush and slip ring. Empty magneto of oil. Make sure magneto is earthed; if not, and otherwise all right, current will be had from low tension terminal to magneto frame, but not to engine frame. If idle some time, suspect damp, and dry out for some time in dry room. If not already done, test current from magneto switch terminal (with cable off) to frame by voltmeter, or by sparks (tapping a wire on frame, which should give faint and irregular sparks as engine is turned over). No current shows a low tension fault. Current shows a high tension fault, or fault in coil. Where a magneto has been dismantled, make sure it has been correctly assembled, so that armature is in correct position at time of breaking of contact. Look for insulated low tension terminal.

23 Single-cylinder Engine (non-trembler coil ignition) stops on road, or will not start up or give a single explosion after tickling the carburetter, and adopting the usual expedients (from No. 8*b*): Test the battery voltage, which should be 3.8 or over. (See note No. 1081 on broken battery bridges, where no current at all is found.) Look for loose leads, open switch, and dirty or badly adjusted contact breaker.

Take high tension lead from plug, and try spark both to plug head and cylinder head both by turning the engine and by

breaking contact by hand if that is possible. A good spark to engine and none to the plug indicates plug points too wide. A good spark when breaking contact by hand, and none or intermittent when engine is turned, indicates faulty contact breaker. If it is not possible to break contact by hand, turn engine only.

(*a*) Good spark to both engine frame and plug head: Examine spark at plug. Bad spark shows defective plug—broken, sooty, oily, wet (where wet see footnote 76*a*), or points too close. Good spark, see No. 106.

(*b*) No spark to either plug head or engine frame: See No. 24.

24 No Spark: Examine again for loose wires, etc. Test voltage across the contact breaker points, taking care that they are not in contact. If they cannot be got to separate. this is, of course, a fault of adjustment.

(*a*) Current: See No. 27.

(*b*) No current: See No. 25.

25 No Current: Test current from coil positive binding screw (not the cable end) to earth.

(*a*) No current: Fault between coil positive and earth through the battery. Test current from battery positive to earth. No current shows bad earth, insulated terminal, or open switch (if in this wire). Current shows bad connection from battery positive to coil positive, such as insulated terminal, open switch, or broken lead. Locate by keeping voltmeter on earth, and touching in turn battery positive, switch terminals, and coil positive. Fault between current and no current.

(*b*) Current: Fault between coil positive and earth through coil and contact breaker. See No. 26.

26 Test Current from coil contact breaker terminal (not the cable end, but the binding screw) to earth.

(*a*) No current: Fault is either a broken low tension winding or a short circuit in the contact breaker, through the condenser, or in the contact breaker wire. To test, remove cable from coil contact breaker terminal, and test current from the terminal from which cable has just been removed to earth. Current shows short circuit in contact breaker or its leads or points not separated. No current, remove coil earth cable from coil and test current from the binding screw from which you have taken it to earth. Current now shows short

circuit through cond nser. Still no current shows internal breakage in coil.

(*b*) Current: As no current was obtained across the contact breaker points, the fault must lie between the coil and the contact breaker or in the earthing of the contact breaker itself. Test current from the contact breaker terminal (to which the coil wire is attached) to earth. Current shows the fault to lie in the earthing of the contact breaker. No current shows a fault between coil and contact breaker.

***27** CURRENT across contact breaker points (from No. 24*a*): Clean and adjust contact breaker. Examine earth wire of coil for looseness or insulation (both ends). Set contact breaker on contact, and test voltage across points (now in contact). Current shows insulated points, or points not meeting. Test spark into high tension lead (other end on plug or earthed). Sparks show leaky lead. No sparks probably a defective coil, but might be a breakage in the high tension lead or its plug end dropped off the plug. Possibly condenser broken down, shown by sparking at the contact breaker points. Possibly short-circuited condenser.

***28** SINGLE-CYLINDER ENGINE, faulty running (from No. 20): For list of special faults not in this list, and more uncommon, see No. 121.

(*a*) Engine runs irregularly, such as misfiring: See No. 29.

(*b*) Engine runs steadily without missing, but will not "pull," and has no life: See No. 34 and then No. 32.

(*c*) Car makes unusual noises: See Nos. 34*h* and 34*i*.

(*d*) Engine fails to pull at once on opening the throttle: See No. 34*j*.

(*e*) Excessive consumption of petrol: See Nos. 34, 33, 32, and 1179.

(*f*) Gear changing difficulty: See Nos. 34*s*, 1173, 1077, and 1078.

(*g*) Car starts with a bound on letting in the clutch: See No. 34*s*.

(*h*) Engine will not stop on the switch: In magneto ignition shows insulated switch or cable off or dirty. In coil and accumulator ignition shows short-circuited switch. Otherwise this indicates pre-ignition, which can be proved by allowing engine to cool down when it will stop on the switch until it gets hot again.

(*i*) Engine runs badly or irregularly on the road, but steadily when examined: See Nos. 32, 33, and 34.

29 MISFIRING OR IRREGULAR RUNNING.

(*a*) Magneto ignition : Remove high tension cable from plug, and examine spark to plug head whilst the engine is running. If the spark is irregular, see No. 39 ; if regular, see No. 33.

(*b*) Non-trembler coil ignition : Adjust contact breaker, with the engine running if possible. Take high tension cable from plug, test spark to plug head, engine running. Regular spark over ¼in. gap, see No. 33. Irregular spark, see No. 35.

(*c*) Trembler coil ignition : See No. 30.

(*d*) Bosch dual : See Nos. 123 and 149.

***30** TREMBLER COIL IGNITION misfiring, or irregular running : Listen carefully to buzz of coil. Sometimes difficult to hear, in which case assume it to be bad. A telephone, if available, will immediately settle the point by coupling it across the trembler.

(*a*) Irregular buzzing of coil or uncertain whether regular or not : See No. 32.

(*b*) Steady and regular buzz : See No. 31.

31 REGULAR BUZZING of coil assured : Take the high tension cable from the plug, and test spark to plug head with the engine running.

(*a*) Regular spark : See No. 33.

(*b*) Irregular spark : Examine trembler for loose platinum, wet, pitting, adjustment of armature, or faults of action generally. Examine the terminal at the coil end of the high tension cable for stray wires, or leakage of the spark into one of the low tension wires. Take cable from the coil high tension, replace other end on its plug, and test spark over ¼in. gap to cable end, with the engine running. Regular sparking indicates a leak in the high tension lead. Irregular sparking indicates defect in the coil, such as a shorted condenser or internal high tension leak. Possibly plug points too wide apart. See also No. 1118 *et seq.* If available, try spare coil, cables, plug, and accumulator in turn, or examine as if the buzz had been irregular. See No. 30*a*.

32 MIS-BUZZING, or uncertain whether buzzing regularly or not (single-cylinder engine trembler coil ignition from No. 30*a*) : Adjust trembler with the engine running. Test voltage of battery (which should be 3.8 or over) with the engine running. Fluctuations of voltage show battery run down, or a broken internal connection in the battery.

Examine binding screws and cables (battery two, earth one, switch two or three, commutator one or two, coil two), and commutator earth wire, if any, for looseness, dirt, rust, insulation, etc.

Press commutator case to test for bad earthing ; see No. 1129.

Examine commutator for dirty or rough or worn wipe path, loose spring, worn wipe, etc.

Clean trembler points, and readjust with engine running. Look for wet on points, try the armature adjustment, etc.

Press the switch into contact to test for looseness, weak spring, dirty contact, etc.

If not quite certain of mis-buzzing, proceed to No. 31.

If quite certain of mis-buzzing, proceed as follows : First of all, unless quite certain of the work done, go over it again for loose terminals, etc., in the above list ; but if certain nothing has been overlooked, the only thing will be to

Try spare plug, coil, accumulator, and low tension wiring. If a spare set known to be in order mis-buzzes, the fault is in the commutator or any other part not replaced ; but its most probable position is the coil, which, failing other means of examination, should be submitted to its makers.

Telephone examination will be found useful here. See No. 105*c*.

33 Regular and Steady Spark from high tension lead to plug head, but engine runs irregularly, and as though missing. Note the following points :

Examine the plug points for set if not done : Should be 17-1,000th inch.

Change plug.

Water in petrol : Usually causes momentary hesitation if small quantity ; violent backfiring if large.

Pre-ignition : Due to shortage of water, defective circulation (radiator cold), shorting in commutator or its leads, double contact in commutator (see No. 1139), or foreign matter in cylinder. In cases of pre-ignition, when bad, the spark lever produces no effect.

Sticky inlet or exhaust valves : Former will usually produce explosions in carburetter.

Partly choked jet : See No. 34. (Unusua , as it usually causes complete stoppage. Produces popping in carburetter, as a rule.)

Shortage of petrol : Usually runs all right after throttle has been shut, and float chamber is full. Shortage may be due to choked petrol pipe, filter, tank vent, empty tank. petrol turned

off, or failure of pressure feed. Will sometimes run with air inlet partly closed. To detect, race engine with retarded spark, open throttle, suddenly turn off petrol, and close the throttle at same time when the float chamber will be found short of petrol.

Badly adjusted carburetter (additional air valve giving too much air) : Usually causes popping in carburetter. Try partly choking inlet pipe. See No. 333.

Sticky additional air valve sticking open : Usually causes popping or stoppage.

Go through list No. 34.

Occasional misfires on four-cylinder engine produce momentary check in speed of car, often without any usual sign of a misfire.

***34** ENGINE RUNS APPARENTLY NOT MISSING, BUT THERE IS SOMETHING WRONG WITH THE RUNNING OF THE CAR OR ENGINE : Faults more or less in order of probability—

(*a*) Slipping clutch : If continued for any time, clutch will be hot.

(*b*) Brakes dragging : Brake drums will be hot when brake has not been used. Prove by jacking up a wheel.

(*c*) Lack of cylinder lubrication : Sometimes causes complete and sudden stop, more often sluggish " pulling " of engine. Engine usually free to turn by hand.

(*d*) Engine fails to pull on opening throttle. Where throttle is spring opened may be due to throttle sticking. More probably due to one of following points : Where engine has always done it, probably design of carburetter. Newly developed fault, may be due to flooding of petrol, due to punctured float, defective balance weights, loose petrol jet, etc., or leak of air into the induction pipe between throttle and engine. Additional air valve (if any) stuck open.

(*e*) Flooding with petrol : Engine difficult to start, perhaps impossible without first ventilating. May be due to punctured float, faulty needle valve or balance weights, or loose jet.

Additional air valve stuck open : Usually causes popping in carburetter if not excessive ; if bad usually stops engine. Engine difficult to start up, perhaps starts after flooding, and stops again.

(*f*) Additional air valve stuck shut: Engine runs all right at low engine speeds, with throttle partly shut, but will not pull at high speeds. Sometimes acts like a governor, the engine refusing to exceed a certain speed. Excessive consumption of petrol.

Additional air valve spring too weak: Falling off in power at high speeds; little difference at low.

(*g*) Additional air valve spring too strong: Excessive consumption of petrol, probably falling off in power at high speeds, especially with open throttle.

Valves wrongly set: Due to faulty assembling, wear of stems, or slipping of the adjustment (if any). See No. **116**.

(*h*) Unusual noises as under—

Squeaking, difficult to locate: Note, if rhythmical, what it corresponds with in periodicity. Examine for hot bearings, cardan joints, road wheel hubs, gear box bearings, driving pinion spindle bearings, and engine bearings. Try for squeaking coach springs by rocking the body. Examine for leak in exhaust pipe joint or silencer, or leak under crank chamber cover. Look for shortness of water or over-heated radiator.

Hissing: Look for leaky compression taps, exhaust joints, sparking plug washers, sparking plug stems, valve covers, piston, etc. Some carburetters always hiss in action.

Popping in the carburetter: Usually too weak a mixture (too much air or too little petrol). Look for choked petrol supply (for causes see No. 106*b*, and to locate see No. 1005). In this case the float chamber will be empty, possibly partly shut petrol tap, when the engine will probably run all right at part power. Might be a sticky inlet valve stem. Possibly automatic inlet valve wrongly set. For effects of partly choked jet, see No. 34*t*. Possibly two leads out of four or more crossed.

Banging and backfiring in silencer: Fairly large quantities of water in carburetter produce this effect. Noticeable on examining float chamber and jet. Ignition faults also produce this effect, for which see tables 44, 114. Sticky exhaust valve stems or broken exhaust springs also produce this effect.

Grinding or grating noises: Look to the gear box and differential gear for broken balls or teeth, or for obstructions in the teeth. To locate see No. 1172.

(*i*) Knocking: Bent connecting rod. The writer has noted one case. When the engine was being turned by hand and the connecting rods were watched the bent one was seen to slide backwards and forwards on its gudgeon pin. It produced a distressing knock due to many causes, and difficult to locate. Loose bearings most likely are the crank pin bearings (big ends) and the gudgeon pin bearings (little ends). Loose piston rings or sticky piston rings sometimes disappear when engine is hot. Looseness in transmission connections sometimes only knocks in certain positions of the throttle. Engine loose on its frame. Loose balance weights.

False contact in commutator: See Nos. 1139 and 1140.

Knocks only in certain positions of the spark lever: Look for shorting of commutator wire or commutator terminal.

Chattering at certain speeds: Look to front end of torque rod for looseness or weak spring holder. See No. 1185.

Sharp single crack on letting in clutch: In chain drive car look to bolts of front end of radius rod for looseness, or to the bracket holding same for looseness. See No. 1186.

Pre-ignition: Due to shortness of water and overheating foreign matter in cylinders, failure of cooling system, deposit of grease or soot in cylinders or on pistons, spark too far advanced, false contact in commutator, cavities in cylinder casting or valve heads, overheating of sparking plug projections, or other projections in cylinders. See No. 1085.

(*j*) Ignition too far advanced: Probably backfires on starting, and knocks or pulls badly with advanced spark.

Ignition retarded too far: Probably difficult to start unless spark is advanced, and takes spark lever as far advanced as it will go when running. For timing see No. 117 *et seq.* Due to slipped chain, key, wipe, or broken or bent control links, see No. 1145 *et seq.*

Leaky inlet or exhaust valves: Loss of compression and general loss of power. Hissing usually not audible, unless inlet or exhaust pipe is off, and engine turned by hand.

(*k*) Leaks from following points—valve covers, cylinder head (where separate), piston, and sparking

plug compression taps: Most of these can be located by listening for the hiss or, better, by pouring oil round the joint and watching for bubbles.

Overheating of engine due to following points—

Lack of water: Radiator usually cold at bottom, probably hot at top, engine hot and probably fizzling. May cause knocking or only bad pulling.

Defective circulation due to obstruction, air lock, pump failure, etc.: Top of radiator hot, bottom cool; lower engine circulating pipes cold or cool.

(*l*) Overheating of radiator, or water boiling away: Due to—

Air lock in pipes, choked pipes, broken-down pump, or lack of water: In all these the bottom of radiator will probably be cold, top hot.

Broken fan belt, or slack fan belt, sticking additional air valve, ignition too far retarded, choked air inlet to carburetter, leaky jet of carburetter, or dirty cylinders: With all these the whole radiator will be likely to be hot, as the circulation is still effective.

> NOTE.—In thermo syphon systems the bottom of the radiator is always cool. The writer believes weak mixtures also run hot.

(*m*) Pre-ignition: Usually causes knocking. Advance spark lever movements have no effect on engine; possibly engine goes on running with spark off. For causes see above No. 34*i*.

Short-circuiting of commutator wire: When complete causes continuous buzz of the coil, but, under certain conditions, the engine will continue to run, but the spark lever has no effect. If short circuit is intermittent causes jerkiness and irregular running.

Choked air gauze to carburetter, or choked carburetter induction pipe: Sluggish running, excessive consumption of petrol; hot running of engine (the writer is uncertain of this result of too strong a mixture); sooting of plugs and valves; sometimes black smoke from exhaust.

(*n*) Hot bearings:

Engine: Engine stiff to turn over, and will not swing well; but, on stopping, brings up suddenly. Crank case probably hotter than usual (remember crank case will always be warm, however). Compare next paragraph.

Hot bearings in gear box primary-shaft: Engine stiff to move with clutch in engagement, free with clutch held out. Bearing at end of gear box hot.

A leak of air into the induction pipe close to one cylinder will often cause the cylinder to miss firing occasionally or to cut out altogether.

(*o*) Gear box lay shaft: Bearing hot. Back wheel jacked up, stiff to move.

Gear box secondary, bevel pinion bearing, or differential case bearing (cannot be distinguished from each other except by dismounting or by position of over-heated spot): Both back wheels jacked up, and one turned one way the other one will turn the other.

Tit of primary-shaft where it engages with socket on cardan: Engine stiff to turn over unless clutch is held out (same so far as for hot primary-shaft bearing). Back wheel jacked up stiff to turn unless clutch is held out, when it will turn easily.

(*p*) Differential-shaft bearing or corresponding road wheel: This road wheel will be stiff, others free.

> NOTE.—In looking for hot bearings, remember that the gear box and back axle will be warm after running on account of the churning of the grease.

Broken balls: Usually cause rattling, shaft often loose. Sometimes a rattle will be noticed at certain positions of the throttle running slowly on top speed on the level.

Worn ball bearing: Symptoms much the same as those given above for broken balls.

Obstruction in gears: See No. 1072.

(*q*) Electrolyte in accumulator too weak: This is an uncertain cause of loss of power. The writer has noted one case only, and that not well ascertained—sparking was regular with engine running, but the pulling of the car was sluggish, engine would not take the spark fully advanced however. Latest theories indicate that as long as the spark can be advanced far enough and the charge is ignited, the strength of the spark is immaterial.

(*r*) Leak of air into the induction pipe: Probably sluggish at low engine speeds, small difference at high. Sluggish in picking up after throttling. Engine will not run slowly when running idle. If this leak is near one cylinder it may cause that cylinder alone to miss or cut

out entirely. The writer has had two distinct cases, on one of which he spent many hours trying to locate an ignition fault.

Oil too thin: Probable effect much as for insufficient lubrication above.

(*s*) Oil too thick: Not likely to have much effect on the running of the engine but makes it stiff to turn over by hand when cold.

Gear changing difficulty: See text, Nos. 1077, 1078, and 1173.

Car starts with a bound on letting in the clutch: Clutch fierce. See text, No. 1076.

Throttle connection broken: Throttle (hand or governor) only partly open. Throttle lever has no effect.

Automatic inlet valve wrong lift: See No. 117.

Partly choked carburetter jet: Rather unlikely cause of sluggish running; usually causes popping in carburetter, or stops the engine entirely.

Crossed leads: If engine runs at all, and all leads are crossed, it will be almost certain to stop with the spark advanced; it will only run with retarded spark. See No. 33.

(*t*) Partly choked jet: In the course of his experiments on carburetters the writer has on about twelve occasions found minute hairs stretched across the bore of the jet. These hairs have been too fine to see with the naked eye, but have been quite visible under a magnifying glass. The effect of such a hair is quite enough to take the "edge" off the "pull" of an engine. It may be expedient, therefore, where an engine has mysteriously lost pull, to pass a cotton through the jet. On no account use a steel wire or needle. Spinning the jet on a thread of cotton is ample. As a rule a partly choked jet produces popping in the carburetter, presumably owing to the hanging fire of a too weak mixture. The writer has no conclusive evidence, but the indications seem to be that a weak mixture, due to partly choked jet or any other cause, produces hot running rather than strong mixtures.

(*u*) Choked silencer: In pressure feed systems this often betrays itself by excessive pressure in the fuel tank.

(*v*) Boiling petrol: See No. 106*d*.

35 SINGLE-CYLINDER ENGINE Non-trembler Coil Ignition : Faulty running. Spark to plug head irregular (from No. 29*b*).

(*a*) Look for loose or dirty terminals (battery two, earth one, switch two or three, coil three, low tension one, high tension, contact breaker one or two, and coil earth one), and contact breaker earth wire (if any). Listen for leak of spark. Test voltage across battery terminal, with the engine running. Fluctuations show the battery down, or broken or loose internal connection. Where contact breaker spindle is in circuit, press it to test for bad earthing (No. 1129). Clean contact breaker points, and adjust it, with engine running if possible. Where the fault is possible, look out for grit on the cam path. See No. 36.

36 THEN TAKE high tension lead from coil (other end on plug), and test spark into lead over ¼in. gap, engine running.

(*a*) Steady spark : Shows leak in high tension lead.

(*b*) Bad spark : Examine plug for spacing of points. Re-examine wiring for loose terminals or broken wires according to the list above (No. 35*a*). Press switch into contact. All no good, fault probably in coil. Try spare if possible. If not available, try wiring whole system by outside wires, cutting out switch and earth wires (see No. 1180). When contact breaker spindle is in circuit, try earthing it by an outside wire. Telephone examination, as under, will probably locate fault. See also No. 1118 *et seq.*

***37** TELEPHONE EXAMINATION OF NON-TREMBLER IGNITION : Test current across contact breaker points, engine running.

(*a*) Regular clicking : Low tension system probably in order, but may be broken-down condenser, bad coil earth, or bad contact breaker. Broken condenser or coil earth should show by sparking at contact breaker.

(*b*) Irregular clicking : Put one terminal of telephone on coil positive, and touch earth.

38 SHOULD GIVE one click, and then silence.

(*a*) Irregular clicking : Keep one end on coil positive, and touch the battery negative. One click, and silence, shows fault between coil positive and battery positive. Irregular clicking shows the fault between battery negative and earth.

(*b*) One click, and silence, shows a fault somewhere between earth and coil positive through contact breaker and coil. Test from battery positive to the coil connection of the contact breaker. Regular clicking shows the fault to be between contact breaker and coil positive through coil. Irregular clicking shows the fault in the contact breaker or its earthing. A possible exception is a leaky coil contact breaker wire making occasional contact.

39 SINGLE-CYLINDER ENGINE High Tension Magneto Ignition, irregular running; spark irregular to plug head (from No. 29*a*): Examine plug for set of points, etc., and change the plug if in any way doubtful.

(*a*) Low tension magneto and separate coil: Test spark at coil high tension, engine running. Regular sparking shows leak in high tension cable or distributer. Bad shows fault in coil or magneto. Clean contact points and set them, taking care that they make and break contact correctly. (See note No. 1156 and No. 118.) If possible, examine cam path for roughness or wear. Empty magneto of oil. Clean off any water about it. Examine all cables and terminals for looseness or insulation, including coil earth (both ends), magneto low tension, and coil low tension. Remove switch connection wire; if right, now shows short-circuited switch or switch wire. Examine collecting brushes for dirt, oil, or loose spring, and press into contact by hand where possible. If magneto is damp, dry out in a dry room for some days. An indication of the position of a fault can be had with a telephone. Coupled across contact breaker, it should give regular clicking; irregularities show fault in magneto low tension. Look to earthing of magneto. Try another coil if available.

(*b*) High tension magneto without coil: Test spark into high tension cable engine running. Good spark indicates leaky lead. Irregular, examine as in (*a*) above.

40 MULTI-CYLINDER ENGINED CAR (from No. 1).

(*a*) Engine will not start up: See No. 42.

(*b*) Car runs badly: See No. 72.

(*c*) Engine runs, but the car will not: See No. 4.

(*d*) Car stops on the road (including the case where the engine stops again after starting up): See No. 41.

41 CAR STOPS ON THE ROAD.

(*a*) Engine continues to run: See No. 4.

(*b*) Engine stops as well as car. See No. 42.

42 ENGINE STOPS AS WELL AS CAR, or the engine will not start up (from No. 40*a* and No. 41*b*) : In trembler coil ignition, where a coil buzzes continuously, see No. 108. Try to start up by merely turning the handle, noting the following points—

(*a*) Engine stiff to turn over : See No. 5*a*.

(*b*) Engine backfires with retarded spark : See No. 5*b*.

(*c*) Engine has no compression : See No. 5*c*.

If in order : See No. 43.

43 ALL THESE IN ORDER, AND THE ENGINE TURNS PROPERLY : Try to start in the ordinary way with the starting handle.

(*a*) Engine gives one or two explosions, and stops again : Look for choked jet and battery run down, and then see No. 107.

(*b*) Engine starts up, and apparently runs all right : See No. 107.

(*c*) Engine will not start up or give a single explosion : See No. 44.

***44** HAVING DUE REGARD TO YOUR PAST EXPERIENCE with the engine, either ventilate or tickle carburetter, and try again. (If you have no experience, carefully ventilate, tickle carburetter, flood carburetter, and add a little petrol to the cylinders in this order.) Whilst tickling the carburetter, look for lack of petrol or stuck needle valve of float chamber by the position of the spindle ; flooding—if obvious, through leakage of petrol ; cables off plugs, or plug switches (of low tension magneto) open. Now try to start engine with the handle.

(*a*) One or two explosions, and stops again : Look for choked jet, and, if not found, see No. 107.

(*b*) Engine starts up : See No. 107.

(*b2*) Where an engine gives one or two " pops " in the silencer, and otherwise refuses to run, and where the fault is possible, look for crossed leads or wrong timing of the spark : See Nos. 114, 115, *et seq.*

(*c*) Still no explosion : See No. 45.

45 MULTI-CYLINDER ENGINE will not start up : Engine free to turn, compression good, and carburetter tickled.

(*a*) Low tension magneto ignition : See No. 54.

(*b*) High tension magneto ignition : See No. 57.

(*c*) Synchronised high tension ignition : See No. 59.

(*d*) Non-trembler coil ignition : See No. 62.

(*e*) Trembler coil ignition with individual coils: See No. 46.

(*f*) Bosch dual ignition: See No. 123.

46 TURN THE ENGINE SLOWLY, and listen for the buzz of the coils.

(*a*) None buzz: See No. 48.

(*b*) Some buzz, some not: If the voltage is above 3.8, it is fairly certain that the fault is not in the "common" circuit (from commutator "wipe" through earth, battery, and switch, to coil positive terminal), and it is even unlikely that the fault is electrical, as the engine would probably run on the coils which buzz, especially if the failure is a sudden one; but where the engine has been out of use some time, some other fault might interfere with these. For buzzing coils see No. 46*c*, non-buzzers see No. 48.

(*c*) All coils buzz steadily in turn: Using ordinary experience, ventilate the engine carefully, flood carburetter, and add petrol to the cylinders. Make sure that you have petrol in the float chamber. Engine starts, or gives one or two explosions, see No. 107. Still no explosion, see No. 47.

47 TEST SPARK (of defective cylinders) to, or at, one of the plugs.

(*a*) No spark: This is unlikely, as it indicates a simultaneous fault in the coils; might be due to dampness of leads. Test spark into high tension leads at coil end; good spark here shows leaky lead, bad spark see No. 12*b*.

(*b*) Good spark: Test spark at plug points (if not done). Good, see No. 106. Bad shows bad plug.

48 MULTI-CYLINDER ENGINE will not run, buzz of one or more coils fails (from 46*a*): Look out for loose or detached wires (battery, earth, coil, commutator, commutator earth if used, and switch). Test voltage (3.8 or over). (See note No. 108*o* on broken battery bridges.) Make sure switch is closed. Examine commutator for loose wipe, weak spring, breakage, dirty path, or points. Set trembler points either when one trembler operates all coils, or where one coil only fails. Test with voltmeter or telephone (a "click" in the telephone corresponds to "current" with the voltmeter) as follows: See No. 49.

***49** PLACE ON CONTACT of a defective coil (see No. 114 to identify): Put voltmeter on earth, and touch coil positive terminal (not the cable end, but the binding screw).

(*a*) Current: See No. 51.

(*b*) No current: See No. 50.

50 TEST CURRENT Battery Positive to Earth.

(*a*) Current: Shows fault between battery positive and coil positive. Locate by keeping one terminal on earth, and touching in turn coil positive, switch terminals (if in this wire), and battery positive. Fault between current and no current.

(*b*) No current: Fault in earth connection of battery. Locate by keeping voltmeter terminal on battery positive, and touching in turn earth, switch terminals (if in this circuit), and battery negative. Fault between current and no current.

A weak current from battery positive to earth shows a bad earth connection, or a bad switch contact if in this circuit.

51 MULTI-CYLINDER TREMBLER COIL IGNITION, engine stops: Engine on contact (current flows from earth to coil positive binding screw, from No. 49*a*). Keep terminal of voltmeter on "earth," and touch in turn all the trembler blades and trembler screws, or those under examination. See Nos. 51*a* and 51*b*.

(*a*) Some fail to show current: Keep voltmeter on "earth," and touch in turn blade, blade screw, trembler screw, and coil positive small screw, and coil positive binding screw again. Fault is between current and no current, as, for instance, an insulated trembler point. See Nos. 1119 and 1120.

(*b*) Current from all blades and screws: Connect voltmeter from coil positive to earth again, and, whilst watching the needle of voltmeter, depress the blade of the coil on contact; to identify, see No. 114.

If no rise in voltage is shown by voltmeter on depressing the blade, see No. 52. If the voltmeter shows a rise in voltage on depressing the blade, it indicates that the current has been flowing through the coil, indicating stuck trembler points, trembler out of adjustment, or armature out of adjustment. To prove, move off contact, and test current coil negative to earth. Current shows that circuit is complete through coil. No current would be unlikely, but if you are correct

as to the rise in voltage, it would be due to a partial fault, such as trembler points only just touching, but nearly insulated.

52 TEST current now from coil positive to coil commutator.

(*a*) Current : See No. 53.

(*b*) No current : Test from coil commutator small screw to earth. No current shows an internal breakage in coil. Current shows fault between coil commutator small screw and commutator earthing. Keep voltmeter on earth, and touch coil commutator small screw, coil commutator terminal, corresponding commutator terminal (to identify, see No. 114), commutator sector, commutator wipe, and spindle. Fault between current and no current.

53 CURRENT from coil positive to coil commutator terminal (from No. 52) : This shows circuit complete, with the exception of the coil. Move off contact, and test current from coil commutator to earth, both with the blade depressed and untouched.

(*a*) Current both positions of blade : Shorted condenser.

(*b*) Current neither position : Internal breakage in coil. See No. 1118 *et seq.*

(*c*) Current with blade up only : This is as it should be. Might show too tight a blade spring, faulty armature, or a high resistance in circuit. Test with ampèremeter across blade, and point with blade depressed should show over two ampères on contact.

***54** LOW TENSION MAGNETO, multi-cylinder engine : Will not start up after tickling carburetter. Engine free, and compression good. No explosion at all.

Use your ordinary experience whether to ventilate, flood carburetter, or add petrol to the cylinders. Lacking experience, do all these in the order mentioned.

One or two explosions after flooding : Probably indicate choked petrol jet ; one or two explosions after adding petrol to the cylinders might mean complete lack of petrol. (For causes of lack of petrol, see No. 106*b*.)

Look for loose wires, closed switch, and lack of petrol.

Remove switch wire from switch. If the engine runs now, the switch is short-circuited. Examine switch lead carefully for short-circuiting. See No. 26.

Still no good : Cut out one cylinder at a time (or in a four-cylinder engine two cylinders) by removing the plug wires or

opening the plug switches where fitted, and try to start up on the remaining cylinders. Engine runs now shows a short circuit in the plugs or leads of the cylinders cut out, or their contact breakers (or one of them) not breaking contact.

Still no good : See No. 55.

55 TAKE THE LOW TENSION CABLE from the magneto binding screw, and attach a length of cable to this screw, and, whilst the engine is being turned by hand, or run on the supplementary ignition, tap the end of this cable on the engine frame (not the magneto frame).

(*a*) No sparks : Examine magneto collecting brush for dirt or oil, and make sure it makes good contact, pressing it into contact by hand if required. Examine cable for chafing. Try with another piece of wire, if possible from magneto terminal to frame (if not already done). Sparks now show leaky lead or dirty terminal. Clean magneto terminal, and make sure magneto frame is earthed. Empty magneto of oil. Test with voltmeter from terminal to frame. Should show a current spasmodically. If it does, it would indicate that the magneto is all right. No current indicates a magneto fault. If not found as above, send to makers. (To make sure, see No. 25*b*, as this test is uncertain.)

(*b*) Sparks : Might be a leaky lead, which does not leak in the new position when off plugs. See No. 56.

***56** SPARKS from magneto lead when tapped on engine frame, turning engine by hand, or running on supplementary ignition (from No. 55*b*).

(*a*) Sudden failure, or fails to start up : See at once No. 106.

(*b*) Car been lying idle some days, or fails after adjustment. See *c* below.

(*c*) If possible examine spark through a valve cover at the contact breaker ; if not possible, assume it to be bad. See *d* or *e*. Be careful that if the gas in the cylinder explodes it will not injure you.

(*d*) Good spark : Look out for timing errors and set of magneto armature (for method of timing see No. 118), especially if magneto has been disconnected. Then see No. 106.

(*e*) Bad spark at contact breaker : If magneto has been out, or if you do not know whether it has or not,

make sure it has been put in with its armature at the correct position. If camshaft has been out, or timing wheels out of mesh, make sure that the tappets break contact at the right time. (For timing see No. 118.)

Connect magneto direct to one plug by a piece of cable, removing all other wires, and try each plug in turn in this way. If the engine runs now on one cylinder, it shows a leak in the system, possibly leaky lead or two leaky plugs, or a couple of tappets not breaking contact, or insulated low tension terminal. (If one only were leaking, this should have been found at No. 54 on the preceding page.)

A leak may be located by connecting in a battery and voltmeter (see text No. 1187), and holding tappets off plugs, or with all in the "break" position.

Failing all this, see No. 106.

***57** MULTI-CYLINDER HIGH TENSION MAGNETO: Engine stops, or will not start. Carburetter tickled, engine free, but will not give a single explosion (from No. 45*b*).

Use ordinary experience of starting, whether to ventilate, flood, or add petrol to cylinders. Make sure that a frayed end of the switch cable is not making a contact with the magneto frame, and that the switch is open. If in any doubt, take off the switch wire and run without it. Look for loose wires, closed switch, and lack of petrol in float chamber. See spark advanced to usual position. [NOTE.—Spark must usually be advanced to start on magneto.] Take out a plug and examine spark.

(*a*) Sparks all right at plug. See No. 106.

(*b*) No spark at plug: Where all cylinders fail suddenly, it is not likely to be plug leads unless they have been wetted. See No. 20.

***58** NO SPARK AT PLUG (from No. 57*b*): See No. 20.

***59** MULTI-CYLINDER SYNCHRONISED HIGH TENSION IGNITION: Engine will not run at all, or give a single explosion after tickling the carburetter. Engine free, and compression good. Turn engine slowly, and listen for buzz.

(*a*) No buzz at all, or buzzes a moment when on contact, and then stops: Place on contact, and see No. 13.

(*b*) Some buzz, some not: Unlikely, except where ignition gear is quite out of order. Non-buzzers, see No. 59*a*. Buzzers, see No. 59*c*.

(*c*) Steady buzz all cylinders: See No. 60.

***60** STEADY BUZZ: If spark in distributer is visible, examine (if not visible, treat as steady spark, No. 61).

(*a*) Irregular or no spark: See that distributer cable is on its terminal. Examine spark into high tension distributer lead from coil. If good, shows a leak in high tension distributer. If bad, see No. 12*b*.

(*b*) Steady spark: See No. 61.

***61** STEADY SPARK: Examine spark to plug head and cylinder head. Former bad, latter good, shows plug points too wide.

(*a*) Both good spark: Examine plug on off chance of failure; but this is unlikely, as all cylinders have failed. Good spark at plug probably not ignition at all, unless leads have been out and have been crossed, or the ignition is timed wrongly. See No. 106. (Where plugs are found wet, see footnote 76*a*.)

(*b*) Both bad: If the spark was seen to be good inside distributer, this indicates a leak between distributer and plug, probably inside distributer, unless leads are wet. If spark was not seen in distributer, test spark from coil into high tension distributer lead; or, if this be difficult, from this lead into distributer.

Bad indicates a bad coil. Adjust trembler. See that high tension distributer wire has not dropped off distributer terminal. Rare fault is high tension wire broken out of sight.

Good spark shows leak between point examined and plug.

***62** MULTI-CYLINDER NON-TREMBLER COIL IGNITION: Engine will not run at all, or give a single explosion, non-trembler coil ignition (from No. 45*d*). Engine free and compression good, and carburetter tickled.

Use your usual experience as to ventilating, flooding, or putting petrol in the cylinders. Lacking experience do all these things in the order mentioned.

Examine all leads and terminals for looseness, test voltage (see text *re* broken bridges, No. 1081). See switch closed.

Switch in spare accumulator if wired.

Take one lead from its plug, and examine spark, both turning engine over, and breaking contact by hand where possible. Test spark both to plug head and cylinder head over $\frac{1}{4}$in. gap. Good spark to cylinder head, bad to plug head, shows plug

points too wide. Good spark breaking contact by hand, bad when turning engine, shows fault in contact breaker. Where examining without assistance, it may be better to examine spark at plug itself.

(*a*) No spark either way, turning engine or breaking contact by hand : If spark only tested at plug, test also to engine frame ; if this gives good spark, shows plug bad. See No. 63.

(*b*) Good spark across ¼in. gap : Examine spark at plug points (if not already done), and if this is found bad (and the spark from lead was good), it shows a bad plug. Spark at plug good, examine carburetter jet. See No. 106. (Where plugs are found wet, see footnote to No. 76*a*.)

63 Bad Spark from High Tension Lead : Test spark at another plug, or at another plug head. If found good, the engine should at least run on this cylinder, therefore see back No. 62*b*. If bad spark here, see No. 64.

64 Test Voltage across all contact points, taking care that they are not in contact when tested. If they cannot be made to separate, this is a fault of adjustment. When examining one only (from No. 84*a*), select the contact points of the defective cylinder. To identify, see No. 114.

(*a*) Current from some, not from others : Unlikely in case of sudden failure, as it shows a compound fault. For those showing no current, see No. 64*b*. For those showing current see No. 64*c*.

(*b*) No current : See No. 66.

(*c*) Current from all : Clean and adjust contact points, then set one pair in contact, and test voltage across them. If a current is found, they are not in contact, and are out of adjustment. If they show no current (which is as it should be), see No. 65.

65 If no Current (which is as it should be), take a high tension cable from its coil, and test spark into it over ¼in. gap.

(*a*) Spark shows leaky lead, and would indicate, in case of sudden failure, that the leads were wet, or some common cause of failure must be present to account for more than one lead failing at once.

(*b*) No spark : Fault probably in the coils, and where more than one has failed, it is likely to be in some

common point, as, for instance, failure of a common earth wire, which would produce sparking at the contact breaker points. Examine earth carefully both ends. Look carefully at contact breaker again, and try re-setting. All else failing, try spare coil, battery, and cables in turn. If coil known to be in order, and new good accumulator will not work, the fault is probably in contact breaker. If no spares are to be had, try wiring the whole system by direct wires, cutting out switch and earth return. See text No. 1180.

***66** No Current across any (or the ones under test) contact points: Look out for loose or detached wires, open switch, or battery down. These apparently right, fault is probably in the "common" circuit. See No. 67.

67 Test Voltage Coil Positive to earth (not from the cable end, but from the terminal screw).

(*a*) Current: See No. 69.

(*b*) No current: See No. 68.

68 Test Current Battery Positive to earth.

(*a*) Current: Fault from battery positive to coil positive. Locate by keeping voltmeter on earth, and touching battery positive, switch terminals, and coil positive. Fault between current and no current.

(*b*) No current: Fault between earth and battery positive; and if battery voltage has been found good, it must be in the earth connection or switch terminals if switch is in battery earth wire. Make sure you have voltmeter on a true earth.

69 Current flows from Coil Positive to Earth (from No. 67*a*): This shows circuit from coil positive through battery and switch to earth right. See No. 70.

70 Test Current from coil contact breaker terminal (*not* the cable end, but the binding screw) to "earth."

(*a*) No current: Shows broken low tension winding or internal connections of same; or short circuit in condenser, coil contact breaker lead, or contact breaker points not separated. Test current from coil positive to coil contact breaker terminal. Current shows short circuit, as mentioned above in this paragraph 70*a*. No current shows broken-down low tension winding or connections. (For this test throughout, the contact

breaker points should be in the "open" position.) See also No. 1118 *et seq.*

(*b*) Current: See No. 71.

71 Test from Contact Breaker Coil Connection on to Earth (points still apart).

(*a*) No current: Shows fault between coil contact breaker connection and contact breaker.

(*b*) Current: Either—

Faulty contact breaker points not making contact (in which case a current will be obtained across them when they seem in contact). Possibly failure to break contact properly (*i.e.*, adjustment), when no current will be had across points when in the "break" position, even when current was bad when the points were forcibly separated.

Conceivable faulty earthing (connection to battery negative) of contact breaker.

Possibly insulated coil earth wire, especially where this is common to all coils. Test by trying current coil positive to coil earth. No current shows insulated coil earth connection.

***72** Multi-cylinder Engine, Defective Running (from No. 40*b*): Run on each cylinder in turn, and note which are defective. [Note.—One cylinder will often run faster than another with retarded spark, but will pull equally well on the road; difference often disappears with advanced spark and partly closed throttle. Governor must be out of action. Where a defect in running only shows up occasionally, and is not noticeable when testing, see Nos. 32, 33, 34, and 328.]

For list of special faults not in this list, see No. 121.

(*a*) Excessive consumption of petrol: See Nos. 34, 33, 32, and 1179.

(*b*) Continuous buzz of trembler coil: See No. 108.

(*c*) Will not pull on opening throttle, but then picks up and pulls all right: See No. 34*j*.

(*d*) Will not stop on switch: See No. 28*h*.

(*e*) Engine shows no signs of missing, cylinders pull about equally, but engine has not its usual power: See No. 34.

(*f*) Odd noises: Popping in carburetter, knocking, squeaking, banging, and backfiring in silencer, etc. See Nos. 34*h* and 34*i*.

(*g*) Engine misses on one or more cylinders, or one or more cylinders out of action: If uncertain whether missing or not, open compression taps, which will usually decide; but if still uncertain, treat as missing. See No. 73.

73 NOTE WHICH CYLINDERS ARE MISSING if possible.

(*a*) Low tension magneto ignition: See No. 74.

(*b*) High tension magneto ignition: See No. 75.

(*c*) Non-trembler coil ignition: See No. 81.

(*d*) Synchronised high tension ignition: See No. 89.

(*e*) Individual trembler coil ignition: See No. 96.

(*f*) Bosch dual ignition: See No. 149.

***74** MULTI-CYLINDER LOW TENSION MAGNETO IGNITION: Missing or irregular running, or one or more cylinders out of action (from No. 73).

(*a*) Missing or not running on some cylinders only, one or more cylinders all right. Clean (or change) plugs of defective cylinders. Adjust tappet of defective cylinders. See wires are not off plugs, and that contact piece to each plug is well home. Look out for broken valve springs or stems, valves stuck open, etc. Make sure tappet makes and breaks correctly (see No. 118). Pre-ignition, test plug for shorting (see No. 1163). See No. 74*b* below.

(*b*) Missing on all cylinders: Examine magneto terminals for looseness or dirt. If missing disappears when running on one particular cylinder (or more than one), suspect shorting of the ignition gear of some of the cylinders cut out, and cut out each cylinder in turn; if missing disappears with one cylinder cut out, shorting is probably in the ignition gear of that cylinder. Remove switch wire; all right now shows shorted switch or switch cable. Examine cable for fraying or leakage. Make sure petrol supply is clear and free from water. If magneto has been out or dismantled, make sure it has been put in right timing (see No. 118 for timing). Clean contact brush and slip ring. Make sure brush spring is pressing brush into contact. Look out for oil or water on magneto, especially on slip ring or terminal. Empty magneto of oil. Clean and change plugs. Disconnect cable from plugs and magneto, and connect each plug in turn to magneto terminal by a length of cable. Make sure armature is correctly timed, and

contact breaker breaks contact at right point, and then try to start up on one cylinder. If engine runs, fault is certainly a short circuit somewhere. For examination of contact breaker, see Nos. 118 and 1163. Look to magneto earthing. If possible, examine spark at contact breaker by mirror or otherwise, but beware of an explosion. If this is right, and the timing is right (for this see No. 118), the fault is not likely to be electrical. Cracked jacket or leaky water head would probably give a steamy exhaust. See No. 33 and then No. 34 and foot note to No. 76*a*.

***75** Multi-cylinder High Tension Magneto: Signs of missing or irregular running, or one or more cylinders out of action. Run on each cylinder in turn.

(*a*) Missing on all cylinders: See No. 77.

(*b*) One or more cylinders all right: See cables are on their plugs, and then see No. 76.

76 Test Spark to cylinder head and plug head, engine running: One good, the other bad shows plug points too wide.

(*a*) Both good: Examine spark at plug, and note set of point, which should be $\frac{17}{1000}$ in. If bad, shows defective plug—sooty, oily, broken, or wet.* See also No. 11*b*. If good, fault probably not electrical, but might still be defective plug.

Where two or more cylinders are defective, and wiring has been interfered with, look out for crossed leads. To identify, see No. 115*c*.

Look for sticky valve, broken stem, broken valve spring, leaky induction pipe near cylinder which is missing, or pre-ignition. Then see No. 33.

(*b*) Both bad: Test spark into high tension lead, or from magneto terminal to magneto frame. Good spark here shows leak in lead. Bad spark to frame. As other cylinders, or one of them, are firing all right, probably indicates a fault of the contact breaker cam, or a short circuit in the high tension distributer, possibly due to wet. If suspected, take out and dry carefully in a warm room. Try adjusting contact breaker. Might also be low tension collecting brush, its spring, or slip ring. Clean and adjust these parts.

* When engine has been running, and plug is found wet, look out for cracked jacket or leaky head joint passing water into cylinder, probably steaming exhaust.

Make sure the test for spark has not been tried over too great a gap; ¼in. is enough. If spark is good to magneto frame, and bad from terminal to plug cable, shows cable broken or off its plug.

77 MISSING ON ALL CYLINDERS (from No. 75*a*): Examine switch cable for frayed ends making contact to magneto frame. If uncertain, remove switch wire. All right, now shows leakage in switch wire. Examine for set of contact breaker and cleanness of contact points (try setting and cleaning); collecting brush for dirt, oil, and weakness of spring (press into contact by hand); wet terminals; cam path for grit or roughness; all binding screws for looseness, including magneto low tension, coil low tension, and coil earth (both ends) if a coil is used.

78 Test spark to plug head and cylinder head. Former bad, latter good, shows points too wide.

(*a*) Both bad: See No. 39.

(*b*) Both good: See No. 378*b*. Examine spark at one or two plugs with engine running. If bad, shows defective plugs—oily, sooted, broken, or wet. If good, not likely to be ignition at all. If the magneto has been out, possibly set wrong; but this more likely to cause sluggish running than irregular. See Nos. 33 and 34.

***81** MULTI-CYLINDER NON-TREMBLER COIL IGNITION: Missing or irregular running, or one or more cylinders out of action.

Test voltage of battery, with engine running, across battery terminals; heavy fluctuations show battery down or internal breakage.

Look for loose wires (coil positive, negative, and earth—both ends; battery positive, negative, and earth; switch; contact breaker; and high tension contact breaker earth, if any).

Press switch into contact.

See that high tension wires are not off plugs.

Press contact breaker spindle when in circuit, or, if not, look for loose contact breaker earth. See No. 1129.

Examine contact breaker for dirty or pitted points, defective set of blade screw, adjust and clean, and where fault is possible look for grit on cam path or pitting of same.

(*a*) All cylinders defective: See No. 87.

(*b*) One or more all right: See No. 82.

***82** EXAMINE SPARK TO PLUG HEAD AND CYLINDER HEAD of a defective cylinder: Good to latter, bad to former, shows plug points too wide.

(*a*) Both good: Examine spark at plug with engine running, and change if necessary. (See note to 76*a*.) Note set of plug points, which should be $\frac{17}{1000}$ in. If good, hardly likely to be an ignition fault, except where wires have been interfered with and two cylinders are working all right, when it might be due to crossed cables. Look for faulty carburation. Try changing air supply. Look for sticky valves or broken valve springs or stem, pre-ignition, etc., leak in induction pipe near faulty cylinder. Then see Nos. 85 and 33.

(*b*) Both bad: See No. 83.

***83** EXAMINE SPARK INTO HIGH TENSION LEAD, engine running.

(*a*) Good spark here: Indicates leaky lead.

(*b*) Irregular, or no spark: Fault in low tension circuit or coil, except in the rare case of a high tension lead being broken entirely or off its plug. After examining and setting contact breaker, looking for loose wires, etc., and sparking at contact breaker indicating a broken-down condenser or insulated coil earth, see No. 84.

***84** (*a*) No spark at all: Stop engine, and see No. 64.

(*b*) Irregular spark: See No. 85.

***85** METHOD OF CROSSED LEADS: Note carefully a contact breaker blade on which the engine runs regularly, and change contact breaker and plug leads of this good cylinder coil with those of a bad cylinder (To identify, see No. 112*b*.)

(*a*) Still missing on the same contact breaker blade as before: Examine spark again at the plug, the terminal of which previously gave irregular sparks. Still irregular, shows the fault to be in the contact breaker. If spark is now regular, and the cylinder misses, the fault is in the plug, or else is not electrical.

(*b*) Now misses on the contact breaker blade, previously all right. See No. 86.

***86** FAULT, THEREFORE, in coil or its leads: Locate as follows—Replace leads as at first. Note the blade which runs without missing and with regular sparking, and one which gives irregular sparking and missing (these should, of course, be as before). Cross both the high tension and low tension leads of the coil connected to the good blade with those of the coil connected to the bad blade.

(*a*) Blade which previously missed now does not miss, shows fault in coil or its earth connection (either end). See also Nos. 1118, 1121, etc.

(*b*) Same blade misses : Fault in leads. Locate by crossing or changing for new ones.

***88** All Cylinders Defective (from No. 81) : Test spark to plug head and cylinder head with the engine running. One good and other bad shows plug points too wide.

(*a*) Both good : Fault probably not electrical, especially if failure is sudden ; but where an engine has been standing, it is as well to look for sooty or oily or wet plugs. Look for water in petrol, leak in air induction pipe, failure of pressure feed. choked petrol pipe (noted by position of float spindle), and sticky valves. Then examine spark to another plug and at plug. Try one or two new plugs. See Nos. 33 and 34.

(*b*) Both bad : In case of sudden missing, go over all the " common " circuit binding screws again, such as battery (two), earth (one), coil - earth (one where common), switch (two or three), and coil positive. See switch is making good contact. Examine contact breaker and trim up and set. Look for defects in cam path, etc. Earth contact breaker by outside wire. Take voltage again, engine running. Test spark into one high tension lead at coil end, engine running. Good shows leads leaking, probably due to wet. Bad shows a fault in the coils or low tension system, probably the latter unless cause likely to damage all coils at once is known. Try spare battery. If possible, try spare coil ; and if that is bad, fault is almost certainly in low tension system. Try rewiring by outside wires the whole system, or at least one coil. See No. 1180.

***89** Multi-cylinder Synchronised High Tension Ignition : Signs of missing or irregular running, or one or more cylinders out of action. Press commutator case (No. 1129). Adjust trembler. If easily done, examine wipe for pitting and its path for dirt, roughness, etc. Look for loose commutator spring, worn wipe, etc. Examine for loose wires, especially if mis-buzzing is suspected. See that high tension wires are not off. Examine all terminals for looseness or dirt—battery (two), switch (two or three), coil (two), commutator (one or two), earth (one or two), and commutator earth (if any). Test voltage, engine running, across battery terminals (fluctua-

tions show battery down or broken battery bridge). Press switch into contact to test for weak spring or bad contact. Watch trembler for sparking due to broken-down condenser. See No. 90.

90 RUN ON EACH CYLINDER IN TURN.

(*a*) Missing on all cylinders: See No. 91.

(*b*) One or more cylinders all right: See No. 93.

***91** IF EASILY SEEN, EXAMINE SPARK in distributer: If regular, see at once No. 92. If irregular, or if not readily seen, examine spark into distributer lead.

(*a*) Regular spark into distributer: See No. 92.

(*b*) Irregular: Probably a low tension fault. Clean and adjust tremblers. Look for wet, pitting, loose platinum, and armature out of adjustment. Clean and examine commutator for grit, pitting, worn wipe, or loose spring. Re-examine wires for loose terminals. Make sure of battery voltage. Press switch into contact. If available, try spare coil, battery, plug, etc., wired in by outside wires. See Nos. 1180 and 1118.

All wires good; fault is probably in coil. Telephone examination No. 105(*c*).

***92** REGULAR SPARK IN DISTRIBUTER, or into distributer lead from coil (from No. 91*a*): Examine spark from one high tension lead (whilst engine is running) to plug head and cylinder head; one good, the other bad, shows plug points too wide. If bad, leads are leaking. If good, fault not likely to be electrical. See, therefore, Nos. 33 and 34.

***93** MISSING OR NOT RUNNING on some cylinders only, one or more cylinders all right: If spark is readily visible in the distributer, examine, and if found regular, the fault is not low tension, but might be a leak between distributer and plug, or a bad plug. If spark is found bad in distributer, see at once No. 94.

Spark in distributer invisible, or found regular: Take high tension lead from plug, and test spark to cylinder head and to plug head, with engine running. One good, one bad, shows plug points too wide, and will not occur where spark in distributer was good.

(*a*) Steady spark both to plug head and to cylinder head: Examine plug itself, and change if suspicious. (If the plug is found wet, see note to 76*a*.) Plug in order and sparking well, it is not likely that the fault is electrical, unless the leads have been crossed. Look

for sticky valve stems, broken valve springs, leak of air into the induction pipe of defective cylinder, pre-ignition, etc., and then see Nos. 33 and 34.

(*b*) Irregular spark or no spark : If the spark was seen to be good in distributer, this shows a leak between distributer and plug. If invisible see No. 94.

***94** Examine Spark into distributer lead : Note that when one spark is entirely stopped, the others will give a sort of regularity which may deceive. See text No. 394.

(*a*) Steady spark shows a leak in the high tension system.

(*b*) Irregular or no spark shows a low tension fault, unless the distributer lead has dropped off the distributer terminal, or a wire is broken out of sight, which latter is unlikely. Most likely the fault is in the commutator. Examine commutator path for grit or pitting. Where one or more cylinders are out of action, set on contact, and proceed to No. 9. Fault almost certainly bad contact in commutator. Where no cylinders are out of action, can hardly be anything but commutator (at least one cylinder being all right), therefore examine for roughness or pitting, and then see telephone examination, No. 95

***95** Telephone Examination : Connect telephone across trembler. Regular buzzing shows fault not in low tension system, unless condenser has gone wrong, which will probably show by sparking at contact points. Note, however, that where one buzz is entirely omitted, a species of regular irregularity will be noticed, probably three buzzes in succession, and then a pause, and then three more, etc.

Irregular buzzing across tremblers, connect from battery positive to commutator terminal. Irregular shows commutator fault, or battery earth loose.

Connect telephone battery negative to earth. Irregular buzzing shows earth wire fault ; silence shows this right.

Coil positive to earth : Silence shows this circuit right ; irregular buzzing shows a fault.

***96** Multi-cylinder Individual Trembler Coil Ignition : Missing or irregular running, or one or more cylinders out of action, but the engine will run (from No. 73*e*). Press commutator case (No. 1129). Look for loose wires—battery (two), coils (one more than there are coils), commu-

tator (same number as coils), commutator earth (if any), battery earth (one), and high tension. Test voltage, with engine running (fluctuations show battery down or broken internal connection). Examine commutator for loose wipe, weak spring, or dirty or pitted path.

(*a*) Missing on all cylinders : See No. 103.

(*b*) One or more cylinders all right : See No. 97.

***97** LISTEN CAREFULLY TO BUZZ of coils of defective cylinders.

(*a*) Mis-buzzing or uncertain whether buzzing regularly or not : See No. 102.

(*b*) Regular buzzing, but at unequal intervals : An uncertain symptom, indicating false contact in commutator.

(*c*) Continuous buzz : See No. 108.

(*d*) Buzzing regularly : Adjust tremblers. See No. 98.

***98** EXAMINE SPARK from high tension lead to plug head and cylinder head : Former bad, latter good, shows plug points too wide.

(*a*) Both good : Examine spark at plug. Points should be $\frac{17}{1000}$ in. apart. Bad—defective plug, broken, sooty, or oily ; if wet see note 76*a*. If spark at plug is good, fault probably not electrical, but change to make sure. Where two or more cylinders are bad, and fault is possible, look out for crossed leads. Look for sticky valve stems or broken valve springs. Look for a leak of air into the induction pipe near the defective cylinder.

Look for preignition caused by foreign matter in cylinders, shorting of commutator wire or in commutator, overheating, etc. : See Nos. 100, 33, and 34.

(*b*) Both bad : See No. 99.

***99** EXAMINE SPARK from coil high tension into lead.

(*a*) Good shows leaky lead.

(*b*) Bad : Clean and true up tremblers (if not already done) whilst watching spark with engine running over $\frac{1}{4}$in. gap into lead. Irregular or no spark probably shows a low tension fault or coil gone wrong, except in the rare case of a high tension lead being broken out of sight, in which case coil will spark to an earth wire ; or where plug end of cable has fallen off its plug. Condenser gone wrong shows sparks at trembler. See No. 1121. Examine tremblers for loose platinum—wet, pitting, faulty armature adjustment, etc. All this failing, proceed as below.

***100** METHOD OF CROSSED LEADS: Note a trembler blade of a coil attached to a missing cylinder, *i.e.*, on which the engine misses, call this M. Another trembler blade on which engine runs without missing, call this G. Now cross the commutator and plug leads of M and G. See No. 114 to identify.

(*a*) Running on trembler blade M alone still causes missing: Shows fault in commutator or plug, or else not electrical.

(*b*) Running on G alone now causes missing: Fault is, therefore, in the electric system. See No. 101.

***101** REPLACE LEADS on their own terminals, so that running on M causes missing: Now change the commutator and high tension leads of G and M *on the coils.*

(*a*) Running on G still does not miss: Fault in the coil of M. See No. 1118 *et seq.*

(*b*) Runs now on M without missing: Fault in the leads originally attached to M.

***102** MIS-BUZZING (from No. 97*a*): Clean and adjust tremblers. Go through the list No. 96 above again more carefully.

(*a*) Cylinders missing only, but will run: See No. 98.

(*b*) One or more will not run at all: Put on contact of defective cylinders. (See No. 114 to identify.) If coil does not buzz, see No. 49. If it buzzes, start engine again, and see No. 98.

***103** MISSING ON ALL CYLINDERS (from No. 96*a*): Run on each cylinder in turn, carefully listening to buzz of coils.

(*a*) Some buzz regularly, some not: Unlikely, as it shows a compound fault. For buzzers, see No. 105; non-buzzers, see No. 103*c*.

(*b*) Regular buzzing, all cylinders: See No. 105.

(*c*) Irregular buzzing, or uncertain whether buzzing or not, all cylinders: Examine carefully battery positive and negative, coil positive and switch leads, and earth connection, and press switch into contact. Press commutator case for bad earth. Examine commutator for bad, dirty, or worn path, loose or worn wipe, and weak spring. See No. 104.

***104** MAKE SURE BATTERY IS UP: Place on contact. If no buzz, see No. 49; if good buzz, start engine again, and test spark to plug and cylinder head. One good, one bad, shows plug points too wide.

(*a*) Spark good to both : Fault probably not electrical, unless for some cause all plugs have gone at once. Look for water in carburetter, leak of air, shortage of petrol due to choked tank vent, failure of pressure feed, choked pipes, stuck needle, defective float gear, etc. See list Nos. 33 and 34.

(*b*) Both bad : Examine spark into high tension lead. If good shows leaky lead ; if bad, coil or low tension fault ; and as all are missing, fault is probably in the "common" circuit. If, however, examination fails to find the fault, try spare battery, coil, etc. ; or, failing these, try wiring system direct by new wires. See No. 1180.

***105** Regular Buzzing (from No. 103*b*) : Take high tension lead from plug, and test spark from it to both plug head and cylinder head. One good, one bad, shows plug points too wide.

(*a*) Both good : Examine spark at plug points. If good fault probably not electrical. Change plug to make sure. Look out for water in petrol. Shortage of petrol due to choked tank vent, failure of pressure feed, choked pipe or filter, or defective float gear. See list No. 33, and then No. 34.

(*b*) Both bad : Test spark into cable from coil high tension. Good shows leaky lead. Bad spark here, and certain that buzz is good, fault is in coil, such as defective trembler points, armature arrangement, etc. ; but these are none of them likely if all coils have gone, in which case fault is almost certain to be one common to all cylinders. If there is any uncertainty about the buzz being good, examine as in No. 103*c*. If possible, change a coil or coils for a known good coil. If this runs all right, the fault must be in the coils ; but this is unlikely where a number fail at once, and some common cause should be sought. Recall any alterations made to the system, and carefully examine these.

(*c*) Telephone examination : It is presumed that you know which cylinders are missing, *i.e.*, on which coils (if any) it will run without missing.

Connect the telephone across the trembler blade of a defective coil. Regular buzzing of the telephone indicates that the fault is not in the low tension system, unless the condenser is out of order, which will probably show up by sparking at the trembler points.

Irregular buzzing shows a low tension fault. Connect from battery positive to commutator terminal of defective coil. (To identify, see No. 114.) Irregular buzzing shows that the fault is in the commutator, except where all coils are buzz-missing, when it may be in the accumulator or earth connection or commutator spindle. To prove the latter points, connect from battery positive to the commutator spindle itself (hold the telephone terminal into the depression in the end of the spindle). Rumbling and clicking noises show defective earth. One click and silence show battery in order and spindle well earthed.

Connect from coil positive to earth. One click and silence show this circuit from earth through battery to coil positive in order; irregular clicking shows a fault in this circuit, and if the battery positive to earth has already been found in order, this fault must lie in the battery to coil cable; possibly the switch out of order.

***106** GOOD SPARK AT PLUG, engine being turned over by hand, but engine will not run.

(*a*) Bear usual experience in mind (if any) as to the order in which the following points should be taken: If you are already certain that tickling, flooding, etc., are no good, see 106*b*. Tickle carburetter; flood carburetter; ventilate engine; add petrol to cylinders; and stop up induction pipe partly. [NOTE.—Single-cylinder engines on the whole are more likely to suffer from lack of petrol than multi-cylinder engines, which latter often suffer from flooding.] One or two explosions after flooding, see No. 107.

Still no explosion—

(*b*) Examine jet for: Chokage (not usually quite choked); lack of petrol due to choked petrol pipe, stuck needle valve, choked petrol filter, or choked tank vent; failure of automatic pressure device; empty tank; closed petrol tap (to locate see No. 1006); water in petrol; flooding due to punctured float, faulty balance weights, worn or dirty needle seat, loose jet, or choked carburetter air gauze.

(*c*) Test timing of spark (see Nos. 117 and 118): Look for choked carburetter gauze causing flooding; stuck or closed throttle due to broken connections, or, where spring operated, to freezing; governor springs or connections broken, and governor stuck shut, or governor

valve stuck shut when spring operated (runs with accelerator pedal down). Make sure additional air valve is not stuck open. Look for leak in induction pipe.

In multi-cylinder engines look out for crossed wires (see No. 114). Examine spark at another plug to make sure.

In single-cylinder engines change plug to be on safe side. Look for timing of valves (see No. 116). Cracked cylinder letting water in usually steams at exhaust, if an explosion can be got, and usually shows wet plugs.

(*d*) Sometimes in cars fitted with exhaust heated carburetters it is found that after running hard for some time, and then stopping for a short time, say up to a couple of minutes, or running downhill with engine dragging and throttle shut, the engine will not start again, but behaves exactly as though the jet were choked; starting up after flooding carburetter, and stopping again, but nothing is found in the jet, and on reassembling all is right for a time. This may be due to too much heat causing the jet to overheat and boil the petrol, thus preventing enough getting through. The writer has had several cases of this.

107 ENGINE STOPS, and on turning starting handle starts up again; stops again after one or two revolutions: Probably choked petrol jet, in which case it will be likely to repeat the performance after tickling carburetter; possibly additional air valve stuck open; possibly leak of air into induction pipe; battery run down; possibly frozen portway of throttle, if throttle is partly closed; unlikely, but possible, choked silencer. Possibly boiling petrol: See No. 106*d*.

If the engine starts and stops again after ventilating, look out for flooding, due to punctured float, choked carburetter gauze, loose petrol jet, defective needle valve, etc. See index.

Engine starts and continues to run: Try to drive in usual way.

Car runs all right: Drive on; such stops may be due to many causes, such as flooding, stuck throttle, boiling petrol, etc.

Engine stops as soon as gears are engaged and clutch let in: Indicates mechanical fault between clutch and road wheels.

Engine stops after fifty yards to a couple of miles: Faulty cylinder lubrication; overheating of cylinders due to loss of water, probably stops on hill after loss of power; failure of petrol, due to choked petrol pipe or filter, stuck needle valve, choked tank vent or pressure feed failed, nearly empty tank, nearly closed petrol tap, water in petrol, possibly but unlikely flooding of carburetter.

In single-cylinder engines, possibly broken valve stem or spring.

Single-cylinder engine runs popping and banging : Might be broken valve or spring, choked jet, water in petrol, or leak of air into induction pipe.

**108* Trembler Coil Ignition, Continuous Buzz of Trembler Blade : Indicates a short circuit in the commutator or its connections. Remove commutator wire from commutator.

(*a*) Buzzing continues : Short circuit is, therefore, in cable or in the coil itself. Take wire from coil. If buzz stops, the short is in the cable ; if it continues, it is in the coil, as when a screw has pierced the coil case.

(*b*) Buzz stops : Fault is in the commutator. Probably a fibre bushing gone, or a loose wire inside connection. After taking the wire from commutator, if the fault is not apparent, move commutator wire about. Close to its old position without actually making contact, as removing it may have broken a short circuit in the cable.

**109* To Identify open and closed position of switch.

(*a*) Trembler coil ignition in good order : Set on contact ; coil buzzes with switch closed.

(*b*) Non-trembler coil or defective trembler coil : See that the battery has some voltage, and move commutator wipe off contact, and test voltage from coil positive to earth with switch in all positions. When switch is open, no voltage will show. If no voltage any position, circuit is defective (see tables). If voltage in all positions, shows switch short-circuited, or else switch is in coil to commutator connection. In this case no voltage will be found from coil negative to earth with switch closed ; voltage with switch open.

**110* To Identify Battery Terminals : Close switch (see No. 109), and test voltage from earth to both battery terminals. That showing voltage is battery positive.

Where both terminals show a current, this indicates that the earth connection of the battery is nearly insulated, as, for instance, where the earth wire is screwed under a very rusty bolt on the frame, or when the switch is in the earth connection of the accumulator, and is making a bad contact. The writer has known one case where an accumulator showing four volts

gave about one volt from its negative connection to the frame, and about two volts from its positive connection. This was due to a rusty earthing nut.

To distinguish the poles of an electric circuit, whether that of a battery or other circuit : If a pole finder is at hand, the plus mark comes up on the positive side, and the minus mark at the negative. If no pole finder is at hand, attach copper wires to the poles it is wished to identify, and plunge the ends of these wires into water to which a little common salt has been added. Bubbles of gas will come from the negative pole, no gas from the positive pole, the oxygen which reaches this pole combining with the copper.

***111** To Identify Coil Binding Screws.

(*a*) Trembler coil ignition or synchronised high tension ignition : Depress all trembler blades, and insulate by paper or otherwise. Test voltage from earth to all coil terminals. That showing current is coil positive.

(*b*) Non-trembler coil ignition : Place on contact of one contact breaker, or short circuit one. Test voltage from earth to all coil terminals. The one showing no current is one coil negative, and is connected to the contact breaker point on contact. Usually this will determine by the position of the terminals which are the other negatives ; but, if not, place on other contacts in turn. On each contact four terminals will show current (three negative and one positive), and when all negatives have been identified, the terminal which showed current every time is the coil positive ; the other four terminals which showed no current at all are the earth connections. To prove this, test current with the contact breaker not on contact, both from the coil positive and from the coil negative to earth connection. Both will show current.

***112** To Locate Switch : Test voltage battery positive to earth with open and with closed switch.

(*a*) No voltage either position, and battery is " up " : Shows defective battery earth or switch itself wrong.

(*b*) No voltage with open switch (see No. 109) : Shows switch in battery earth connection.

(*c*) Voltage both positions of switch : Shows switch in battery coil wire or, rarely, in coil commutator wire. If in latter, coil positive to earth will show a current with both positions of the switch, whilst coil negative to earth

will only show a current (commutator on contact) with open switch.

*113 To Identify Wires on switch with two batteries wired up: Disconnect positive wire (see No. 110) from one accumulator.

(*a*) Trembler coil in working order: Place on contact, move switch till coil buzzes. The switch terminal then in contact is connected to battery coupled up.

(*b*) Non-trembler coil or defective trembler coil: Test voltage from switch terminals to earth with switch open (see No. 109). That showing voltage is connected to the wired-up accumulator.

*114 To Identify Low Tension (Commutator) Cables.

(*a*) Individual trembler coil ignition: If coil is in order set on contact, the coil buzzing is connected to the commutator segment on contact.

Where coil will not buzz: Set on one contact, and test current from coil positive (to identify see No. 112*a*) to each of the coil negatives; that showing current is connected to the segment on contact. If none show current (and current is good from coil positive to earth), commutator or its earth is at fault.

(*b*) Non-trembler coil ignition: See No. 111*b*.

115 To Identify High Tension Cables.

(*a*) Trembler coil ignition: If in order, set in contact (making one coil buzz), and test spark by metal tool from plug head to cylinder head; the plug sparking is connected to the buzzing coil. If a considerable spark is had from more than one plug, the leads are leaking. A very faint spark can often be had from another lead. This will not be more than one sixty-fourth part of an inch long.

If not in order: Earth one plug (or put terminal on the engine frame), and test voltage coil positive (see No. 112*a* to indentify) to each of the high tension terminals on coils or distributer. That showing current is the one earthed.

(*b*) Non-trembler coil ignition: If in order, and anyone is at hand to help, have him turn engine, or break contact by hand, and test spark from plug head to engine frame with a tool, and also from coil high tension terminals to earth. The plug and terminal which spark are connected.

If no one is at hand, and you have a voltmeter, proceed as No. 115*a*. If no voltmeter is obtainable, take one high tension cable from coils, and arrange ⅛in. away from its binding screw. Break contact by hand until this terminal sparks. Take off each high tension cable from plugs in turn, arrange ⅛in. from earth (or from its own plug), and break contact with the same contact breaker which caused spark at detached coil terminal. When a spark is observed from plug end of one cable, that is the one connected to the coil high tension detached. With voltmeter proceed as in trembler coil ignition above.

(*c*) High tension magneto : When in order and spark is visible in distributer, remove one plug cable, and take care it does not earth. Run or turn engine by hand. The distributer terminal which does not spark is connected to the detached lead.

Sparks not visible in distributer : Remove a plug, and lay it on cylinder, and take off (or earth) all but one of the high tension leads on the distributer. If the visible plug now sparks, the distributer lead on terminal (or the one unearthed) is connected to this plug. If the plug does not spark, try another three until you find the lead which makes it spark and that is connected to it.

Alternative : Where all plugs have to be removed in any case, lay them so that points are visible, and earth all distributer terminals but one, or disconnect all but one. The plug that sparks is connected to the connected (or unearthed) lead.

***116** TIMING VALVES : In modern engines the better way of setting the valves is by the clearance between the end of the valve stem and the tappet. This should be from five to ten one-thousandths of an inch. The distance is measured by a set of feeler gauges. If the distance is found too great, packing must be applied, or adjustment made as the circumstances permit. Broadly, the less the distance between the stem and tappet, the better the engine runs in a modern engine of good make. Some old engines, however, had heavy clearance here ; in this case use the method mentioned below. In all cases it is advisable to apply to the makers for information as to the valve set or stem clearance, but it may usually be assumed that the distance is within five to ten one-thousandths of an inch. In a modern car, if the timing wheels are set correctly and have not slipped, setting the valve lift will make the timing right. If possible, obtain

particulars from maker for engine in hand, as setting varies considerably.

(*a*) Exhaust valves: The closing point is more important than the opening point; the valve should, therefore, be set by its closing point. Exhaust valves should close after the end of the exhaust stroke, and before the completion of the first sixtieth part of the suction stroke. 6° movement of the flywheel after the beginning of the suction stroke is a good average. Usually opens 40° before end of working stroke.

(*b*) Inlet valve, mechanically operated: Should be set by closing point, which should be after the end of the suction stroke, and before the piston has made one-sixtieth part of its compression stroke. Good average, 6° to 9° movement of flywheel after bottom dead centre. Inlet valve must not open until well after closing of the exhaust valve, however. Usually opens 10° to 12° after beginning of suction stroke.

(*c*) Automatic inlet valve: All sizes seem to work best with from $\frac{3}{32}$in. to $\frac{1}{8}$in. opening. Tension of spring appears not to be very important, usually from one to five ounces.

[NOTE.—On a flywheel 18in. diameter: 6° will be about $\frac{7}{8}$in. on flywheel rim; 9° will be about $1\frac{1}{4}$in. on flywheel rim; 12° will be about $1\frac{7}{8}$in. on flywheel rim; 40° will be about $6\frac{1}{4}$in. on flywheel rim. Larger size flywheels greater distances, and smaller less distances in proportion to diameter.]

To ascertain the position of the crankshaft, see No. 120.

***117** TIMING IGNITION, Coil and Accumulator (trembler and non-trembler).

(*a*) The spark should take place with retarded ignition just after the piston has begun its working stroke. The usual position is between the beginning of the stroke and the end of the first $\frac{1}{8}$in. of the working stroke.

(*b*) Approximate rule: Turn engine slowly, watching exhaust valve stem of No. 1 cylinder (or any other given cylinder). When the exhaust valve closes, give the engine one complete revolution by the starting handle, and the piston is now at the firing position (with retarded spark) of the cylinder under observation.

(*c*) More accurate rule: Ascertain position of piston (see No. 120), and set in accordance with instructions, 117*a* above.

(*d*) Very rough rule for roadside use : Note buzz of trembler as engine is turned against compression with retarded spark. Buzz should begin at top of compression.

*118 MAGNETO IGNITION.

(*a*) Fixed point magneto ignition : Where there is no spark lever, set the contact breaker to break contact (to determine see No. 118*c*, *d*, and *e*) about 10° to 20° before the end of the compression stroke. If possible, get information from maker, otherwise try various sets, or take 15° as an average. For measurements of fly-wheel corresponding to degrees, see note No. 116.

(*b*) Hand-controlled ignition : With retarded spark contact should break when piston has just completed its compression stroke. Spark will have to be advanced from this position for starting on magneto alone ; so if you find you cannot advance spark far enough for running purposes with this set, you may advance the set a little without danger.

(*c*) To determine the moment of make and break.

(*d*) Low tension magneto :

First method.—Turn the engine over slowly, watching the make and break mechanism. A point will be noticed when the moving arm comes down on to the sparking plug. This point will be seen by the outside end of the make and break arm no longer touching the operating cam or rod, and the circuit is now complete. In this position, if the make and break arm be moved a short distance by the finger, it will be quite obvious that it is not the outer end striking the cam or rod which arrests the motion, and that it must, therefore, be the inner end striking the plug which does it. If now, whilst this oscillating movement is kept up, the engine be slowly rotated, it will be seen that each oscillation brings the outer end of the make and break arm nearer to the cam or rod. The moment when it actually touches the cam or rod is the moment of " break."

Second method (the writer is indebted for this method to an article in *The Autocar*) : An accumulator and voltmeter are required. Connect one pole of the accumulator to " earth " (any bright part of the engine will do) by a wire, and connect the sparking plug to the other pole through a voltmeter. Now rotate the engine. Immediately contact is made, a current will flow

through the voltmeter, and immediately the contact is broken the current will cease flowing. The moment of make and of break is, therefore, clearly and sharply indicated. The method has the further advantage that the moment of electrical break is what is indicated, and that is what we want.

(*e*) High tension magneto :

First method (for this method it is necessary that the contact breaker should be accessible) : Take a thin " feeler " (a piece of tempered steel not more than $\frac{4}{1000}$ in. thick), and insert it between the contact points. As the engine is slowly rotated, it is easy to feel when the points come together and when they separate. Failing a " feeler," a piece of paper may be used, but it should be thin but very good, or there is danger of a piece adhering to the contact points and insulating them.

Second method (electrical) : Obtain a small electric bell cell, the smaller the better. Couple a voltmeter across its terminals. If in good order it will show about $1\frac{1}{2}$ volts. Now couple one of the cell terminals (one voltmeter terminal will, of course, be coupled to it too) to the magneto switch terminal, and the other (to which the other voltmeter terminal remains attached) to the metal work of the magneto (earth). Now turn the engine over slowly. Whilst the magneto contact breaker is not in contact, the current from the bell cell will have to flow through the armature windings of the magneto, and the resistance of this circuit will cause the voltmeter to show some pressure. Immediately the contact is made, however, the current will fall sharply, thus determining with absolute accuracy the point of break. This method is in use in the works of two leading magneto makers, or at least so they informed the writer. It may therefore be used without fear of injuring the magneto by magnetisation, etc.

(*f*) Bosch dual ignition : This may be timed as in an ordinary high tension magneto, but there is a simpler method. Take care before putting the magneto in place that each of the two contact breakers breaks contact at the same moment. Wire up, see No. 119. Now turn the engine over by hand, whilst the coil " push " of the coil is held lightly in (so that the coil will buzz). When the low tension (coil) contact breaker comes on to

contact the coil will stop buzzing; when it breaks the coil will start buzzing again. As both contact breakers make and break at the same moment, you will thus know when the magneto contact breaker breaks.

119 To Wire a High Tension Magneto.

(*a*) Ascertain the position of the piston by one of the methods mentioned in No. 120, and mark the flywheel, if it is not already marked. Now retard the spark (if it is variable), and by one of the methods (No. 118) ascertain the point of "break," whilst the engine is being slowly turned over by hand. If this takes place as described in No. 118*a* or 118*b* the magneto is correctly coupled up. If not, slack off the coupling and carefully move the magneto spindle till things are right.

(*b*) What we have to do, of course, is to ascertain which magneto terminal is sparking when the engine turns dead centre.

First method: Where the distributer can be readily uncovered, the direction in which the rotating arm points will usually indicate the active terminal of the magneto for the time being, which is therefore to be coupled up to the plug of that cylinder in the firing position. See No. 319.

Second method: Open the compression taps. Place one finger on No. 1 magneto high tension terminal (for the purpose of this examination you can call any one of the terminals No. 1) and another finger of the same hand on the metal work of the magneto. Now gently rock the flywheel backwards and forwards, so that one of the pistons passes through its firing position (see No. 118*a* or *b*). If no shock is felt in the fingers on the magneto, turn the flywheel half round, and repeat, then another half turn, until a shock is felt. If no shock is felt, go round again, moving the flywheel a little more sharply until a shock is felt. (We assume that the magneto is in order.) As soon as a shock is felt, note which cylinder is in the firing position. (In a four-cylinder engine, to determine which of the two pistons on dead centre is the right one, see No. 319.) Now connect No. 1 high tension terminal to the cylinder in the firing position. Select another terminal on the magneto, call it No. 2, and proceed again as before to determine to which cylinder it should be attached, and so on for the rest. [Note.—The writer has tried this

method with a magneto out of its car, and the shock is by no means severe if the magneto be turned slowly. If the compression taps are left shut, and the starting handle is used, the shock is apt to be unpleasant.]

Third method : Instead of touching the high tension terminal, connect a telephone terminal to it and the other to " earth." A click will be heard in the telephone when this terminal sparks. The instructions for connecting are as in the first method.

Bosch dual ignition : Place the magneto in position and, at least approximately, time it, see No. 118. The terminals on the coil are marked 1 to 6 (for internal wiring and diagram see No. 419), and these binding screws are to be coupled up as follows (1910 and 1911 system) :

Low tension cables : No. 1 on coil to the contact breaker terminal on magneto (situated under the cover which protects the magneto contact breaker). No. 2 on coil to the switch terminal of magneto (just above the cover of contact breaker). No. 5 on coil to the *negative* terminal of the accumulator. No. 6 on coil to " earth " (*not* direct to the positive terminal of the battery). Battery positive to " earth."

High tension terminals : No. 3 on coil to the high tension binding screw of magneto (situated at the driving end, opposite end of magneto from the distributer and plug wire connections). No. 4 on coil to the high tension terminal (in the middle of the distributer, just over the switch terminal). Ascertain which cylinder is in the firing position by method No. 117*b*. Remove cover of distributer, and note which terminal is active. Connect the plug of this segment to the firing cylinder, and so on for the rest.

For diagram of Bosch dual ignition, see No. 419.

120 Dead Centre of Crankshaft : To determine. The " dead centre " is the position of the crank when a line drawn through the centre of the piston and the centre of the crank pin passes through the centre of the crankshaft. Roughly and usually it is the position of the crank pin when the piston is either at the top or bottom of its travel. To determine this point with accuracy is not too easy, because at these points the crank can move a considerable distance without the piston appearing to move at all.

(*a*) First method: If the base chamber is off, turn the engine till the piston is, say, 1in. from the top of its stroke approximately. Measure the distance of the piston from any fixed point convenient, usually from the mouth of the cylinder. Now mark the flywheel temporarily but accurately. Turn the engine until the piston has reached the top of its stroke and is coming down again, until the piston is again at the same distance from the fixed point as it was when the first measurement was taken. Mark the flywheel again temporarily. Bisect the distance between these two marks, and this point is the position of the flywheel when the piston is at the top of its stroke. Example: Say that you select the mouth of the cylinder to measure from, and that the distance from this point to the rim of the piston is 1¾in. Turn the engine over until the piston is again 1¾in. from the bottom of the cylinder. Mark both points on the flywheel. Measure the distance between them. Let us say it is found to be 12½in. Measure off 6¼in. from either mark, and this point is the "dead centre."*

(*b*) Where there are compression taps in the middle of the top of the cylinders: Insert a knitting needle through the compression tap, and turn the engine over until the knitting needle is as high up as it will come. This point is the dead centre. If preferred, and more accurately, mark off a point on the knitting needle when the piston is nearly up (say about 1in. short of up). Mark the flywheel for this; turn the engine over until the knitting needle has dropped to the same position that it occupied at the first measurement. Mark the flywheel again, bisect the distance between the two marks, and this is the dead centre.

(*c*) Rough method: Remove a valve cover, feel for the piston with a rod or "scriber" until it is at the top of its stroke, and mark this for dead. The method is, however, inaccurate, as it is most difficult to determine when the piston is up.

(*d*) Roadside method: For this purpose it is assumed that the set of the valves is approximately correct. Select one cylinder, say, for instance, No. 1. Watch the exhaust valve whilst the engine is being turned over.

* This method of making two marks and bisecting the distance between them is not to be followed in the case of an engine in which the crankshaft is not directly in line with the cylinder centre (where the axis of the cylinder produced does not intersect the axis of the crankshaft).

Immediately the exhaust valve of No. 1 cylinder closes is exactly on the top dead centre, or perhaps a fraction down on the firing stroke.

It is, however, at the end of the exhaust stroke, and to put it into the firing position (at the beginning of the working stroke) it must have exactly one revolution.

121 SPECIAL FAULTS OF RUNNING.

(*a*) Smoky exhaust: Where the exhaust smokes bluey-white, the pistons are getting too much oil either from the dashboard oiler or from the splashing of the cranks.

Where the exhaust smokes black sooty smoke, the engine is getting too rich a mixture (too much petrol or too little air).

(*b*) Occasionally the car, when running otherwise all right, checks momentarily, and then runs on again. This may be due to the following causes—

Small quantities of water in the petrol. This will be proved by examining the float chamber when some drops of water will be found in it.

In a four-cylinder engine it may be due to the missing of one cylinder occasionally. Probably this will be very difficult to locate, as the engine will not do it when running idly. It may be proved, where two ignitions are fitted, by switching in the auxiliary ignition as well as the magneto for a time, when the trouble, if due to this cause, will disappear.

(*c*) Advance spark lever has no effect: This indicates one of the following points—

Pre-ignition, due to foreign matter in the cylinders, shortness of water, obstructed circulation, or unsuitable plug or other projection being overheated. For other causes see No. 1147. For remedies, etc., see No 1147.

Breakage of the advance spark connections, which may be located by examination, and by watching the commutator whilst advancing and retarding the spark lever.

Where double ignition is fitted, and the advance spark lever affects only the coil and accumulator, and both ignitions are in use, the magneto will be doing all the work, and the advance spark lever will naturally have no effect.

(*d*) Engine will not run slowly, but seems to pull all right when opened out: Look for additional air valve (or Krebs valve) stuck open. This, however, usually causes "popping" in the carburetter.

Leak of air into the induction pipe : This can usually be found by pouring oil round the joints whilst the engine is running, which will be sucked into any leak.

Where the carburetter is warmed by exhaust gases, look for chokage of the pipes conveying the exhaust.

(*e*) Engine will not accelerate, but pulls all right at low speeds : Additional air valve stuck shut. The writer has met a case where this acted exactly as a governor would.

Governor mechanism gone wrong, as, for instance, accelerator pedal broken : Watch the governor throttle with the engine racing as far as it will whilst you operate the accelerator pedal.

(*f*) Bumping coach springs, allowing the body to come down on the axle : Usually the spring is too weak ; sometimes, however, in threequarter elliptic springs the fastening of the half spring may be bent, allowing the half spring to point too much uphill, which will reduce the play of the springs, and cause bumping. See No. 1020.

(*g*) Cylinder compression bad : Look for leakage in valves, sparking plugs, compression taps, valve covers, and piston rings. See Nos. 1054, etc.

(*h*) Radiator boiling : Look for the following points—Broken fan belt, see No. 1021. Slipping fan belt, No. 1022. Leaky radiator, No. 1023. Leaky pipes, No. 1024. Choked pipes or radiator, No. 1025. Broken pipes, No. 1026. Choked pump, No. 1027. Leaky pump spindle, No. 1028. Air lock in circulation system, No. 1029. Broken pump spindle, No. 1030. Empty radiator, No. 1031.

(*i*) In magneto ignition, when an attempt is made to stop on the switch, the engine does not stop, but misses and backfires : Probably a bad contact in the switch, or a short-circuited switch wire coupled with an insulated switch. Try disconnecting the switch wire altogether. If the fault is as suggested, this will stop it.

(*j*) Engine knocks heavily with the spark lever in certain positions : If this is not merely due to the spark being too far advanced, look for a short circuit in the commutator terminal or its cable due to the movement of the commutator case bringing the terminal or cable into contact with some part of the engine.

(*k*) Engine runs, but bumps and knocks heavily : Look to the timing (see Nos. 117 and 118). A dull bump

more felt than heard is sometimes caused by faulty carburation and by a deposit of soot on the piston heads. See No. 34.

(*l*) Coil battery cable smoking or burning: Shows short-circuited wire. See No. 1182.

(*m*) Choked silencer: Sometimes leads to excessive pressure in pressure feed system.

122 TERMS USED:

Battery Positive: That terminal of the battery, whether actually the positive or negative, to which the coil is attached.

Battery Negative: That terminal of the battery, whether actually the positive or negative, which is connected to the "earth."

Coil Positive: The terminal on the coil attached to the battery.

Coil Negative: The terminal on the coil attached to the commutator or contact breaker.

Commutator Contact Piece or Segment: The pieces of metal inside the commutator to which the coil cables are attached.

Commutator Wipe: The piece of metal inside the commutator, which makes contact with the commutator contact pieces in turn.

Commutator Spindle: The revolving spindle carrying the commutator wipe (occasionally carrying a disc of metal with a notch in it) which forces the contact arms into contact with contact studs as it rotates. Also occasionally carries a cam to perform the same function, but this more often in a contact breaker.

Commutator Earth Wire (where fitted): Is the wire connecting the stud pressed by a spring into the middle of the commutator spindle to earth.

Coil Positive Small Screw: In most coils there is a small screw on top of the coil box near the trembler, and just above the coil positive binding screw, to which the latter is wired internally. This is called the coil positive small screw in this book.

Coil Negative Small Screw: A small screw just above the coil negative binding screw, and wired to it internally.

123 BOSCH DUAL IGNITION:

Engine runs badly: See No. 149.

Engine will not run at all. From No. 45.

(*a*) Engine will not run (or start) on magneto: See No. 144.

(*b*) Engine runs on coil or magneto, but coil will not buzz: Trembler dirty or out of adjustment, or voltage of battery low.

(*c*) Engine runs on coil or magneto, but will not stop on switch when running on magneto: Shows fault in switch contacts in coil or broken or insulated magneto to coil switch cable. (No. 2-2 Bosch instructions.)

(*d*) Engine will not run (or start) on coil: See No. 123A.

123a Engine will not run (or start) on coil: Punch the switch button *hard*. (This button has two motions: A light pressure brings the trembler into contact, a heavier pressure breaks the auxiliary contact.) If this puts things right, the auxiliary contact was dirty. It will be well to have it examined when convenient.

Still no good. Advance spark switch over to magneto and try to start by swinging the engine right round (not merely pulling it over top centre).

(*a*) Starts on magneto: See No. 131.

(*b*) Still no good: See No. 124.

124 Engine will not start up or run on either coil or magneto. From No. 123A. Switch back to coil. Make quite sure that the magneto contact breaker is not in contact. If the coil buzzes, this is sure proof that the contact breaker is *not* in contact; but if it will not buzz, it may be either that the magneto contact breaker is in contact or the coil trembler out of order. Therefore, after trying buzz, if there is no buzz take off magneto to coil low tension cable (No. 1-1) from either coil or magneto. Press trembler button.

(*a*) No buzz: See No. 140.

(*b*) Buzzes: See No. 125.

125 Engine will not start magneto or coil, but coil buzzes. Shows all the low tension coil circuit in order, except perhaps coil to magneto low tension and magneto coil contact breaker: Test spark at one of the plug heads whilst coil is buzzing with a screwdriver or similar tool.

(*a*) No sparks from any plug head: See No. 130.

(*b*) Sparks at one plug (sparking at more than one would show leaky distributer or distributer to plug cables). A good spark at one plug and a very faint one at others can be neglected as due to induction. See No. 126.

126 Take out plug and examine spark at its points, coil buzzing. As all cylinders have failed, it is unlikely that the plug is bad, unless you have four wet plugs, as when standing idle for some weeks. If the plug is dry and will not spark, whilst you are sure that a good spark is being delivered to it, you probably have a coincidence of two distinct faults at once. Fit new plug. Good spark at plug. See No. 127.

127 Coil buzzes, good spark at plug, but engine will not run. From No. 126: Turn engine over and watch for spark, with the coil not buzzing.

(*a*) Good spark: See No. 106.

(*b*) No spark: See No. 128.

128 No spark when turning engine on coil ignition, but good spark when coil buzzes: High tension leads therefore in good order, the fault will be in coil or magneto coil contact breaker. As coil buzzes, fault is between end of low tension winding and the magneto coil contact breaker. Make sure that the magneto coil contact breaker is off contact by making the coil buzz, and then test current with voltmeter from low tension magneto terminal (No. 1) to earth.

(*a*) Current. Turn engine over whilst watching voltmeter (or place on contact and test again). If current still shows, or if there is no drop in current, shows that low tension contact breaker is not making contact. If the current drops as it should do, there is a mistake in the test somewhere.

(*b*) No current. See No. 129.

129 Test current coil magneto terminal (No. 1) to earth.

(*a*) No current: Internal breakage between low tension coil winding and No. 1 terminal. Probably the auxiliary contact breaker (No. 15/16 Bosch book) is not making contact.

(*b*) Current: Coil to magneto wire insulated at terminals, dirty terminals, or broken cable.

130 No spark at plug heads. From No. 125. Take out a plug. Test spark (coil buzzing), turning engine over between tests to make sure you have the right plug, *i.e.*, try all four in turn.

(*a*) Good spark. You were mistaken in the absence of spark when testing with screwdriver. See No. 127.

(*b*) No spark: See No. 146.

131 Engine will not start on coil, but starts up on magneto. From No. 123. All high tension cables and distributer are therefore in order or magneto would not work. Stop engine on switch. If it will not stop on switch the coil earth is insulated or off its terminals, which would put the coil out of action. See contact breaker not in contact. If coil buzzes this is certain. Press button.

(*a*) No buzz : See No. 135.

(*b*) Buzzes : See No. 132.

132 Take out a plug of the firing cylinder and examine spark, coil buzzing.

(*a*) No spark. Provided you are sure all cylinders were firing when running on magneto, the fault is an internal short circuit in coil high tension. Return coil to makers. If you are not certain as to all cylinders firing, try all cylinders for spark.

(*b*) Spark : See No. 133.

133 Examine spark at a plug whilst turning engine by hand (coil not buzzing) on coil ignition.

(*a*) No spark : See No. 128.

(*b*) Sparks all right : See No. 134.

134 Almost certainly something wrong with the testing. Conceivably battery all but down, or dirty low tension terminals causing resistance.

135 Engine will not run on coil, runs on magneto. Coil will not buzz. From No. 131. High tension terminals, cables, and plugs are therefore in order, if you are sure the engine is not missing on magneto. If it misses on magneto, or one cylinder is not firing, this is probably a separate fault, for which see No. 149 : Make quite sure that contact breaker was not on contact when testing the buzz. To do this turn engine over by hand, with the button pressed in. If it buzzes at certain parts of the revolution this is as it should be, and you will see back to No. 132. If it does not buzz at all, test voltage from coil battery terminal (No. 5) to coil earth terminal (No. 6). Both terminals of the coil are meant.

(*a*) Current : See No. 136.

(*b*) No current : See No. 137.

136 Current is therefore in order from coil earth terminal through earth, battery, and battery coil cable : Fault therefore internal or else contact breaker is out of order.

Frozen trembler blade: Current will be had from No. 6 coil terminal to end of No. 6 (earth) cable in all positions of engine, except when contact breaker on magneto is in ontact. Continuous current here whilst engine is turned over shows contact breaker not making contact. Take off cables Nos. 6 and 1 from coil. No current from either of these to earth indicates internal breakage as between low tension winding and trembler blade or switch not making contact. Return coil to makers is the best thing.

137 No current from coil terminal No. 5 to No. 6. From No. 135. Test current coil battery terminal (No. 5) to earth.

(*a*) Current. Insulated coil earth cable.

(*b*) No current: See No. 138.

138 Test battery voltage (should be over 3.8 for Bosch trembler).

(*a*) No current. Battery down.

(*b*) Current: See No. 139.

139 Test current battery coil connection (should be battery negative if properly connected up) to earth.

(*a*) Current. Fault between coil battery terminal and battery coil terminal, *i.e.*, insulated terminals or broken cable.

(*b*) No current. Fault between battery and earth. Insulated or broken battery earth wires.

140 Engine will not run on magneto or coil. Coil will not buzz. From No. 124. If failure to run on magneto is not merely an accident (it is sometimes difficult to start an engine on the magneto when it is in order even), this means a compound fault, which is not very likely unless the whole system is disorganised. Therefore examine spark at plug with magneto switched on and turning engine by hand.

(*a*) Sparks. Probably failure to start on magneto is due to retarded spark or engine not swung vigorously enough. For examination of coil, see No. 135.

(*b*) No spark. A compound fault; both coil and magneto out of order. For coil, see No. 135; for magneto, see No. 141.

141 No spark at plug, magneto switched on and engine hand turned; engine will not run on coil, and coil will not buzz: Remove cables from terminal No. 3 (magneto

to coil high tension) and test spark here to frame of magneto over $\frac{1}{16}$in. gap.

(*a*) Sparks here : See No. 143.

(*b*) No sparks : See No. 142.

142 Take off earth wire from magneto (No. 2) and try again.

(*a*) Sparks now. Shows short circuited earth cable of magneto.

(*b*) Still no good. Set contact breaker (of magneto, not coil), examine collecting brushes, and then return magneto to makers.

143 Good spark from No. 3 magneto terminal to magneto frame. Engine will not run. Fault therefore in the high tension system : Replace cable No. 3, remove No. 4 (distributer), and test spark from No. 4 to No. 2.

(*a*) Sparks here. Fault in distributer or plug cables or plugs. As all cylinders fail, the latter is hardly likely unless there is some common cause, such as wet : Test by removing plug cables from distributer end and testing current from one of the holes from which their contact pieces have been removed to earth by a piece of bent wire or a hairpin. Spark here shows that the plugs or plug leads are at fault. No spark shows a leak in the distributer.

(*b*) No spark. Leak in cable connecting No. 3 to No. 4 magneto terminals through coil. If engine runs on coil, it will be a fault in No. 3-3 cable (magneto to coil) ; if on neither, probably in No. 44 cable (coil to magneto distributer).

144 Engine will not run on magneto. From No. 123. Try on coil.

(*a*) Will not run on coil : See No. 123A.

(*b*) Engine runs on coil : See No. 145.

145 Therefore the high tension cable from coil to distributer, distributer plug cables, and plugs are in order since these are common to both circuits : Remove No. 3 cable (magneto to coil high tension) from magneto terminal and No. 2 cable (magneto switch) *from coil*, and arrange spark gap from former terminal to magneto frame. Start engine on coil and watch spark over $\frac{1}{4}$in. gap here.

(*a*) Regular sparking. Short circuit in cable No. 33 : Confirm by connecting terminal No. 3 to No. 4 on magneto (magneto high tension to distributer). Should run

on magneto if the engine can be got to start on magneto. Of course, coil is now out of action.

(*b*) No spark : Take off switch cable (No. 2) from magneto whilst the engine is running. Regular sparking now shows short circuited switch cable. Irregular still, internal fault in magneto. Adjust contact breaker. Examine such other parts as experience warrants, and if nothing discovered return magneto to makers.

146 Engine will not run at all. Coil buzzes, but no spark is to be had at plug. From No. 130*b*. Take cable off distributer (No. 4) and test spark from cable to distributer terminal, with coil buzzing.

(*a*) No spark : See No. 148.

(*b*) Spark : See No. 147.

147 Replace distributer cable and take off plug binding screws, and whilst coil is buzzing lift each cable off its plug in turn.

(*a*) One or more spark all right. Unlikely, as the engine should run on those in order, for which see faulty running. If engine has been standing idle for some weeks, might be due to wet leads and plugs combined.

(*b*) All good. Look for wet or defective plugs, and then see No. 106, as it is not an ignition fault.

(*c*) All bad. Leak in distributer to plug leads, as when wet. Examine spark into plug cables from distributer. Good shows fault in plug cables; bad shows fault in distributer.

148 Replace distributer cable on its terminal (No. 4) and remove the other end of it from No. 4 terminal on coil, and test spark from terminal into this cable.

(*a*) No spark. Looks like an internal short circuit near switch (a short circuit further inside coil would not affect magneto). Prove this by disconnecting the cables from the magneto collecting terminal (No. 3) and distributer terminal (No. 4), and connecting these two terminals the one to the other with a separate cable. Engine should now run on magneto; if not, either the trouble is that you are not turning fast enough to make a spark under compression or you have some compound fault.

(*b*) Sparks here show leak in the distributer cable (No. 4-4).

149 Bosch Dual Ignition : Defective running. Sluggish running, but no misfiring, see No. 106. Missing on one or more cylinders, or one or more cylinders out of action. From No. 73.

(*a*) Missing (or one cylinder not firing) on magneto only : See No. 154.

(*b*) Missing (or one cylinder not firing) on coil only : See No. 155.

(*c*) Missing (or one cylinder not firing) on both ignitions : See No. 150.

(*d*) Will not stop on switch. Shows partly insulated magneto switch cable (No. 2-2).

150 Missing for one cylinder not firing from No. 149*c*.

(*a*) All cylinders defective : See No. 151.

(*b*) One or more cylinders all right : See No. 153.

151 Fault therefore probably in " common " high tension circuit : Take off magneto to coil cable from magneto terminal (No. 3). Start engine on coil and watch spark from terminal No. 3 (on magneto) to magneto frame over about $\frac{1}{8}$in. gap.

(*a*) Irregular sparking. Shows magneto fault, see No. 154. This is an unlikely fault, as it means both coil and magneto have gone wrong together. Just possibly it may be due to a defective magneto earth wire : Take off magneto to coil earth wire from magneto. If right now, shows an earthing fault (short circuit).

(*b*) Regular sparking : See No. 152.

152 Magneto therefore in order : Take off both magneto high tension cables (Nos. 3 and 4). Connect these two high tension terminals by a spare wire (naked wire will do if it does not go within $\frac{1}{2}$in. of "earth "). Start up on magneto.

(*a*) Runs regularly now. Fault in coil to magneto cable or a compound fault.

(*b*) Still irregular. Fault in distributer or plugs or plug cables : Locate by testing spark to plugs.

153 Bosch Dual : Missing (or one cylinder not firing) on both ignitions, one or more cylinders all right. Probably fault in plug cables or plugs ; but if two cylinders are missing, and these are either Nos. 1 and 4 or Nos. 2 and 3, fault possibly in the contact breaker roller : Examine spark to plug head and cylinder head, engine running. Good to one bad to other shows plug points too wide apart.

(*a*) Regular sparking. Defective plug.

(*b*) Irregular sparking. Fault in cables, distributer contact breaker, etc. Latter unlikely.

154 Bosch Dual: Missing on magneto only. Coil ignition all right: Remove switch cable from the magneto whilst the engine is running on magneto.

(*a*) Right now, shows short circuiting switch cable.

(*b*) No better: Loosen the high tension cable on magneto (No. 3). Run on magneto, and note spark into magneto to coil cable whilst engine is running.

Regular spark, shows a leaky magneto to coil cable (No. 3-3).

Irregular spark. Shows magneto fault: Try set and condition of contact breaker, brushes, etc., and examine for dirt. Still obscure, return magneto to makers.

155 Missing on coil only. High tension cables therefore in order. If engine, when running on magneto, will not stop on switch, but spits and misses, look for defective coil earth cable or defective earthing either end. This in order, test coil for buzzing. If it will not buzz properly, examine voltage of battery (should be well over 3.8). It seems to require a good voltage to buzz a Bosch coil when running on two cells and not three.

Battery voltage up, examine all terminals for dirt or looseness or defective leads, especially battery earth connection and coil earth (both ends).

Examine contact breaker and set (the one on magneto which operates the coil). Connect battery earth (should be positive) to terminal No. 6 on coil direct. Right now, shows a defect in the "earth" system. Then connect battery negative to coil (No. 5) terminal with new outside cable. Right now, shows defective connection coil to battery.

All this no good. Probably an internal coil fault, such as auxiliary contact breaker (Bosch fig. No. 15/16) dirty, or switch faces inside coil defective, or breakage of wire.

Notes on the Use of the Tables.

296 ARRANGEMENT OF NUMBERS: The numbers used in the explanatory notes in the following pages correspond to those used in the tables. Thus, to find the explanatory note referring to any number in the tables, add 300 to the number in the tables, and look this number up in the explanatory notes.

For example: Suppose you wish to have some more information as to "tickling the carburetter," from No. 7, you add 300 to 7, and look up paragraph 307.

297 THE NAMES USED FOR TERMINALS: The arrangement for names of the terminals of wires is uniform. For instance, where the writer is speaking of the cable joining the battery to the coil and its terminals, the cable will be indifferently called the coil battery or the battery coil cable; but if he is speaking of one of the binding screws holding this cable, then the end of the cable first mentioned indicates the position of the terminal, and the point mentioned second indicates the place to which the cable leads. Thus the coil battery binding screw, or terminal (also called coil positive), indicates that terminal on the coil connected to the battery, and the battery coil binding screw (also called battery positive) indicates the terminal or binding screw on the battery connected to the coil. This rule has been uniformly followed. For the other terms used, see the list of names (No. 122).

298 THE USE OF THE TABLES: If you wish to look up symptoms, turn at once to the tables No. 1 to No. 122. If you know what the fault is you are looking for, and want symptoms of it, or the remedies for it, look up the fault in the MAIN INDEX. The writer recommends most strongly that in all cases where symptoms are being dealt with, and the cause of trouble is being sought by the tables, it will be much safer to begin at No. 1 of the tables for every fault, although in the case of the more obvious symptoms the INDEX to PRINCIPAL SYMPTOMS given at the end of the book may be consulted and will possibly save time. As the time saved by looking for a special fault in the index, and then referring to the tables, will be very slight, he recommends in every case that No. 1 in the tables should be looked up, and the fault traced right through. As an illustration: Suppose misfiring due to ignition were looked up for electrical trouble,

and reference was made to No. 39, an electrical fault would probably be found; but if a mistake had been made, and the fault were not electrical, all other sources of failure would be passed over, whilst the time saved by this process would be only that necessary to look down the list of symptoms No. 28 to pick out "misfiring or irregular running," and to turn up No. 29*a*, from which reference is at once made to No. 39, the point of reference of the Main Index. It will be found in practice that almost any single fault can be chased through the tables in a few minutes, apart, that is, of course, from carrying out the examination on the car itself, which, tables or no tables, would presumably have to be done. The tables are intended to ensure that sources of error shall not be overlooked.

The author holds out little hope that the tables will discover a fault not in the list of faults No. 1000 *et seq.*: but the tables having been checked for each individual fault in this list, there is at least a fair prospect of finding *them*.

In the great majority of cases, the tables may be relied on to detect a cause of total stoppage with certainty; but causes of loss of power are another question, as so much depends on each man's description of what he thinks wrong. For instance, to define the difference between a "bump" and a "knock" in words with any certainty is a task which the present writer at least has no intention of undertaking.

299 EXAMPLE OF THE USE OF THE TABLES: In order to be quite clear, we will first assume a fault, then state the symptoms which it will produce, and then trace these symptoms through the tables.

Let us then suppose that a bit of a fly's wing has become fixed between the trembler points of the ignition coil of a single-cylinder engine. The coil will refuse to "buzz," and the engine will stop. We turn to the table No. 1. The car is single-cylinder, therefore we look on to No. 2, and it does not matter whether we select No. 2*a*, "Engine will not start up," or No. 2*d*, "Car stops on the road, and engine stops also." Both refer us to No. 5. On turning up No. 5 we glance down the headings. Now an expert will know at once from the way his car stops that the engine has not seized a bearing; but the novice will try his engine with the handle to see; and as the expert would also try to start up to make sure the fault was not one of those momentary causes of stoppage which are sometimes met with, both the expert and the novice will do much the same thing, *i.e.*, try to start up with the starting handle. Both will notice that (1) The engine is free to turn

except for the compression, (2) that it does not back-fire, and (3) that the compression is good ; and the novice following the tables will then try to start by merely turning the handle which is just what the expert would have done *whilst* he was making the first trial ; the novice is, therefore, still close on the heels of the expert. The engine, however, will not start, nor will it give a single explosion for either the expert or the novice. Here the expert would probably cut a corner, for he would have noticed that the coil was not buzzing ; but the novice must be a little more careful ; and, turning to No. 7 (to which No. 5 refers him), he tickles the carburetter, and tries his engine again. Quite likely the expert will have done exactly the same thing, but probably he will by this time be a lap ahead. Our novice, however, still gets no result, and refers to No. 8 ; and, having noticed that the carburetter is not leaking, and knowing that he has a trembler coil ignition, he goes on to No. 9, and, following instructions, he finds he is minus a "buzz." The expert has already found this out, and is by this time busy testing accumulators, and generally dancing from point to point of the outfit ; and guided by the tables. the novice is now after him ; but, unlike the expert, he is protected by the tables from overlooking some important point—a thing which your expert can most easily do. At this stage the expert will probably be playing with his trembler, and if he elects to take out the screw and true up the points, he comes in top ; but, suppose he has done this thing that very morning, he will look elsewhere first, as, for instance, make sure that the commutator lead has not got loose inside its connection ; and the novice takes his voltmeter, and sets to work to test the ignition scientifically, in a way which no source of electrical obstruction can hope to elude. First he takes the voltage from "earth" (say the steering column) to the tail end of the trembler blade ; but, the fly's wing being under the blade, no current can reach the blade, and the voltmeter shows nothing ; and, turning to No. 15, he tests the current from the coil positive terminal (that terminal on the coil connected to the battery) to earth, and here he gets something like four volts ; and he knows that the fault is between the coil positive and the tail of the blade ; and, following the tables, he keeps the voltmeter terminal (one of them) on the "earth," and touches in turn coil positive (he already knows that this shows a good current), coil positive small screw (good current), trembler screw (good current), and trembler blade (no current). The fault is, therefore, between the trembler blade and the trembler screw, and by far the most

likely fault here is insulation of the points, or they are so far out of adjustment that they are not touching. If the expert has recently adjusted his "points," it is an even bet that the novice gets home first; whilst had the fault been that some maliciously disposed practical joker had put two neat little rubber washers each side of his earth wire, the novice would find this as certainly as he would find the first fault, whilst the expert might readily be worrying about for an hour looking for a fault which he could not possibly expect.

In a similar way the method of "crossed leads," which the writer has used in refractory cases of missing, is practically infallible as a means of locating a case of missing on one or more cylinders of a multi-cylinder engine where one cylinder is working all right. Being somewhat laborious, it does not appear in the tables until all ordinary means of locating the trouble have been exhausted.

Running Commentary on the Tables.

[NOTE.—Where the tables are thought to be self-explanatory, no reference is given.]

301 Multi-cylinder engine includes every engine with more than one cylinder.

302 (*c*) Notes on bad running will be found under the sub-divisions of No. 328. This case includes all cases where an engine will run under its own power and drive the car on the level. The isolated cases where an engine will just turn over under its own power, but will not move the car, may be taken either under No. 28 or under No. 4. Both tables will lead to the same result as far as this fault is concerned.

304 Car stops but the engine continues to run: Except in the extreme case just mentioned, where the engine has no power, and stops as soon as the gears are engaged, this will indicate a mechanical fault of some sort. The method of procedure is to examine the transmission mechanism. That is to say, leave the gears in engagement, but as a precaution leave the brakes hard on, then examine the transmission to see how far the motion is being transmitted. For instance, you note that the flywheel is turning and the clutch is not, then the fault lies between these points. The clutch is moving, and on opening the gear box the first motion-shaft is found to be moving, but the second motion-shaft is not; then the fault is between these points, as, for instance, the gears being out of mesh, a key stripped, bolts given way, etc. If the motion is being transmitted through the gear box to the differential casing, but the wheels are not moving, the fault is in the differential or its gears, and so on.

305 (*a*) The method employed is to locate the obstruction or stiffness before or behind the clutch, as indicated. A reference to the list of faults (No. 1072 and index) will give a more careful determination of the locality of the obstruction.

Engine stiff at certain parts of a revolution has been put in as the most likely symptom of a bent crankshaft, etc., which could be given. It would be scarcely a reliable symptom, though probable enough.

(*b*) To examine approximately for roadside work, use the rough method by compression given in No. 117. A false contact

in the commutator is a source of trouble known to the writer due to wear of the wiper allowing the wiper arm to make a contact in advance of the wiper.

306 (*b*) The commonest sign of a choked jet is that after tickling carburetter, the engine will take a few revolutions. The writer has, however, had the same result from a stuck additional air valve.

307 Tickle carburetter: Most float chambers are arranged with the spindle projecting through the top of the float chamber. To " tickle " the carburetter, this spindle is more or less lifted by hand, as experience dictates. Where you have no experience, it will be best to confine yourself to two, or perhaps three, smart lifts of the spindle. As a rule, however, the best results are had by holding the spindle up until petrol runs from the waste pipe of the float chamber. This causes a jet of petrol to shoot from the jet into the induction pipe, wetting its sides, and causing good carburation. Care must be taken not to overdo the " tickling," or too rich a mixture will be formed, and the engine will not start up for this cause, and every further addition of petrol will only make things worse.

" Whilst tickling carburetter : " When the float chamber is empty, the spindle protrudes further than usual, and can be depressed by putting a finger on it. If the float chamber is full, the spindle will be as far down as it will go, unless it is stuck, when petrol will probably be noticed running from somewhere round the jet or from the vent of the float chamber, indicating flooding.

308 " Before going further," etc. : It is not intended that you shall dismount things to find out this point ; it is only meant that you should take note of any obvious leakage of petrol. A further examination will occur further down in the tables, when more likely sources of error have been eliminated

310 " Test spark," etc. : A $\frac{1}{4}$in. gap has been selected as about the smallest spark usually of any good ; but the writer has known cases where a much smaller spark fired quite correctly. Too rigid an adherence to this limit should, therefore, not be insisted on, especially as the intensity of a spark from a trembler coil is very difficult to judge by appearances.

311 "Test spark," etc. : By "plug" head is meant the part of the sparking plug to which the wire is usually attached. Throughout these tables the spark is tested to this point, especially in faulty running of double or more cylinder engines, as, by comparing the spark to the plug head and to some part of the metal frame of the engine, a ready means is obtained of finding out whether the plug points are too wide apart.

312 (*a*) If the spark into the high tension cable from the coil is found to be good, and no spark will come out of the high tension cable, the fault is tolerably obviously a leak in the lead. It can usually be found by examination in a dark room, when the spark can be seen, especially if the lead be moved about.

313 "Switch in spare accumulator : " This would be usually done on the instant of failure before the engine had actually stopped. If the accumulator, when tested, shows a good voltage, it is hardly worth while to waste time wiring in another ; but if the other is ready wired, it can be switched in instantly.

"Loose wires : " To do this, test each binding screw with the fingers to see that it is tight. Be specially careful that the battery and earth connections are not corroded.

"Adjust trembler : " At this stage all that is intended is to adjust with the screw. Cleaning and trimming up come later on, when more obvious faults are looked out. The trembler of an engine which has been all right does not usually fail suddenly and entirely. It usually misses first, so that a sudden source of failure is hardly likely to lie in dirty points, but might readily be a trembler screw worked loose.

314 "Examine with voltmeter : " This method of examination will be more easily carried out if the theory of it is known ; but, as a matter of practice, it is better to follow the tables blindly rather than to think out as you go along. The writer knows from very annoying experience that it is only too easy to overlook what may be called a "collateral" cause of failure ; as, for instance, if the trembler points are stuck together, one is apt to jump to the conclusion on getting a current from earth to the tail of the blade that the circuit is in order—a conclusion guarded against in the tables.

However, for those who want it, the following short account of the method of examination is given—

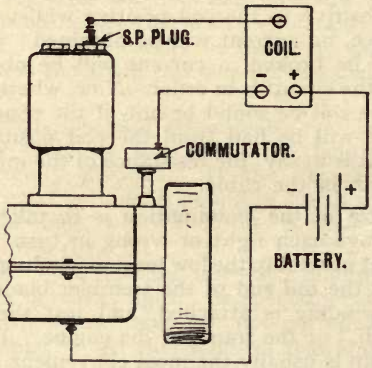
The figure gives a diagrammatic sketch of the wiring of a

single-cylinder trembler coil. The current tends to flow from the battery positive to the battery negative by the shortest metallic route. In the correct path it flows first to the coil positive, through the coil by way of the trembler and the low tension winding of the coil to the coil negative, thence to the commutator, then, usually, through the commutator spindle to the frame of the engine, and thence by the earth wire back to the battery negative. Now, for all practical purposes, the low tension winding of the coil acts as a break in the circuit; that is to say, if the voltage be tested from, say, the battery positive to the coil positive whilst the connecting wire is in place, no current will be obtained; but if the connecting cable be broken, a current will be obtained as long as the rest of the circuit is in order. Now, whether the internal winding of the coil be sound or not, if the connections are in order, current will be had from the coil positive to the coil negative; that is to say, the resistance of the internal windings acts as a break in the cable.

The principle of the examination is to take the circuit in parts, and prove each right or wrong in turn. We therefore select the point nearest to the low tension winding on the positive side, which is the tail end of the trembler blade to which the low tension winding is attached, and test the current from here to "earth," or the frame of the engine. In practice, the steering column is usually the most convenient point to select. If this is found to be in order, it means that the current is flowing steadily from the battery positive through the trembler to the tail of the blade, thence through the voltmeter to the "earth" and back through the earth, and this part of the circuit is therefore in order, subject to some minor considerations, such as a short circuited condenser, which the tables take care of. Now, let us suppose that there is a break in the circuit through the coil positive binding screw being insulated. No current will flow past this point, and no current will be had from the tail of the blade. We therefore test current from the coil positive binding screw to earth. Reference to the tables will show that instruction is given to test from the binding screw itself, and *not* from the cable end, which is done for this very fault. We therefore test from the coil positive binding screw to earth, and as the cable is insulated at this point we get no current. (Had we touched the cable end, a current would have been had which would be deceptive.) We therefore continue to hold the voltmeter terminal on "earth," and touch in turn battery positive (the battery being in order current flows), and we next touch the

switch terminals (these being in order show current), and we then touch the cable end at Q and get a current ; but from the binding screw, to which the cable end is supposed to be electrically connected, we get no current, so we know that the fault is between these two points, and this can only be an insulated cable end, and the fault is found.

It is not necessary to go through the whole of the tables in detail ; but the same principle applies to the whole examination by voltmeter.



314a (*a*) Current flows : This shows that the current is flowing from the battery through the switch, and across the trembler points to the tail end of the blade.

(*b*) No current from the tail of the blade to earth : Indicates a break somewhere between the battery and the blade through the switch (if the switch is in this circuit).

315 Acting now on the general principle, we select a point nearer to the source of current, the coil positive binding screw, and test current from here to earth ; and if we find a current we know that the circuit is in order up to the coil positive binding screw ; and as no current was had from the tail of the blade, the fault must be between the coil positive binding screw and the tail of the blade ; and by touching the various points in this circuit, as the trembler screw, the small screw to which the internal wire from the coil positive binding screw is attached on top of the coil, etc., we can find two adjacent points, one of which gives current and the other not ; as, for instance, the trembler screw and trembler blade showing insulated points.

(*b*) If no current is obtained : We know that the fault is between the battery earth connection and the coil positive. The method of locating is then the same as the above principle, the points of contact being given in the tables.

318 The current having been found all right (from No. 314 above) from tail of blade to earth : The fault is probably not in the circuit from the earth through the battery to the coil ; and we test the current from the tail of the blade to the binding screw on the coil carrying the commutator wire.

(*a*) If we get no current here : Then, as we know that current will flow from the tail of the blade direct to earth, we know that there must be insulation in the commutator wire or its cable or connection, and, as before, we locate it by testing current at different points in this circuit.

(*b*) If a current is obtained : We know that the whole circuit outside the coil itself is in order.

319 We have now to examine for an internal breakage, stuck trembler points, etc. : We therefore test the current first of all from the coil commutator terminal (the coil negative, that is) to the trembler blade ; and, whilst keeping this connection up, we depress the blade, watching the voltmeter. Then we make contact from the coil negative to the trembler screw, and depress the blade whilst watching the voltmeter. When the blade is depressed out of contact with the trembler point, only one of these should show current to the coil negative. If both do, it proves that the current is flowing past the trembler points when they are apart, etc., as indicated in the tables.

320 High tension magneto : A magneto is by no means as easy to test accurately as other sources of electricity. All its indications given with ordinary instruments are very uncertain. If, however, a telephone is at hand, it will give a fairly clear indication whether the fault is a low tension one or not.

After examining all the cables for loose connections, we take out a plug and lay it in the cylinder head whilst turning the engine over, taking good care that the cable end does not touch the metal of the engine. On the whole this is better than examining the spark from the cable end to the plug head, or to the engine frame, unless help is at hand, as it is very difficult to arrange the cable end just the right distance away from the metal whilst turning the starting handle.

321 (*c*) To test the spark from the magneto high tension, it is expedient to take off the cable if easily done, and to fasten a short piece of wire to the high tension terminal, and bring it to within about $\frac{1}{16}$in. of the frame of the magneto. When being turned over by hand, the spark from a high tension magneto will not jump a gap much exceeding $\frac{1}{16}$in.

322 Care must be taken that the distance from the cable end to the coil terminal is not more than $\frac{1}{16}$in. ; and if no assistance is at hand, it will be necessary to fix the cable in position.

(*c*) If a telephone receiver is at hand, it is better than either a voltmeter or the method of tapping the cable. Every time the current is broken by the contact breaker, a click will be heard in the telephone.

When testing for a low tension magneto current by tapping the wire on the frame of the engine or other " earth," remember that only very faint and irregular sparking will be seen in any case ; as to obtain a spark, the current must be broken exactly at the right moment. Any indications of a spark at all are fair evidence that the low tension circuit is in order.

If a telephone is at hand, and indicates that a good low tension current is flowing, and still no spark can be obtained from the magneto, it will usually be best to send the magneto to its makers for overhaul, as the indications are of a high tension failure. In the separate coil type magneto, the current can be tested with a telephone from the coil low tension terminal (not the earth terminal) to earth. Regular clicking here as the magneto is turned indicates that the low tension circuit and magneto are in order ; and as no spark was had from the coil high tension to the distributer lead, the chances are that the coil is wrong, and should be sent back to its makers for overhaul, after looking to see that the coil earth is all right and making good connections. This latter point can be proved by testing with the telephone from the coil low tension to the coil earth terminal, when, if the clicking in the 'phone is as distinct as when testing from coil low tension (the terminal connected to the magneto low tension) to earth, it is a legitimate inference that the earth connections are all right.

(*f*) " Take off : " The switch of a magneto is arranged to short circuit the magneto when it is desired to stop ; therefore, when the wire is off the switch, the magneto should run. If it does run, it shows that there is a leak in the cable ; the switch is closed or leaking.

"Clean:" As a rule, the collecting brush of a magneto is a button of carbon pressing against the end of the armature spindle, and it is as well occasionally to clean the dirt and grease from this. Water also should be cleaned off from the high tension terminals.

'Empty:" In some of the older magnetos where much oil was used, it found its way on to the brushes, and interrupted the action of the machine.

"Make sure:" This will only apply to a magneto fitted with a separate coil or a low tension magneto. If the magneto is not earthed, current will be had from the low tension terminal or the switch binding screw to the magneto frame, but not to the engine frame.

"If idle some time:" High tension magnetos are liable to become damp through standing idle some time, and the distributer shorts.

324 The principle of the examination by voltmeter here is exactly the same as that for trembler coil ignition above. The first trial is of the whole circuit by testing across the contact breaker points. If a current is obtained, it shows that current is flowing round the whole circuit. If no current, that there is a break in the circuit somewhere.

325 We then proceed to take different points of the circuit, and try them, thus locating the position of the fault.

327 This comes down from No. 324, and indicates that the circuit is complete, and the fault is therefore probably a high tension one. If it is the condenser short-circuited, it can only be partly short-circuited, as were it a perfect conductor all the current would flow direct from the coil negative through the condenser to "earth," and no current would be had across the contact breaker points.

328 These are by far the most difficult faults to locate, especially as in some cases they are entirely imaginary. Even where they are real enough, they shade so into one another that it is most difficult to so define the symptoms that no mistake will be made.

(*a*) Even an expert may be misled by a small four-cylinder engine misfiring unless he has had previous experience with the same engine or a similar. Speaking generally, it is not possible so to describe missing that a novice can identify it at once. A method of making an engine miss artificially is described in the list of faults for the benefit of those who wish

to be able to recognise this fault in their own case. Generally, this paragraph refers to disturbances of the running of the engine lasting for short intervals. That is to say, this does not include the case where an engine is running regularly but badly, but those where the power seems to stop entirely for a moment, and then come on again.

(*b*) See (*a*) above.

(*c*) Noises are most difficult to locate, and no method is known to the writer other than a general examination of likely places.

(*d*) In some cases it will be found that when the engine has been running throttled down for some time, and the throttle is suddenly opened, the engine all but stops or refuses to exert any "pull" for a few seconds. A description of the causes and remedies will be found in the list of faults.

(*f*) This includes all cases where difficulty is experienced in engaging the gear silently. Reference should be made to the list of faults.

(*i*) This is one of the most irritating faults that can occur. No general rules can be given. The best that can be done is to refer the enquirer to the list of faults referred to in Nos. 32, 33, and 34.

330 In using a telephone for examining a trembler coil, it should be coupled from the trembler screw to the tail of the blade. If the blade is buzzing, the noise produced in the telephone is deafening.

333 When searching for an obscure cause of weak or irregular firing, it is sometimes useful to try partly closing the induction pipe to enrich the mixture. This can be done by fastening a piece of tape or similar substance across the mouth of the induction pipe. If required, this can be cut away a bit at a time. Where this is found to improve the running, the mixture is too weak. Possibly on account of microscopic dirt in jet. If improved running is produced by playing with the float spindle, the same deductions can be made, as this enriches the mixture.

334 Little or no help can be given with this list. The only thing to do is to read through the list in the hope of alighting on a suggestion which will be of use.

337 Telephone examination of non-trembler coil ignition: In using the telephone for examination an ordinary telephone receiver is used, which can be had for about 5/-. Preferably, one terminal should be provided with a

small clip, such as a tie clip, to enable it to be temporarily attached to any point desired; the other can have an ordinary metallic point attached to it. Then, when it is desired, for instance, to test the current across a trembler blade the tie clip is attached to the trembler screw, and the trembler blade socket is touched by the point. The noise produced is nearly deafening, and the slightest falter is instantly detected. The use of the telephone for a running engine is in principle the same as the use of the voltmeter for one not running. The worst of the telephone for this purpose is that it is too delicate, the faintest current being distinctly audible. Great care must be taken where the car is vibrating much to touch the points mentioned firmly. If the terminal of the telephone moves much on the point touched, a rumbling noise is produced in the telephone, which will be deceptive.

344 An engine when its ignition is in good order may refuse to fire, either on account of too rich a mixture or one too poor, and, which it is most likely to be depends on the individual engine under consideration. Speaking generally, an engine more often has too little petrol when it is cold. With a hot engine, however, it is difficult to say which is the most likely. Probably the expert, not knowing his engine, would give the starting handle several vigorous turns, and then tickle the carburetter; and if he got no explosion at all, he would then think about ventilating, and trying over again. It will often take a good man quite a little while to get a new engine running. After he gets to know it, he has some confidence that he is doing the right thing, and consequently gets going with more certainty. It is inexpedient at this stage of the proceedings to waste much time tickling the carburetter, as it may be something else is wrong. See here remarks No. 307.

349 See remarks on the examination of single-cylinder engines, No. 314.

354 See 344.
"Still no good:" In a low tension magneto the result of a short circuit of one plug is to interrupt the firing of all the cylinders. As, therefore, this is a common fault, one of the first things we do is either to try and run the engine on one cylinder alone, trying each one in turn, and cutting out all the rest, or else we cut out one cylinder at a time (or two at a time) and run on the rest. If, then, the engine will run, say, on all but one cylinder, it is almost certain that the plug

of this cylinder (or its cable) is short-circuited, and we proceed to change the plug, or, failing a spare one, struggle on on the remaining cylinders.

355 Where the engine will not run on any one cylinder : Our first care is to get some indication as to whether the fault is in the magneto or in the wiring. We take the cable from its plug, and, either with a spare length of wire or with the low tension cable disconnected for the purpose and connected to the magneto binding screw, we tap the engine frame whilst the engine is being turned over by hand. If the magneto is producing current, very faint and irregular sparks will be produced, which is fair evidence that the fault is not in the magneto.

(*a*) Read over No. 322 (*f*).

356 It is sometimes possible to examine the spark at the contact breaker through a valve cover, but care must be taken not to look straight into the hole, as some petrol vapour may cause an explosion. The best method is to examine the spark reflected in a piece of bright metal. If this is found to spark all right, the chances are enormously in favour of the trouble being other than ignition.

" Leak may be detected : " If there is still evidence that the ignition is at fault, and the necessary apparatus is at hand, test as follows : Take off the cable from the magneto, and see that the switch is open. Connect one pole of an accumulator or dry cell, such as is used for electric bell work, to the " earth " (any part of the engine frame giving good, clean, metallic contact), and attach one terminal of a voltmeter to the other pole. Now touch the end of the cable which you have taken from the magneto with the other pole of the voltmeter. At the same time take care that all the contact breakers are in the " break " position, or that the contact pieces are fixed out of contact with their plugs. If a current flows, it shows that there is a leak somewhere. We then take parts of the system by themselves, and try them separately. For instance, we take off the whole of the plug cables, and try again. Still leaking : Take off the switch cable. Still leaking : The leak should be fairly easy to locate, as it must be in the cable itself. Of course, if, after the plug cables have been removed, there is leakage, and after the switch wire has been removed the leakage disappears, obviously the leakage is in the switch, and we proceed to drive with the switch disconnected.

(*c*) If the magneto will give sparks, as it has done if you have arrived at this point in the tables, the inference is that

either the plugs or wiring are wrong, or the ignition is all right, and the fault elsewhere. To eliminate the wiring as far as possible, therefore, we connect one plug direct to the magneto, and try to start up on that cylinder alone.

357 See also No. 308 *et seq.*, also No. 344. If you have no experience with the engine, and it will not start up on turning the handle, it will be usually as well in the first instance, if the engine is cold, to lift the spindle of the carburetter until petrol flows from the vent pipe of the float chamber, then try again. Still no good. Take a little petrol from the vent pipe of the float chamber (usually in the radiator stopper, unscrewed for the purpose), and put it into the compression taps, or through the sparking plug holes, or in through the additional air valve. If this is still of no use, proceed as in tables.

359 (*b*) This would almost certainly indicate wear in the commutator, which should be seen to at once.

360 Very often the spark can be seen inside the distributer by merely opening it. Otherwise it will be better to proceed as in tables. It will be easier to examine the spark into the distributer than to dismount things.

361 "Steady spark:" The spark should jump at least ¼in. gap. If it does this to the engine frame, but not to the cable connection of the plug, it is obvious that the resistance of the plug is too great, and this can hardly be the case unless the points are too far apart. Of course, it does not follow that if the spark will jump to the plug terminal that the plug is all right.

"Bad indicates:" It is necessary to be careful when examining high tension wiring by noting the spark that each wire is replaced as finished with. For instance, suppose you examined the distributer end of the coil to distributer cable first, and forgot to fix it on properly, and it dropped off. When you came later on to examine the spark from the coil into this cable, you would get no spark to it, and conclude that the coil was wrong, whereas the fault might be that the lead was leaking.

362 "Use your usual experience:" If you have no experience, the usual course is as follows: With a cold engine which has not been running, first try to start in the ordinary way by setting the ignition and turning the starting handle. Then tickle the carburetter by lifting the spindle until the petrol overflows from the vent pipe. Then

if that fails, pour a little petrol into each compression tap (or sparking plug hole), and try again. If that fails, and the ignition is in order, the engine is probably flooded, and you open the compression taps, or depress the additional air valve, and turn the handle. This is the procedure which would be followed with a new engine just delivered from the makers which could not be started up.

"Breaking contact by hand:" To do this, uncover the contact breaker, and sharply tap a blade with the finger or handle of a pocket knife, so as to bring the contact points together, and separate them sharply.

365 (*b*) "If no spares are to be had:" It may be that the fault is in the wiring; and if no spare parts, such as coil and accumulator, are to be had, it is worth while making sure. To do this, see No. 1180.

366 "Common circuit:" By this is meant that part of the circuit common to all the coils.

372 "Run on each cylinder in turn:" As a rule, it is enough to do this with the engine running idle; but as pointed out in the tables, it is necessary to be on one's guard against being deceived by the seeming sluggish running of one or more cylinders. Owing to a variety of obscure causes, it will often be found that one cylinder of a multi-cylinder engine will run the engine much faster than another. The writer has known a case where a change of sparking plugs had this effect, but the power developed on the road was the same. In cases where this sort of thing is suspected, it is expedient to get the car on to a good flat road, put it in first speed, and let the engine run the car on one cylinder at a time. If the change from cylinder to cylinder be made suddenly, it will be immediately noticed whether each cylinder is doing its share of the work.

(*c*) See No. 328 (*d*).

(*e*) See No. 328 (*a*).

(*f*) Popping in the carburetter: This is an explosion of gases inside the carburetter, and most often it is caused by too weak a mixture. For all odd noises this reference should be consulted, though noises on a car are the most difficult things to locate.

(*g*) If the car is fitted with an exhaust cut out or an exhaust whistle, it will often be possible to tell by using it whether the engine is missing explosions or not. Otherwise the com-

pression taps may be tried. This reference includes the case of an engine with one cylinder which does not fire at all.

374 (*a*) "See contact pieces home:" In some engines the connection from the cable to the plug is made by a switch, one for each plug. This instruction has reference to these switches, as if one of them were loose, missing would be likely to result.

(*b*) Consult the remarks on low tension magnetos, No. 354 *et seq.*

Examine cable, etc.: Look more especially at the points where the cable bends over a metallic projection.

"Make sure," etc.: In some cases, owing to the wear of the carbon brush, the spring fails to press it into contact with the collecting ring, and missing results. This can be tested by pressing the brush into contact by hand.

"Examine earthing:" The current of a low tension magneto returns, as in the case of a high tension magneto with separate coil, to the low tension winding through the frame of the machine, and if this is insulated from the frame of the engine, an interruption to the flow of the current takes place, causing missing.

"Disconnect cable:" This test is to prove definitely whether the fault is in the cable, switch, etc., on the one hand, or in the plugs or magneto on the other. Incidentally, it will also show up if the missing happens to be due to a partial short circuit of one plug, as missing will take place on this cylinder only when connected up by separate cable to run on each cylinder in turn.

"If possible:" Care must be taken that if an explosion occurs it will be harmless. The flash of flame from an open valve cover would be very dangerous to anyone holding his head near the hole, so care must be taken to use reflectors to preclude the possibility of injury.

375 "Test spark:" To do this remove the sparking plug nut, start up the engine, and then lift off the high tension lead, noting the spark across about $\frac{1}{8}$in. gap as it jumps first of all to the sparking plug terminal. Then lower the lead until the spark jumps to the cylinder casting. If the spark to the casting is all right, but there is no spark or irregular spark across a narrow gap to the plug head, it indicates a heavy resistance to the plug, and probably the sparking points are too far apart.

(*b*) To examine the spark at the plugs with the engine running, it will probably be necessary to put spare plugs in

the plug holes for safety's sake, whilst the engine is running on the other plugs (the ones not under examination). If preferred, it will probably do quite as well to change a couple of plugs or one plug, as it is not likely to be a fault of the plugs where all cylinders miss suddenly. If the engine has been lying by for some time, however, it may be a case of defective insulation of all plugs, but this is more likely to cause a total failure than missing.

381 See note on No. 328.

" Test voltage : " If a battery is well up and in good order, it will show practically the same voltage when firing an engine as when idle ; but if all but down, or if there is an internal breakage, the voltage will fluctuate wildly.

" Press switch : " It sometimes happens that the contact in the switch is defective, and by shaking it about and pressing the parts into contact, the missing will stop.

Press contact breaker spindle : This only applies when the current passes through the spindle on its way back to the accumulator. See No. 1129.

" Examine contact breaker : " See note on contact breaker in list of faults. See index.

382 " Examine spark," etc. : This is done by removing the plug binding screw, starting engine, and then lifting the high tension wire from the plug, and allowing the spark to jump from the cable to the plug head, and then lowering the cable to allow the spark to jump to the cylinder casting. If the latter is good and the former bad (the gap must not be more than about $\frac{1}{8}$in. to the plug head), the plug points are too far apart. Should the missing stop on this cylinder when the spark is jumping to the plug, but continue when the cable is on its terminal, it indicates a sooty or oily plug.

(*a*) Instead of this a new plug may be tried if preferred.

383 (*b*) The complete breakage of a high tension lead is almost unknown ; but in carrying out this test, one has to guard against the error of forgetting to replace the high tension cable on its sparking plug (or earthing it) before testing the spark into the high tension cable, for it is obvious that if the plug end of the cable is swinging in mid air, no spark will go into it, and one may be deceived into believing that the coil is out of order.

" Insulated coil earth : " In order to fit the condenser in properly, non-trembler coils are provided with a separate

earth, and should the earth end (or the other) of this cable be detached or insulated, the coil will fail.

385 "Method of crossed leads:" This method is useful as a last resource when a fault cannot be located. Its function is to settle definitely whether a fault is one of ignition or not, and if so in what part of the circuit it is located. For its employment at least one good cylinder is necessary, *i.e.*, one cylinder which is firing regularly.

The principle is to exchange the ignition gear of one of the defective cylinders with that of one of the good cylinders. Obviously then, if this exchange leaves the original cylinder still good, the fault is not ignition, because that ignition system which formerly fired the good cylinder all right will not make the defective cylinder fire correctly, and the fault is, therefore, in some part of the system not exchanged. In practice it is seldom possible to make a complete exchange. The commutator has to be kept as it is, but the whole ignition system, except the commutator, can be changed over readily as directed. The method of identification used in the tables has been chosen to avoid mistakes. It is most easy in the hurry of an examination to make a wrong deduction. Thus if, after the exchange, the engine misses when running on the same trembler blade as before, it is very easy to come to the conclusion that the fault is in the coil or leads, which it is not. By using the tables slavishly, some time will be saved.

"Note carefully:" This can be done by either taking all the cables but one off the contact breaker, or by holding the blades from making contact by putting bits of paper between the contact points. Any method which leaves the engine running on one cylinder will do. We now note one of the blades running on which the engine does not miss, and we note which cylinder this is firing (to identify, see No. 111*b*). Call this cylinder and contact breaker No. 1. Note another blade on which the engine misses, and call this and its cylinder No. 2. Now put the plug cable of No. 1 cylinder on No. 2, and that of No. 2 on No. 1. Also put the contact breaker cable of No. 1 on No. 2 contact breaker terminal, and *vice versa*. The whole ignition gear of No. 1 cylinder, except the contact breaker is now transferred to No. 2, and that of No. 2 to No. 1. Now run the engine again on No. 1 and No. 2 contact breaker. blades in turn. If the engine still runs without missing when running on No. 1 blade, as it did before the exchange of cables, the fault is not in the coil or its cables, but may be in the contact breaker or plug, or else is not electrical.

"Examine": This is to make certain an error has not been made.

"If spark," etc.: This would also indicate a compound fault of a most unlikely nature unless both cylinders now miss. In that case it would indicate that there were originally two faults in No. 2 cylinder, one being electrical and the other not.

(*b*) "Replace leads as at first:" This is merely to avoid confusion. If you think that you can bear the process in mind. it is not necessary to do this; but in nine cases out of ten confusion results from its omission.

The method of this examination and its object is much the same as the previous one, to locate the fault either in the leads or the coils.

388 See No. 382 for method of testing spark.

391 "If easily seen:" This means "if you can see the spark in the distributer by merely opening the cover."

392 "Examine spark," etc.: For method see No. 382.

393 "Readily visible:" That is, if the spark can be seen by merely opening the cover of the distributer.

"Test spark:" For method see No. 382.

394 (*b*) A high tension cable is unlikely to break out of sight, but where the spark has been examined from the high tension distributer lead into the distributer, it is possible that it may have dropped off through careless replacement, and this must be guarded against.

"Note:" If, for instance, one out of four cylinders is not sparking at all owing to a defect in the commutator, the sparks from the distributer lead (or into it) will come in sequences of three with a pause between, which may possibly deceive the examiner unless he is on his guard against it.

395 "Telephone examination:" An ordinary watch-shaped telephone receiver is used. If possible, its terminals should be provided with some sort of clip for attachment to the various points of contact. An ordinary necktie clip will do very well.

396 "Test voltage:" This must be done across battery terminals, and not from any other part of the circuit. When an engine is not running, the voltage can sometimes be taken from the switch handle, but this will not do for the purpose here meant.

397 (*a*) In this examination very little reliance has been placed on the correct answer being given to the question whether or not the coils are buzzing. It is assumed that, unless you are absolutely certain that the coil is buzzing all right, as when you have examined it with a telephone, you will treat it as defective.

(*b*) This would be the result of a double contact in the commutator. See index, No. 1139.

398 "Examine spark:" See No. 382 for method.

399 "Examine," etc.: By removing the cable from the high tension terminal, and holding or fixing it about $\frac{1}{4}$in. to $\frac{1}{8}$in. away from its terminal, and watching the spark into it.

(*b*) If the plug end of the cable is on the plug $\frac{1}{4}$in. gap may be too wide for examination; but if the plug end is earthed, it will be about right.

400 Method of crossed leads: This is only intended for use in refractory cases as a last resort. If you cannot make certain by other means whether a fault is electrical or not, and, if the former, where it is located, and if there is one good cylinder, this method will be found to give certain results.

It is necessary not only to note the coil and trembler on which the engine misses, but to be quite certain to which cylinder this is attached, *i.e.*, which cylinder this coil is firing (see Nos. 114 and 115). By crossing the commutator and plug leads of M and G, you have transferred the coil and cables which formerly fired cylinder M, which was missing, to cylinder G, which was previously running all right.

The writer recommends that you adhere slavishly to the rules laid down, as he has found from experience that in the hurry of an examination it is most easy to make a wrong deduction from a result. One has to think out, for instance, whether holding down the same blade means that one is now running on the same coil as before or not, etc., and wrong deductions are easy. If, however, the rule of thumb given be followed, these mistakes will be prevented. You can think out the accuracy of the deductions at leisure afterwards.

(*a*) It will usually be best in this case to test the spark over a small gap to the plug head of the cylinder now missing; and if this is found to be regular, the fault is either a defective plug or not electrical. The most common non-electrical fault is a leakage of air into the induction pipe of the cylinder in question close up to the inlet valve. The writer knows of two

cases of this. The fault also causes sluggish picking up on opening the throttle.

(*b*) That is, in that part of the electric system interchanged, the coil and cables.

401 "Replace," etc.: This is merely done to avoid confusion, and except for this purpose it is unnecessary. The object of these further tests is to ascertain whether the cause of trouble is in the coil or its leads.

403 (*a*) It will be best in this case to tackle one source of error by itself first of all.

404 To examine spark: See No. 382.

(*b*) "Examine:" Do this by taking the lead from its coil terminal, placing the plug end of the lead on its plug (or earthing it), and testing the spark from the high tension terminal into the lead over a small gap (not more than $\frac{1}{8}$in. if the other end is on the plug, about $\frac{1}{4}$in. if it is earthed).

"Wiring direct," etc.: To do this see No. 1180.

405 To test spark, see No. 382.

(*b*) See No. 404 (*b*).

406 (*a*) Where you have no experience, the following remarks may be useful: After trying the engine in the usual way with the starting handle, and, if possible, swinging it round and round (*i.e.*, not merely pulling it over one compression), lift the spindle of the float chamber until the petrol overflows from the vent pipe of the float chamber. This causes a jet of petrol to squirt up the induction pipe, and wet it internally, and is more certain and effective than merely "jiggling" the spindle. Now try the engine again as before. If it still refuses to start, take a little petrol, and put it into the compression taps, into the cups provided for the purpose on the induction pipes of some cars (as, for instance, some Daimlers), or in through the sparking plug holes if no other orifice is available, and try again. If the engine refuses to start now, one of two things is almost certainly wrong. Either the ignition is wrong (and where you have seen that the spark at the plug is good, this is unlikely, unless the timing is wrong) or you have too much petrol. Therefore, open the compression taps, turn off the petrol, and give the engine several revolutions. If it gives one or two explosions, and then stops when doing this, it is an indication that you are on the right track. Some engines which are difficult to start in the ordinary way can

often be started by stuffing an old glove or a duster or rag into the mouth of the induction pipe.

The most convenient method of collecting the petrol for the cylinders is as a rule to hold the cover of the radiator stopper under the float chamber vent pipe, and raise the spindle of the carburetter until the petrol overflows.

(*b*) In all well designed cars the jet is fairly accessible. To examine the jet, remove the cover so that the jet can be seen. No general directions can be given for this, as instructions would vary for every make of car on the market. Then, while watching the jet, raise the carburetter float spindle. When the float chamber fills, a circular fountain-like jet of petrol will issue from the nipple. If it comes out raggedly, the jet is partly choked. A single glance at the jet of a good carburetter will tell you for all time afterwards how it should behave. If the liquid comes out like oil, and immediately runs down the side of the jet like a slug, or in a bead, it indicates water in the petrol, which assumes this form when issuing from a jet. Once seen, this also can always be recognised.

For all the other items of this list see Main Index. In the list of faults the remedies are given in detail.

408 Caution: Where the fault is due to a shorted cable, it may happen that merely removing the cable from the commutator terminal may take the cable away from the point at which it is shorting. In a refractory case, where the cable is much hidden away, it will be easy to find out whether the leakage is in the commutator or cable by taking a piece of wire, and, after removing the commutator wire both from the coil and from the commutator, connecting it from the coil to the commutator terminals. If the coil buzzes, the leakage is in the commutator, if not it is in the cable just removed. Of course, take care that the wipe piece is not on contact.

(*b*) In some commutators, such, for instance, those fitted to the old Wolseley cars, the connection took the form of a hollow cap covering the terminal. Sometimes in stripping the covering of the cable to insert it in this cap, one or more of the strands of the cable would be cut, and these falling loose inside the cap would short-circuit it.

409 It is often rather puzzling on the road with a new car to say at a moment's notice what each wire is. The rules at No. 109 have been devised for quickly and certainly settling the point.

(*a*) Or, if preferred, place the switch in one position, and slowly turn the engine two complete revolutions, and a bit more. If it does not buzz, the switch is open.

(*b*) If you do not know which is the coil positive binding screw, select any one of the binding screws on the coil, which will show a voltage. If the switch is closed, several will probably show voltage ; but for the purposes of this test, it does not matter which you select. For instance, in a trembler coil you will obtain current from each one of the trembler screws and from each of the blades if the circuit to these points is in order. For the purposes of this examination, any point on the coils from which current can be had will do.

410 The writer has noted one case in which the current shown across battery terminals was four volts. That shown from one terminal to earth was one volt, and that shown from the other to earth about two volts (approximately). At first this was a bit puzzling, but it soon appeared that current must be flowing round the circuit through a high resistance somewhere. This was found in the earth end of the earth wire, which was fastened between a very rusty nut and a rusty frame. As a temporary cure, the writer connected the battery negative to earth by a naked wire, which answered all right. There is, of course, no reason for insulating the earth wire whatever other than that it is usually more convenient to use a bit of the ordinary cable than a wire.

411 (*a*) " Insulate by paper : " Do this by putting a fragment of paper between the trembler points. E.I.C. coils are now provided with a catch to keep the blade depressed.

412 This is to decide whether the switch is in the battery earth wire or the battery coil wire.

413 (*a*) If preferred, instead of placing on contact, turn the engine over slowly, when the coil should buzz somewhere in two revolutions.

414 " Test spark by metal tool : " For instance, take a screwdriver, and, being careful to rest the end of it *first* on the top of the engine casting, bring the middle of the metal part of the blade close to the plug head, when a spark will jump to it. If you touch the plug first, you are liable to get a shock.

" Earth one plug," etc. : Either by connecting the plug head to the engine frame by a wire or, usually more easily, by taking

off the cable and resting it on the engine frame, taking care it makes good electrical contact.

(*b*) "With a tool:" See No. 115*a*. In testing the spark from the coil high tension, it will usually be easier to test it from the high tension terminal to one of the low tension terminals (either one of them will do), but preferably to the "earth" terminal.

416 To know when a valve closes, proceed as follows: First turn the engine until the valve is obviously raised, grasp the stem (or the spring washer) in the fingers, and rotate the valve backwards and forwards slightly. It will be found quite easy to do. Now have the engine turned slowly as the valve closes. Immediately the valve touches its beat, it is no longer possible to move it with the fingers, and this determines with considerable accuracy the closing point. The opening point can be determined in the same way.

417 (*d*) "The top of compression:" This is when the resistance to rotation due to the compression disappears. The method is only very rough.

418 "You now have:" If at the first trial this result is not obtained, the driving gear (or chain) must be unmeshed and advanced or retarded one or more teeth as required. If you have the gear (or chain) off, you proceed slightly differently. Retard the magneto spark, turn the spindle by hand until the contact breaker just breaks contact, now rotate the engine until the piston has just turned centre, mesh the gears (or put on the chain). Turn engine over, and note position of piston at the moment of "break" to check the setting, and if correct tighten up nuts.

In a fixed point magneto, find the position of "break," and then set the engine in the position indicated in No. 118 (*a*), mesh the gears, test the setting, and lock the nuts.

419 (*b*) In a four-cylinder engine, two pistons will be at the top dead centre when the spark takes place. To determine which of these is the one which is in the firing position, look at the exhaust valves. One of them will be just closing, and if the flywheel be moved a little further "ahead" the inlet valve will be seen to lift This is the wrong cylinder; therefore, select that cylinder the valves of which do not move.

Bosch Dual Ignition: This ignition consists of the combination with an ordinary Bosch high tension magneto with a single coil.

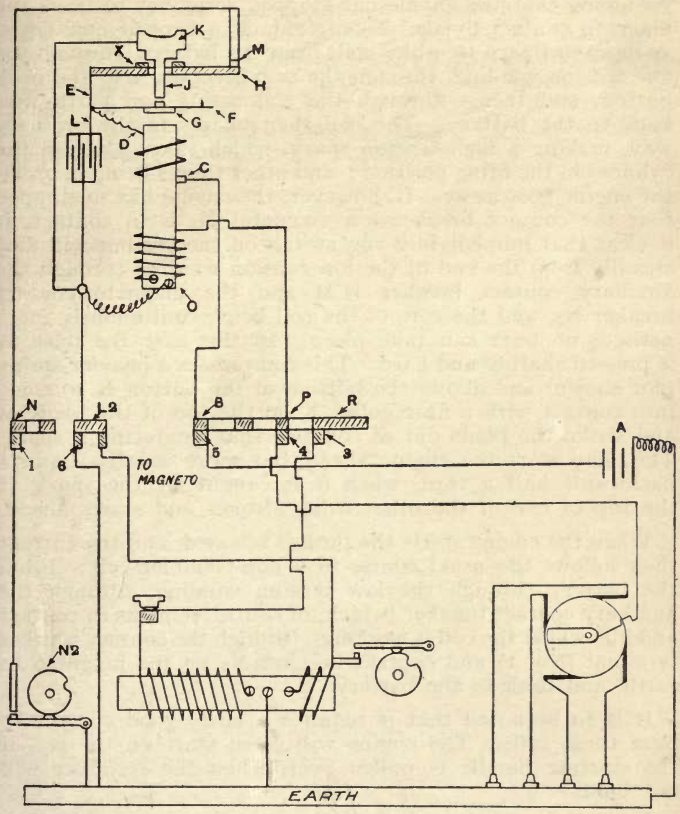
To effect this purpose, the magneto has fitted to it an extra contact breaker to operate the battery and coil low tension current (terminal No. 1 in Bosch instructions), and the connection which usually exists between the high tension collecting brush and the high tension distributer is broken, the connection being made through the coil, so that either the magneto high tension current or the coil high tension current may be sent to the distributer as desired. This must be remembered, for if the coil break down it is no good to disconnect the high tension wires from the coil to magneto with a view to running on the latter, since, in that case, there is no connection between the high tension collecting brush and the magneto. If, therefore, it is desired to cut out the coil, it is necessary, after removing both high tension cables from the magneto (terminals Nos. 3 and 4 Bosch instructions), to connect these terminals the one to the other by a length of cable or wire, care being taken to keep this connection clear from contact with metal unless it is a high tension cable. Apart from these things the magneto itself is as usual.

The Coil: This is a very ingenious and compact arrangement, but delicate in its construction, and should be handled with the greatest care. It is normally an ordinary plain coil when driving the engine, but it has attached a press button, which, when lightly pressed, turns the coil into a trembler coil.

Fig. 419 gives a purely diagrammatic representation of the coil, so that the principle of the wiring may be understood. A is the accumulator, which, for very high speed engines, should be (according to Bosch instructions) 6 volts, but 4 volts will do for all ordinary work.

The negative terminal (Bosch instructions) is connected to terminal No. 5 on the coil, which is internally connected to the switch B communicating with the end of the low tension winding *c*. The other end of this winding *d* is connected to the bridge piece E. This bridge piece carries three connections: F the trembler blade with its armature *g*, the auxiliary contact breaker H (through a hole in which passes the trembler contact piece J, carrying at its outer end the push K), and a connection to the condenser L. The other connection of the condenser is connected to the earth terminal of the coil *b* through the switch L_2. The auxiliary contact breaker *i* has contact points M connected by internal wiring through the switch N to the contact breaker N_2 on the magneto (magneto terminal No. 1). The high tension winding O is earthed at one end through the earth wire, and the other

end is connected through the high tension switch P to the high tension terminal (No. 4 Bosch instructions). The high tension winding of the magneto is coupled to terminal No. 3 connected to the contact piece R, which, when the switch



is thrown over, is brought into contact with the contact piece connected to the terminal No. 4 (coupled to the distributer of magneto).

The action of the dual ignition. Starting on the switch. This is, of course, only possible if there is gas in the cylinders. In the writer's experience it is always uncertain in an engine

with cylinders less than 4in. bore, for what reason he does not know. Switch the coil over to the accumulator side and press the button. This brings the point of the trembler contact J into contact with the contact on back of the blade F. Assuming that the engine has stopped so as not to leave the magneto contact breaker N_2 in contact, a current now flows, as in an ordinary trembler coil, from the battery, through the low tension winding, through the trembler blade to the push button, and thence through the coil casing and earth wire back to the battery. The coil then buzzes in the ordinary way, making a high tension spark, which takes place in the cylinder in the firing position ; and other things being in order, the engine goes away. If, however, the engine has so stopped that the contact breaker (on magneto) N_2 is in contact, it is clear that immediately you switch on the current will flow steadily from the end of the low tension winding through the auxiliary contact breaker H M and the magneto contact breaker N_2, and the core of the coil being continuously magnetised, no buzz can take place. In this case the push K is pressed sharply and hard. This compresses a heavier spring (not shown) and allows the bottom of the button K to come into contact with a fibre collar X on the top of the blade M and strike the blade out of contact, thus producing a spark. This may start the engine ahead, but more usually it starts backwards half a turn, when it is caught by the spark at the top of one of the other firing strokes and starts ahead.

When the engine starts the push is released, and the current then follows the usual course in a non-trembler coil : From the battery through the low tension winding, through the auxiliary contact breaker (which, of course, remains in contact and idle whilst the coil is working), through the contact breaker terminal (No. 1) and contact breaker N_2 on the magneto to earth, and back to the battery.

It is to be noted that it requires a fairly good current to buzz these coils. The engine will often start on the coil if the starting handle is pulled over, when the trembler will not buzz.

It will be noted that whether the coil or the magneto is working, there are certain parts of this system which are in work. These " common " parts are the plugs, distributer, and the cable from the distributer to the No. 4 terminal on the coil. As will be seen from the tables, this system lends itself to fault diagnosis rather well, as the various circuits enable the intelligent operator to locate faults with some ease, and instru-

ments, such as a voltmeter, are seldom wanted. As stated in No. 118, they also lend themselves readily to timing.

It should be noted that by removing one screw in the face of the coil the cover of the trembler blades can be removed, after giving it one quarter turn, and removing one further screw allows the whole coil to be withdrawn for the inspection of the switch faces, but as these are particularly delicate it is strongly recommended that they be not disturbed. As a rule this apparatus had better be returned to the Bosch people in case of internal derangement other than blade contact and magneto contact breaker troubles.

LIST OF FAULTS

With Symptoms and Remedies.

[NOTE.—The symptoms are seldom absolutely reliable, and must be taken as indications only.]

1001 PARTLY CHOKED AIR SUPPLY TO CARBURETTER—*Symptoms :* Generally sluggish running and excessive consumption of petrol. Sometimes accompanied by black smoke from the exhaust, and sooty plugs.

Remedy : See that the carburetter gauze is clean and the air supply unobstructed. If the fault is structural, which will not be the case in a good design, try a spare carburetter jet, and (beginning with it very small) slowly enlarge it until better running is obtained. If no success is met with, replace old jet. Do not tamper with the original jet. See that the induction pipe, where it envelops the exhaust pipe, has not become loose and fallen on to the exhaust pipe so as to restrict the opening.

1002 COMPLETELY CHOKED AIR SUPPLY TO CARBURETTER.—Unlikely except where the carburetter has been intentionally tampered with.

Symptoms : Engine will not run at all except where simultaneously with the fault a large leak has opened into the induction pipe, as, for instance, where a flange has come loose and has allowed a leak of air through the flange, whilst at the same time completely blocking the intake by allowing the induction pipe to fall on to the exhaust pipe. Will show flooding of the jet chamber, possibly one or two explosions at starting, and then complete stoppage.

Remedy : As in preceding paragraph, and usually obvious.

1003 CHOKED JET OF CARBURETTER (completely choked).—This is not usual ; the jet is usually only partly choked.

Symptoms : Complete stoppage of engine, and will not give a single explosion after flooding. Will be obvious on examining jet and flooding carburetter, as no petrol will flow.

Remedy : Clear jet carefully, not with a steel instrument, but with a stem of grass or a broom bristle.

Choked jet of carburetter (partly choked).—

Symptoms : If very slight causes loss of power, probably accompanied with popping in the carburetter. Under these circumstances the obstruction will be scarcely visible to the naked eye, and can be easily overlooked. If more complete, engine stops, and after tickling or flooding carburetter, engine starts up and takes one or two revolutions, and stops again. The appearance of the stream from the jet on flooding carburetter will indicate chokage, as stream will only just show instead of leaping up two or three inches.

Remedy : Same as in last paragraph, but obstruction can often be blown or shaken out (on to the back of the hand preferably, as this admits of its being examined, and the nature of the obstruction may enable precautions against a recurrence to be taken). The writer has known one case of a four-cylinder engine fitted with an ordinary mushroom auxiliary air valve, where a choked jet acted precisely as a governor. The engine would run up to about 600 revolutions with the throttle open, and beyond that it would not go at all, though it appeared to have plenty of power below this point. The reason of this action is not very obvious, but there is no doubt about the facts being as stated. There was no sign of popping in the carburetter or of unsteady running.

1004 CHOKED AIR VENT OF GRAVITY FEED PETROL TANK.—

Symptoms : Engine stops on the road through lack of petrol. Usually stops pulling for a few yards, pulls again apparently all right for a little while, fails again, and finally stops. These are the general symptoms of failure of petrol. Usually there is no intermediate state ; the engine is either pulling all right, or not at all. If float chamber be examined (by the position of its spindle) immediately engine stops it will usually be found empty If the obstruction to the vent is permanent, the float chamber will not fill again ; but if it be due to a cushion pressing on the vent (or similar cause), it is possible that the removal of the driver's weight may cause it to clear, and the float chamber will fill at once. In all such cases, if suspected, it is well to turn off petrol immediately on the engine stopping, and then examine float chamber.

Remedy : See that the air vent in the tank cannot be obstructed. A small piece of stick laid across it will often be effectual in keeping a leather cushion off it.

1005 CHOKED PETROL PIPE, FILTER, OR TANK OUTLET.—

Symptoms : The same as with a choked tank vent, but in case of a choked filter the engine is sometimes starved for petrol before complete failure takes place, and " popping " may be noticed. This failure may be distinguished from a choked jet by the engine running much longer on restarting, as the float chamber will have leaked itself full, and on this the car will probably travel from 200 yards to half a mile.

Remedy : To locate, uncouple the union under the float chamber, and note the flow of petrol. This should be a steady stream the full bore of the pipe. If the flow is of this nature, the stoppage is not between this point and the tank, and must be sought in the float chamber or its admission port. Therefore, see to balance weights, float, and spindle. If the flow of petrol is only a dribble, uncouple a union further back, preferably the filter (if there is one), or perhaps, better still, examine the filter at once if at all easy to do. If this shows a steady flow, the fault is between the first and second points examined ; if this also shows a bad flow, the obstruction is nearer the petrol tank, and the tank union may be examined, and so on.

To remove : A long piece of wire will be the best way of clearing a pipe as a rule, but should this not be available, the pipe may be taken out and made nearly red hot for some time (provided it is not soft soldered) ; and if the obstruction is combustible, as it often is, it may afterwards be washed out. Where a filter is found full up with bits of fibre, hair, petrol, tin, paint, etc., and this trouble is of frequent occurrence, it is a fair proof that carelessness obtains in filling the tank, or a funnel without a filter is being used.

1006 CLOSED PETROL TAP (completely or partly).—

Symptoms : If the petrol has not been turned on, the engine will stop suddenly and almost (or entirely) without warning in about the first hundred yards. If the tap has jarred shut, the symptoms will be as in a choked petrol filter. Probably the engine will be starved first, and will not pull with open throttle, but continue to

pull with throttle partly shut, and perhaps for a few seconds after it is opened wide (*i.e.*, until the float chamber is nearly empty). Also, after running down hill, full power may be had for a few seconds, and then again failure.

Remedy : If the tap has a cross handle, and jars shut, have one end of the cross handle cut off, so as to upset the balance ; and as it is 1,000 to 1 the tap is not exactly horizontal, it will keep open.

(*a*) EMPTY PETROL TANK.—

Symptoms : Complete and usually very sudden failure of the engine. This class of failure is unlike any other, except the sudden dropping off of the high tension lead of a single-cylinder engine, or the falling out of the accumulator wire. Even this latter very often gives one or two misfires from looseness first. In case of absolutely sudden failure of power, the petrol is the most likely source of trouble.

Remedy : A spare tin in the toolbox. Occasionally a car can be driven home on paraffin.

(*b*) STUCK CARBURETTER NEEDLE VALVE.—

Symptoms : The same as those for a choked petrol pipe. See No. 1005.

Remedy : This will depend on the cause of sticking. If the sticking be due to roughness of the spindle, cleaning with knife powder may do. If it be due to faulty adjustment of the carburetter weights and levers, examination only can give a guide. In general, when the float chamber is empty, the float should be down and the spindle up, and if this is not so something is wrong. Possibly the balance weights or the float are not heavy enough. Possibly so much wear has taken place in the joints that the levers no longer lift the spindle.

1007 FAULTY PRESSURE FEED IN PRESSURE-FED SYSTEM.—

Symptoms : The same as those of choked tank vent (No. 1004), except that the carburetter will not fill up on standing. The pressure gauge usually shows the fault.

Remedy : Take out the valves, if exhaust pressure fed, clean their seats, and replace. Oil the washers of the tank filling stoppers. Examine joints of piping for leakage and unions for looseness. A squirt of oil

will often disclose position of leakage by bubbling. If the pressure is kept up by an air pump, examine tank vent first for leakage through dry washer, and oil the washer, and then clean the valves of the pump.

1008 PUNCTURED FLOAT IN CARBURETTER.—*Symptoms :* If the engine usually starts after just tickling the carburetter or slight flooding, it will probably be difficult to start, and will require ventilation before it will start. If the engine is very difficult to start, requiring the addition of petrol to the cylinders, it may now be quite easy. After running down hill with the throttle shut and the car driving the engine, it will probably be sluggish in picking up its load. Little difference will be noticed, except in very bad cases, when the car is pulling with open throttle.

Remedy : Place the float in a glass of hot water, when the bubbles of vapour will locate puncture. Expel all petrol by heat, being careful, however, not to apply too much heat so as to burst the float. Get a *good* tinman to solder the hole with a *very little* soft solder, taking care that the float is approximately balanced where he has done it, *i.e.*, that it floats " on an even keel."

1009 LOOSE PETROL JET.—*Symptoms :* If quite adrift will stop engine ; petrol will probably be seen leaking out from under the carburetter. If partly unscrewed, probably same effect as punctured float. The writer has no experience of this fault.

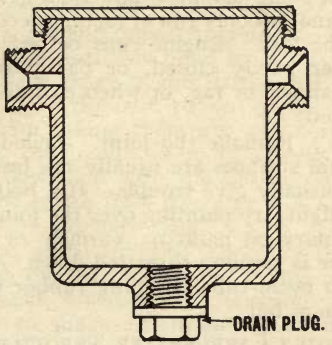
Remedy : Screw tight, and remember that the engine is fairly sure to want ventilating before it will start.

1010 WATER IN CARBURETTER.—A common fault in pressure-fed systems through condensation of exhaust gases (mostly steam) in petrol tank.

Symptoms : If the water is due to condensation of exhaust, it will not be in great quantities, and the effect is usually to cause a momentary faltering in the running of the car just as if the throttle had been quite shut for a couple of seconds, and then reopened. Or the engine may flutter, just as though the ignition had all gone wrong for one or two seconds, and then pull away as well as ever. If much water is in the petrol, the engine misses continually, and explodes violently in the silencer. If the jet be examined whilst the carburetter

is flooded, petrol will come out in a lively jet whilst water will come out sluggishly, and fall down the side of the jet.

Remedy : This must depend on the cause to some extent, and if large quantities of water are finding their way into the petrol tank, the leakage must be stopped ; but if the quantities are small, a drain cock at the lowest point of the petrol pipe may cure the trouble, or else the fitting of a water trap, as per fig. No. 1010.



1011 ADDITIONAL AIR VALVE STUCK OPEN.—

Symptoms : The engine will probably stop if the throttle is partly closed, and will be very difficult to start up. Often accompanied by popping in the carburetter ; and sometimes makes its presence known by the hiss of the entering air.

Remedy : Clean the valve and its dashpot (if any) carefully with a dry, clean rag ; and as a general rule avoid oil, as it clogs with the dust which is constantly entering the valve. Sometimes the fault is due to the weakening of the spring controlling the apparatus, and a temporary remedy is to stretch the spring, or pack it up with washers of paper, metal, a tool, or anything handy.

1012 ADDITIONAL AIR VALVE STUCK CLOSED OR PARTLY CLOSED.—

Symptoms : Engine pulls all right at low speeds, as when climbing a hill slowly on top speed, but will not pull with open throttle. Possibly sooty plugs, probably excessive consumption of petrol, and possibly over-

heating. The writer has known a case when the effect was the same as that of a governor, the engine failing to accelerate beyond a certain speed whether running light or driving the car.

Remedy : Same as where valve is stuck open, except that the spring will not be weak in this case.

1013 LEAK OF AIR INTO INDUCTION PIPE.—*Symptoms :* If close to one cylinder often affects that cylinder only. On opening the throttle, engine refuses to pull for some distance, and then gets away. Sometimes engine will only run at racing speed on the cylinder nearest the leak. Engine runs better with air inlet to carburetter partly closed, or partly obstructed by a finger, spanner, or rag, or when carburetter is continually flooded.

Remedy : Remake the joint. Boiled linseed oil and plain metal surfaces are usually the best form of joint. Washers usually give trouble. If a boiled oil joint will not stay tight, try painting over the joint, after making, with ordinary oil paint or varnish or enamel, whilst the engine is running throttled down. A joint made of pure, thin cycle tube patching rubber will often stand where others fail.

1014 FROZEN CARBURETTER THROTTLE.—*Symptoms :* If spring operated, the throttle will not move in the direction in which the spring moves it. Thus, if the spring opens the throttle, and the engine has been running throttled for some time, the spring is not able to open the throttle when the hand control lever is operated, and the engine will not pull. As the ice slowly melts, the throttle opens, and unless the fault is detected at once, it may not be at all. If the throttle is spring closed, which is unusual, this fault is not likely to be noticed, as throttles do not freeze much when they are wide open. If the throttle is fully hand-controlled, nothing serious is likely to arise from freezing ; in fact, it will probably pass unnoticed.

Remedy : Put in a stronger spring, or supply the carburetter with warm air. Pack the existing spring by a washer, bit of paper, etc., behind it.

1015 FROZEN PORTWAY IN CARBURETTER.—*Symptoms :* Usually only noticeable when throttle is nearly shut and engine running slowly idle. Engine runs for a few moments, and then stops, starting up

again on turning the handle with the throttle more open. Due to formation of ice round the portway.

Remedy : Warm the air, or do not try to run with the throttle so much shut.

1016 DRAGGING BRAKES.—

Symptoms : Loss of power and brake bands and rims overheating. An experienced driver will notice a dragging brake by the extra suddenness with which his car stops when he takes out the clutch, and by its sluggishness down hill running free.

Remedies : Band brakes fibre lined. These should not begin to hold until the hand lever has moved through half its whole range of movement. If they drag then, they are very difficult to put right. They may be improved by taking them off, and correcting the curvature of the bands to more closely fit the drums. Running down hill with the brakes on will sometimes cure a new brake from dragging. A spring or springs to pull them off may help.

Metal to metal brakes. The only thing to do with these is to release them ; and if this makes them slip and not hold, a structural alteration will probably be necessary to make the brake band fit more closely to its drum.

Grease on the brake drums will both cause the brake to drag and at the same time prevent it from holding, and is most treacherous, as the brake will appear to hold when gently applied, but will fail in a sudden emergency. This grease drags between brake and shoe, and consequently causes heating. The remedy is. of course, to keep it off the drum, but if that cannot be done, a temporary cure may be effected by fitting a slow feed (say thirty drops a minute) of paraffin oil to the brake drum. Provision must be made for keeping this paraffin from being thrown on to the coachwork.

(*a*) In external brakes, if the grease which is doing the damage is coming out around the shaft on which the brake drum is mounted, a sheet of copper may be fitted, as in fig. 1016 (*a*). Any good coppersmith can fit this, and if it is well fitted, it will entirely prevent the grease reaching the brake drum even if the flange N projects only $\frac{1}{8}$in. or less beyond the drum, as centrifugal force will throw it off. The writer has tried this, and found it entirely successful ; but care must be taken that the

copper fits the brake drum closely, or the grease will get between the copper and drum, and thus on to the working face.

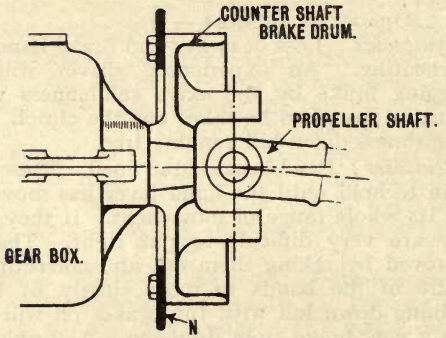


FIG. 1016A.

(*b*) In internally expanding brakes this remedy is not possible, but a very effective remedy to apply to a live axle is to fit two screw-down grease cups to it, one at each end, as close as they can be placed to the axle ends. Feed these with very thick grease, and this will act as a packing to keep the thin grease round the differential in its place.

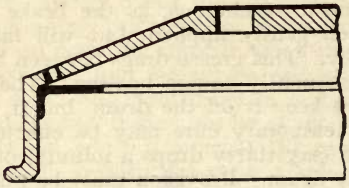


FIG. 1016B.

In the case of a dead axle, where grease is coming from the back hubs into internally expanding brakes, use a thicker grease; but if this is found ineffective, the arrangement shown in fig. 1016 (*b*) may possibly work, but is a more serious thing to fit.

In badly designed cars you will occasionally find that a brake which is free when the car is empty will bind when the car is loaded. The remedy is a structural matter, depending on design and circumstances.

1017 BINDING BRAKES (stopping the wheels).—Same remarks apply as in the case of seized bearings. below. See under the head of "Gear box."

Remedy : The same as for dragging brakes above, or as circumstances dictate. This fault is very unusual.

1018 BRAKES NOT HOLDING.—

Symptoms : As a rule obvious, but where a brake has grease on it, it may hold for ordinary use, and fail in an emergency, giving the feeling, even to an expert, that his wheels have slipped, thus cloaking the real cause. The symptoms of this are a sensation much as though the brake were holding, but the wheels had lost their stopping power.

Remedy : See No. 1016.

Where grease is not the trouble, examine the action of all the brake connections whilst someone moves the pedal or lever for you, noticing whether everything is free, and that none of the levers are at the limit of their movement. In an internally expanding brake operated by a cam, see that the cam is not as far over as it will go, in which case the brakes or drums must be relined. A close watch of the various moving parts will often show by very small (even minute) movements that strains are causing springing of parts which should not spring, and thus lead to location of the trouble. Such movements may not amount to $\frac{1}{64}$in.

A newly cleaned and assembled brake drum seldom holds well at once.

1019 SQUEAKING SPRINGS.—

Symptoms : A distressing squeak, which cannot be located, and does not seem to synchronise either with the revolutions of the engine, wheels, or gears, though this absence of synchronism may not be readily noticed. As a rule, if the car and engine be stopped, and the body rocked on its springs, the springs will squeak.

Remedy : Jack up the body (not the axle) until the spring leaves open, and then insert grease and graphite with a knife blade. At the next overhaul, the plates should be thoroughly cleaned and rubbed in grease and graphite.

1020 DEFECTIVE SPRINGS.—

Symptoms : (*a*) Passengers thrown from their seats when travelling over rough roads. This is a sign of

springs being too elastic, and is a fairly common fault with cars having three-point suspension behind.

Remedy : Apply shock absorbers, or, if that is not possible, stiffen the springs.

Symptoms : (*b*) Roughness. This is caused by too strong a coach spring, or where there is not enough play in the springs. May possibly be cured by taking out a spring plate, or by having lighter springs

(*c*) Bumping. Due to too light a spring. In the case of threequarter elliptic springs, may be due to the half spring not pointing sufficiently far downwards, and thus not having sufficient play.

1021 BROKEN FAN BELT.—

Symptoms : Overheating of the radiator, boiling of the water, and steam from the radiator. If long neglected, shortage of water and overheating with loss of power, and the ignition lever loses control on account of pre-ignition.

Remedy : New fan belt—an old trunk strap cut down as required, which can be done with a little care with a penknife. A belt may be fastened by rivets, copper wire, boot laces, or string for a temporary repair.

1022 SLIPPING FAN BELT.—

Symptoms : The same, but not so pronounced as those for a broken belt. See No. 1021.

Remedy : Resin on the belt. Tighten the belt; relace it or refasten it. See No. 1021.

1023 LEAKY RADIATOR.—

Symptoms : If not noticed by the leakage of water, will cause overheating, pre-ignition, and loss of power. If the overheating is bad, it may be noticed that movements of the spark lever have no effect on the speed of the engine on account of the charge being fired by pre-ignition.

Remedy : It is hardly possible to do more than give a few general hints, as the treatment must vary with the circumstances. Where a leak is through a pipe joint, it will often stop if about a teacupful of barley meal or fine oatmeal be mixed with water, and placed in the radiator whilst the engine is running. After about two minutes drain out the water, and refill. Be careful if there is a filter in the circulating system, as there some-

times is in the pump, that it is taken out and cleaned, as it will almost certainly choke.

With a honeycomb radiator, a makeshift is to have a pair of plates of stout sheet iron cut out, backed with rubber insertion or red lead putty, and bolted to the two sides of the radiator (front and back) with bolts through the holes. Neat little caps with spring connections are sold for closing single tubes of honeycomb radiators. In making a repair by soldering, it is almost always necessary and better to take the radiator bodily off.

1024 LEAKY PIPES OF CIRCULATION SYSTEM.—*Symptoms :* The same as those for a leaky radiator. See No. 1023.

Remedies : Roadside repairs. In some cases nothing can be done, but in many expedients are possible. With a leak through a flange, a dose of oatmeal or barley meal may take you home (see No. 1023). Where the leak is in the body of a pipe, it is sometimes possible to serve it over with insulation tape, strips of rubber cut from an old tube or a tobacco pouch, or even greasy rag or strips of a pocket handkerchief, the whole thing being served over with string if time serves ; and, for a more permanent job, black varnish over all.

Where the pipes are completely broken, it may be possible to draw the ends together by wedging or fastening by wire, leaving the actual ends unencumbered by wire, and then serving round as described above. The writer has travelled many miles with this sort of a makeshift.

For a more permanent repair, solder will serve ; but merely loading up with solder is of little use, as it breaks away at once. Proceed as follows : Clean the ends of the pipe for an inch each side of the breakage with emery paper or a file, and clean about five or six yards of copper wire (from .06in. to .02in.) with emery, a file, or a knife blade. Arrange the pipe ends touching one another if broken apart, and then wind the wire zigzag and crossways all over the breakage, making a tangle of copper wire over the breakage and for one inch each side of it. Now load the whole tangle up with soft solder. The copper wire supplies a foundation which will hold the solder.

For a permanent repair a new pipe or a sleeve brazed (not soldered) on the pipe will do.

Where circulating pipes are constantly breaking in one spot, do not join them up metallically, but slip a piece of hose pipe over the breakage, and wire it. The breakage is probably due to " play " of the parts, and the hose will allow this.

For a petrol pipe, hose must not be used, but a spiral of one or two turns in the pipe will allow of sufficient play for the purpose.

1025 CHOKED PIPES OR RADIATOR.—

Symptoms : Cylinder jackets and delivery pipes will be hot, and the pump and lower part of radiator cold, and top of radiator possibly boiling. Remember that in a thermo-syphon system the bottom of the radiator is always comparatively cold.

Remedy : Locate by first of all examining all the constrictions in the pipe, especially pump filter if any. If this does not locate the fault, a hose will be required. Take the system part by part, and try how much of it you can force water through. Thus, for example, disconnect the delivery pipe from the cylinders to the radiator, and from the radiator to the pump. Apply the hose to the latter, and try to force water through the cylinder jackets. If it will not flow through any of the jackets, the obstruction will be in the pipes common to all cylinders ; if it flows through all but one jacket, in the pipes supplying that jacket only.

1026 BROKEN CIRCULATING PIPES.—

Symptoms : If not noticed by the leakage, overheating will result with loss of power, possibly stopping of the car on a hill, and often the ignition lever will have no control due to the firing of the charge by pre-ignition.

Remedy : See No. 1024.

1027 CIRCULATING PUMP CHOKED.—

Symptoms : The same as for a choked pipe. See No. 1025.

Remedy : Take apart and clean. The class of obstruction should furnish a guide as to the source of trouble. It is often caused by pieces off the inside of the hose connections. There should be little length of hose exposed, and if the pipes do not come to meet before the hose is put on, a short length of metal pipe may be placed between them to keep the water off the hose.

1028 LEAKY PUMP SPINDLE.—

Symptoms : The same as those of a leak in radiator (No. 1023) or pipes (No. 1024).

Remedy : The leakage is often round the spindle, which is often awkward to pack properly. A small grease cup put in the spindle casing, and stiff grease forced in through it, will often stop the leakage ; in fact, many good cars have no other packing.

1029 AIR LOCK IN CIRCULATING SYSTEM.—

Symptoms : By this is meant the filling up of part of the circulating system with air, and thermo-syphon systems are much more liable to it than those with pump circulation. Where the piping rises to a high point, and then falls again, air will collect at the highest part of the system, and stop the circulation in a thermo-syphon system. Obviously if through any cause a centrifugal pump is filled with air which cannot get out, as, for instance, when its delivery pipe after leaving the upper part of the pump casing bends sharply downwards again, and the supply pipe from the radiator comes in at the bottom, the pump will not work. The remedy is to let out the air by slacking a connection or other means.

Remedy : A small tap at the uppermost part of the system, or the place where air is found to collect, will usually cure the trouble ; but if this fault is possible, the system is badly designed.

1030 BROKEN PUMP SPINDLE.—

Symptoms : With a centrifugal pump, and a system so arranged that thermo-syphon circulation can take place, the engine may go on working as though nothing had happened, and can be left at that, if no evil results, such as loss of power or waste of water occur. Where the pump is a positive drive type, it will obstruct the circulation if it stops, and create the same symptoms as a choked system (No. 1025). Where it is possible to remove veins from the pump, it can often be rendered harmless, and the car worked on thermo-syphon system.

Remedies : For the roadside see if you can take out the operative parts of the pump, such as the veins and gears, and stop up the spindle hole with grease, insulating tape, rags, or anything handy. If the drive to the spindle is by a tongue on its end, it can be mended by cutting a notch in its end, and fitting in a tongue of

steel to engage with the slot on the driving-shaft. Where a pump is constantly failing in this way, examine to see whether it is in line with its driving-shaft, whether the spindle is being jammed in screwing up, the face on too tight, etc., so as to remove the source of failure. A pump has little work to do, and should not fail unless it is being ill-treated.

1031 EMPTY RADIATOR.—

Symptoms : Overheating of the engine. Ignition lever of no effect on account of pre-ignition, loss of power, etc.

Remedy : Cool the engine down by allowing it to stand for some time (half an hour or so). It may be gently cooled down if not very hot by pouring water on the outside of the cylinder jackets. Fill up the radiator at the handiest spot. If no bucket is at hand, a tool-box, tyre repair box, or a hat may serve.

1032 BOILING RADIATOR.—

Symptoms : Steam from radiator, hot water from radiator stopper, and loss of water. If long continued, same as those for shortage of water. See No. 1031.

Remedies : If the engine has been previously all right, look out for the following points—

Fan belt gone, when the whole circulation system will be hot.

Fan belt slipping, same as if it were gone. Pump failed or the pipes choked, top of radiator and jackets hot, bottom of radiator and pump cold, additional air valve to carburetter stuck, and whole system overheated.

Ignition too far retarded, as when the commutator wipe has slipped, especially where ignition and throttle levers are inter-connected. See No. 1188.

Obstruction of the air supply pipe to carburetter. See Nos. 1001 and 1002.

1033 INLET VALVE (AUTOMATIC) STUCK OPEN.—

Symptoms : If the valve is fixed open, there will be no compression, and probably the charge will be felt and heard surging back through the carburetter. In a multi-cylinder engine, explosions may be expected in the carburetter. If the valve is only sticky, the result will be loss of power, and probably this will be more pronounced at high speeds. The writer has no personal experience of the fault.

Remedy : If due to deposit on the stem, clean off with petrol (gasolene) or paraffin, or clean down with emery paper. If the spindle is bent, a new valve will be required.

1034 INLET VALVE (MECHANICALLY OPERATED) STUCK OPEN.—

Symptoms : Much as in No. 1033.

Remedy : As in No. 1033.

1035 INLET VALVES (AUTOMATIC), WRONG LIFT.—

Symptoms : If the lift is too little, probably engine will lose power at high speeds, but there will be little difference at low speeds.

If the lift is too much, the cylinder will not run at all at low speeds in some cases ; whilst, on the other hand, the writer has known cases where excessive lift has had exactly the opposite effect.

Remedy : Usual lift $\frac{1}{8}$in. for all sizes. See No. 116 (*c*).

1036 INLET VALVES (MECHANICALLY OPERATED), WRONG SET.—

Symptoms : Probably loss of power, but if it opens before the exhaust valve closes, probably makes odd noises in the carburetter.

Remedy : For set see No. 116 (*b*).

1037 BROKEN INLET VALVE STEM.—

Symptoms : In nine cases out of ten, the cylinder will fail entirely, but it is just possible with a mechanically operated valve it might run slowly and very irregularly, the valve closing by gravity. With an automatic valve, the valve will drop into the cylinder, and may cause a smash, or be knocked to pieces by the piston.

Remedy : If any parts are in the cylinder, they may be removed by making an electro magnet from a long coil of low tension cable and an accumulator, the cable being wrapped many times round a bar of iron. This will pick up any bits of steel. Nothing can be done by the roadside, so take out the pieces, and try to come home on the other cylinders. If this is not possible, it is just conceivable that you might be able to arrange a slight spring on the end of the stem, and come home using the valve as an automatic, but the idea is not hopeful.

1038 BROKEN INLET VALVE SPRING.—*Symptoms :* Depend on the extent and character of the damage. Might be loss of power, probably irregular running. In an automatic valve, probably impossible to accelerate the engine, or else to run it slowly. The writer has no personal experience, and defective valves play such unaccountable games that it is impossible to foresee what exactly might happen in each case, but you are not very likely to be left long in doubt about something being wrong.

Remedy : Probably little or nothing can be done, but it is just possible that if you are in a deserted spot you might pack the spring, taking out part of it, so that you could get on with the other part alone. The arrangement must left to ingenuity. The idea is to block up part of the spring so as to keep it bearing down on the valve. A conceivable method is to wire the spring down to the valve lifter holding down bolts. In an automatic valve, if no spare spring is to be had, a fairly hard iron wire spring may bring you home. In this case reduce the lift of the valve to less than $\frac{1}{16}$in., and if possible block it so that it cannot open more, so as to keep the strain off the spring.

1039 EXHAUST VALVE STUCK OPEN.—*Symptoms (partial) :* Probably loss of power and symptoms of missing, possibly explosions in the silencer, and generally odd noises. If complete, the cylinder will be out of action, and there will be no compression.

Remedy : Clean the stem or, if bent, put in a new valve. With a bent spindle, you may get home by filing the part of the stem which shows signs of rubbing, so as to make it easy in its hole.

1040 EXHAUST VALVE WRONGLY SET.—*Symptoms :* Loss of power, sometimes so much so that the cylinder will only just run idle.

Remedy : See No. 116 (*a*) for timing of valves. Where the lift is not enough, and the lifter is not adjustable, it may be possible to pack something between lifter and valve stem to increase the lift as a makeshift.

1041 EXHAUST VALVE NOT CLOSING.—*Symptoms :* Loss of compression, and generally the same as if it had stuck open. See No. 1033.

Remedy : If you cannot set the lift, and are sure you have not got the valve in the wrong cylinder, the only thing to do will be to file off some of the stem, so as to allow it to bed on its seat, as the fault is almost certainly due to the stem and lifter being too close together, but the fault is unlikely, unless valves have been wrongly assembled.

1042 INLET VALVE NOT CLOSING.—
Symptoms : Much the same as for the valve sticking open.
Remedy : The same as for the exhaust valve. See No. 1041.

1043 BROKEN EXHAUST VALVE SPRING.—
Symptoms and *Remedy* as in No. 1038.

1044 BROKEN EXHAUST VALVE STEM.—
Symptoms and *Remedy* as for inlet valve. See No. 1037.

1045 CAMSHAFT SET WRONG.—
Symptoms : Loss of power. See set of valves, No. 116.

1046 BROKEN CONNECTING ROD OR GUDGEON PIN (WRIST PIN).—
Symptoms : Usually a hopeless smash.
Remedy : A new one.

1047 BROKEN CRANKSHAFT.—
Symptoms : Usually a hopeless smash, but occasionally where the breakage is in a bearing, the engine will continue to run.
Remedy : New part.

1048 SEIZED ENGINE BEARING.—
Symptoms : Engine stops very quickly, bringing car to a standstill, but not with the suddenness of a breakage. Engine will be stiff or immovable.
Remedy : Ascertain the part, cool down, and ease off, or else supply liberally with oil. The part can usually be located by its heat, and it may be necessary to cool off with water. This will do no harm unless the temperature is about red heat. A little Dixon's best graphite may help matters.

1049 SEIZED PISTON.—
Symptoms : The same sort of thing as a seized bearing. The engine will be immovable.
Remedy : If due to lack of cylinder lubrication, overheating, etc., and the piston has really stuck in the cylinder, soak in paraffin oil (kerosene) for a couple of

hours, and apply moderate force (all you can put on the starting handle by hand will do no harm). If that does not do, it is a job for the machine shop ; but if you cannot come by one, the only thing to do is to try more drastic measures, such as levering the flywheel over, but it is very likely to lead to a smash. Try tapping the piston fairly hard with a piece of hard wood and a hammer if you can get at it.

If the fault is due to a ring slipping over the bore of the cylinder, you are rather in trouble, unless you can get the cylinder head off, which is unusual in a modern engine ; and if the bore is not bell mouthed at its upper end, as it should be, the job is one for the makers, and the piston may have to be cut out in pieces.

(*a*) CRACKED CYLINDER.—Causing leakage from jacket into cylinder.

Symptoms : Probably shows steam at exhaust.

Remedy : New cylinder. If it is found difficult to start the engine on account of the wetting of plugs, put in spark intensifiers. If none are available, fasten the leads to the plugs with string, so that the spark will have to jump about $\frac{1}{8}$in. to its plug. This may enable you to start up.

1050 (*a*) CRACKED WATER-JACKET.—

Symptoms : A leak of water from jacket.

Remedies : Cast-iron water-jacket. Take off the circulating pipes and plug the holes, arranging for a tyre valve to be set in one of the plugs in order that a pressure may be raised by the tyre pump. Dissolve about one ounce of sulphate of copper in two or three quarts of water, and fill the water-jacket. This liquid will leak through the crack, and will very quickly show signs of stopping. Then apply pressure with the tyre pump until the leak stops. Wash out all the sulphate, and re-connect.

With an aluminium jacket. If the crack is not bad, an uncertain repair may be made by putting some fine oatmeal in the water, otherwise there is nothing for it but to patch the crack or have a new jacket.

1051 INSUFFICIENT LUBRICATION OF CYLINDERS.—

Symptoms : Sometimes loss of power of greater or less extent ; but if very bad, the engine may stop suddenly just as if the piston had seized, but on turning starting handle the engine will probably be free and

easy to move, and will start up again, stopping again in from fifty yards to a couple of miles.

Remedy : This depends on the cause of insufficiency. Sometimes it will be found that there is a back pressure from the crank chamber acting through the oil pipe. It may be possible to cure this, where the lubricator is or can be made air-tight, by connecting the crank chamber to the top of the lubricator by a separate pipe, so as to equalise the pressure.

If the oil pipes are choked, this will be obvious from the sight feed, if any. Possibly the oil in the crank chamber is too low to touch the crank pins.

1052 Oil too Light or too Heavy.—

Symptoms : Probably much as in insufficient lubrication, but not so pronounced. More likely to show a falling off in power only.

Remedy : Change of oil, if possible consult makers of car.

1053 Bent Crankshaft.—

Symptoms and *Remedy :* Probably the engine will be stiff to turn at certain points of the stroke. The compression taps must be opened or plugs removed, or you are apt to be deceived by the compression. The only remedy will be a new crankshaft.

1054 Leaky Plugs, Valve Covers, Compression Covers, and Cylinder Heads (where separate).—

Symptoms : Lack of compression, and possibly hissing when running. Loss of power.

Remedies : In the case of sparking plugs, look to the washers ; renew, or temporarily pack with greasy string, or try a new plug.

Valve covers. Try new washers ; pack with string and boiled linseed oil. Paint the screw thread over with boiled oil before screwing up. Take care that every particle of dirt is taken off the valve cover and its seat before putting in the washer.

Water head joint. Good surfaces in very good order. Clean up most carefully, but take the utmost care not to file or rub depressions in the surface with the emery paper or file. Oil carefully with boiled linseed oil, and fit together. If that is no good, clean it all off again, and cut out a washer from the thinnest cycle tyre tube patching rubber (*not* insertion), cutting away the rubber opposite the water ports. This will often stand

quite well. Failing that, apply to the makers for the material, or try a sheet of good thin copper softened in the fire.

Compression taps. Grind the tumblers in as directed for valves (No. 1062) with knife powder instead of emery. Make sure that the tumbler is held down on its seat by its nut.

Cylinder heads and valve covers with ground joints. Grind the joint as directed for valves in No. 1062, and after carefully removing every trace of emery reassemble. If the joint, after showing a good "beat," still leaks, oil it carefully with boiled oil, and try again. Still leaks. Loosen without taking right out. Give one quarter turn and try again. As a rule, one position will not leak out of the four.

Emery or other abrasive should be removed from all working parts with a paraffin brush very carefully.

1055 LEAK IN WATER JOINT OF CYLINDER HEAD.—*Symptoms :* If not bad, probably steam from the exhaust, if the leak is internal; or a visible leak of water from the jacket if external.

Remedy : In an old car with a cast-iron head, where an easy method is desired, use sulphate of copper, as in No. 1050 above. If a better method is required, see No. 1054.

1056 THROTTLE VALVE NOT OPENING.—*Symptoms :* Where the fault is not bad, probably the engine will pull as well as ever at low speeds (of engine), but will not develop its full power at high speeds, so that this fault might be confounded with a stuck additional air valve. It will usually be noticed that the engine takes the throttle lever in an unusual place.

Remedy : Examine and reset.

1057 GOVERNOR THROTTLE NOT OPENING.—*Symptoms :* The behaviour of the car will be different from its usual. Commonly, when the speed of the car falls to governor speed and the accelerator is not in use, the car will jump away. If the throttle is sticking, you will probably notice that the car goes away sluggishly, but on depressing the accelerator goes as usual.

Remedy : Remove and clean with a dry rag and no oil. Look out for a bent spindle.

1058 GOVERNOR SPRINGS BROKEN.—
Symptoms : It may be impossible to start the engine, or, with other arrangements of governor, the engine may give a couple of explosions, and stop again, because the governor cuts the speed down too low. The fault might therefore be mistaken for a choked jet.
Remedy : Place a weight on the accelerator, and immediately the engine starts remove it, or the engine will race. Rubber bands may act as a substitute temporarily, or the governor may be temporarily tied up, so that it will not work.

1059 LOOSE BALANCE WEIGHTS.—
Symptoms : Usually produces a distressing knock. Can be located only by trying them.
Remedy : Screw up and make tight.

1060 PISTON RINGS WORN, STUCK IN THEIR GROOVES, OR BROKEN.—
Symptoms : Leakage past the piston, which will be audible as a hissing in the crank chamber on turning the engine over against compression.
Remedies : Temporary remedy. Take about half a teaspoonful of Dixon's fine graphite, and blow it into the cylinder through a tube with the piston at the bottom of its stroke. Look out for sooty plugs afterwards. Spark gaps (intensifiers) will probably enable you to overcome a sooty plug.
Permanent repairs can only be made with new rings.

1061 FOREIGN MATTER IN CYLINDERS.—
Symptoms : In small quantities and of such a nature as broken sparking plug porcelain usually causes pre-ignition, producing knocking, and rendering the spark timing lever of no effect.
Remedy : Remove the foreign matter. As this is not always easy to do, the following hints are offered—
If the foreign matter consists of one or two largish pieces, such as sparking plug back nuts (which are, however, not large enough to jam between the piston and the end of the cylinder in any case), the writer has found it effective to start the engine on one of the other cylinders, when the object has jumped out on to the exhaust valve.
If the matter is in small pieces (not steel or iron), it may be possible to wash them out with a paraffin

brush, or to fish for them with wires. It may be necessary to take off the cylinder to save it from being cut by such a material as porcelain. If the foreign matter is iron or steel, and the under-mentioned apparatus is at hand, proceed as follows : Take a coil of covered wire (bell wire will do) of such a length and thickness that it will take from one to four ampères from a four-volt accumulator. Wrap about ten yards of this round an iron bar, and connect both ends to an accumulator. The bar will now become a powerful magnet, which will pick up any loose bits of iron or steel in the cylinder.

1062 LEAKY VALVES AND VALVE SEATS.—

Symptoms : In the case of the valves usually shows by lack of compression only, but with valve seats (where used) a little oil poured round the seat will show leakage by bubbling.

Remedy : Grind in and make good.

Take the valves out, clean them, and apply a mixture of lubricating oil and medium fine emery to the " beat " (that part which touches the cylinder, and makes the gas joint). Replace the valve in its place, and with a screw-driver or special tool supplied, turn the valve backwards and forwards on its beat. After every six double movements or so, take care to lift the valve off its seat, and drop it again. If this is not done, the valve is liable to be ground into rings instead of smoothly. After about twenty double movements, take out, wipe, clean, and redress with emery and oil, and grind again. This process should be continued until the beat assumes a white surface without spots on it. If an exhaust valve has been allowed to run for long unground, it may take an hour or more to grind out the spots. It is of very little use using a carpenter's brace for grinding, as little pressure is required, the weight of the hand and the valve itself being sufficient.

In the case of a valve seat with a ground joint (*i.e.*, where the valve seats in a loose seat, which in turn fits the cylinder with a ground joint), see the method of bedding valve covers (No. 1054).

After all grinding operations, all emery must be most carefully removed with a paraffin brush.

Note that a newly ground valve is almost always leaky until it has been run for a short time. Note also that occasionally (the writer knows of one case) the beat

and the valve will take a sinuous form (the shape of the outline of a 1in. round hole drilled through the side of a 2in. thin tube at right angles to the axis of the tube), and no amount of grinding with the original valve will make these tight, though the beats of both may look perfect. Take another valve, and grind this in, and then, if desired, regrind the original valve on to the new beat. This cured the difficulty in the one case the writer has known.

1063 Loose Engine Bearings.—

Symptoms : If very bad, the result is a knock plainly audible, but as a rule the effect, with a four-cylinder engine, or to a less extent with any engine, is simply that the engine is generally noisy. The fault should be sought in the big end bearings (the end of the connecting rod furthest from the piston, *i.e.*, the end which embraces the crank pin) and the gudgeon pins. The main bearings of the crankshaft do not get slack so readily. A knock can be rendered plainly audible by resting a piece of wood or a steel rule on the engine frame whilst it is working, pressing the teeth against the other end of it, and stopping up the ears. Some considerable skill, however, is required to detect strange noises from ordinary ones. A medical stethoscope can be used in the same way, but practice and experience are required to interpret its indications.

Remedy : Big end bearings. Glue or tack a sheet of medium emery paper to a flat board. Take out big end bearings and rub them gently backwards and forwards on this, taking care to keep the pressure of the fingers evenly distributed. After every few rubs put the bearing together and try it for slackness. For the amateur it is well to leave the bearings a shade slack, as if the work be overdone the bearing will require scraping, which is a job requiring a highly skilled mechanic. Should too much be accidentally removed, the bearings may, however, be packed apart with very thin paper. For gudgeon pins a new bushing will be required, and in the case of hardened steel pin and bush, probably both pin and bush will have to be renewed. Main bearings if slack will usually require re-bedding, which is a job for a first-class machine shop, and should be entrusted to no other, as a good bit of skill is required. As a rule, it pays to send the engine to the makers for overhaul.

The bearings of the crank pins and crankshaft will not wear nearly as quickly if the lubrication is carefully attended to. Most makers recommend draining the oil from the crank case once every 2,000 miles and substituting fresh. One maker recommends adding half a gallon of paraffin after draining and running engine for thirty seconds, draining out paraffin, and filling with fresh oil, but it is a little doubtful whether this is to be recommended.

1064 BENT GEAR SHIFTING MECHANISM.—*Symptoms :* In a gate change speed gear, if two of the gears will mesh correctly whilst the other two will not, the fault will be in the levers operating the two gears only, and, therefore, not in the change-speed lever or its shaft, but in the gear box levers ; and it will be found that when the lever is in neutral, the gears will be half in mesh, and the change-speed lever will not go to the end of its stroke in one notch.

If the lever itself is bent, all gears will be out, and the change-speed lever will not go to the end of its travel in one direction in either slot. In a sector change-speed gear, it will probably be found that the change-speed lever will not stop in its notches, or, if it does, that the gears are not in mesh at these points.

Remedy : The only thing will be to dismantle the gear, and put it right. The car may be driven home on such gears as can be engaged.

1065 WORN CLAW CLUTCH SLIPPING OUT OF GEAR.—*Symptoms :* When driving, the gear will suddenly slip out of mesh, and the engine race. Where the lever of the change-speed is fixed by a notch and latch, there is danger that it will be bent in the process. The fault is more likely to occur just after the throttle has been closed.

Remedy : The gear must be dismantled, and the teeth of the claw clutch trimmed up or renewed.

1066 STRIPPED GEAR TEETH.—*Symptoms :* The gears, probably noisy, possibly slip with a tearing sound every now and then when pulling hard. If some only of the teeth are gone, there will be a rhythmical roar or grating from the gears.

Remedy : The gear must be renewed. It will be well before trying to drive to the end of the journey on other

gears to search the gear box for bits of steel which may damage other gears.

1067 SEIZED BEARING IN GEAR BOX OR BACK AXLE.—*Symptoms :* If the bearing is completely seized, the car will not run at all, except in case of differential-shaft, when the car will move only in a straight line (see No. 3 below). If only partly seized, it will be stiff to move.

Remedies : The first thing is to locate, and when found it may or may not be possible to do anything on the roadside according to circumstances.

Place in neutral, and try to turn the engine over with the clutch engaged. If the engine is free, the seized bearing is not in the first motion-shaft front bearing, but may be anywhere else in the transmission.

Begin by jacking up one back wheel, and try rocking this wheel backwards and forwards as far as the backlash (looseness of the gearing) will allow, noting the while to what portion of the transmission the motion is transmitted. If the cardan-shaft is seen to move backwards and forwards, the trouble is probably in the gear box ; certainly so if the bearing is seized up tight. In the unlikely event of a bearing having gone in such a way that it will rotate through part of a revolution, this test would not be conclusive. This test may locate the trouble nearly enough with the assistance of the indication afforded by heat. If not—

Jack up both back wheels, and attempt to rotate one of them ahead.

(1) The other wheel moves in the opposite direction : The fault is in one of the following points—the differential casing, the rear bearing of the first motion gear box shaft (front end of cardan), or the layshaft (either end).

(2) The wheel is immovable : Fault will be in the wheel bearing itself.

(3) The other wheel also moves ahead : Seized up differential-shaft bearing or differential gearing. Car will move all right in a straight line, but will not turn well or at all, the front wheels tending to slide sideways when the steering gear is put over.

1068 BROKEN BALLS.—*Symptoms :* None reliable. Usually the bearing will be slack, and the shaft may be shaken. Sometimes the gears and transmission will clatter with the throttle lever in one position and in no other.

1069 BROKEN GEARSHAFT.—

Symptoms : Usually the gear will be immovable.

Remedy : A renewal is the only remedy, except in rare cases, when it may be possible, where the layshaft is broken, to get home on the direct drive ; but as the layshaft is then in motion, though not driving, this is not likely.

1070 SEIZED EXTENSION TIT OF FIRST MOTION-SHAFT (DIRECT DRIVE).—

Symptoms : The car will not run when in any other speed than direct drive. If a back wheel be jacked up, it will not be possible to turn it unless the gear lever is in neutral or direct drive, and then only if the engine is turned also, or if the clutch is held out. That is to say, if the engine does not move, the wheel cannot be turned at all, except with the clutch held out, and neither with the clutch in or out if any gear is engaged except the direct drive. Also in neutral the clutch must be held out, or the engine will turn with the back wheel.

Remedy : Dismantle the gear box, and ease the bearing. This bearing is usually a small extension either on the end of the shaft carrying the sliding gears, and which extension enters a hole in the front end of the cardan-shaft at the back of the gear box, or else (not usually) the small extension is on the cardan, and enters a hole in the shaft on which the gears slide. It may be possible tog et home on direct drive alone, starting the engine with the clutch held out.

1071 BROKEN CARDAN-SHAFT.—

Symptoms : Usually obvious enough.

Remedy : As a rule there is nothing to be done but wait for a new shaft, but in some cases the following hints may be of use—

(1) If the breakage is not quite at one end of the shaft, get a blacksmith to forge two V-shaped pieces of iron about 6in. or so long, and bolt them on to the cardan, as per sketch (fig. 1071).

(2) As a very temporary remedy, where wire is obtainable in considerable quantities : Use wire preferably about as thick as the lead of an ordinary lead pencil. First of all, select a couple of spanners, two pieces of stick or similar objects, and lay them alongside the breakage, so to speak, putting it in splints, and fasten lightly in position. Attach the end of a piece of wire

to the forward side of the breakage, and wind it round the two parts of the shaft in a spiral from front to back over the "splints," taking care to wind in the opposite direction to that in which the shaft rotates when driving ahead. Now continue to wind the wire backwards and forwards over the breakage until as much is on as there is room for under the car. There will, of course, be a regular bundle of wire wound on it in this way, and care should be taken that a considerable length of broken shaft at each end of the breakage is wrapped in wire to give the shaft a hold on the wire.

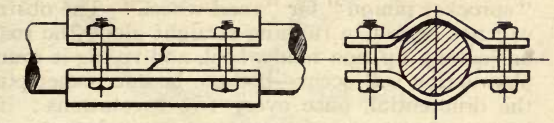


FIG. 1071.

Now drive on slowly, and take care not to reverse the gearing under any circumstances, neither let the car drive the engines down hill, but let the engine drive the car down hill gently against the brakes. The writer has never actually tried this expedient, but believes that if it were carefully done, it would be effective as a temporary repair. A piece of unravelled clothes-line wire would probably do the work well. The idea is to make a sort of wire rope round the breakage, and let the driving be done by this. The more tightly the wire grips the shafts at each end of the breakage, the more likely the result would be satisfactory.

1072 OBSTRUCTIONS OR BREAKAGES IN GEAR TEETH.—*Symptoms :* Usually a rhythmical grating noise repeated at every revolution of the defective gear.

Remedies : The difficulty is to locate the source of trouble, and the following hints may be useful—

Obstructions or broken teeth in the differential or its driving bevels.

In the driving pinion : Back wheel jacked up, the noise will occur at each revolution of the cardan-shaft, or, in chain drive cars, the pinion-shaft in the gear box. If the obstruction is too great to allow of rotation, and the road wheel be tried backwards and forwards, it will be noticed that the cardan-shaft (or pinion-shaft, as

the case may be) will move backwards and forwards not quite one revolution.

Obstruction in main crown wheel of driving gear: Noise comes at every revolution of the road wheels when driving on the road in a live axle car and at every revolution of the sprocket pinion in a chain drive car; but if one back wheel be jacked up and rotated, the noise will recur every two revolutions of the road wheel in live axle cars, and every two revolutions of the sprocket pinion in chain drive cars.

Obstructions in the large gear of the differential gear: In this paragraph, where the car is chain driven, read "sprocket pinion" for "road wheel." The obstruction will not be felt in running straight along the road, but on jacking up one road wheel, and trying it round, the obstruction will occur—if there be one planet pinion in the differential, once every two revolutions; if there be two planet pinions, once every revolution; if there be three planet pinions, three times every two revolutions, or once each two-thirds revolution; if there be four, once every half revolution.

Obstruction in the gear box: Open the gear box and engage the gears which are found to be noisy. Jack up a wheel, and note position of obstruction.

1073 BROKEN DRIVING CHAIN.—*Remedy:* Unless you can mount every hill between you and home on your second gear at least, you cannot get home without mending the chain. If, however, you can drive home in ordinary circumstances without using your lowest gear, you may be able to get home in the following way—

Wrap the *end* of the broken chain round the driving sprocket pinion, and fasten it so by wire, or, better, by passing a bolt through the links (it is not wanted to go round, but simply to be fastened to the sprocket). Lead the end of the chain backwards or forwards, and make it fast to a spring, mudguard support, dumb iron, or any other substantial support. Take care that when the pinion begins to drive, it will pull on the long part, and not the short part, of the chain, or the fastening will probably break away. You now drive on one wheel only, and your gear ratios throughout are doubled, *i.e.*, if top speed is normally thirty miles per hour, it is now sixty. If, therefore, your second speed is

just double your first speed, you can only just get up a hill at all which you can normally just climb on second speed.

See fig. 1073.

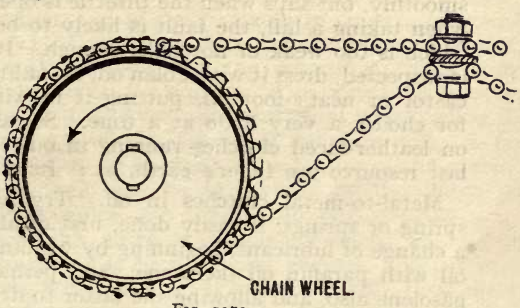


FIG. 1073.

1074 BROKEN REAR SPROCKET STUDS (holding the sprocket wheel to the rear road wheel spokes).—*Remedy :* Take off the wheel, and remove the sprocket entirely. Drive home on one chain, as described above. Note, however, that you have only one brake now acting on the transmission. If both brakes act on the rear hubs or drums of the sprockets, you have no brake, unless you make fast the ends of the brake rods, as the brakes are compensated, and the wheel with the sprocket pinion intact has no purchase for its brakes. You must, therefore, wire back the ends of the brake rods to a spring hanger, spring, or mudguard support, and drive with extreme caution, as this "lash up" may fail at any time. Further, note that on any gear your engine has only half its usual stopping power as a brake.

1075 SLIPPING CLUTCH.—*Symptoms :* If the clutch be suspected of slipping, open the throttle and apply the brake, when the car will slow down, but the engine will not. If the slipping has taken place for any length of time, the clutch will be hot.

Remedies : Temporary, drive with partly closed throttle.

Leather-faced clutches. First see it the spring can be tightened, but the treatment depends on the sort of slipping which is taking place. When the clutch

slips persistently when starting the car from rest, and then bites with a jerk, this is not usually due to too weak a spring, but to the dressing of the leather, for which see below. If, however, the clutch takes up nicely and smoothly, but slips when the throttle is opened wide, or when taking a hill, the fault is likely to be the spring, which is too weak or not tight enough. If the leather is suspected, dress it with Colan oil, or, failing that, with castor or neat's-foot oil, putting it in with a feather for choice, a very little at a time. See also No. 1076 on leather-faced clutches running in oil. Only as the last resource use fuller's earth, as it ruins the leather.

Metal-to-metal clutches in oil. Try adjusting the spring or springs, if easily done, first of all. Then try a change of lubricant, beginning by washing out all the oil with paraffin oil (kerosene), and perhaps petrol or gasolene also, and allowing the latter to dry out. Now add a thicker or thinner oil than you have previously used, and try different thicknesses.

1076 FIERCE CLUTCH.—

Symptoms : Car starts with a bound on letting in the clutch.

Remedy : Leather-faced clutch. Apply about a teaspoonful of paraffin oil (kerosene) to the leather at a time until it is better. If it then slips, apply Colan, as described above (No. 1075).

Metal-to-metal clutch. Try a change of lubricant, and more of it.

Leather-faced clutch in oil. The writer has tried a leather-faced clutch running in oil. The size was 15in. diameter, 15° taper, spring pressure 350 lbs., and the power transmitted at 1,000 revolutions (25 h.p.) without slip. This clutch was found to be perfection. The car could be stopped when coming down a hill of one in eight, the reverse engaged, the car allowed to run forward down the hill at ten miles per hour, and then stopped on the clutch and run backwards up the hill without jolt or jar.

To apply this to an ordinary clutch requires an oil-retaining ring to be fitted, and it is essential that very little oil be used, or the clutch will not stop when withdrawn. The co-efficient of friction appears to be from 15% to 20%.

1077 CLUTCH SEIZED ON CRANKSHAFT EXTENSION.—*Symptoms :* Difficulty in engaging the first speed in starting from rest, because the clutch and first motion gear box shaft will not stop revolving.

Remedies : This fault is probably due to lack of lubrication, and is always likely to occur unless means are provided for oiling the clutch through the centre of the crankshaft, because the centrifugal force throws off all oil put on the outside. The best thing is to work the clutch in and out with the pedal whilst oiling it.

In metal-to-metal clutches of the plate type, the fault is more likely to be due to the failure of the plates to separate, and may be aggravated by the clutch pad, usually provided, not coming into engagement.

Where the clutch is completely seized up, the only way to get on is to start your engines, and get people to move the car (or let it run down hill), then throttle down your engines, and "feel" for the first speed with the change-speed lever. Engage speed up, and repeat the process for the second. In changing down a gear, the engine must be momentarily throttled. The gear will then disengage, and the engine must then be speeded up, and the gear felt for until it engages. With a little skill the clutch can be entirely dispensed with, except for starting from rest.

1078 BROKEN OR WORN CLUTCH PEDAL OR CONNECTIONS.—*Symptoms :* Same as the above.

Remedy : Breakage must be repaired or wear taken up. Car can sometimes be brought home by driving with the floor boards up, which may give the pedal the additional movement required. As a last resource it may in some cases be possible to leave the floor boards up and work the clutch by a rope, but this will depend on the arrangement.

1079 ACCUMULATOR RUN DOWN.—*Symptoms :* Very much the same as a shortage of petrol. Engine falters, picks up, falters again, and stops. After stopping, engine will often start up, and take a few revolutions, and stop again.

Remedies : Change accumulator for a spare one. If both accumulators are found to be down below 3.6 you can often get home by coupling up both. Couple the positive terminal of one to the negative of the other, and then couple the unconnected positive terminal to

the coil wire, and the unconnected negative to the earth wire. See also No. 1082.

1080 ACCUMULATOR BRIDGE BROKEN.—By this is meant the breaking of the piece of metal connecting the two cells, making up a battery of two cells.

Symptoms : Car stops suddenly. Often after moving or shaking, the battery will run quite steadily, and then suddenly fail again. The breakage is often invisible. The accumulator will show no voltage across its outside terminals (to which the ignition wires are usually attached), but one cell, and sometimes both, will show full voltage taken alone.

Remedy : The writer has reached home on one occasion by kicking the accumulator box every time the engine failed. Another method is to connect the broken parts by fine copper wire. The break may be located by keeping one terminal of a voltmeter on the battery negative binding screw, and touching in turn, with the other voltmeter terminal, first of all the battery positive binding screw, the second cell negative, the second cell positive pole, and the first cell negative pole. The fault will be between the two adjacent points touched, one of which shows current and the other no current.

1081 BATTERY BRIDGE CRACKED.—

Symptoms : Missing of the engine on all cylinders possibly only noticeable at high engine speeds, possibly more pronounced at high car speeds and on rough roads Fault will disappear on switching in spare accumulator

Remedy : Much the same as in the case of a broken bridge, but the fault is much more difficult to locate If the engine can be made to miss when the car is standing still, the fault will show up by fluctuations of the voltmeter if the voltage be taken across the battery terminals with the engine running. It may in that case also be located in this way by the same method as described in the last paragraph. If the battery is up and in good order the voltmeter will show a steady voltage across the battery terminals with the engine running. This will not be the case if the voltage be taken from, say, that coil positive to earth on account of the resistance of the wires.

A telephone held across battery terminals will also show up if the fault be continual, clicking as the engine

misses, whereas it should give one click on making contact, and then silence. Care must, however, be taken that the telephone terminals do not slip about, or a rumbling sound will be the result.

1082 SHORT-CIRCUITED PLATES.—

Symptoms : The car will probably stop, and the voltage will be down to about two volts. All this pressure will be obtained from one cell, none from the other.

Remedy : The only permanent remedy is to send the accumulator to the makers. By carefully adjusting the tremblers and setting the plug points very close together, it may be possible to run on one cell of the battery.

1083 ELECTROLYTE WEAK.—

Symptoms : The only case which came under the writer's notice is a little uncertain in its results. The only noticeable result was a loss of power without missing. The coil high tension terminals gave steady and good sparks (with the engine running) over about ½in. gaps, but the car refused to develop its power. The owner reported that, on making up his electrolyte to full strength of 1,200, the power of the car was restored. It may be noted that this is contrary to the accepted theory of ignition to-day, which holds that as long as the spark can be advanced as far as necessary, the strength of the spark is of no importance.

1084 ELECTROLYTE LOW IN CELLS.—

Symptoms : Loss of capacity of accumulator, and probably permanent damage to plates. Make up with clean distilled (or rain) water. Occasionally test density, which should be 1,200.

1085 PRE-IGNITION.—

Symptoms : The spark lever may have no effect. The engine may, and probably will, run with the spark switched off. Probably the engine knocks heavily.

Remedies : These will depend on the causes as follows—

Foreign matter in the cylinders. See No. 1061.

Shortage of water. See No. 1031.

Holes and fissures in the cylinder walls. Sometimes a small hole for the grinding tool in the valve head will cause pre-ignition, acting as a tube igniter.

Short circuit in commutator. See Nos. 108, 1138, and 1139.

1086 CROSSED LEADS ON PLUGS, COILS, MAGNETO, DISTRIBUTER, OR COMMUTATOR.—

Symptoms : As a rule, the engine will not start, but all ordinary tests of the ignition will show it to be in order. Occasionally an explosion will take place in the silencer. Sometimes, however, the engine will run slowly with retarded spark. If, therefore, all examinations show the ignition in order, it is well to make sure that the leads are on their right plugs, and that the right cylinders are firing.

Remedy : See Nos. 114, 115, *et seq.*

1087 DIRTY OR LOOSE BINDING SCREWS, giving bad electrical contact.—

Symptoms : Missing. It is difficult to explain to anyone who has no experience of " missing " how to detect it ; but a very little experience of it will lead to its instant identification. The best description the writer can give of it is a species of faltering in the pull of the engine. To those who have had any experience of an intermittent heart beat, it will be found to resemble that physiological trouble.

Remedies : See the tables according to circumstances and type of engine. The tables have been checked for the following binding screws—

Battery earth, one. Battery, two or four. Switch, two or three. Trembler coils, one positive for all coils in common and one negative for each coil. Non-trembler coils, two for each coil (one earth and one negative) and one common to all coils (the positive). Non-trembler coil, one earth connection (there may be one for each coil or one common to all coils). Commutator or contact breaker, one for each coil.

Low tension magneto : Magneto binding screw, one. Individual switches on plugs, one for each cylinder.

High tension magneto with separate coil : Low tension on magneto, one. Low tension on coil, one. Coil earth, two (one each end of wire). Magneto earth wire if any (one both ends). High tension magneto self-contained magneto to contact breaker if an external wire or held in binding screws, two ends.

1088 INSULATED TERMINALS OR CABLES OFF TERMINALS.—

Symptoms : Stoppage of engine or cylinder cut-outs.

Remedies : See tables according to circumstances. An insulated terminal can always be located by a voltmeter, as indicated in the tables. The tables have been checked for insulated terminals at the following points—

The whole list given in No. 1087 above.

The following points in addition—

High tension cable off : Plugs, one for each cylinder. Coils, one for each coil. Distributer (whether of magneto or synchronised high tension ignition), one for each cylinder and one for the coil or magneto. Magneto, one for each cylinder.

1089 High Tension Cable Broken out of Sight.—*Symptoms :* This is a very unusual fault, and the writer has never met with it. The effect would be to stop the flow of current. No spark could be drawn from the cable and no spark would go into it, so that it might be thought that the ignition gear was broken down if the spark from a coil high tension terminal, for instance, were tested into the high tension cable. The same effect would be produced if the plug end (or distributer end) of a high tension cable had dropped off its terminal whilst the spark was being tested into the other end.

1090 Leaky High Tension Plug Cable.—*Symptoms :* Missing or stopping of the cylinder affected. The leakage can often be detected in the dark by sparking. A good spark will go in and a bad one come out of the cable.

Remedy : Usually a new cable is the only thing, or else binding with insulation tape, or arranging so that leaky part is not near metal.

1091 Leaky Coil to Distributer Cable (magneto or synchronised high tension).—

Symptoms : Missing or stoppage of all cylinders. A good current will go into the distributer lead, but spark inside distributer or to any plug lead will be irregular, or no spark will be obtained.

Remedy : New cable as a rule. Insulation tape may serve a temporary cure, or fastening the cable away from metal may serve.

1092 LEAKY DISTRIBUTER (magneto or synchronised high tension).—

Symptoms : Missing or stoppage of all cylinders. Generally the same effect as a leaky distributer lead, No. 1091 above.

Remedy : Usually the leakage is either due to wet (in which case drying will cure it) or to broken insulation, which will usually require a return to the makers. The possibilities are too numerous to go into. As in tables, the fault can be located by trying the spark at different points.

1093 HIGH TENSION TERMINAL SHORTING.—

Symptoms : The spark will be seen and probably heard jumping over the face of the insulation. If the spark is long, it probably indicates that the plug points are too far apart. Otherwise there will be no handy remedy. Drying may effect something.

1094 LEAKY COMMUTATOR CABLE.—

Symptoms : This will produce a false spark, and will probably cause bumping of the engine. If the leakage is continuous, a continuous buzz of the coil will be the result. See No. 108 to locate. The symptoms of temporary and momentary leakage are very difficult to describe. The writer has seen the flywheel of a two-cylinder engine start to rotate backwards from this cause when the engine had slowed down in climbing a hill. In general, the fault is much like missing, and more like pre-ignition, but is not as regular as the latter.

Remedy : The difficulty is to locate or, rather, to diagnose, as once diagnosed the location is usually an easy matter. The cable should be examined where it passes over metal projections, or passes near the flywheel. Insulation tape will cure the trouble, also probably a piece of rag, or tying the cable out of the way will also do so.

1095 LEAKY CONTACT BREAKER CABLE OF NON-TREMBLER COIL.—

Symptoms : Probably will cause missing, as the leakage will not be likely to produce a regular spark; but as it will probably produce an occasional spark, some signs of pre-ignition may be expected. The writer has no personal experience of the fault.

Remedies : The same remarks apply as in No. 1094.

1096 BROKEN CABLES.—

Symptoms : Generally the same as for the same cables off their terminals. The tables have been checked for the following cables both for complete breakage interrupting the current entirely and partial breakage causing missing—

Battery to coil. Coil to commutator or contact breaker. Coil (non-trembler) earth. Battery earth. Magneto earth. Magneto to coil low tension. Low tension magneto cable coil to distributer high tension. Coil to magneto high tension.

1097 BROKEN SPARKING PLUG.—

Symptoms : According to circumstances a complete stoppage or missing. As a rule, the former, and the fault is detected in nine cases out of ten or oftener by examining the spark at the plug. In the tenth case, where a plug will not spark under compression, but will spark in the open, this is not so. The writer has, however, never met with such a case. The fault has been taken into consideration in the tables.

Remedy : New plug or new insulation.

1098 SOOTY OR OILY PLUG.—

Symptoms : Usually stops the engine or cylinder in question, but occasionally causes missing. This latter more often due to oil than soot. Such a plug will usually work all right if worked with a spark gap.

Remedy : Put in an intensifier or spark gap. If none available, and no spare plugs, tie cable to plug with string, allowing a small gap of about $\frac{1}{8}$in. or less for the spark to jump to the plug head.

1099 WET PLUGS.—

Symptoms : Much the same as for oily plugs, but the writer has no information as to whether a wet plug will fire with a spark gap. The fault is unusual, unless an engine has been lying by for some time, as far as the internal part of the plug is concerned; but in wet weather the leakage of a spark down the porcelain of a wet plug outside is common.

Remedy : If wet externally, as from washing the car or from rain, dry off with a handkerchief or rag, switching off current first. If wet internally, dry in a fire or over a lamp, or put in spares.

1100 PLUG POINTS TOO FAR APART.—
Symptoms : Missing or stoppage according as the fault is bad or not. In case of complete stoppage of a single-cylinder engine, or with either stoppage or missing of a multi-cylinder engine, the spark will be found to jump readily from lead to the metal of the cylinder head, but irregularly or not at all to the plug head. In a single-cylinder engine it is not possible to try this test for missing, as the engine will naturally not run whilst the spark is being tried to the cylinder head.

Remedy : Set plug points. As a rule about as close as possible without touching. The recognised distance is seventeen thousandths of an inch—about as thick as a thumb-nail.

1101 PLUG POINTS TOO CLOSE.—
Symptoms : Usually missing. The spark to the plug head will be regular. The points will appear to be touching when examined. In the writer's experience, any space which appears to be a space at all, no matter how little, will work. The points of a magneto plug should be closer than those of a coil plug.

1102 SWITCH NOT CLOSED (or in magneto not open).—
Symptoms : Engine will not start up. See tables.

1103 SWITCH NOT MAKING CONTACT.—
Symptoms : If bad, same as an open switch (No. 1102), but if contact is bad the effect is to produce missing.

Remedy : Examine, and apply remedy as circumstances dictate. Possibly the terminals will be found dirty, perhaps the spring is weak, or the switch handle does not move far enough.

1104 WEAK SWITCH SPRING.—
Symptoms : As in No. 1103.

1105 MISSING, TO REPRODUCE (on all cylinders).—
For the novice who wishes to see what missing is like in order to recognise it when encountered, the following method is the most effectual. Artificial means are necessary to produce this fault; as in ninety-nine cases out of a hundred a purposely slacked terminal will work as steadily as if it were soldered up solid, whilst one which comes loose on its own account will, of course, miss as if, or better than if, it had been made for no other purpose.

Detach the earth cable of the battery from its terminal on the frame. Fasten a light spanner or other metal weight to it, and let it rest loosely in the tin mudshield, or put it to sit on top of the gear box or crank chamber. Start up the engine, and it will miss as well as the heart could wish, especially if the terminal is in a tin mudshield. On a gear box or crank chamber the results are not as "reliable."

1106 MISSING, TO REPRODUCE (on one cylinder only).—This is not as simple to reproduce artificially as missing on all cylinders, and will require more arranging.

Place a piece of board on any flat surface on the car, and on this mount a small tin dish, taking care that it does not make metallic contact with the frame of the car anywhere. Remove one of the commutator leads, and attach it to the tray. Attach a length of insulated wire to the commutator binding screw from which the lead has been taken, and to the other end attach a small metal tool, and let it rest loosely in the tray. Start the engine, and the cylinder of which the commutator lead has been dealt with will miss persistently as soon as the tray begins to vibrate.

1107 TREMBLER POINTS DIRTY OR PITTED.—*Symptoms :* Missing of the cylinder affected. With individual coil ignition one cylinder only; with synchronised high tension ignition all cylinders will miss. Probably the blade will seem to buzz all right.

Remedy : Clean and file flat with a very fine file.

1108 TREMBLER POINTS INSULATED.—*Symptoms :* The cylinder affected will not fire at all. Testing with a voltmeter, current will flow from the trembler screw to earth. but not from the trembler blade to earth.

Remedy : Clean and reset. Preferably the setting should be done with the engine running.

1109 TREMBLER BLADE NOT MAKING CONTACT WITH THE SCREW.—*Symptoms* and *Remedy* the same as in the last preceding paragraph, No. 1108.

1110 TREMBLER BLADES NOT BREAKING CONTACT.—*Symptoms :* Complete failure of the cylinder in question if the failure to break is complete; but if

partial, missing. If the commutator sector in question (to identify see No. 114) be put on contact, and the voltage taken from the coil positive to earth, and the blade be then depressed, a rise of voltage will be noticed. With the commutator sector off contact, a current will flow from the coil negative in question to earth, which will not be the case if the blade is insulated or not making contact.

Remedy : Examine the armature to see whether it strikes the blade when attracted by the coil core. Generally the fault is due to bad adjustment, but if the points have fused, it will be necessary to file them flat with a fine file.

1111 TREMBLER POINTS FUSED TOGETHER.—
Symptoms and *Remedy :* See No. 1110.

1112 TREMBLER BLADE SPRING TOO STRONG.—
Symptoms and *Remedy* the same as those of a fused blade. See No. 1111.

1113 WATER ON THE TREMBLER.—
Symptoms : If this has any effect at all, it usually causes missing.

1114 ARMATURE OF COIL OUT OF ADJUSTMENT.—
Symptoms : Missing or total failure depending on the amount the adjustment is out. A fairly common fault is the unscrewing of the restraining stop, which prevents the armature from moving too far.

Remedy : This will depend on the fault, and will usually be obvious. The following general remarks may be offered.

In most tremblers the armature is distinct from the blade, and is so designed that when it is attracted by the core magnetism, it strikes the blade out of contact with the trembler screw before the armature has reached the limit of its travel. The current then breaks, the core is demagnetised, and the spring of the blade and armature return the blade into contact with the trembler screw, and the operation is repeated. If then the stop is unscrewed, the armature will bring up against its stop before the projection which actuates the blade comes into contact with the blade, and the contact will not be broken ; the current will continue to flow, and no spark will be produced. On the other hand, if the

armature is at fault in the other direction, the hook or projection which actuates the blade will not allow the blade to come back into contact with the trembler screw, and no current will flow. In general, a careful examination (which should be almost microscopic, as the movements are very small) will show in which direction the fault lies. Of course, the spring of the blade (as in the case of a bent blade) may be so strong that the armature cannot strike it out of contact, and no spark will then be made, or the same result will follow too strong a spring on the armature. This fault, where the spring is one which has worked before, will be uncommon or impossible, unless the spring is caught somewhere, and consequently is more compressed than usual, for springs do not strengthen in use. Where the armature is in one with the blade, as in some old-fashioned coils, the only thing which can be done is to see that the points are clean, and then adjust the screw with the commutator on contact. If the blade will not buzz, it may be possible to prove that the blade spring is too tight by very lightly resting the finger tip on the tail of the blade, thus slightly relieving the pressure. If this makes it buzz, take the blade out, and slightly bend it so that the armature comes a shade nearer to the coil core.

1115 LOOSE PLATINUM IN BLADE OR SCREW.—

Symptoms : Usually causes intermittent missing. As far as the writer knows, the trouble can only be detected by examination of the blade in action.

Remedy : Get it soldered in by a watchmaker. Fit a new blade or screw. If by the wayside a rather risky expedient is to slightly rivet the platinum point with a hammer. This may make it tight for the return journey.

1116 CONDENSER BROKEN DOWN.—

Symptoms : Missing or complete failure, but the blade will continue to buzz. Usually accompanied by violent sparking at the trembler points or the contact breaker points.

Remedy : The fault is usually that the connection from either the blade or the trembler screw to the condenser is broken down. As a rule, the coil cannot be taken to pieces to get at this, and must be returned

by the maker ; but if the connection can be made good, the trouble will probably be cured. As a rule, return coil to makers, borrowing a spare if possible to go on with.

1117 CONDENSER SHORT-CIRCUITED.—

Symptoms : Missing or complete stoppage of the cylinder affected. Current will flow through a voltmeter connected from the tail of the blade to earth and from the trembler screw to earth, whether the blade be depressed (out of contact with its point) or not ; whilst if the condenseris properly insulated, current will only flow from one of these points to earth with a depressed blade.

Remedy : As the fault is probably due to a failure of the condenser insulation, the coil should be returned to its maker. If, however, the owner proposes to try it himself, the coil must be dismantled, the paraffin wax with which it is filled being carefully melted out, and the condenser replaced with a new one, as it will usually be impossible to locate the fault, or to get the leaves of the condenser apart.

1118 INTERNAL COIL CONNECTIONS BROKEN AS UNDER.—

General Remarks : In the case of partial breakage, where the wires retain contact and cause missing, all these faults are very difficult to locate. These faults are much more common than might seem probable, especially in connection with those terminals to which the external wires are attached, and are brought about by too violently screwing up the terminal nut, and thereby moving the terminal screw itself, and thus breaking away the wire fastened to it inside the coil. Considerable care should be exercised in screwing up these terminals.

1119 COIL POSITIVE TO COIL POSITIVE SMALL SCREW.—

Symptoms : In case of partial failure, missing on all coils accompanied by misbuzzing, though this may only be audible in the telephone. In the case of complete breakage, the failure of the buzz of all coils. In the case of missing, the fault is difficult to locate ; but in complete failure, the method given in the tables will locate it.

Remedy : Connect the coil positive to its small screw by an external wire.

1120 COIL POSITIVE SMALL SCREW TO TREMBLER SCREW (connection broken).—

Symptoms : The writer has never met the fault, but it would cause missing or stoppage of the coil in question.

Remedy : If detected, an external connection from under the trembler screw check nut to the coil positive small screw would be a remedy.

1121 TREMBLER SCREW TO CONDENSER (connection broken).—

Symptoms : The writer has no experience of the fault. It would cause missing on the coil in question, as each time the wire broke contact, the condenser would be out of action. Sparking at the trembler would be noticed.

Remedy : Probably nothing could be done without dismantling the coil.

1122 TREMBLER BLADE TO CONDENSER (connection broken).—

Symptoms and *Remedy* as in No. 1121.

1123 TREMBLER BLADE TO LOW TENSION WINDING (connection broken).—

Symptoms : Missing if partial. Cutting out of the coil if total. The fault will locate by the tables with certainty if complete ; or if partial with a telephone.

Remedy : Nothing without dismantling the coil.

1124 LOW TENSION WINDING (broken).—

Symptoms and *Remedy :* Same remarks apply as to No. 1123.

LOW TENSION WINDING TO COIL NEGATIVE, SMALL SCREW (connection broken).—

Symptoms and *Remedy :* Same remarks as in No. 1120.

1125 COIL NEGATIVE SMALL SCREW TO COIL NEGATIVE (connection broken).—

Symptoms : Missing if partial ; complete stoppage if total. The method of the tables will locate the fault with certainty if complete, as will a telephone used with care if partial.

Remedy : Connect the coil negative to its small screw by an external wire. The writer has several times come across the fault due to rough handling of the terminal.

1127 BROKEN HIGH TENSION WINDING.—

Symptoms : Failure of the coil if the break is long, and if it is short probably the sparking will destroy the

insulation. If bad, the sparks can be often heard.

Remedy : Nothing short of the coil maker.

1128 SHORTED HIGH TENSION WINDING.—

Symptoms and *Remedy :* Same remarks as last paragraph.

1129 COMMUTATOR SPINDLE LOOSE.—

Symptoms : This is one of the commonest faults of an old engine, or even of one which has run over five or six thousand miles. For some reason no maker seems to take the trouble to earth the spindle of his commutator, and in consequence the return current has to find its way through the spindle with its coating of grease to the bearings and gear wheels ; and when it has worn loose it fails to do it regularly. The pressure of the finger on the centre of the commutator case, so as to press the spindle into contact with its bearings and gears, will cause the engine to accelerate, and, where the fault is bad, will stop the missing.

First Remedy : Where the commutator spindle is naked and accessible where it rotates. It need only be in sight for a length of $\frac{1}{8}$in. or less. Obtain about two feet of No. 16 ($\frac{1}{16}$in.) copper wire. (The size is only material from a point of view of strength on the one hand and ease of manipulation on the other.) Pass one end of it round the naked spindle and form a loose loop in it, twisting the wires together to make the loop. Fasten the long stray end of the wire under any convenient nut on the engine frame, and through the loop pass a spring which will give a tension of anything from two or three ounces to two or three pounds (an ordinary bell spring obtainable from any ironmonger will do), and secure the other end of the spring to any convenient point to put a strain on the copper loop, and keep it bearing against the commutator spindle. The function of this arrangement is *not* to bring the spindle into contact with its bearings—for that a stronger spring would be required ; but to act as a sort of dynamo brush to collect the current and earth it. In use, the wire brightens the spindle, and acts as a good earth return. See fig. 1129.

Second Remedy : Where the commutator spindle is not exposed. This is not as simple an operation as that already described, and will require the assistance of a mechanic. The apparatus will be understood with refer-

ence to fig. No. 1129 (*a*). A is the commutator spindle in the end of which will be found a depression. (If this depression does not exist, the earthing spindle B, instead of having a pointed end to enter the depression, will have a rounded convex end to press against the commutator spindle end ; in other ways the apparatus will be the same.) C is the cover of the commutator box. A hole is drilled in the commutator box cover opposite the end of the spindle. The most convenient way of finding the centre of the spindle is as follows :

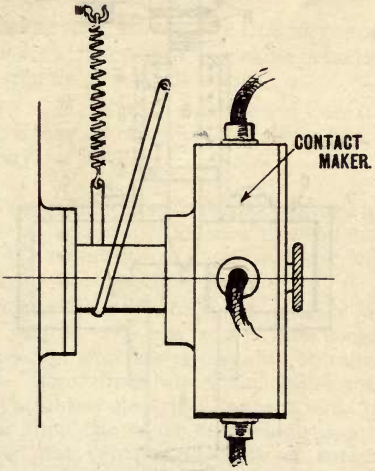


FIG. 1129.

Put a pad of thick lubricating grease inside the cover, sticking to the metal. Rub a little oil (very little) over the end of the commutator spindle, close the commutator cover so that the pad of grease touches the end of the spindle, turn the engine over two or three times, and an impression of the end of the spindle will be found in the grease inside the cover, from which the centre may be marked off accurately with a scriber. Over this hole is fitted a cap D, inside which works loosely the earthing

spindle B, on which is fastened the disc E. The end F of the earthing spindle is threaded for two small nuts, to which the earth wire is attached. Inside the cap D, and pressing against the disc E, is a light spring G. The action of the apparatus is fairly obvious. The spring G keeps the earthing spindle B pressed home into the hole in the end of the spindle of the commutator (or the curved convex end against the curved convex end of the commutator spindle, as the case may be),

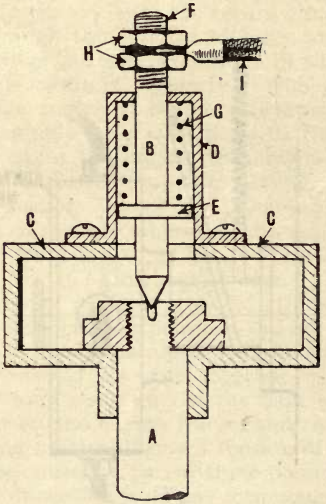


FIG. 1129A.

and thus makes a good electrical contact with the commutator spindle. The earth wire is attached, as to one end, to the nuts H, and the other end is secured under any clean fixed nut on the engine or gear box frame. The current then finds its way back to the battery through the spindle ; but instead of having to pass through bearings and gears, partly insulated with grease, passes through the earthing spindle and earth wire to the engine frame, and thus to the battery. If preferred, the earthing wire I may be attached direct to the battery negative instead of to the frame ; but in that case, if the wire

comes off from the nuts H, the engine will stop, whereas if the battery had been earthed in the ordinary way, the engine could still be run, the current finding its way by the old inefficient path.

Third Remedy : Attach a tension spring to the commutator box of such strength as will keep it bearing over towards one side. This has the same effect as keeping the box pressed over by hand. It has the disadvantage of throwing considerable pressure on the bearings, and consequently causing increased wear.

The writer has tried all these methods, and found them effective.

1130 DEFECTIVE EARTH TO COMMUTATOR.—*Symptoms :* These are the same exactly as those of a loose spindle described above.

Remedy : Make the earth good, or if that is impossible, either of the remedies described for No. 1129 above may be applied.

1131 WORN COMMUTATOR WIPE.—The wipe is the piece of metal, sometimes fitted with a roller, which travels round inside of the commutator case, or under which the commutator rotates, as the case may be.

Symptoms : If very bad, no contact will be made, and the engine will not run ; but usually the fault causes missing, which is aggravated by oiling or greasing the path. Sometimes where the wiper rotates, and its end, which makes electrical contact with the segments, is heavier than the other end which is attached to its spring, so that centrifugal force of rotation tends to increase the effect of the spring, the engine will miss (or even fail entirely on one cylinder) at low speeds, but run regularly at high speeds.

Remedy : In the sliding type, which has a brass head. Either have a new wiper, which usually costs very little, or else take out the old wiper, file it flat, and have a piece of brass soldered on to it to make up for the wear. This is quite effective, and will last as long as the original wiper. Loading up with solder is no good ; it wears too quickly. In the case of a roller, a new roller or a new path will be required. With a hardened steel wiper a new one will usually have to be used, but a brass one may work as a makeshift.

1132 DIRTY COMMUTATOR WIPER OR WIPER PATH.—*Symptoms :* These will depend on the sort of dirt and grease. If thick, and if the spring of the wipe is not strong, the effect of this is missing on one or more cylinders ; complete stoppage of one or more, according to the quantity and density of the grease. A little oil will cure this, or the grease may be cleaned out with paraffin oil (kerosene) and a brush or rag.

Road sweepings. If bad, this usually causes complete stoppage, and used to be a common fault in old cars, but is now unusual. The remedy is obvious, and a recurrence may be prevented by shielding the commutator or for temporary purposes by tying it up in a duster, or putting an old glove on it.

Brass filings. Where a commutator has been running dry, brass will sometimes rub off the contact pieces, and form a metallic path. If this only extends a short distance, it will do no harm, as it only continues the duration of the spark, and does not affect the time of the first (and only useful) spark. The writer has, however, heard of cases where the contact continued from segment to segment, and in that case pre-ignition of one or more cylinders will take place, or even a continuous buzz.

Remedy : Clean out well with a brush and paraffin oil (kerosene) or lubricating oil, and keep lubricated. A commutator will, if its spring is decently strong, run effectively full up with lubricating oil.

1133 GRIT ON THE COMMUTATOR WIPE PATH.—*Symptoms :* Missing at high speeds of the engine. Especially is this so in those commutators which have a fairly heavy roller on the end of a long flexible spring. A microscopic piece of grit will in these cases cause persistent missing by making the commutator roller jump.

Remedy is obvious.

1134 GREASE ON THE COMMUTATOR PATH.—*Symptoms :* As a rule, unless very thick, does no harm. See No. 1132 above.

1135 WEAK COMMUTATOR WIPE SPRING.—*Symptoms :* Same as those described for a worn pipe. See No. 1131.

1136 DEFECTIVE CONTACT BETWEEN WIPE AND WIPE PATH.—

Symptoms : The same as those described for worn wipe above. See No. 1131.

Remedy : This must depend on the cause in each case. Most of the causes will be found in this list.

1137 NO CONTACT BETWEEN COMMUTATOR WIPE AND WIPE PATH.—

Symptoms : Entire failure of ignition, and coil will not buzz, current being obtained, when the commutator seems to be on contact, from earth to commutator segment, and not from wiper (or *vice-versa* according to arrangement), the fault being, therefore, between them.

Remedy : This depends on the fault, and will probably be found in this list of separate faults.

1138 SHORT CIRCUIT OF COMMUTATOR.—

Symptoms : Continuous buzz of the coils affected. Engine may or may not run ; this depends on the sort of plug used. An ordinary De Dion plug will, as a rule, not run. A plug of the type having a hollow hemispherical end with hole in it through which the plug terminal looks out will sometimes run the engine at one speed ; but, of course, the ignition lever has no effect on the engine speed.

Remedy : See No. 108 for locating the fault, and treat as circumstances suggest.

1139 DOUBLE CONTACT IN COMMUTATOR.—

Symptoms : This is not a usual fault, but the writer has met with it, and it then caused a distressing knock, the false contact only occasionally making contact, and then causing pre-ignition. The fault was in this case due to wear of the wipe, allowing the wipe lever itself to make a contact against the segment, as per fig. No. 1139 on next page.

Remedy : According to circumstances. In the case just mentioned, the remedy was to line up the wiper head with a piece of sheet brass soldered to it.

1140 FALSE CONTACT AT CERTAIN POSITIONS OF IGNITION.—

Symptoms : Usually produces knocking or racing at a certain position of the ignition lever, the effect depending (as in No. 1139 above) on the type of plug

and speed of the engine at the time. If the fault is due, as it almost always is, to the bringing of a naked wire into contact with some part of the metal work of the car, the effect is a continuous buzz, which will be noticed if the coil be uncovered.

Remedy : Obvious. Insulation tape, or, if this does not happen to be handy, a piece of old rubber or a piece of rag or a piece of old glove may act as a temporary remedy.

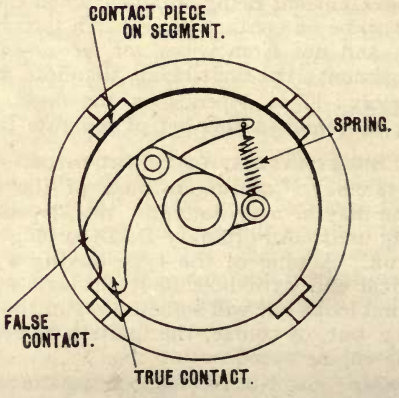


FIG. 1139.

1141 CONTACT BREAKER OUT OF ADJUSTMENT.—*Symptoms :* Missing or failure of ignition.

Remedy : The setting of contact breaker points is usually a delicate matter, and often less than one-eighth of a turn of the adjusting screw will make the difference between too close an adjustment and too far apart, so that wherever possible it is well to set the point whilst the engine is running. It does not in the least follow because the points come together, make good electrical contact, and separate again, that a good spark will be produced. If it is not possible to set the points with the engine running, the only thing to do will be to set the points just to make contact, and gradually tighten up the screw about one-sixteenth of a revolution at a time, and try again after each setting.

1142 INSULATED POINTS.—

Symptoms : Failure of the ignition of the cylinder concerned. Current will be obtained with a voltmeter connected across the points when they seem to be in contact.

Remedy : This depends on the source of trouble. Clean the points, true up, and reset the contact breaker, as in No. 1141.

1143 POINTS NOT MAKING CONTACT.—

Symptoms and *Remedy* as in No. 1142.

1144 INSULATED CONTACT BREAKER EARTH RETURN.—

Symptoms : This fault is only applicable to a case where the earth return is by separate wire, and in that case, if the insulation is complete, the engine will, of course, stop. In testing with a voltmeter, no current will be had across the points, but current will flow from the coil contact breaker wire to earth. If the insulation is imperfect, missing will result, and a telephone across the contact breaker points will give irregular clicking instead of regular ; and if connected from the coil positive (or battery positive) to the contact breaker earth wire, will give irregular clicking instead of one click and silence.

1145 TIMED WRONG, due to slipped driving chain, where the commutator or contact breaker is driven by a separate chain.

Symptoms : If the slip is not considerable in extent, the chances are that the spark will be retarded, and the engine will be difficult to start, and when running will take the spark fully advanced.

If more considerable up to half an engine revolution, probably no explosion will result, but possibly a puff in the silencer, as the ignition will take place just as the exhaust valve opens. Up to a further half revolution late (that is, from the end of the working stroke to the closing of the exhaust), much the same result will follow ; no explosion in the cylinder, but probably an occasional puff or explosion in the exhaust.

If the timing is exactly one revolution late or early, an engine will sometimes run with retarded spark due to the trapping of a small quantity of gas in the combustion chamber after the exhaust valve closes. The engine will probably stop on advancing the ignition.

During the next half revolution (the suction stroke which will mean the commutator slipped one and a half revolutions late, or advanced from one-half to one revolution), if there is an explosion at all, there will be a pop back through the carburetter.

If the spark is one and a half to two revolutions late (that is, during the compression stroke, and is the same as from correct timing to half a revolution early), the result will be a back fire in starting, and heavy knocking or stopping when running.

Remedy : Re-time the ignition. See Nos. 117 and 118.

1146 TIMING WRONG DUE TO SLIPPED KEY.—*Symptoms* and *Remedy* as in No. 1145 above.

1147 TIMING WRONG DUE TO SLIPPED CONTROL LEVER.—*Symptoms :* This is almost certain to retard the spark, but it is possible that it may not do so. The control lever will, of course, be inoperative.

Remedy : Examine and mend, connecting with wire and a spring if necessary for the time. In some cases it may be possible to get home by tying a weight, such as a spanner, on the commutator box, to keep it advanced, and retarding by a string tied to it. Or it may be possible, after starting the engine, to advance the spark to a moderate extent, and fasten the commutator case in position, thus travelling home on fixed ignition. For the correct point of timing, see Nos. 116, 117, and 118. In this case the ignition point would be found as in Nos. 117-120 (*d*). The engine would be left in that position, and the commutator case would be moved into such a position that the smallest movement of the commutator wipe in the ahead direction would make contact of the cylinder placed in the firing position. To identify leads see No. 114.

[NOTE.—If the control lever is only bent, and not quite loose or broken, the spark lever will be effective to some extent ; but the ignition handle will have to be placed in a new position, which fact will in itself indicate that something is wrong.]

(*a*) WRONG TIMING DUE TO SLIPPED WIPE.—

Symptoms : By a slipped wipe is meant that the piece of metal inside the commutator which makes electrical contact has slipped on the commutator spindle so as to make the timing wrong. The symptoms are the same as for those of a slipped chain, No. 1145 above.

1148 HIGH TENSION MAGNETO, LOW TENSION WINDING SHORT-CIRCUITED.—

Symptoms : If the short circuit is complete, the result will be total cessation of sparking and stopping of the engine. No current will be obtained from the low tension terminal (or switch wire or its terminal) to earth by a voltmeter. No sparks will be obtained in tapping the low tension (or switch) wire on earth whilst the magnet is turning over. Probably, but not certainly, there will be no noticeable difference in the voltmeter reading (see method of testing, described in No. 118), no matter what the position of the engine.

If the short circuit is only partial, the result will be either to cause missing or cut out certain cylinders. Thus if the short circuit was caused by a loose piece of metal rubbing against the armature, the shorting would take place at each revolution of the armature, which might have the result of cutting out cylinders in a certain rhythmical order. Thus with a Bosch magneto and a four-cylinder engine, one cylinder would be quite cut out; but with most other types of magneto, two cylinders would fail, the magneto running twice the camshaft speed. The writer has no experience of such a fault.

Remedy : No general instructions can be given, and in most cases the magneto will have to be sent to its makers; but an examination may show a possible remedy to the man of commonsense.

1149 HIGH TENSION MAGNETO, LOW TENSION COLLECTING BRUSH DIRTY.—

Symptoms : Missing or complete stoppage of the engine according to the extent of the mischief. If the insulation were complete, no current would be had from the switch terminal to earth with a voltmeter; but if the insulation were only partial, this test would be unreliable; but an irregularity would probably be found with a telephone connected from switch terminal to earth. If none of these instruments are at hand, an examination may show the source of trouble.

Remedy : The brushes of a magneto are almost always of carbon, and may be cleaned with petrol, and the path (often the end of the armature spindle) may be cleaned in the same way, and a very little oil put on before re-assembling. In putting together, make sure

that the brush spring is free and forcing the brush firmly but lightly into contact with the brush path. At the same time the source of the dirt should be sought, and if possible a recurrence prevented. Too much oil on these parts will generally lead to trouble.

1150 HIGH TENSION MAGNETO, OIL ON LOW TENSION BRUSH PATH.—

Symptoms and *Remedy :* Much the same as for a dirty brush (see No. 1149). It may be necessary to empty the magneto of oil.

1151 HIGH TENSION MAGNETO, WEAK LOW TENSION BRUSH SPRING.—

Symptoms : Generally the same as for a dirty brush or brush path (see No. 1149). The writer has seen one case where a motor bicycle engine magneto would spark when turned backwards only, this being due to the brush being tilted by the reversed motion, and brought into contact. Bending the spring put matters right. Sometimes pressing the brush into contact with the finger stops the missing or failure.

Remedy : This will depend on the definite source of trouble. Possibly packing the spring with paper may serve as a temporary measure, or it may be enough to clean dirt out of the spring casing where it is a light spiral spring in a tube.

1152 HIGH TENSION MAGNETO, WET ON THE LOW TENSION BRUSH PATH.—

Symptoms : The writer has no personal experience of this, but the probable effect would be to short circuit the low tension current, and thus cause missing or stoppage. Probably an examination would be the only way of finding the trouble. A circuit of high resistance, like that of a voltmeter, will sometimes carry the whole low tension current of a magneto, and stop it working.

Remedy : Dry the whole magneto if it is likely to be damp, or else wipe off with a clean dry rag.

1153 HIGH TENSION MAGNETO, LOSS OF MAGNETISM.—

Symptoms : This fault is difficult to detect, because the magnetism of a magneto with the armature in place appears very weak in all cases ; but where you have some experience of the particular magneto, it may be

possible to detect the trouble by turning the armature by hand. In a good magneto of the size usually used on full size cars, it is usually about all one can do to turn the armature over by grasping the spindle in the fingers. If there were a serious loss of magnetism, there would be a decided falling off in the resistance to motion.

Remedy : Send the magneto to be re-magnetised. It might in some cases be possible to connect in an accumulator between the collecting brush and contact breaker, and thus use the magneto as a coil and accumulator ; but the result would probably be damage to the magneto. The method of connecting up would depend on the construction of the magneto, and must be left to the judgment of the operator. In general, the method would be to connect the accumulator to the collecting brush by one of its terminals ; and after disconnecting the wire from the collecting brush to the contact breaker, to connect the other terminal of the accumulator to the side of the contact breaker, from which this last mentioned wire or connection has been removed. The experiment should not be tried except in a last resource.

1154 HIGH TENSION MAGNETO, COIL OF (SEPARATE COIL TYPE), FAILED.—

Symptoms : See coil faults Nos. 1107 et seq. above.

1155 HIGH TENSION MAGNETO, HIGH TENSION WINDING BROKEN DOWN.—

Symptoms : Whether tested by voltmeter or telephone from switch terminal to earth, a regular current will be indicated, and faint sparks will be had from the switch wire tapped on the engine frame whilst the magneto is being turned over ; and in general the low tension system will show all signs of being in order, but no sparks will be had from the high tension distributer or from the supply cable (or connection) of the distributer where that can be tested.

Remedy : Where the fault is a true short circuit of the high tension coils, nothing can be done by the amateur, and the magneto must be sent to its maker.

1156 HIGH TENSION MAGNETO, CONTACT BREAKER NOT MAKING CONTACT.—

Symptoms : If the magneto be tested with an accumulator resistance and ampèremeter, as indicated at No. 118 (*e*), it will be found that there is no variation

of ampèrage, if the failure is complete, no matter what the position of the contact breaker. If the failure is not complete (causing missing of the engine only), a telephone will probably indicate it by irregular clicking.

Remedy : Adjust contact breaker. This is an operation requiring some care, as the running of the instrument greatly depends on the set of the contact breaker. Most modern instruments are sent out with a feeler gauge consisting of a thin steel blade so thick that it will only just pass between the points of the contact breaker when operated to their fullest extent. Different instruments are supplied with different tools, varying with their construction. As a general rule, the distance between the points when widest apart is 0.4 millimetre, or, say, $\frac{17}{1000}$ in. This is not far from the thickness of a visiting card or the thumb nail. This is also the distance apart of magneto plug points.

1157 HIGH TENSION MAGNETO, CONTACT BREAKER NOT BREAKING CONTACT.—

Symptoms : Failure or missing according to extent. In testing with an accumulator resistance and ampèremeter, it will be found that the internal resistance of the magneto does not show anything. That is to say, if the ampèremeter will take one ampère through the resistance, it will take one ampère through the magneto connected from switch terminal to earth in all positions of the armature, instead of showing almost infinite resistance at certain points.

Remedy : See No. 1156.

1158 HIGH TENSION MAGNETO, CONTACT BREAKER OPENING TOO WIDE.—

Symptoms : Difficulty in starting engine on the magneto. Possibly missing or loss of power. The correct distance in a Bosch magneto is 0.4 mm., or about $\frac{1}{64}$ in. (the same distance as the spacing of the magneto plug points).

Remedy : See No. 1156 for adjustment.

1159 HIGH TENSION MAGNETO, CONTACT BREAKER NOT OPENING WIDE ENOUGH.—

Symptoms and *Remedy* as in No. 1157 (not breaking contact).

1160 HIGH TENSION MAGNETO, HIGH TENSION DISTRIBUTER INSULATION BROKEN DOWN.—

Symptoms : If the fault is at one of the distribution sectors, missing or failure of that cylinder only ; if on the distributing arm or its spindle, missing or failure of all cylinders. The spark in the former case will be regular at all the distributer terminals but one, and regular into the distributer, where that can be tested. In the latter case, the spark at all terminals will be irregular or non-existent, but good into the distributer.

Remedy : This depends on the cause. If it is found that the insulation material is cracked, the instrument must go to its makers unless the part seems within the scope of a repair shop job ; but if no source of trouble can be seen, it may be that the fibre is wet, and drying the instrument will cure it. The writer knows of one case of this sort, where he was instructed by the owner to dip the magneto bodily in a bucket of petrol, and did so under protest, but the fault was cured. He does not recommend this as a regular thing, and in no case must it be done with a self-contained high tension magneto, or the condenser will probably suffer. The magneto treated in this way was a low tension instrument and did not seem any the worse.

1161 HIGH TENSION MAGNETO SWITCH SHORT-CIRCUITED.—

Symptoms : Missing or failure. Engine will run with switch wire removed.

Remedy : Run with the switch wire off, and to stop the engine slip the cable on to its terminal until the engine stops. The function of a magneto switch is to act as a means for the current to waste to earth, so that a short-circuited switch stops the engine ; but a switch making no contact will not stop the engine, *i.e.*, the engine cannot be stopped on the switch.

1162 HIGH TENSION MAGNETO, SWITCH WIRE SHORT CIRCUITED.—

Symptoms and *Remedy* as in No. 1161 above.

1163 HIGH TENSION MAGNETO, SWITCH SPRING WEAK.—

Symptoms : Engine will not stop on the switch, but when the switch is put in, the " stop " position continues running, but misses.

Remedy : Examine and rectify. As a temporary measure, the magneto may be short-circuited to earth by a spare piece of cable or by the switch wire taken off (from the switch connection) for the job.

1164 HIGH TENSION MAGNETO, SWITCH TERMINALS LOOSE OR DIRTY.—

Symptoms : The same as in No. 1163 above.

Remedy : Obvious.

1165 HIGH TENSION MAGNETO, BAD MAGNETO EARTH (separate coil type).—

Symptoms : This is not a common fault, as magnetos are usually earthed by their seating so as to secure ample earth return ; but where a magneto is seated on paper packing, it is possible that missing might result, and in that case it would probably be cured by fitting an earth wire precisely as recommended for the commutator spindle in No. 1129, the wire being fitted round the magneto spindle where the drive takes hold.

1166 LOW TENSION MAGNETO.—

For *Symptoms* and *Remedy* see "High Tension Magneto" : Low tension winding short circuited, No. 1148. Brush contact dirty, No. 1149. Brush contact oily, No. 1150. Brush contact wet, No. 1152. Brush spring weak, No. 1151. Loss of magnetism, No. 1153. Switch short circuited, No. 1161. Switch wire short circuited, No. 1162. Switch spring weak, No. 1163. Switch terminals dirty, No. 1164. Switch terminals loose, No. 1164. Bad earth. No. 1165.

1167 LOW TENSION MAGNETO TAPPETS NOT MAKING OR BREAKING CONTACT CORRECTLY.—

Symptoms (*a*) *:* Partial failure. Where the contact is not made, the cylinder affected will not fire, but the others will ; but where the contact is not broken, if the failure to break continues during the firing point of any other cylinder, that other cylinder will also fail. Where the failure is only slight, it will be difficult to distinguish between not making or not breaking ; but where it is pronounced, it will probably show up through the whole engine failing for a revolution or so (where the contact is not broken), or through one cylinder only missing. Where contact is not made in either case, where the failure is confined to one cylinder only, the

cutting out of that cylinder by the removal of its plug connection will allow the remaining cylinders to fire correctly, and will, therefore, show that the fault is confined to the single cylinder. To locate, therefore, cut out one cylinder at a time by disconnecting its plug.

In testing with a voltmeter or telephone, it is necessary to detach the plug wire, and connect the voltmeter or telephone from the "bus-bar" (the supply wire of all cylinders) to the plug under test. If working correctly, a current will be shown at every revolution by a jump of the voltmeter, or by a click in the telephone. Where the contact is not made, no current will pass; where it is not broken, the current will be more than momentary. This latter effect will not be pronounced in the telephone, which will only show the fault in each case by irregular clicking, whereas the voltmeter will probably show it up with its cause if it is at all pronounced.

[NOTES.—To connect a voltmeter or telephone from the plug to earth will usually stop the whole engine in the case of a low tension magneto. This is not the case where the connection is made from the switch terminal to earth of a high tension magneto. The voltage produced from the bus-bar to earth of a low tension magneto is usually from three to fifteen volts.]

Remedy: Adjust the contact. If the tappet rods will not adjust any further, it may be possible to put things right by partly turning the plug round so as to bring a new point of contact into operation. This can usually be done by adding another sparking plug washer or a piece of string or wire under the washer. The method indicated at No. 118 for timing can be followed for setting if the apparatus is available.

Symptoms (*b*) *:* Complete failure. If the tappet is not breaking contact, the whole ignition will fail; but if this cylinder be cut out by detaching its plug connection, the other cylinders if in order will fire all right. If the failure is to make contact, the cylinder in question will be out of action, but the others will run. In testing with a voltmeter with the plug wire off the defective cylinder plug, if the failure is to break, a current will flow continuously from the bus-bar to the plug, and probably the whole ignition will fail each time the circuit is completed with the voltmeter or telephone, as

the author has proved by experience. If it is a failure to make, no current will flow at all.

Remedy : Adjust the tappet rod or plug or both. See the method for timing, No. 118.

1168 Low Tension Magneto, Plug Insulation Broken Down.—

Symptoms : These will be the same, whether partial or total, as those for a failure to break contact. See No. 1167.

Remedy : New plug, or if not available cut out this cylinder, and drive on the remaining ones.

1169 Low Tension Magneto, Low Tension Cable Short Circuited.—

Symptoms (a) : Partial. Missing on all cylinders whenever a short circuit takes place. Cutting out the ignition to any number of plugs will still leave the engine missing. If the engine has dual ignition, and it be run on the other ignition, and all the plug wires be removed, and the plug wire be taken from the magneto, a current will be found to flow intermittently (by voltmeter or telephone) from the magneto terminal to the cable. In making this test, take care that moving the cable has not stopped the short circuit, in which case the test will give a false result. One method would be to tap the low tension wire on its terminal with the plug wires off, when intermittent sparking would take place.

Remedy : This is a matter of locating, as once the fault is located it can be readily insulated by tape or even a piece of rag or string, or by fastening the cable so that the bare part does not earth. It may be possible to locate the fault by cutting the wire, thus taking out one or two cylinders at a time with their cable. If the remaining ones do not miss, the fault is in those cut out and their cable. Begin by cutting out the switch by removing its wires. If a preliminary examination does not show up the fault, cut out sections of cable at a time, and replace by spare cable. If nothing else is available, ordinary electric bell wire will do as a makeshift. If good working is restored by this means after any change, the last section replaced is at fault.

Symptoms (b) : Complete failure. The engine will fail entirely, and cutting out cylinders will not make the rest run. Current will flow from the low tension

terminal of the magneto (when the engine is moved) into the cable if removed from its terminal.

Remedy : This is again a question of locating. The same method as for partial failure should be employed.

1170 LOW TENSION MAGNETO, BAD CONTACT BUS-BAR TO PLUG.—

Symptoms : Where there are separate switches to each plug, if the switches are loose, the contact may be bad, and the result will be missing of the cylinder in question. Trying the switches by hand will probably stop the missing, and this should indicate the location of the fault. A voltmeter connected from the bus-bar to the plug whilst its switch is closed should, if things are in order, show no current ; but if the switch is making bad contact, it will show irregular currents, as will a telephone.

1171 LOW TENSION MAGNETO, ARMATURE SET WRONG.—

Symptoms : This may lead to total failure, or possibly to failure of the ignition with the advance spark gear in certain positions, depending on the extent of the error.

In the rotating armature type of magneto, the break of the contact in the cylinder should take place approximately when the metallic parts of the armature are up and down, and the windings, therefore, closest to the poles of the magnets. Or, in general, to those who know anything about the elements of the construction of these machines, when the number of magnetic lines passing through the coils is a minimum, and, consequently, the rate of cutting lines of magnetism by the armature coils is a maximum. In the Bosch type of magneto with revolving shield and fixed armature, there are four maximum and minimum positions per revolution of the armature shields, and the position of the shields for the point of breaking of contact will be when the line joining the centres of the two shields is either parallel to or at right angles to the line joining the centres of the pole faces of the magnets. These magnets require specially careful adjustment of the time of breaking contact.

1173 NOISY GEAR CHANGING.—

Where difficulty is found in changing gears silently, the following remarks may be of use—

When a change is to be made from a lower to a higher gear, the male portion of the clutch, which is attached

to the first motion gear box shaft, must in all cases be reduced in speed before the change can be made.

When a change is to be made from a higher to a lower speed, the male portion of the clutch must in all cases be increased in speed before a change can be made.

These are the two root principles, on a proper apprehension of which skilful gear changing depends; but after they have been apprehended, some considerable experience will often be necessary to effect a change.

Let us consider a change from a lower gear to a higher (neutral to first, first to second, second to third, etc.) first of all.

As we have said, the speed of the male clutch must be reduced, and in most modern cars this is done by the friction of the collar used for withdrawing the clutch; but in some, especially with plate clutches, a special brake or collar is provided, against which some portion of the male clutch rubs when it is fully withdrawn in order to slow it down. If, therefore, you are standing still in neutral, and desire to place the change speed lever in the No. 1 notch, you depress the clutch fully, and, waiting till the clutch stops, press the lever forward. A very little experience will tell you how long you have to wait; usually a couple of seconds is enough. There are one or two things to remark, however.

Sometimes the gears will not engage at all. You then return the change-speed lever to neutral, and let the clutch engage for a moment, and try again. Sometimes this has to be done three or four times in succession before the gears will engage.

Sometimes the male clutch will not stop at all, and the gears, in consequence, invariably grind when getting into first speed. This fault may possibly be structural, as, for instance, when a plate clutch is so designed that there is not enough friction to stop it against the friction of the oil between the plates. Possibly a thinner lubricant may put things right. It may be due to the clutch brake (sometimes called the clutch pad) being out of adjustment, or the clutch pedal out of adjustment, so that the clutch brake or pad does not touch the clutch. Sometimes it is due to the clutch withdrawing collar, being too well lubricated. In this case try a heavy grease instead of oil.

Now let us suppose we are going from first speed to second. Silent changing depends on the clutch being held out until the speed of the gears about to be engaged has become exactly equal, neither more nor less, and the amount of time necessary for this will vary with every individual car; but a very little experience will teach you what it is. Proceed, therefore, as follows: Depress the clutch, and move the change-speed lever forward into the No. 2 position fairly smartly. If it grates, try next time a little more slowly until you find the right timing to give good results. When you have found the timing, and can hit it off with fair certainty, you will practise to send the gears into engagement quickly and smartly. That is to say, the expert takes his gears out of engagement, then lets his change-speed lever pause for a fraction of a second, and then slams them in smartly. Especially is this so if the clutch is of the leather-faced cone type.

Changing through the gate. In a gate change speed, the change upwards through the gate will depend on circumstances. If you find from experience that, in order to get a silent change, you have to pause a considerable time between the gears, all you need do will be to depress the clutch, and quietly move the change-speed lever through the gate, and slam it home. If, however, the change from first so second (not through the gate we are assuming) has to be done quickly, it may well be that you will have missed the correct moment by the time you are through the gate, and the gears grate. If this is the case, proceed as follows: Depress the clutch, and disengage the gears. Let the clutch in again as you move the change-speed lever through the gate, disengage the clutch again, and then, waiting the necessary time which experience dictates, slam your gear in.

In some cases it is better to feel for your gears, and not to slam them in. Especially is this true for the novice and for the expert handling a new car for the first time.

Changing down. By this we mean changing from a high speed to a lower (fourth to third, third to second, etc.) In this case, as stated above, the speed of the male clutch has to be increased by the necessary amount to effect a silent change. In order to effect this, the clutch is slightly depressed to disengage the gears, and the change-speed lever slipped just out of its notch, and

stopped half-way to the next notch, then the clutch is engaged for a fraction of a second, and then smartly disengaged completely, and the change-speed lever slammed into the next notch. It is not possible, in the writer's experience, to feel for the gears in changing down; it must be done smartly and accurately. Thus, for this operation the clutch is depressed twice for each change. In some cases, with sector change, however, it will be found easier to merely tap the clutch. Thus, you grasp the change-speed lever, and pull it firmly towards the next lower notch, and then, whilst keeping a steady pull on it, you give the clutch pedal a smart tap with the foot. In some cars this results in a perfectly silent change, but the rule is not by any means of universal application, whilst the double clutch trick is.

Use of the throttle or accelerator in changing speed—

Changing up. The throttle is completely closed, or the accelerator pedal released. A possible exception is the case of a car fitted with too strong a clutch pad or brake, where it is necessary, in changing through the gate, to accelerate a little. In that case, it may be necessary to touch the accelerator pedal or open the throttle, as the clutch is momentarily let in to accelerate the male clutch.

Changing down. If you are smart about it, it is usually possible to do this with the throttle wide open and the accelerator pedal depressed; but it may be more convenient to experiment until you find the right place for the throttle lever, so that the engine will not accelerate quite so quickly, and having found the place, always close the throttle to this place in changing down.

Always, as far as you possibly can, obtain the right speed of the gears by the clutch or the clutch pad, as the case may be, and *not* by the friction of gear against gear, which makes an unpleasant noise, and damages the gear teeth.

The whole difficulty of changing speed from a higher to a lower gear is a question of knowing just what the motions of hand and foot should be, and then practising assiduously. For the sake of the nerves of His Majesty's lieges, and the King's peace, it will be as well to do the practising alone at first, as the noises produced by the beginner are suggestive and productive of suffering.

Let us say you have to change from third to second through the gate, and let us suppose that third speed is towards you outside the gate, and second from you inside.

As I have said, the clutch is taken out twice for this change; now the whole difficulty lies in correctly timing the hand and foot together, and in the writer's experience the way to overcome these difficulties is to concentrate the mind on the *end* of the motion. The change is made in two distinct stages. The clutch s disengaged and re-engaged, and a pause made; this is the first stage for the clutch. Simultaneously, the change-speed lever is moved forward to neutral, and across through the gate, being brought to rest opposite second speed notch, but in neutral, thus describing an inverted L. This is the end of the first motion of the change-speed lever, and a pause is now made. Now, what you have to do is to fix your mind on these two motions, and practise till you get them together. The change-speed lever has to describe an inverted L. and the clutch has to be disengaged and re-engaged. Then a pause is made, the duration of which varies with different cars and with the speed of the car at the time of the change. Thus, if the car is running at twenty miles per hour in third, and the pause is found to be half a second, then, when the car is running at twenty-five miles per hour in third when the change is made, the pause will be longer. Thus the higher the speed for any given gear the more slowly the change is made, as the engine does not accelerate as quickly when running fast as when running slowly.

The second half of the change is easy. The clutch is depressed, and the gear engaged smartly, and the clutch let in.

All this sounds very complicated, but it is really very simple, and very well worth learning, for there is a real satisfaction in getting on to a car which is a little beast to drive, and having your passenger say what a delightfully easy change-speed gear it has. That is when you feel that your life has not been wasted; and when your motoring passenger has a try, and makes a noise calculated to wake the seven sleepers of Ephesus, you know not only that it has not been wasted, but has been a triumphant success.

The writer found it a great help to practise this change speed with the poker and his feet on the fender.

Having become proficient in this method, you will notice that the car gives a jerk on engaging the clutch for the second time, because the engine is running too fast. If you are desirous of fresh fields to conquer, you can now begin all over again with your practice —you will find it amounts to that—and as you disengage the clutch for the second time, let up the accelerator pedal with the right foot, and as you let in the clutch for the last time, depress the accelerator. Thus the first half of the motion is the same in both cases, but the accelerator is released for the second half. This stops the jerk, and, if properly done, makes a beautiful change speed.

The writer found it necessary to drive for some miles on the level, changing speed all the way, before he got hold of it, and this in spite of night school on the fender and poker arrangement till his muscles ached.

There is yet one further special refinement applicable to one special case. Sometimes a car fitted with a leather clutch gets possessed by an evil spirit, which refuses to allow the clutch to be withdrawn when the engine is pulling. This is very nasty, and makes a neat change nearly impossible, because you never know when the clutch is coming out.

In this case, if you care to practise it, you begin the whole process by letting up the accelerator. Then the left foot disengages the clutch, and the hand the gears, whilst simultaneously the accelerator is depressed, and the clutch re-engaged. This is the end of the first motion. It is exactly what it was before, except that the foot is lifted off the accelerator, and immediately depressed again as a start to take the drive off the clutch.

This motion is rather complicated, and makes one look as though one were pedalling an imaginary organ, but it is quite effective.

If the change is direct, and not through the gate, the rules are the same exactly, except that the change-speed lever is moved forward, and stopped instead of describing an L through the gate.

The whole thing to remember in changing through the gate is that the change-speed lever stops dead after describing the L. On no account try to do the whole

motion through the gate and into the next speed without a pause if you wish to acquire real skill. Many cars will let you simply drag the lever diagonally through the gate, but, on the other hand, many others will not tolerate such a liberty ; and if you learn a slovenly style on the first class, and try it on the second, you are apt to be greeted with a feminine-like shriek of offended dignity and damaged gear wheels.

1174 STARTING HANDLE BROKEN OR LOST.—To start engine.

First Method : Jack up one back wheel, block the front wheels, place the change-speed lever in top speed, retard spark (or place it in usual starting position), and then pull round the jacked-up wheel by the spokes. Some knack is required, and care must be taken not to get the arm caught in the wheel security bolts or valve cap.

Second Method : Push the car to the top of a hill, if near one, hold it on the brake, put in top speed, take out the clutch, take off the brake, let the car run down by gravity and let the clutch in, taking it out as soon as the engine starts.

Third Method : If sufficient help is at hand, have the car shoved along, and act as in the second method.

Fourth Method : Wrap a length of rope round the rim of the flywheel in such a direction that when pulled off it will turn the flywheel in the running direction, and then pull it off sharply. The writer has not tried this, but believes it would work

1175 TO FIND THE "RETARD" POSITION OF THE SPARK LEVER.—

Open the commutator box, turn the engine slowly, noting the direction of motion of the wiper. Now move the ignition lever, noting the direction of motion produced. When the direction of motion of the spark lever is such that the distance between the wiper and contact piece is diminished (measured in the direction of motion of the wiper when in action), the spark is being advanced. Thus, for example : Let us suppose that the face of a clock is the commutator. The hour hand is the wiper, and the contact pieces of a four-cylinder engine are at twelve, three, six, and nine o'clock. The direction of the wiper is found, by turning the engine, to the usual

direction of clock hands, and it comes to rest at two o'clock. On moving the spark lever in a certain direction, three o'clock (one of the contact segments) is brought nearer to the hour hand; then the spark is being advanced.

In a few contact breakers the case does not move, but the spark lever makes the wiper itself move. The rule is still the same. If the distance between wiper and the next contact piece it will come to is diminished, the spark is being advanced. Thus, in the above example, if a motion of the spark lever in the given direction brought the hour hand from two o'clock to half-past two, then this direction is "advancing" the spark, and the retard position is, of course, at the extreme end of the motion in the opposite direction.

1176 ENGINE WILL NOT START ON SWITCH.—It will sometimes be found that an engine which usually starts on the switch refuses to do so any longer. The writer knows of no general rule which can be given as a remedy. Generally a tune up all round will effect the desired result. Grind the valves, tune up the ignition, setting the ignition points, etc. It is, of course, assumed that the coil and accumulator ignition is in good working order, as far as actual sparking is concerned. Should this be out of order, it must, of course, be put right before any results can be obtained. The carburetter must also receive attention, and any leaks of air into the induction pipe must be stopped up. A good method is to paint the joints with boiled oil, whilst the engine is running with the throttle partly closed. This partial throttling produces a partial vacuum in the induction pipe, and sucks the oil into any leaks. The engine is then left for some time, and another coat applied. In this way small leakages can be completely closed up. Why it is that some engines will start on the switch and others not the writer does not know, and he has never heard a reason advanced. It goes without saying that the necessary condition for starting on the switch is that the cylinders shall remain full of an explosive mixture; but why it is that one engine will retain these conditions for many hours whilst another of the same general design will not retain them for half an hour, or even five minutes, is by no means clear.

1177 TREMBLER BLADE SPRING TOO WEAK.—*Symptoms :* If the writer has come across this fault, he has not recognised it. The probable effect would be missing of the engine, unless, of course, it was so weak that no contact were made, in which case the effect would be the same as the points not making contact. See No. 1109.

Remedy : Very possibly bending the blade judiciously would put matters right, or, failing that, a new blade should be put in.

1178 CARBURETTER NEEDLE VALVE STUCK OPEN.—*Symptoms :* Flooding of the carburetter, as in Nos. 1008 and 1009. Probably petrol will leak out from under the carburetter ; but in some cases it will leak back into the induction pipe, and render the engine difficult to start up.

Remedy : This depends, of course, on the cause of the sticking. It is not usual to find the cause to lie in a leaky valve proper, *i.e.*, the valve itself usually closes tight, and the writer has never once found the fault to lie in this point. As a general rule, it will be found in the balance weights or mechanism whereby the float lifts the needle. One very common source of trouble in some carburetters where the needle, as is usually the case, passes through the float, is to find that the collar on the needle on which the balance weights operate is resting on the float itself, so that the needle cannot go home on its beat. Wear in the joints of the balance weights and in the weights themselves, where they rest on the float, is another source of trouble. In a persistent case of leakage, it may be possible, especially if assistance is at hand, to drive home with the petrol tap alternately open and closed.

1179 EXCESSIVE CONSUMPTION OF PETROL.—In the nature of the case it is obviously impossible to give any definite rule for this. Any cause which increases the work to be done, such as dragging brakes or badly lubricated bearings on the one hand, or on the other diminishes the efficiency of the engine, will increase the consumption of petrol, as a general rule, though it does not follow that because the car has lost its "life" that the petrol consumption will go up. The only thing to be done is to go through the list of faults No. 34, and then possibly No. 33.

1180 WIRING BY OUTSIDE WIRES.—
In several points in the tables, where the engine is missing, and the fault cannot be found, the use of outside wires is suggested. By this is meant the following process—

Disconnect the wires in use one by one. For instance, disconnect the coil positive wire and the battery positive wire (these are both the same wire, but opposite ends of it). Now take a piece of cable or a piece of electric bell wire, and connect the battery positive to the coil positive direct without connecting in the switch. If the missing disappears now, you know that the fault is either in the cable removed or the switch if in this wire. Next remove both ends of, say, the earth wire of the accumulator, and substitute another wire, and so on through the whole. In emergency, for testing purposes a naked copper, or even iron, wire might be used, care being taken that it does not come in contact with any metal work of the car by placing waste or rags round it where it passes such points.

1181 COMMON CIRCUIT.—
The writer uses this term to indicate that part of the electrical wiring of a multi-coil installation which is common to all coils. Thus, in a four-coil installation, the circuit from the commutator spindle, through "earth" battery, switch to coil positive terminal, is common to the whole of the coils.

1182 SHORT-CIRCUITED BATTERY TO COIL WIRE.—
Symptoms : The insulation will probably smoke and burn due to the overheating of the wire, and smoke will be seen coming from the point of leakage. A leak of this sort will very shortly ruin an accumulator, and if complete will almost certainly fuse the wire.

Remedy : Replace the wire, insulate with tape, a piece of rubber, or even rags for the time.

1183 BROKEN FRONT AXLE OR WHEELS AND STEERING GEAR.—
In the case of an axle broken near the middle, it may be possible to effect a roadside repair by laying a couple of pieces of strong wood, iron bars, spanners, etc., alongside the break, and binding them in position by wire or rope, so to speak putting the fracture in splints, or, as it is technically called, "fishing" the breakage.

Where the breakage is of such a nature that this cannot be done, or where the steering gear is hopelessly deranged or a wheel hopelessly broken, the following plan may bring the car home. The writer has never tried it, and is indebted to *The Horseless Age* for the idea.

Obtain two short scaffolding poles or other similar pieces of wood, and lash them to the frame of the car, so that they project five or six feet in front of the car. Borrow a two-wheel light cart, and turn it with its shafts toward the car, standing in front of the car with the shafts projecting back over the driver's seat. Now jack up the car, and sling the ends of the scaffolding poles to the axle of the cart by ropes, allowing a fair amount of swing if possible. The front wheels will now be off the road. Start up the engine, and drive the car slowly, steering by the shafts of the cart used as a tiller or "Bath chair" handle.

Broken back axle. The only thing to do will be to "fish" the breakage, as described above, for a front axle, if this is found to be possible, and to drive slowly. If the axle is a live axle, the job will probably be hopeless.

1184 VENTILATING.—

Where an engine has too much petrol, the mixture will be too rich, and the engine may not start up. To add more petrol in such a case is obviously worse than useless, and the method is to ventilate the cylinders. How this may best be done depends on the particular engine in question. One method is to open the compression taps, and after closing the throttle turn the engine over several times, when it will usually start up. If an additional air valve is fitted, this may be depressed and kept open with a knife blade or piece of wire, and the engine turned over with the spark switched on and retarded. In this case you must be ready to take out the knife or wire immediately the engine starts, or it will stop again. In a word, the method is to open a supply of air into the induction pipe in some way. Where this is not possible, the only thing to do is to pin down the carburetter spindle or turn off petrol, and grind the engine round several times.

1185 TORQUE ROD (FRONT END LOOSE).—

The front end of the torque rod of a live axle car is held either between two springs, as in the best practice, or else by a bolt passing through an eye in the end

of the rod. In the former case, if the springs are too weak, the driving strain will compress them, and at certain speeds and pulls may allow the end of the torque rod to touch the top of the slot through which the torque rod passes. This produces a most distressing chattering sound, rather like that produced by a piece of sheet metal touching the flywheel as when the flywheel oil shield comes down on top of it. The fault can be proved by getting someone to stand on the torque rod through the tonneau floor (floor boards removed for the purpose) whilst the car is being driven. To remedy either take out the upper spring—that which takes the strain in forward driving—and replace by solid steel block, or else use stronger springs.

If a bolt is used to secure the end, this may have —it is sure to in time—worked loose in its hole. To remedy, rebush and fit a new bolt, or, perhaps better, fit a strong spring to the top of the end of the torque rod, holding it upwards, as to the bottom of the front seat. This keeps the slack always taken up in the ahead driving position, and stops the clatter when driving ahead. It is better than rebushing, in that the latter operation will have to be done again ; the spring arrangement is permanent. As the spring has to be much too strong to stretch by hand, a little ingenuity and a jack will facilitate matters in fixing.

1186 RADIUS ROD FRONT END BOLT OR BRACKET LOOSE.—As soon as the clutch is engaged, the slack is taken up, bringing the bolt smartly up against the front side of its hole, and producing a sharp click as though something had broken. The best thing to do is to rebush the hole and fit a new bolt ; but if the wear is bad, packing the space between bush and bolt with thin " pen steel " will cure the trouble.

1187 LEAKAGE IN LOW TENSION MAGNETO SYSTEM.—The effect is to stop the engine. Method of search by accumulator and voltmeter.

Connect one pole of the battery to any part of the engine frame—not to the ignition system. Connect one pole of a voltmeter to the other pole of the battery, and take care that all contact breakers are out of contact. Now proceed to remove high tension cable from magneto, and take care that it does not come in contact with the engine. Now proceed to touch

various points of the ignition system with the free pole of the voltmeter, taking off terminal after terminal. As long as there is leakage, a current will be shown, but immediately the defective part is cut out by removing the cable from it, no current will flow, and the fault will be thus located.

1188 Where the throttle and spark are inter-connected, it is sometimes found that the radiator boils. This may be due to incorrect synchronisation of timing and throttle levers, and adjustment of these by advancing the spark will put things right. Sometimes the substitution of a six-volt accumulator for a four will effect the desired cure.

Remember in driving such a car that you must act as though you had only a spark lever, and were driving on that. Banish from your mind all idea that you have a throttle at all, but behave as though the throttle lever were lost, and you were driving with the throttle full open, and controlling the speed with the spark lever. Thus, to slow up, you retard the spark, and also, when the engine is pulling hard on a hill, you retard the spark. Contrary to what might be expected, this does not reduce the power, because when the engine is running slowly, the cylinders are able to get a full charge through a partly open throttle.

1189 A Few Notes on the Carburetter.—First and foremost it has yet to be shown that a carburetter jet ever varies its size once it is finished by its maker, and, in consequence, if the carburetter is suspected in a case where it has previously given satisfaction, it is all but certain that the trouble is not a permanent alteration in the size of the jet. Therefore we give this immutable rule. Where a carburetter has once given satisfaction on a car under no circumstances whatever ream the jet. Of course, where a carburetter has some arrangement for closing and opening the jet, as in certain special cases, this may not be true. In any case, whether the carburetter is new or otherwise, never ream the original jet; give the manufacturer credit for knowing something about his product, and for having the common honesty to turn out a tuned-up instrument. If you must play tricks with the jet, get a new jet from the makers and experiment with that. As one who has conducted

during the past twelve months something like 15,000 trials of carburetters, the writer can say with some confidence that, except in the special case to be mentioned below, no good is likely to result from it.

The weak spot of the modern carburetter is the float chamber and its gear. This is one of the weakest features of the modern car.

It follows from these remarks that if anything is supposed to be wrong with the carburetter, it is well to look to the float to see it is working properly and giving a correct petrol level.

To test this latter point it is best to take the float chamber right off, remove the jet, and fit a piece of glass

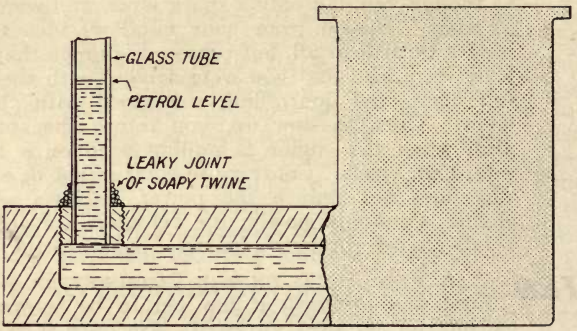


FIG. 1189.

tube in place of the jet, tied round with a few threads of cotton. It is particularly desirable that the joint where the glass tube goes in where the jet usually lives shall *not* be petrol tight, but shall leak freely. The reason is that the writer has seen cases where there was no leak at this point, and where the petrol rose, in consequence of a momentary failure of the needle valve, to nearly ¼in. above its true level. Having now got the glass tube in place, with the float chamber coupled up to any suitable temporary petrol supply, and the level constant in the glass tube, turn the jet upside down alongside of the tube. The level should be flush with the seating of the jet. Fig. 1189 gives an illustration of the apparatus in use.

When an engine is pulling hard with open throttle a difference of $\frac{1}{16}$in. in the petrol level makes practically no difference to anything, but when the engine is throttled down running idle it makes all the difference in the world. Under these conditions $\frac{1}{16}$in. may make a difference of 300% in the amount of petrol supplied for a given position of the throttle The mixture for slow running has to be enormously rich to allow for leakage, which takes place in every engine made, probably past the piston rings.

ADJUSTING A THREE-JET CARBURETTER ON THE CAR.—

Three-jet carburetters seem to be coming into favour just at present, and some of them seem as though specially sent out with a view to the user tuning them up himself.

Should the amateur wish to fit such a carburetter the following arrangement may be tried :

First of all obtain three spare jets, and having carefully marked the original jets so that they can be replaced in their proper holes, fit the new ones in place.

Fit the carburetter on, and then note the exact position of the throttle lever on the steering wheel which corresponds with that position of the throttle which brings each jet into action.

Place the throttle lever in that position which just fully opens the first jet only. Start the engine. Leave the engine running till it is quite warm. Now close the throttle slowly till the engine is going as slowly as it will. Count the revolutions by the number of lifts of a valve stem. (Revolutions of engine double the lifts of the valve stem per minute.) Now take out the jet and ream it slightly larger, and try again. Go on doing this until reaming will not make the engine go any slower than it did before the jet was reamed. If you have only reamed out a very little each time, this will then be the best size for the small jet. An ordinary jet reamer should only be allowed to go $\frac{1}{8}$in. further into the jet at each trial.

Now take the car on to the road. Select a piece of level ground, and mark off a distance of about 400 yards.

Take the car to some definite position, such as opposite a gateway, and having opened the throttle to

just uncover the second jet, drive over the measured stretch with the throttle in this position, noting the time taken by stop watch. It is best to repeat this three times.

Now ream the jet and repeat the performance. Continue till on reaming the jet no increase in speed is noticed, and leave it at that.

For the third jet it will be usually better to select a hill which the car will comfortably take on second speed, as testing a car "all out" on the level disturbs other traffic.

Repeat the performance with a measured stretch and a stop watch as before, reaming the third jet.

If in the case of the small jet the first two reamings do not make the engine run slower or in the case of the second and third do not make the car go faster, the jet was too big at first; load the small part of it with soft solder, drill a small hole in it and try again.

For slow running it is supremely important that all induction pipe joints be air tight. Making joints with cycle tube patching rubber or painting with oil paint may help. The writer has reduced the minimum possible speed of a four-cylinder 90 × 100 engine from 280 revs. to 160 revs. by painting the induction pipe joints.

This process is laborious, but it will give satisfactory results, or at least as satisfactory as the shape of your induction pipe will permit. The shape of the induction pipe has more effect on the action of an ordinary proprietary carburetter than anything else known to the writer, and may, and does often, make the difference between an ideal carburetter and a thing which it is purgatory to drive. There seems, however, to be no sort of rule that can be given. The reason is that there is no carburetter known to the writer, except the Lanchester wick type, which evaporates its petrol. Every other carburetter delivers a mixture of liquid petrol and air, and the liquid petrol, far from being in a spray, runs in a stream along the bottom of the induction pipe. It is easy, therefore, to understand, that a certain shape of induction pipe might lead all this liquid petrol to two cylinders out of four, with, of course, disastrous results.

Heating the air supply to a carburetter increases the petrol consumption, that is to say, enriches the mixture,

in some cases to as much as 25%, and has little or no effect on evaporation once the petrol has collected at the bottom of the pipe. Heavily exhaust jacketing the induction pipe might work, but the exhaust supply pipes would have to be at least ⅜in. bore.

Exhaust heat to a carburetter should invariably be taken from the top of the exhaust pipe, not from its under side. Oil coming from the engine, which it often does, finds its way to the bottom of the exhaust pipe, and thence into the carburetter jacket, which immediately chokes. If exhaust gases are taken from the top of the pipe little trouble is experienced.

1190 SLEEVE VALVE ENGINES.—The one point to be noted in dealing with this type of engine is the lubrication, and the writer has been unable to learn any special symptoms whereby shortness of oil makes itself felt. It is therefore necessary to be particularly watchful that the oil supply does not fail. It has been said that these engines are no worse off than ordinary engines in case of shortness of oil, but the writer believes that this is a mistake, for the following reason: In the average slide, piston, or sleeve valve engine the valve travels about one-fifth of the distance traversed by the piston and at half the number of strokes (due to the half-time gears), so that in a given time it travels one-tenth of the distance traversed by the main piston. By an elementary law of physics, therefore, a force applied to the sleeve to stop the engine must be ten times as great as the force necessary to effect the same result when applied to the main piston.

Now, when an ordinary piston runs short of oil, the result is usually that the side thrust of the piston against the dry cylinder wall on the firing stroke, due to the angularity of the connecting rod, sets up so much friction that the engine has no power at all, and the shortness of oil is detected by lack of power. A moment's thought will show that the power developed by the explosion is then exerted not to drive the crankshaft round, but to put a longitudinal drag on the wall of the cylinder, and little or none of this strain falls on the connecting rod and crankshaft. It is unusual for much harm to be done through lack of lubrication when the engine is running under the influence of the

flywheel. An engine which has refused to drive the car on account of lack of oil is usually quite free to turn over by hand.

Now suppose that the lack of oil takes place in a piston valve or sleeve valve.

Let us suppose that the lack of lubrication takes place between the piston and inner sleeve of a sleeve valve engine, whilst the lubrication of the outer sleeve remains fairly good. The suddenness with which lubrication of cylinders fails leaves room for doubt whether the sleeves and piston would ever run short at the same instant. The piston presses hard on its firing stroke against the side of the inner sleeve, thus putting a downward drag on it. As there is no serious friction between the inner and outer sleeves, this downward drag must be resisted by the sleeve connecting rod, which is unlikely to be strong enough to resist it. On the other hand, should the lubrication of the outer sleeve fail and that of the piston remain good, the piston will have its full power, but the side thrust, being transmitted through the sleeves, will set up heavy friction between the outer sleeve and cylinder. Thus the whole force of the explosion will be transmitted to the crankshaft, whilst friction enough to stop the engine, if it had been applied to the piston, will be called into play at the outer sleeve, which will have to be overcome through the camshaft and half-time gears by the outer sleeve connecting rod, which is then liable to fail. If the lubrication of the sleeves and piston fails at the same instant, then probably the sleeve engine would be no worse off than an ordinary engine, since the friction would be equally distributed. For these reasons it seems to the writer a mistake to say that sleeve valve engines are no more liable to accident through failure of lubrication than the poppet valve type. The stems of poppet valves are never lubricated, and are in consequence never liable to stick through lack of lubrication. A case of one sticking shut and wrecking the valve gear has never come under the writer's notice, whilst a valve sticking open, though it may stop the engine, causes no other damage.

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