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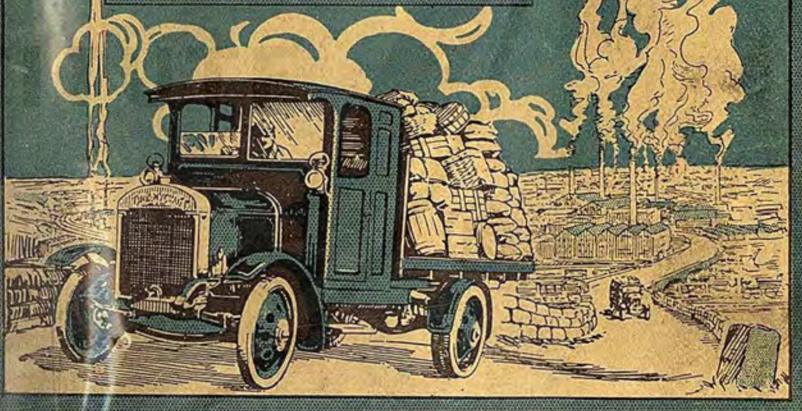

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THE BOOK OF THE THORNYCROFT

THE BOOK OF THE THORNYCROFT

BY

"AURIGA"

THE
WAR-TIME WORKSHOPS OFFICER
AND PEACE-TIME FLEET ENGINEER

SHEWING HOW TO RUN AND MAINTAIN THE WAR OFFICE "J" TYPE AND OTHER LORRIES MOST EFFICIENTLY

LONDON
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CHAPTER I

INTRODUCTORY

1. THE J-type War Office Thornycroft petrol vehicle is now so widely used that it seems to me a book giving some account of it and of the best ways of maintaining it may prove useful. Having had charge of a large number of these well-known lorries throughout the Great War, and been responsible since for the upkeep of a fairly large fleet engaged in commercial work, I have enjoyed exceptional opportunities of becoming intimately acquainted with all the practical details of their maintenance under widely varying conditions. I therefore venture to hope that the information given herein may be found of some value to other "Thornycroft" users as well; and, although differences in the details of designs render actual experience with each particular type of vehicle desirable in order to obtain the best results from it, yet, as the general underlying principles of most motor vehicles are similar, it is thought that this little book may be found also of some service to a still wider circle of readers.

2. In the second chapter will be found a description of the J-type Thornycroft vehicle, together with references to most of the modifications introduced since its first appearance as a "subsidy" vehicle in 1914. Such

alterations as have since been made are almost wholly in details, and for the most part can readily be incorporated in vehicles even of the earliest class. Messrs. Thornycroft have informed me that about 10,000 of their vehicles were in existence at the end of 1922, but that any owner may at any time ascertain the class or classes to which his vehicles belong on application to them, quoting their name-plate number and preferably also the number stamped on the chassis frame adjacent to the near side front dumb iron ; these two numbers should, of course, agree. (*See* § 38 A.)

3. The third chapter opens with a brief sketch of the earlier history and development of Thornycroft motor vehicles, and continues with some references to the varied services rendered by the J-type lorries during the war.

An account is next given of our organization for repairs and overhauls in connection with motor transport columns, and the leading features of our procedure in relation to overhauls are sketched. By kind permission of Major Strickland, some extracts from an interesting and valuable criticism by him of motor vehicles are then introduced, and finally the important matter of bearing springs is referred to in some detail.

Some of our war practices in connection with repairs and overhauls are not, of course, to be recommended for adoption under the conditions of ordinary everyday commercial service, nor when dealing with very small fleets only ; it is thought, however, that they are of sufficient interest to be placed on record as indicating a general procedure followed with considerable success in dealing with great numbers of vehicles under circumstances frequently of unparalleled difficulty.

Great differences are observed in the treatment accorded to commercial motor vehicles by their owners.

Enlightened firms, recognizing the enormous value of the services they are capable of rendering when efficiently maintained, treat them with the same care as that extended to their high-class mechanisms in general, and institute adequate systems of regular cleaning, lubrication, adjustment, inspection, and overhaul. Unfortunately, however, there are also owners who appear to give no more thought to their motor vehicles than to their rough carts, and are yet indignant when confronted with frequent failures really caused solely by their own erroneous policy. Vehicles habitually overloaded and over-driven are too often seen, apparently never properly cleaned nor adjusted, and sometimes even housed *in the open* in all weathers ! Owners cannot be too strongly impressed with the necessity of setting up and vigorously maintaining in their own interests an adequate " garage organization " for their fleets, whether comprising many or few vehicles : in this way only can the full advantages of the use of motors be enjoyed.

The deplorable condition in which heavy motor vehicles are often to be seen at work is really striking evidence of their remarkable reliability, but economically such practice is thoroughly unsound.

The London General Omnibus Co., owning perhaps the greatest fleets of motor vehicles in Great Britain, attach great importance to cleanliness, and attribute the very successful running results they obtain largely to their firm insistence on this point.

4. In the fourth chapter this matter of cleanliness is further emphasized, and the beneficial effects of motor parades, etc., are referred to. A detailed account of the procedure recommended in dismantling a J-type chassis prior to an overhaul is next given, and is followed by an account of methods of conducting

adjustments and repairs that have been found effective. Reference is finally made to the comparatively recent setting up of motor lorry " service " organizations, and Messrs. Thornycroft's practice in this direction is described in some detail. The question of the adoption of standardized over-size and under-size spare parts for replacements as an alternative to the more primitive practice of making unstandardized repairs is also dealt with in this chapter.

Among those owners who have acquired reconditioned War Office vehicles at very low prices are some whose policy seems merely to run them to a standstill with the minimum of attention and outlay, when they are promptly scrapped and others similarly acquired and similarly treated. This practice, though but a temporary phase, tends not only to discredit motor vehicles as a class, but is surely a mistaken business policy in most cases. By stocking standard over-size and under-size replace parts, as now promptly obtainable from most of the leading British makers, I believe such vehicles would in general soon get into a condition in which they would prove themselves not only a really good investment, but become also a valuable medium of advertisement to their owners.

5. The fifth chapter refers to running costs and to some methods of recording them, and also to the matter of the treatment and organization of drivers, to which our American friends have in recent years given considerable attention.

In the sixth chapter I deal, firstly, with points connected with lubrication, practical precautions to be observed, oils recommended for use with the J-type Thornycroft lorries, and the procedure to be followed in order to obtain a satisfactory economy of lubricants. Fuel consumption is next referred to, and the various

factors which combine to cause waste of petrol are detailed; some hints on the conduct of fuel consumption tests are also given, together with a table of valuable results of tests with a J-type lorry fitted with different carburettors, which appears by courtesy of Messrs. Thornycroft, as also do details of a bench test of the M/4 engine fitted to this type of vehicle. Next is given a description of the Thornycroft paraffin vaporizer, and some account of the points to be observed when paraffin instead of petrol is used as fuel. After this comes a reference to the special experimental engine used by Messrs. Thornycroft in trying various liquid fuels and fuel mixtures. The chapter concludes with a brief account of the use of benzol, alcohol, kerosene, and producer gas as fuels for heavy motor vehicles.

The seventh, and last, chapter is concerned with Messrs. Thornycroft's latest practice and with their other types of motor vehicle, together with a reference to the services for which these are specially suitable.

6. My aim, then, is generally to place on record an account—somewhat discursive, I fear—together with some conclusions, of my experiences principally with " Thornycroft " vehicles, in the hope they may be found useful by others, and also to urge strongly the necessity—already well understood in many quarters—of owners and drivers realizing that the correct and in every way best policy with their motor vehicles is to accord them that degree of systematic care and attention in respect of cleaning, lubrication, adjustment, housing, and general treatment and maintenance so necessary to the continued efficient working of every kind of high-class machinery.

CHAPTER II

THE J-TYPE THORNYCROFT MOTOR VEHICLE

7. THE J-type Thornycroft chassis was constructed as far as possible in accordance with the conditions laid down by the War Office in their "Subsidy Scheme," under which owners of approved vehicles received an annual grant provided their fleets were so maintained as to satisfy periodic inspections made by a W.O. official.

I give here a brief account of the leading features of this well-thought-out scheme :—The War Department Subsidy Scheme, 1912,* had two principal aims—(1) To make alike the manipulation and control of all military motor vehicles ; and (2) to minimize the number of spares to be carried in service, having regard to the different classes of vehicle which might compose the transport columns. The principal requirements laid down were—

Loads. The useful loads carried were to be either 3 tons or 30 cwts., and these even with the heaviest bodies called for by the military authorities ; it was considered that the gross weights in the two classes, when fully loaded, need not exceed 7½ tons and 5 tons respectively.

Accessibility. Emphasis was laid upon the need of easy access to all parts, as it was pointed out that vehicles in the field would have to be capable of quick repair without such conveniences as pits, etc. ; particular attention was to be given to rear axles in this respect.

* 92/1578. *Tech. App. A.* (Harrison & Sons, printers.)

Engines. These were all to be of the vertical four-cylinder petrol type, with a minimum bore of 4½ ins. for the heavier and 4 ins. for the lighter class, the corresponding minimum R.A.C. ratings being 32·4 and 25·6 respectively.

Cylinders were to be cast in pairs, and all valves were to be mechanically operated with stems enclosed by easily removable dust-tight covers.

Crank-chambers were to have inspection doors of ample size to enable big-end bearings to be examined and bolts tightened up when necessary ; the lower portion of the crank-chamber was to be capable of easy removal without disturbing main bearings, excepting only when ball bearings were fitted.

All engines were to be governed so as not to be capable of running at more than 1,000 r.p.m., corresponding vehicle speeds being 16 and 18 miles per hour in top gear, in the two classes ; and the controls of throttle, ignition, etc., were to be by rods and not by wires.

Ignition. High-tension magneto ignition was specified, and a spare magneto was to be carried ; to facilitate timing, the fly-wheel rim was to be clearly marked with reference to a fixed pointer. High-tension leads were to be coloured red, green, yellow, and blue, in order from front to rear, to prevent incorrect connections. All magnetos were required to fit on a standard base and to have a standard drive to render them interchangeable.

Starting Handles. These were to have their cranked portion at 9-in. centres, and all made to fit on a shaft 1 in. square, so as to be interchangeable.

Radiators. These were to be of the straight gilled-tube type, not honeycomb, and of simple form to allow of easy repair. They were to be mounted entirely above the chassis frame, upon trunnions near their lower end and by a connection at the top, with water inlet and outlet branches of invariable size and placed in fixed positions ; two outlet branches were to be provided, one on each side, that not used being blanked.

Pump circulation was demanded, but the pumps and piping were to be so disposed that if the former failed, a temporary circulation could be maintained by convection or "thermo-syphon" action. The air fan was to be of sufficient capacity to prevent the water in the radiator from boiling during any official trials.

Petrol Tanks. These, holding 30 galls., were to be fitted to both classes of vehicle, with gravity feed supplemented, if necessary, by hand-pressure pump on the steering column. A petrol gauge and gauze filter in filling hole were to be provided, together with some means of cleaning out the tank.

Engine Lubrication. This was to be effected by a positively-driven pump, the oil reservoir to hold sufficient for a run of at least 200 miles.

Gears. Both classes of vehicle were required to have four forward speeds and a (safety-catch) reverse, with gate change having two slots and two selectors only ; all gear positions were to be clearly marked. The speed reduction in bottom gear was to be about 42 : 1 in the 3-ton class, and about 37 : 1 in the 30-cwt. class ; the reverse gear to be preferably lower than the bottom gear. All vehicles were to be capable of ascending a road gradient of 1 in 6 when fully loaded, either in bottom forward gear or in reverse gear.

Transmission. The drive was not to be transmitted through the rear bearing springs. The preferred method was by propeller shaft, with combined radius and torque member terminating in a universal joint. The final transmission was required to be by live axle, with bevel

drive of approved pattern ; chain-driving was not permitted. The rear axle was to be capable of being dismantled in the field without taking the load off the rear road wheels.

Hooks. Four towing hooks of standard pattern, two at the front and two at the rear, were to be fitted, the front hooks to swivel in the dumb irons.

Brakes. The travel of foot-brake pedal was to be about $3\frac{1}{2}$ ins. ; the hand-brake lever was to be arranged to push on, to be well clear of the change-speed lever, and to be 6 ins. longer, with a plain cylindrical handle.

Sprags. Two independent sprags of the road spike type, hinged to the back axle and operated simultaneously, were to be fitted, to prevent the vehicle from slewing.

Control. The clutch pedal was to be on the left, brake pedal on right, and an accelerator pedal still more to the right. The clutch and brake pedals were to be provided with flanges $\frac{1}{4}$ in. high to prevent the driver's feet from slipping off, and some means of adjusting the slope at the top of pedal was to be provided. The pedals were to work independently of each other, and were to be fitted with springs of such strength that the driver could leave his feet on them continuously if desired.

The change-speed lever was to be 6 ins. shorter than the hand-brake lever, and to terminate in a spherical knob.

Road Wheel. These were to be of steel throughout, and fitted with solid rubber tyres of band type of the following sizes—

Type of vehicle.	*Front wheels.*	*Rear wheels.*
	MM.	MM.
3-ton . .	900 × 120 singles	1050 × 120 twin
30-cwt.. .	870 × 100 singles	1030 × 100 twin

and the minimum ground clearance, with new tyres, was to be 12 ins.

All road wheels were to be carried on floating bronze bushes, and certain dimensions and limits were laid down.

Ball Bearings. To minimize stocks to be carried in the field, all ball bearings were to be included in the sizes Nos. 5, 10, and 12–20 inclusive, as given in the catalogue of the Hoffmann Co., of Chelmsford. This was exclusive of the small ball bearings used in magnetos.

General. A considerable amount of further interesting detail was included in the scheme relating to screw threads, etc., for which there is not space here; it is hoped, however, that sufficient has been said to render clear to the reader its nature and general scope.

The War Office authorities realized that it would be almost certainly useless to insist on different motor vehicle builders so far sinking their several identities as to build lorries all to one design, but it was thought not unreasonable to attempt a firm stand on at least a few points as, for example, radiators and road wheels. Even this, however, proved too much for the individualism of the British manufacturer to accept, and finally beyond a correspondence in different designs in the mode of suspension of the radiator, and a similarity in the dimensions of road wheel bushes, there was little necessarily alike in the "subsidy" designs of different makers other than the towing hooks and the brackets for supporting the special military type of body.

Before the war, although Whitworth and gas threads were in general commercial use, the Admiralty had their own standard fine thread, while the War Office had another which was specified for the retaining nuts of road wheels of all "subsidy" chassis. The W.O. thread proved, in practice, too fine, and a coarser thread was substituted during overhauls and in later vehicles.

During the war, also, steel castings were not easily procurable, and accordingly the deeply-dished plate wheels, which are so well known a feature of the Thornycroft vehicles, were designed. In most cases, the dished plates were riveted to a welded rim of T-section; with the progress of hostilities, rolled T-sections became unobtainable, and the rims were then formed by dishing the plates themselves; thus made, the wheels, though serviceable, were necessarily less stiff than when with T-section rims.

At another stage of the war, sprags were demanded on all vehicles, and these are still retained by some post-war owners, though it is preferable to dispense with them. The presence of a sprag, in my view, is an admission that the brakes are inadequate; and when a vehicle has to stop upon a hill, a scotch behind the wheel is safer than a sprag.

8. The Thornycroft J-type Chassis. A general external view in plan and elevation of the 1922 design of J-type (W.D. Model) chassis appears in Figs. 1 and 2. It is designed to carry a net load of 4 tons on an open lorry body, or $3\frac{1}{2}$ tons with a van body, and is also eminently suited for use as a motor coach or motor omnibus. The weight of the chassis itself, in running order, is $3\frac{1}{4}$ tons.

The Frame. The frame is of channel section in pressed steel, and is now of stiffer design than as originally fitted in the 1914 type; the longitudinal members have been thickened, and extended gusset plates rigidly connect them with the cross members.

A further improvement introduced by the makers is that the sub-frame, on which the engine, clutch, and gear-box are mounted, is now attached to the main frame at three points only, in such manner that however the main frame may be twisted the power unit remains always in perfect relative alignment and free from any racking action.

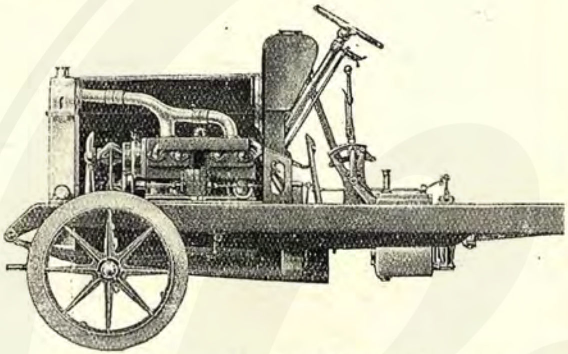


FIG. 1.—GENERAL ARRANGEMENT

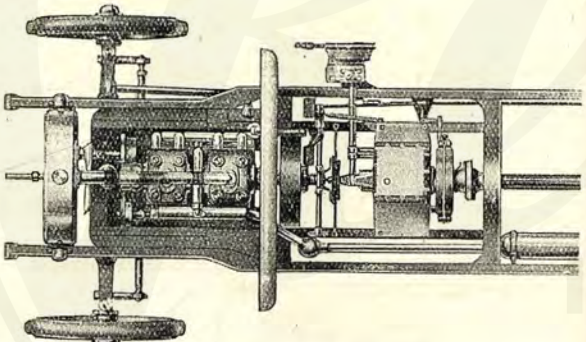
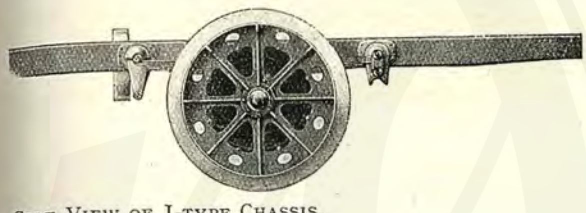


FIG. 2.—GENERAL ARRANGEMENT

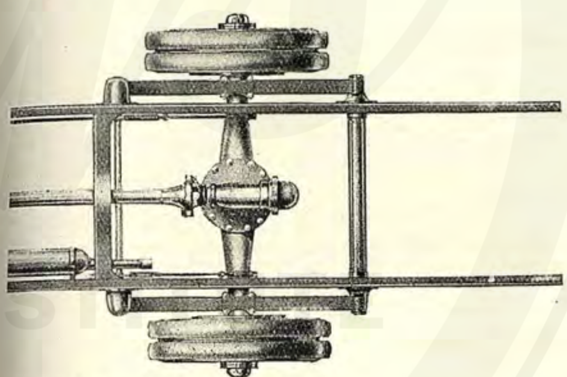
In the original J-type vehicles, the engine only was mounted in the three-point manner, and during the war we had cases of the engine and gear-box getting

out of line after specially severe service, resulting in rapid wear of the clutch spigot, failure of the front universal joint, and sometimes breakage of the crank-shaft.

9. **Front Axle and Steering Gear.** The front axle is of H-section steel, drop-forged in one piece and heat treated ; the swivel arms or stub axles are drop



SIDE VIEW OF J-TYPE CHASSIS.



PLAN VIEW OF J-TYPE CHASSIS.

forgings of nickel steel, with ball thrusts in the swivels, which greatly ease the steering.

The jaws are formed in the steel axles, and are fitted with hardened steel bushes to receive the hardened swivel pins.

Ball bearings are fitted generally throughout the steering gear, and a large lock is provided to facilitate manœuvring. Consequent on experience gained during the war, the general details of the steering gear have been considerably strengthened by the makers, partly by enlarging dimensions and partly by increased employment of alloy steels.

In the earliest " J " vehicles, it was occasionally found that the steering ball pins in the axle arms worked loose; this has been remedied not only by increasing the size of the ball pins, but also by housing them in deeper bosses in the axle arms.

The cross-over steering tube was furnished originally at one end with a brazed-in ball socket, and at the other end with a locking clip brazed to the tube into which the second ball socket screwed, thus rendering the length of the cross-over tube adjustable and so enabling the leading wheels to be kept always in correct alignment. The screwed thread proved, however, in some cases a source of trouble, for if the clip was not securely locked the thread quickly hammered away; accordingly all recent vehicles have both ball sockets brazed into the tube, and this practice is found in service to give entire satisfaction.

The steering gear is of the worm-and-nut type, a steel screw engaging with a nut having cast in it a threaded lining of white metal. The screw spindle is mounted in ball thrust and journal bearings, and the combination of screw and nut works immersed always in lubricant in an enclosed grit-excluding chamber, with the absolute minimum of friction and wear.

The leading wheels, agreeably with a W.O. requirement, run on floating phosphor-bronze bushes mounted

upon the stub axles; end play is taken up by inserting a thin *fibre* washer behind the thick bronze washer, which resists the end thrust. Steel washers should not be employed for this purpose, as they have a tendency

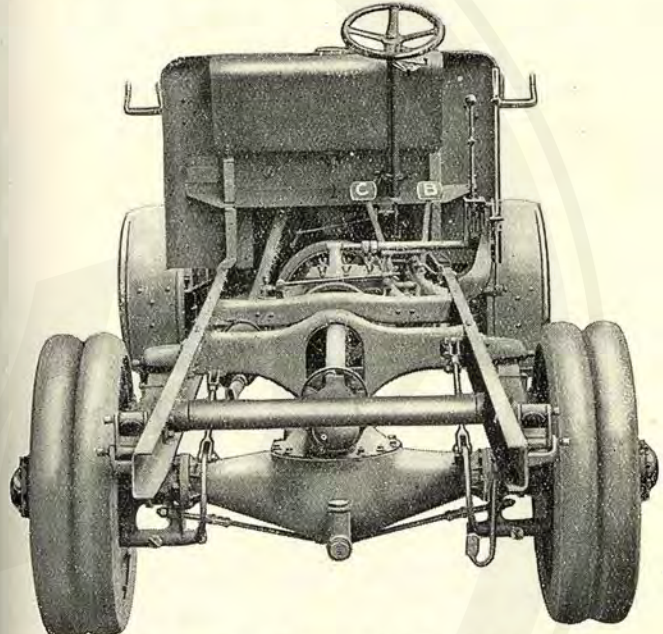


FIG. 3.—REAR VIEW OF J-TYPE CHASSIS.

to score a groove round the stub axle, which may result in its failure through rapid fatigue arising from its reduced diameter.

10. **Rear Axle.** The live rear axle is driven by an overhead worm (standard ratio 8·25 : 1), which, with the differential gear, runs immersed in oil in an enclosed

casing of cast steel. The worm, worm-shaft, and bearings may be readily examined or removed without even taking the load off the axle ; the external view of the rear part of the chassis, given in Fig. 3, indicates clearly how this may be done.

The general internal arrangement of the driving worm, worm-wheel, and differential is illustrated in

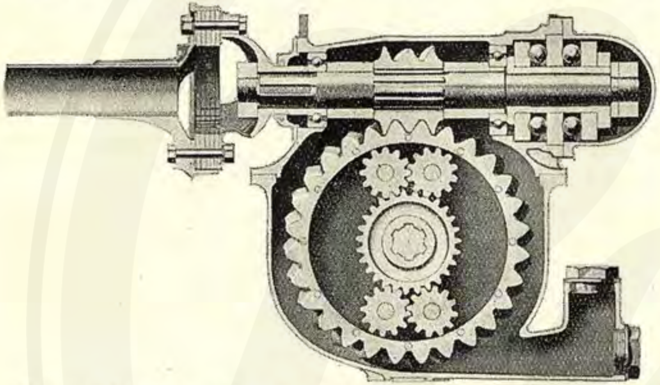


FIG. 4.—SECTIONAL VIEW OF DRIVING WORM, WORM WHEEL, AND DIFFERENTIAL OF J-TYPE CHASSIS.

Fig. 4 ; the splined worm spindle, with the worm at centre and rear universal joint on the left, is mounted in ball bearings, the driving thrust being resisted by the large double-thrust ball bearing on the right. The drive is transmitted to the worm-shaft through the tubular propeller shaft shown, the connection with the worm spindle being effected by a very simple and reliable universal joint, comprising a pair of forks connected to a series of superposed rings of flexible material, shrouded as indicated. During the war and for some little time after, leather rings were always used, but Messrs. Thornycroft have informed me that in some

tropical services it has been found preferable to use rings built up of alternate layers of linen and rubber, and this fabric is accordingly now fitted in many cases, though leather continues to be preferred by some owners. With either material this type of joint confers great smoothness and silence in service with a

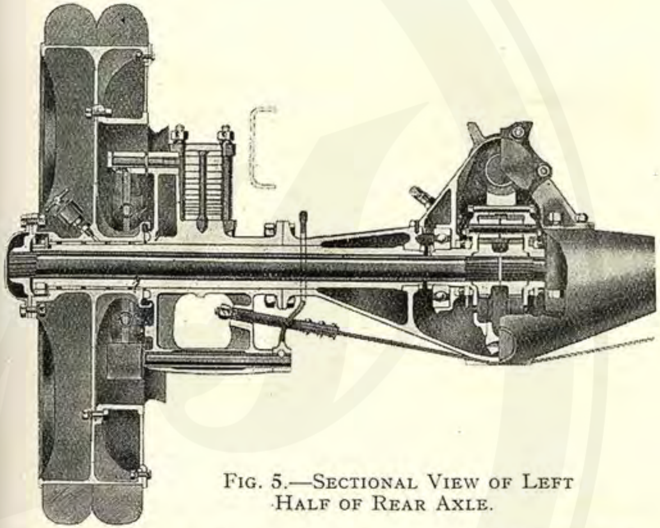


FIG. 5.—SECTIONAL VIEW OF LEFT HALF OF REAR AXLE.

flexible drive and entire absence of rattle or backlash, resulting from worn pins, as in the more usual arrangement. The leather or fabric rings are readily renewed. A section through the rear axle and one back wheel is given in Fig. 5.

11. The J-type Thornycroft vehicle dispenses altogether with " radius " and " torque " rods, extended experience in a great variety of circumstances having shown that the transmission both of the driving effort and of the torque reaction directly through the rear

bearing springs to the frame to be entirely satisfactory. The main drive being through the back springs, it is important that the holding-down bolts of these be kept tightly screwed up to prevent risk of shearing the head of the bolt passing through the centre of the spring itself, which spigots into the axle-palm ; should this occur, the rear axle might get seriously out of square with the chassis. Even if the bolt head is not sheared, if the spring bolts have become slack the axle can tilt sufficiently to cause early failure of the universal joint leathers.

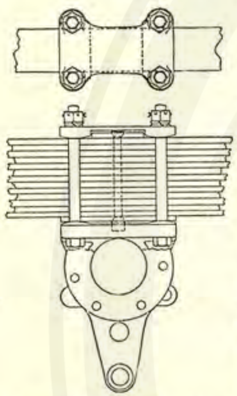


FIG. 6.—SPRING ATTACHMENT TO REAR AXLE.

In the earlier J-type chassis, the rear spring bolts required tightening at not infrequent intervals, the bolts being stretched by the large flexing of the springs caused by fast driving over bad surfaces. In later designs the (patented) modification illustrated in Fig. 6 is fitted ; the spring is gripped between the top " strong-back " and a second thinner plate on the axle palm, each being provided with two slightly projecting curved surfaces making line contact only with the spring at the bolt centres. Variations in spring camber with this arrangement have no tendency to stretch the holding-down bolts, which accordingly remain permanently tight.

12. The universal joint fork at the forward end of the driving worm spindle (*see* Fig. 4) was made originally, I am informed, in malleable cast-iron. While, in general, these proved quite serviceable—many hundreds of vehicles thus fitted having survived the war—it has yet been thought that, owing to the slight uncertainty of this material, particularly in so important a situation in the chassis, stamped steel forks are preferable, and such have accordingly been fitted in all recent J-type vehicles.

13. **Wheels and Tyres.** The road wheels are now of cast steel, and are ordinarily fitted with solid rubber tyres ; the leading wheels have single tyres $34\frac{1}{2}$ ins. diameter, the driving wheels, twin tyres, $41\frac{1}{2}$ ins. diameter. The track of the leading wheels is 5 ft. $7\frac{1}{4}$ ins., and the track, from centre to centre of tyres, 5 ft. 6 ins. for the driving wheels.

The standard J-chassis has a wheel base of 13 ft. $7\frac{1}{2}$ ins. ; but for coach and omnibus bodies chassis are built with wheel bases 14 ft. $4\frac{1}{2}$ ins. and 15 ft. 6 ins. The standard chassis will turn in a circle of about 53 ft. diameter, the long chassis in circles of about 56 ft. and 60 ft. diameters respectively.

Chassis for coach or 'bus service are furnished with a lower gear ratio (i.e. a higher revolution speed of back axle) and lighter rear springs to ensure comfort to the passengers. The solid rubber tyres fitted are guaranteed for 12,000 miles in the United Kingdom, but it is usually found in practice that their mileage life is considerably greater.

14. **Pneumatic Tyres.** It is sometimes urged that large pneumatic tyres would prove greatly superior to solids on quite heavy motor vehicles in certain services. Messrs. Thornycroft conducted some actual trials at Basingstoke during 1920, and the author is enabled to give here some of the results obtained.

At the date of these trials there was a comparatively small pneumatic tyre offered by the Michelin Co. in connection with their detachable plate wheels ; single tyres were provided for the front wheels and twins for the back wheels. The Goodyear and Goodrich Companies of America offered single pneumatics of very great size—the so-called "giant" tyres. British tyre manufacturers were also experimenting with pneumatics, but had not then put any designs on the market.

All the makers of these large pneumatics maintained that the life of the vehicles fitted with them would be prolonged in consequence of the lessened vibration, and urged this type of tyre as particularly suitable for passenger service and on vehicles carrying fragile loads as eggs, glass, furniture, etc. Some also claimed that an economy of petrol of 10 per cent or more would result, but others remained silent on this point.

It is by no means certain, however, that there is even lessened vibration with these large tyres, the experience of one company who used them for some time being that they had to be pumped up so hard that vibration was actually *increased*. Fuel consumption also would probably rather be increased than diminished. Messrs. Thornycroft's report is given hereunder—

15. "We enclose herewith copy of test report of a vehicle run over our standard test route of 28 miles, including main roads and cross-country roads. The chassis was first tuned up and then run over the test route on solid tyres. After this, the wheels were removed and replaced by Michelin wheels with pneumatic tyres, the vehicle being then run over the same route on the same day. We had, thus, the same vehicle, the same load, the same carburettor adjustment, the same road, and the same atmospheric conditions. The only difference was a slight alteration in the total gear ratio, owing to the pneumatic tyres having a diameter of 955 mm., whereas the diameter of the solids was 1,050 mm.

"As much of the running was done on the governor,

the vehicle speed on the pneumatics was slightly reduced.

"It will be observed that in these trials the fuel consumption was higher when using pneumatics. The sizes of the Michelin tyres used were as follows—

955 × 155 mm. singles on front wheels
955 × 155 mm. twins on rear wheels

"No mileage guarantee was offered, but the makers stated the tyres 'might do 9,000 miles.'"

JOHN I. THORNYCROFT & CO., Limited,
BASINGSTOKE.
22nd November, 1920.

REPORT OF ROAD TESTS OF A THORNYCROFT $3\frac{1}{2}$-TON MOTOR VEHICLE

Fitted with Michelin Wheels and Pneumatic Tyres as against Standard Wheels and Solid Tyres

	Michelin wheels and pneumatic tyres: 955 m/m	Standard wheels and solid tyres: 1,030 m/m.
Distance	28 miles	28 miles
Time travelling	1 hr. $36\frac{3}{4}$ mins.	1 hr. 33 mins.
Fuel (total)	4·19 galls.	3·6 galls.
Gross load	6·25 tons	6·25 tons
Speed (m.p.h. average)	17·3	18
Miles per gallon	6·68	7·77
Ton-miles per gall. (gross)	41·76	48·6
Fuel per gross ton-mile	·024 galls.	·020 galls.
Time per gross ton-mile	·55 min.	·53 min.
Carburettor (type)	Solex 40 mm.	Solex 40 mm.
Choke tube	28 mm.	28 mm.
Main jet	135	135
Pilot jet	55	55
Fuel per 1,000 revs. of driving wheels	2·228 pts.	2·06 pts.
Pulling	Good	Very good
Acceleration	,,	Good
Deceleration	,,	,,
Weather	Fine	Fine
State of roads	Greasy & sticky	Greasy & sticky
Date of trial	19/11/20 a.m.	19/11/20 p.m.

The fitting of pneumatic tyres in lieu of solids at the above date would also have involved a substantial increase in both first cost and annual running cost, the latter being based upon an estimated life of 9,000 miles for the pneumatics as against a guaranteed 12,000 miles for the solids.

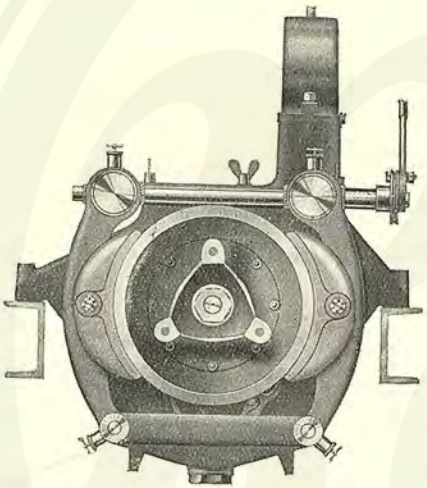


FIG. 7.—J-TYPE FOOT BRAKE

16. **Brakes.** Many of the earlier designs of foot-brake possessed the defect that the forces simultaneously applied to the two brake shoes were unequal, so that there was a resultant force pressing the brake drum to one side, which tended to deflect the shaft and threw an unnecessary and possibly large load on the adjacent bearing.

In the J-type Thornycroft lorry this point has received attention, and the action on the two shoes is always equal and opposite. The foot-brake itself is of the

external contracting type, operating on a drum of large diameter mounted just behind the gear-box. (*See* Figs. 2, 7, and 14.) In all recent vehicles, the drum is machined all over, thus ensuring that it is in balance; this is important, as it revolves at considerable speed, and hence any want of balance would set up pressure

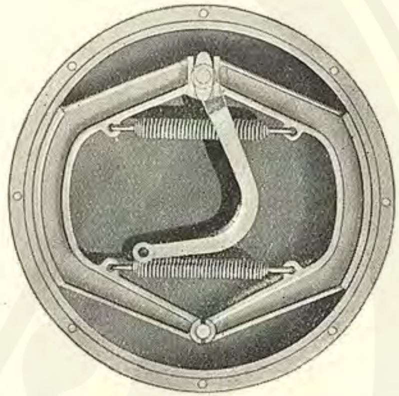


FIG. 8.—EARLY FORM OF REAR BRAKE.

in the adjacent bearing and might prove a source of unpleasant vibration at high speeds.

Reference may be made here to the casting forming the housing of the ball bearing and ball thrust bearing at the rear end of the gear-box. As shown in Fig. 14, this was for some time attached to the gear-box casting by three studs only, but in all recent vehicles the number of studs has been increased to six, which provides a more rigid support for these bearings.

The Hand Brake. The hand brake operates directly on the two rear road wheels, and is of the internal expanding type, the shoes being lined with pads of a die-pressed asbestos composition, which are pressed against the inner surfaces of large brake drums bolted to the rear wheel hubs; a view of the earlier form of rear brake, without asbestos pads, is shown in Fig. 8 while Fig. 9 shows a brake in place on the chassis.

The rear-brake shoes were originally of cast-iron and,

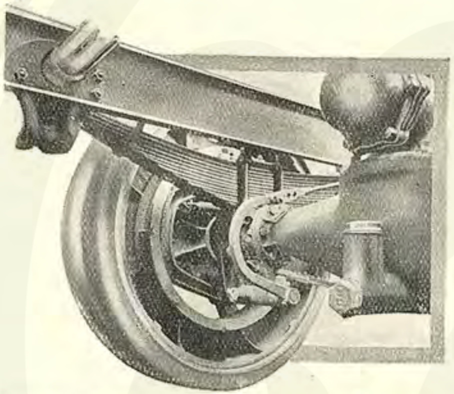


FIG. 9.—VIEW OF REAR BRAKE IN POSITION.

on the whole, rendered good service, though we had a number of breakages caused by stones getting in, and sometimes also as a result of exceptionally rough usage. In all recent vehicles the shoes are of cast steel, fitted with asbestos composition pads as already mentioned.

The rear-brake drums were originally strengthened by the addition of a pair of flanges through both of which passed the securing bolts, as indicated in Fig. 9, but the latest drum is a plain flanged cylinder of cast steel, as shown in Fig. 10. Thus the rear brakes are now made in cast steel throughout, and are consequently of great strength and durability.

The War Office scheme required the hand-brake to be of the " push-on " type, but I think the makers have done wisely in changing this to the more convenient and more usual " pull-on " pattern in all recent vehicles. Both foot- and hand-brakes are immediately adjustable by the driver without involving the use of any tools.

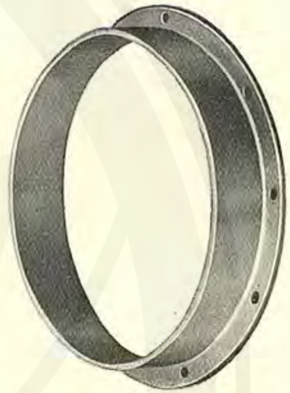


FIG. 10.—IMPROVED FORM OF BRAKE DRUM ON THORNYCROFT MOTOR VEHICLES.

For years, many motor designers have arranged the rear brakes so that they should be " compensated," i.e. some device has been incorporated in the leverage providing that the two brakes should both act equally and automatically on operating the hand-lever. These usually behaved satisfactorily when correctly adjusted, but unfortunately they were often incorrectly adjusted, whereupon their advantages promptly disappeared.

Messrs. Thornycroft have informed me that some time ago, after a careful examination of the whole question, they came to the conclusion that rear-brake compensation was practically unnecessary, and that, on the whole, more satisfactory braking was obtainable by adopting a direct connection between the hand-lever and the two rear brakes; the objection that with this arrangement it is possible for a careless man to adjust the brakes so that only one acts, has been met by causing the adjustment to be effected on a single rod acting equally on both brakes.

On first assembling, care is taken that the clearance between pads and drums, when disengaged, is equal throughout ; if on application of the brakes, when new, any slight difference in pressure exists, it is found that this rapidly adjusts itself, the brakes thereafter acting equally and the pads wearing down at an equal rate. With compensated brakes, failure of either renders the other inoperative ; it is an important advantage of the arrangement adopted by Messrs. Thornycroft that failure of either brake does not in any way prejudice the action of the other.

17. **Undershield.** As shown in Fig. 1, a light sheet steel undershield, fixed under the forward part of the chassis, protects the mechanism above from mud and grit. The minimum clearance under the chassis, when fully loaded, is about 12 ins.

18. **Control.** There are two levers on the steering column, by one of which the time of ignition may be varied, while the other regulates the admission of mixture to the engine through a throttle valve placed just above the carburettor ; this throttle may also be operated by a foot accelerator. A second throttle valve placed just above the hand throttle is governor-operated, and prevents the engine from being run at an excessive speed. (*See* Fig. 18.) The two pedals are arranged in the usual manner, that on the left operating the clutch and on the right the foot-brake. (*See* Fig. 3.)

19. **Radiator and Cooling.** The radiator, mounted on trunnions, is of the excellent take-down type, the top and bottom reservoirs being bolted to the upper and lower tube plates respectively ; defective tubes are thus readily replaceable, and the radiator is easily accessible for complete internal cleansing when required. A front view is given in Fig. 11.

We found the pattern of radiator required by the

War Office too high to enable the driver to see clearly in front of the vehicle, and for the same reason very inconvenient when requiring to be filled with water. Driven by a V-belt from the engine, and situated immediately behind the radiator, a three-bladed fan maintains a strong current of air through it and gives adequate cooling effect even at the lowest vehicle speeds. The cooling water is circulated by a centrifugal pump, also driven by the same V-belt ; but the water pipes fitted are as large as if the cooling were of the "thermo-syphon" or "convection" type, thus minimizing pumping effort and providing a means of maintaining a temporary water circulation in the event of failure of the driving belt.

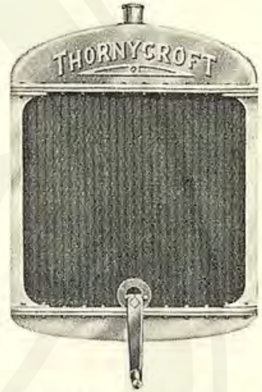


Fig. 11.—Front View of Radiator.

With the quality of petrol now supplied, the circulating water should be kept at as high a temperature as possible, short of boiling.

In cold weather the cooling is frequently *too* effective and at such times it is of benefit to blank off part of the radiator. Good results are obtained either by fitting baffles at the back ranging from $\frac{1}{4}$ to $\frac{1}{2}$ of its height, or a variable blind may be fitted in front if preferred.

20. **Petrol Tank.** This has a capacity of 20 galls., and is fitted on the dashboard (Fig. 1). Thus placed, there is an adequate "gravity feed" to the carburettor in all circumstances of running. A specially large filter is provided, which renders unnecessary the use of a funnel.

21. **The Clutch.** A sectional view of the clutch appears in Fig. 12, which shows also the clutch pedal and the leather or fabric universal joint interposed between the clutch and the gear-box. The clutch itself is of a simple cone type, the inner member consisting of

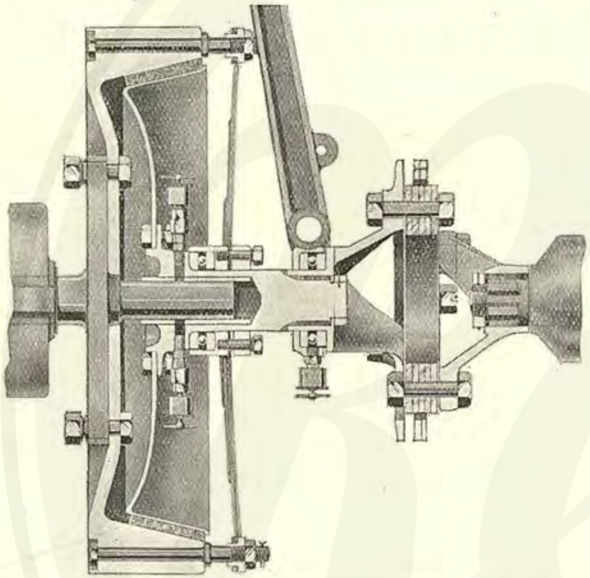


Fig. 12.—Sectional View of Clutch and Forward Universal Coupling.

a very light pressed steel dished cone, of large diameter, faced with asbestos fabric. This engages with the coned inner surface of the fly-wheel rim, the necessary pressure between the two being provided by an easily adjustable laminated spring acting through a ball-thrust bearing as shown.

The large diameter of the clutch cones and the small

mass of the driven member ensure smooth running, absence of slip, and long life to the asbestos lining. An efficient clutch stop is provided to facilitate gear-changing. The general arrangement of this part of the chassis is clearly shown in Fig. 13. The clutch spring is adjustable at any time in a few minutes, as the adjusting nuts being at the flywheel rim are readily accessible. In the most recent J-type lorries, I notice that the

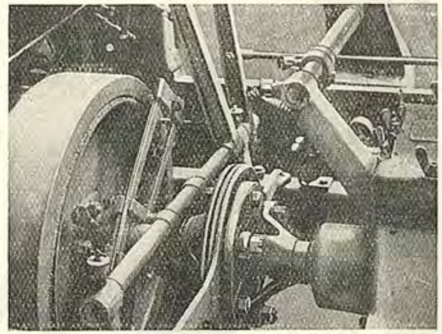


Fig. 13.—View of Clutch and Laminated Clutch Spring Adjustment.

pressure needed to operate the clutch is considerably reduced.

22. **Use of Clutch.** Drivers should not make a practice of slipping the clutch in order to get the vehicle under way when in too high a gear, as this causes heating and undue wear of the clutch fabric.

To change from a lower into a higher gear, the clutch pedal should be pressed firmly down and the gear freed by the change-speed lever ; a pause for a second or so should then be made before engaging the higher gear.

In changing *down*, it is preferable to adopt " double clutching." Thus, in dropping from, say, top to third speed, the clutch pedal should be first slightly depressed and the gear moved into neutral, at the same time releasing the clutch. The pedal should then again be slightly depressed so as partially to disengage the clutch, when it will be found that, with a little practice, the third speed can be quietly engaged; the engine need not be throttled down during double clutching. Great care should be taken to avoid jarring or grating the gears when changing.

23. **The Gear-box.** This is a one-piece casting, provided with a large inspection cover on top; there are four forward speeds and a reverse, with gate change, the top speed giving a direct drive.

In Figs. 2 and 3 the change lever is on the driver's right, but in the most recent J-type chassis it is placed centrally (i.e. on the left of the driver). With the engine running at 1,000 r.p.m., the vehicle speeds are—

Top (fourth)	14·5	m.p.h.
Third	8·5	,,
Second	5·0	,,
First	2·75	,,
Reverse	2·25	,,

A sectional view is given in Fig. 14; the shafts are short and stiff, and are carried in ball bearings. The through shaft is of square section within the gear-box, with a splined rear end to which is attached the fork of the second of the three universal joints; the foot-brake drum is bolted to a flange formed with this fork, as shown. The front end of the through shaft is cylindrical, and upon this end rides the bushed first member of the gear, which is carried in ball bearings and is furnished with a splined forward end to which is attached the fork of the first universal joint (i.e. that between the gear-box and clutch. (*See* Fig. 2.)

The gear wheels were made originally all of cut and case-hardened steel, but I am informed that in recent vehicles heat-treated alloy steel is employed for the third-speed wheel and pinion, as these are specially hard-worked in ordinary service.

24. The only parts of the gear-box ordinarily liable

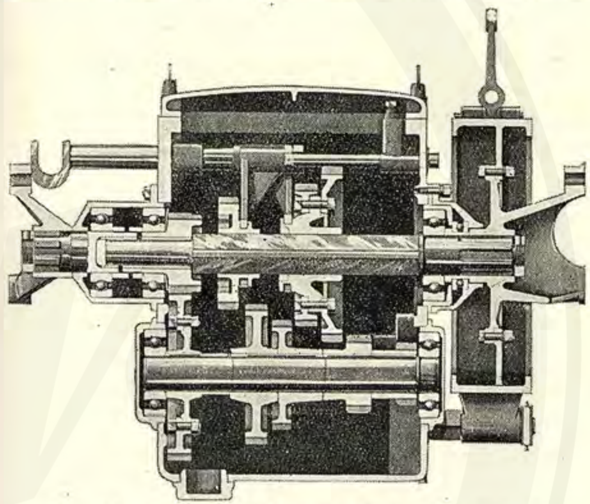


FIG. 14.—SECTIONAL VIEW OF J-TYPE GEAR-BOX.

to damage are the engaging surfaces of the gear wheels; however excellent may be the material of which these wheels are made, if damage is to be avoided, judgment and care in gear changing must be exercised. When climbing hills, drivers are apt to carry on as far as possible in top gear, and have then no time to adjust the engine speed to that of the vehicle in double clutching, so that when a change down becomes imperative, the gears are forcibly thrust into engagement, chipping their edges and in time stripping away a considerable portion of the working width of the teeth. When chipping is detected, the gear-box should at once be thoroughly cleaned out, or the steel chips may get into the ball bearings and cause extensive damage. Drivers should have it strongly impressed upon them that a four-speed gear-box is provided to allow the engine to be run always at its proper speed and also that there is no merit whatever in postponing a change down as long as possible. By changing down in good time, labouring of the engine is avoided, and the change can be quietly effected without any necessity of slipping the clutch.

It has already been mentioned that the most recent J-type Thornycroft lorries have the gear-change lever (and the hand-brake lever also) on the left of the driver. We older drivers were taught to steer with the left hand and use the right for gear-changing, braking, and signalling, and to us at first the change is just a little awkward; experience shows, however, that drivers who have learned on the older method very soon become quite at home with the newer. The principal difficulty felt at first is that with the older arrangement hand-signalling to other road vehicles was done with the right hand, and thus there was no necessity to change hands on the steering-wheel on such occasions; but this is soon overcome. The main reason for the change —which is now being widely adopted both in heavy lorries and in cars—is that with the older method a change-speed shaft has to be carried from near the centre of the chassis to the extreme right-hand side; constructionally this was always somewhat awkward, and trouble was at times occasioned through friction and even jamming of the various links and levers necessarily involved. With the newer method, the

change-speed lever is fixed directly on the gear-box, fewer connecting members are required, and all the above-mentioned risk of jamming is eliminated. In practice it is found that the left-hand gear change results in much easier operation due to reduction in friction; there is a saving also in production cost, in the number of parts, and in wear and tear in service.

25. **The Engine.** The engine is of the four-cylinder vertical water-cooled type, Mark M/4, with cylinders in pairs. The bore is 4·5 ins. and stroke 6 ins., and the R.A.C. rating accordingly $0{\cdot}4 \times 4{\cdot}5^2 \times 4 = 32{\cdot}4$. Actual bench tests show that fully 34 B.H.P. may be developed at 1,000 r.p.m.; some test results are given in Chapter VI.

Cylinders. The cylinders are of the T-headed type in cast-iron, flat-topped, and well water-jacketed; an external view from the exhaust valve side appears in Fig. 15, and a partly longitudinal section is given in Fig. 16.

The large inspection doors provided in the crank-case will be noted in Fig. 15; also the rising water mains of large diameter, the plain hot-air casing surrounding the exhaust manifold, and the location of the magneto, with its driving spindle carrying at the forward end a pulley driving the air fan and centrifugal water pump by V-belt, as already described; further details of this drive appear in section in Fig. 16.

26. **Pistons.** The pistons are of cast-iron having flat crowns, and with three narrow spring rings near the top and a scraper ring lower down. Just below the scraper the skirt in earlier engines was recessed and perforated as indicated. The present design effectually prevents waste of lubricating oil by passing upwards into the combustion chamber, where, as so often happens, it is partly burnt and causes rapid deposition of

carbon therein, and also upon the piston crown and in the exhaust pipes and silencer. Some further remarks upon the important point of oil consumption will be found in Chapter VI.

27. **Connecting Rods.** These are of I-section, in stamped steel with a bronze bushed eye and white-metalled big ends, the cap being attached by two bolts.

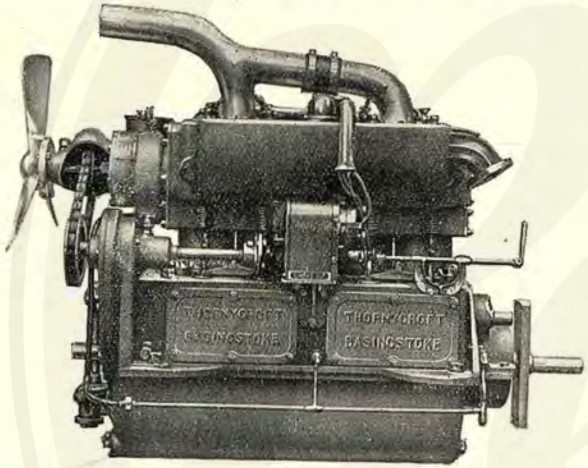


FIG. 15.—40-H.P. ENGINE. (EXHAUST SIDE VIEW.)

In the earlier engines, bushes wholly of white metal were fitted, but in recent engines a much stiffer and more durable big end bearing is obtained by using white-metalled bronze shells. Earlier engines also had the gudgeon pin fixed in the piston bosses, but the present practice is to use a floating gudgeon pin. In Messrs. Thornycroft's view, when the bearing surfaces in the eye and piston bosses are suitably proportioned, the wear with a floating pin does not exceed that with

a fixed pin, and it is considered that there is less liability to piston seizing and "flap." The floating gudgeon avoids all risk of distorting the piston in fitting and especially in replacing. Connecting rods very rarely fail. The only two failures in my experience both occurred at the smallest section, near the eye end, and appeared to have resulted from the hammering action set up during heavy running with slack big ends. Immediate attention should be given to any engine knock; if caused by slack big-end bolts, these are simply tightened up and re-locked; should the bearing be worn, it must be taken up as described in § 98.

28. **The Crankshaft.** The solid steel four-throw crankshaft is carried in three long bearings of white metal (Fig. 16), and terminates rearwards in a long palm for the attachment of the flywheel and spigot for guiding the clutch. (*See also* Figs. 12 and 15.)

The author has rarely experienced breakage of a crankshaft except in cases where vehicles have been re-conditioned after severe war service. Every case of failure investigated has occurred in early type vehicles, and has proved to have been caused by a slight sagging of the underframe, causing the engine and gear-box to become out of line. This cannot happen with recent J-type vehicles, as already explained in § 8.

Owners of early type vehicles will find a simple method of lining up the gear-box with the engine described and illustrated in Chapter IV.

29. **Lubrication.** Lubrication is forced by a rotary gear-pump mounted on the front of the crank-chamber and driven from the camshaft through an external vertical shaft, as shown in the lower left-hand corner of Fig. 16; in all recent vehicles this pump is fitted near the level of the oil in the crankcase sump; it is thus

free from liability to failure of suction, and no priming tank is then required. The pump forces oil to all the crankshaft main bearings and to the big ends of the connecting rods through the ducts indicated in Fig. 16, whence it exudes and lubricates the pistons, cam-shafts, tappet-rods, etc., by the splash. The pressure in the

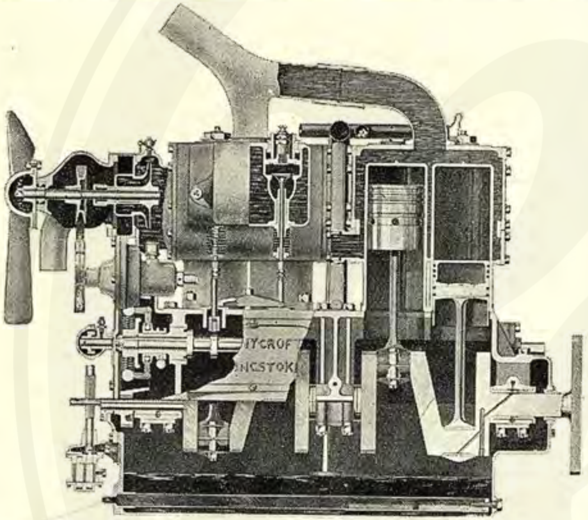


FIG. 16.—40-H.P. ENGINE. (SECTIONAL VIEW.)

oil pipes is regulated by a relief valve, and a long strainer is provided in the pump suction, which can be withdrawn from the front of the engine for cleaning, as shown in Fig. 16.

The early J-type vehicles had the oil pump situated above the oil level in the sump, rendering it necessary to prime the pump before starting, particularly in cold weather. Failures of big-end bearings sometimes occurred through drivers racing the engine on starting

in winter, in the hope of persuading the pump to function without a preliminary priming ; the whitemetal of the big ends became thus heated and plastic, and filled up the oil grooves, causing subsequent complete failure when under load from lack of lubrication. An indicator is fitted on the top of the crankcase, showing by inspection the level of the oil in the sump.

30. Over-lubrication of the pistons, with consequent waste of oil, increase of carbon deposits, smoky exhaust, oily plugs, and loss of power is caused largely through main bearings, and especially big-end bearings being worked in too slack a condition. If the pistons themselves are not worn, this waste may be prevented by fitting baffle plates between the cylinders and crankcase, which is very quickly, easily, and cheaply done. The mileage per gallon of oil in one case in the author's experience was, in this simple manner, just doubled. All recent engines are so fitted by Messrs. Thornycroft, except where their special narrow-ringed pistons are provided, when the baffles are omitted, as it is found that when used in conjunction these pistons have a tendency to remain actually too dry. Some further remarks on oil consumption will be found in Chapter VI.

31. **Valves.** The valves being on opposite sides of the cylinders, there are two camshafts which are driven by single helical cut gears from the crankshaft, as shown in the front view of the engine (Fig. 17). The valves are interchangeable and very readily accessible through holes above closed by the bayonet jointed cone-seated plugs that have been a feature of Thornycroft engines for many years. In Fig. 17, roller-ended plain tappets, as originally fitted, are shown ; but in all recent engines, roller-ended tappets, with adjustable heads working in guides, are provided, giving very much increased bearing surface ; the wear of the tappet

guides and consequent rattle is thus much diminished, and the easily-adjusted tappet clearances enable the engine to be quietened and the full lift of the valves always maintained with scarcely any trouble.

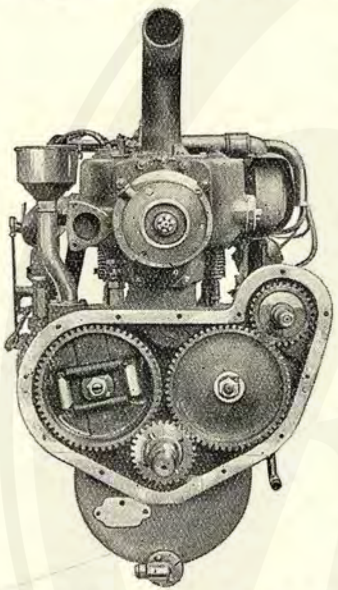


FIG. 17.—FRONT VIEW OF 40-H.P. TYPE M/4 ENGINE, WITH TIMING GEAR AND GOVERNOR EXPOSED.

The cylinders are now fitted also with removable valve guides; these, when quite worn out after having once been reamered out and fitted with over-size valves $\frac{1}{32}$ in. large in the stems (*see* § 83), are readily replaced, the old guides being simply pushed out and the new ones pushed in.

32. **The Governor.** The gear wheel of the inlet camshaft is arranged to form also the "spider" of a neat and compact centrifugal shaft governor, which is completely enclosed within the crankcase; it is clearly shown in Figs. 16 and 17.

This governor actuates a throttle placed in the inlet pipe, as already described in § 18, and thus determines the maximum revolution speed of the engine.

33. **The Magneto.** The accessible position of the high-tension magneto will be noted in Fig. 15. It is

driven by a special shaft, parallel to the crankshaft, by means of a single helical pinion meshing with the wheel of the exhaust valve camshaft. In the earlier engines fitted to J-type lorries, the shaft driving the magneto was carried in a plain white-metal bearing; this shaft, as will be seen on reference to Fig. 15, has a forward extension, upon which is mounted a pulley from which the radiator fan and water-circulating pump are driven by a V-belt. It was found that owing to the pull of the belt, this white-metal bearing soon wore sufficiently slack to render the drive rather noisy. The design was accordingly modified by replacing it by a ball bearing of which the wear in this position is negligible. As a plain collar-thrust bearing is much quieter in action than a ball thrust, and as the plain thrust also holds up well in service, this has been retained; the combination of ball-bearing and plain thrust-bearing has proved very satisfactory.

The ignition can be varied, as already mentioned in § 18.

34. **The Carburettor.** The carburettor fitted to the M/4 Thornycroft engine is the Thornycroft type of "Solex," and a supply of warmed air for it is derived from a casing fitted over the exhaust pipe, as shown in Fig. 15. An external view of the inlet valve side of the engine, showing the carburettor in position, together with the hand and governor throttles, and the inlet manifold, is given in Fig. 18; and a sectional view of the carburettor itself, as fitted in J-vehicles of War Office type, in Fig. 19.

In the "Solex" carburettor, the proportion of petrol to air is automatically regulated by employing a jet submerged in a petrol well. The level of the petrol in the well varies with the difference in pressure between the atmosphere and that at the *vena contracta* of the choke tube, and advantage is taken of this variation in level to cause more or less air to mingle with the petrol issuing from the jet. The carburettor is completely enclosed, and thus cannot easily be tampered with by unauthorized persons.

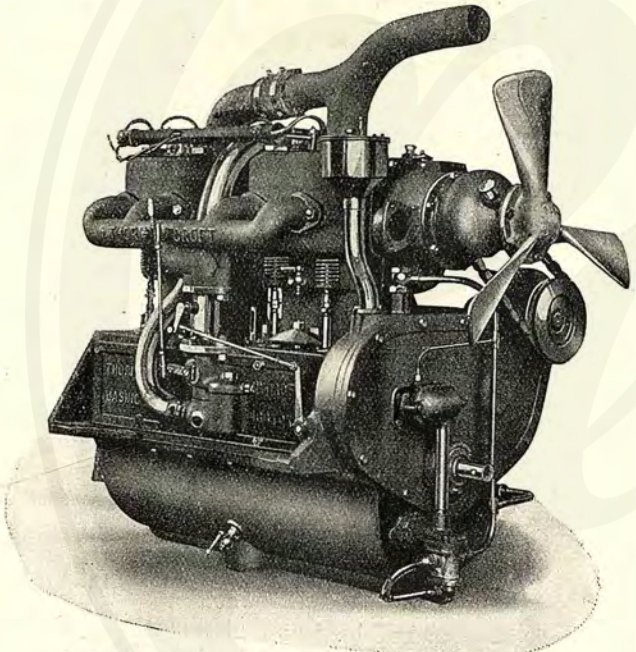


FIG. 18.—40-H.P. ENGINE. VIEW OF INLET SIDE.

35. Referring to Fig. 19, petrol is supplied to the top of the float chamber through the branch shown on the right, the flow being regulated by the short needle valve p, with the lower end of which the top surface of the float is in direct contact. Through the duct shown

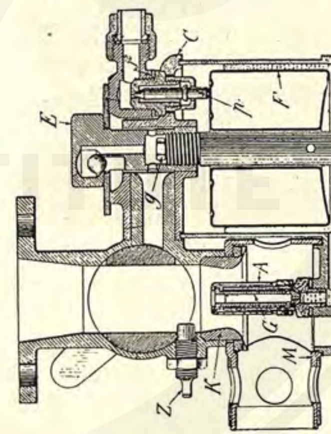


FIG. 19.—SECTIONAL DIAGRAM OF EARLIER THORNYCROFT-SOLEX CARBURETTOR.

A = Jet cover. C = Float chamber cover. E = Dismounting nut. F = Float. G = Main jet. g = Auxiliary jet. K = Choke tube. M = Main air inlet branch. Z = Throttle by-pass screw.

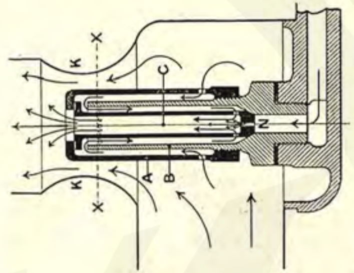


FIG. 20.—ENLARGED VIEW OF CARBURETTOR NOZZLE.

A = Jet cover. B = Jet carrier. G = Petrol well, or main jet tube. $K K$ = Choke tube. N = Main jet. $X X$ = Petrol level when at rest.

from the bottom of the float-chamber, the petrol next passes to the compound nozzle, shown to an enlarged scale in Fig. 20. *G* is the petrol well, having in its bottom a small orifice, *N*, termed the " main jet " ; and just above this orifice two small holes are bored in the walls of the tube *G*.

Surrounding *G* is a second tube *B*, closed at the bottom and open at the top ; and surrounding *B* is a third tube *A*, having, near its lower end, a row of holes open to the atmosphere as shown. The main choke tube is indicated at *K K*, and the top of the nozzle is at, or near, the level of the *vena contracta*.

The action is as follows : When the engine is at rest the petrol stands within the well and surrounding annular space between *G* and *B*, at the level *XX*. On starting the engine, the partial vacuum produced in the choke tube sucks the petrol out of the well and annulus, and so helps to give a rich starting mixture. The engine having started, the increased suction causes the air to completely empty the annulus and pass into the tube *G* by way of the two small holes near its bottom, wherein it mingles with the petrol in the well, the super-rich mixture next issuing from the top of the nozzle, where it meets and mixes with the main air supply passing through the choke tube. If, owing to increased engine speed, the suction at the *vena contracta* is increased, more air flows into the bottom of the petrol well, thus relieving the suction at the orifice and so preventing the tendency of the mixture to increase in richness with the engine speed, and *vice versa*.

36. The proportions of the orifice, choke tubes, and holes are ascertained by experiment, and the carburettor as adjusted by the makers should on no account be tampered with by the driver. It will be noted that the tube *G* is very easily changed if it be desired to work with a larger or smaller orifice.

For slow running, what is virtually a secondary carburettor is provided. Referring to Fig. 19, it will be observed that above the choke-tube a cylindrical throttle is fitted which, when almost closed, connects the auxiliary choke-tube (shown on the right) with the inlet pipe to the engine. At the right-hand end of this auxiliary choke-tube is situated the auxiliary jet *g*, which is in communication with the petrol in the float-chamber through the holes in the lower part of the hollow central column, as shown. The necessary air is supplied through holes in the plate below the large nut *E* ; the shank of this nut is smaller than the upper portion of the carburettor through which it passes, and around the annular space thus created, air passes, traversing the auxiliary jet *g* through the small holes shown.

A simple ball valve within the nut *E* automatically provides for a supply of extra air when required, as, for example, when the throttle is suddenly closed, bringing the auxiliary carburettor instantaneously into operation under strong engine suction, and thus tending to cause a heavy rush of petrol through *g*. The increased suction, however, causes the ball immediately to rise from its seat and admit additional air, so preventing waste of fuel. The screw *Z* (Fig. 19) regulates the extent to which the throttle may be closed down, and thus enables the slow-running speed of the engine to be adjusted.

The 1923 Thorny-Solex carburettor is shown in section in Fig. 21. So far as the main jet is concerned, no change has been made, but the auxiliary jet is now situated nearer to the main jet, as shown. The air supply to this auxiliary jet is by way of the passage *Y* and the annular space surrounding the jet nut *g*. By means of a spring-mounted rod *X*, the float may be depressed so as to cause the carburettor to flood and thus facilitate starting from cold ; this " tickler," as it is called, should not be violently used ; a gentle, steady pressure with

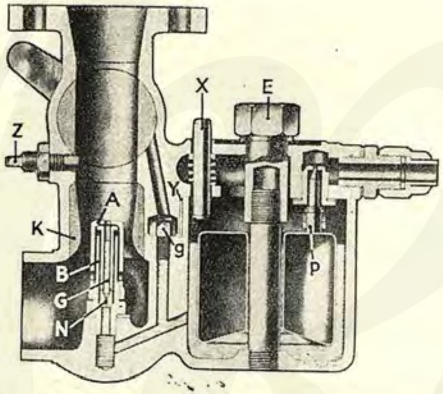


FIG. 21.—SECTION OF IMPROVED THORNYCROFT-SOLEX CARBURETTOR.

A = Jet cover.
B = Jet carrier.
E = Dismounting nut.
g = Auxiliary jet.
G = Main jet.
K = Choke tube.
N = Spraying orifice of main jet.
P = Needle valve.
X = " Tickler."
Y = Air passage to auxiliary jet.
Z = Throttle by-pass screw.

one finger is all that is necessary, and risk of damaging the light metal float is thus avoided.

In addition to the above changes, this improved carburettor is somewhat deeper in the body, in order to accommodate a rather larger choke-tube of more effective form. The carburettor itself is also now made up of two main castings only, whereas the earlier pattern involved more, together with some brass tubing

and soldered joints—the latter always an objectionable feature in a carburettor.

37. A distinguishing feature of the Thorny-Solex carburettor is the unusually easy accessibility of its internal parts ; by simply unscrewing the large nut *E*, the whole device comes apart.

The main adjustments consist in changing the main and auxiliary jets and the choke-tube, and these are settled before they are sent out ; the standard sizes used are—

Item.	*No.*
Main jet *G*	120
Auxiliary jet *g*	65 or 70
Choke tube *K*	28

38. Messrs. Thornycroft state that over their standard 28-mile course at Basingstoke, including various types of road, a properly-adjusted fully-loaded J-type vehicle runs from 7·5 to 8 miles per gallon, or 60 to 65 gross-ton-miles per gallon, *without coasting* ; on a straight run along the main road, coasting whenever possible, the mileage per gallon is increased to from 8·75 to 9. And that on the main road, with a trailer, and non-coasting, from 80 to 85 gross-ton-miles are obtainable per gallon of petrol.

38A. A general reference is made in § 2 to alterations from time to time made in the J-type vehicle as the result of experiences gained during the progress of the war, and I am indebted to Messrs. Thornycroft for permission to use the tabular statement following which embodies most of these alterations and this may be found useful by owners. This table was originally got out for the use of the War Office, and is brought down to the end of June, 1918.

Alterations in Details of Type "J" Thornycroft War Department Lorries. August, 1914, to March, 1917

ENGINE CRANKCASE AND FITTINGS.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
June, 1915	Fitting of indicator to show level of oil in engine crankcase	63,818 63,819	63,312 60,724	Crankcase interchangeable
Mar., 1916	Plain valve tappets replaced by adjustable roller tappets. Diameter of tappet guide spigot increased, necessitating larger hole in crankcase	64,252 64,244 62,749 62,750 64,242 64,251 64,006 64,243 —	63,818 43,234 60,845 — 44,449 43,208 — — 47,365	
Apr., 1916	It was found advisable to increase diameter of tappet guide spigot mentioned above, necessitating larger hole in crankcase for same	64,884 64,883 64,887	64,252 64,251 64,007	

PISTONS AND CONNECTING ROD.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Feb., 1915	Height above gudgeon pin increased $\frac{1}{16}$ in. Depth below increased $\frac{11}{16}$ in. Oiling groove omitted. Six $\frac{9}{16}$ in. holes added below gudgeon pin	62,944	61,081	Interchangeable
Jan., 1916	Big end bush changed from white metal to brass stamping white metal lined	63,716 63,717 63,699	49,431 49,432 49,452	Interchangeable as a complete rod
June, 1916	Skirt thickened up	64,474	62,944	Interchangeable

FAN, PUMP, AND MAGNETOS WITH THEIR DRIVES.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Nov., 1914	Plain bearings on magneto-driving shaft replaced by ball bearings	63,214 Ball B Auto 252	60,779 60,772 —	Interchangeable if ball-bearing is included
,, ,,	Driven pulley mild steel stamping instead of brass Driving pulley solid instead of in halves	63,225 — 63,226 —	62,475 62,092 62,093 62,094	Interchangeable
,, ,,	Washers added to accommodate ball bearings	63,250 63,251	— —	
Nov., 1915	Increase fan in diameter	57,790	54,925	Interchangeable
Jan., 1916	Change fan pulleys from ½ in. to ⅝ in. belt	64,247 64,245	63,226 63,225	Interchangeable
Nov., 1916	Ball bearing and detachable housing with thrust bearing, added in place of plain white metal bushes	65,359 65,361 65,239 65,356 65,360 65,358 65,357	— 60,774 64,884 — 62,361 — 60,773	

STEERING GEARS.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Feb., 1915	Adjusting plug in bottom of steering gear box enlarged to facilitate operation of boring inside for ball bearings Arms of **quadrant lever** increased in width and slot in rocking disc widened to suit	57,731 57,732 57,733 57,751 57,818 57,819	54,530 54,531 54,536 54,537 55,046 47,535	Moving parts interchangeable Interchangeable as a set of lever and two discs
Oct., 1915	Spring-loaded ball joint fitted at front end of fore and aft tube in place of plain type	Sk. R3/662	Sk.R3/589	Interchangeable
Sept., 1916	All lever bosses holding ball joint pins made deeper to accommodate longer shank on ditto	58,239 58,240 58,237 58,238	57,267 54,399 57,224 58,226	
Sept., 1917	Bracket fixing column to footplate superseded by new bracket bolted to dashplate	58,312 57,721 58,314	57,613 — —	New bracket can be fitted to any chassis of "J" type

CHANGE SPEED GEAR.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Dec., 1914	Hand-lever shaft shortened and near side bearing bracket removed from side member of frame to front of gear-box	57,895 57,652 57,650 57,863	56,902 54,990 54,992 54,995	Interchangeable
Dec., 1916	New laminated springs at bottom of lever in place of single leaf type	58,294	54,996	Interchangeable

Alterations in Details of J-type W.D. Lorries.

REAR AXLE, INCLUDING WHEELS.

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Apr., 1915	New type bar anchored on spring palms substituted for old pattern attached to flanges of central casting	57,935 57,936 57,937 57,938 —	57,236 57,249 57,461 57,257 57,255	
Jan., 1916	New central casting with deeper section arms. Also new type flat tie bar with stamped end riveted on in place of round section flattened in centre	V. 562 58,121 58,146	V. 554 57,938 —	Interchangeable Interchangeable
May, 1916	Sleeves carrying wheels screwed with coarser thread for locknut; also fitted with new type, locking arrangement for same, which involves a new thrust washer	58,208 58,212 58,210 58,211 58,243	57,237 57,238 56,076 58,127 55,510	Old nuts 16 T.P.I. New nuts 10 T.P.I. When thread on old sleeves becomes worn, new thread may be cut on slightly small diameter and special nut fitted. For details, *see* Drawing Sketch 4086
June, 1916	Recess machined in outer face of nave for new bronze thrust washer	57,729 58,283 T. 258	57,729 — —	Wheel with recess and washer interchangeable with wheels without ditto
Aug., 1916	**Brake Shoes.**—Separate renewable pads instead of solid shoes	57,748 57,749	54,481 —	Interchangeable

MISCELLANEOUS ASSEMBLIES.

5—(4534w)

Date.	Nature of Alteration.	Part No. of New or Altered Part.	Drawing No. of Original Part.	Remarks.
Nov., 1914	**Hot-air Oven.**—Oven deepened	63,209	60,840	Interchangeable
Feb., 1915	**Hot-air Pipe.**—Made in one piece as against two. Bend with sleeve, etc., cancelled	63,310 63,311 — — —	62,582 60,829 60,870 49,194 48,967	Interchangeable
Oct., 1914	**Propeller Shaft.**—Shroud ring fitted over universal coupling leathers	57,766	56,974	Interchangeable
Jan., 1915	**Universal Coupling.**—Between clutch and gear-box altered from 2-arm to 3-arm, with leathers to suit	57,765 57,784	56,334 56,457	Interchangeable as a pair
Mar., 1915	**Towing Hooks.**—New standard pattern substituted for old type	57,977 57,976 57,808	56,053 57,453 54,564	
Jan., 1916	**Sprags.**—Top lug forming hinge altered from M.I. Casting brazed inside tube to M.S. stamping brazed outside ditto	58,108	58,041	Interchangeable
Jan., 1917*	**Spring Brackets.**—New design rear spring rear bracket, of stronger section	T. 288*b*	T. 200*b*	Interchangeable

* *N.B.*—Alterations marked with an asterisk, although in progress, had not at the date of compiling this list, 24th March, 1917, actually been fitted to any Chassis.

Alterations in Details of J-Type W.D. Lorries.

March, 1917, to June, 1918.

Date.	Vehicle No.	Nature of Alteration.	Part Nos. of Original Parts.	Part Nos. of New Parts.	Remarks.	Authority for Alteration.
June, 1917	5105	Magneto Coupling, positive to flexible	60286 60037 63210 63212	65918 65917 65920 66603 66996 66326	Interchangeable as a whole	Evolved by us on recommendation of Inspecting Officer
July, 1917	No record, as information not necessary	Governor Weights, material and pattern altered to facilitate manufacture	8602 63698 60863	66314 66317 66316 66315	Interchangeable	None Alteration was to facilitate manufacture only and is perfectly interchangeable
Dec., 1917	No record, as information not necessary	Timing Gears cut on Fellows Gear Shaper instead of hobbed	49212 64806 64807 60780	66974 66976 66975 66977	Interchangeable	None Done to facilitate manufacture only
June, 1917	No record, as information not necessary	Piston Rings, stepped instead of diagonal joint	40240	66217	Interchangeable	None Done to increase efficiency
Oct., 1917	5531	Front Spring, Front Brackets, length of palm increased	57523 57524	58512 58511	Interchangeable	Evolved by us to increase strength.
Nov., 1917	5732	N.S. Engine Bearer, increased bearing surface for 3-point suspension pin	57679 57700 57715	58497 58498 58499 58500	Interchangeable as completeN.S. Bearer	Evolved by us owing to cases of undue wear on suspension pins.

CHAPTER III

39. For the references herein to the earlier history of Thornycroft motor vehicles, and to some incidents relating to their war services, I have supplemented my own experiences by consulting various pamphlets which from time to time have been issued by the company, and also other matter from friends who took their part in "The Great Adventure."

Messrs. Thornycroft have built motor vehicles continuously from 1896 to the present time, firstly steam-driven and, later, petrol (and paraffin); their first vehicle was actually in existence before the Act of 1896 came into operation, and was for some time probably the only commercial self-propelled vehicle in existence in Great Britain.

In 1899 the military authorities purchased their first "Thornycroft," and an illustration of this early steam wagon, with steel-tyred wooden wheels, appears in Fig. 22. This was handed over to the Royal Engineers, who experimented with it during the autumn manœuvres of that year. In the following year, 1900, Messrs. Thornycroft lent one 6-ton and two 3-ton steam vehicles to the War Office for further trials during manœuvres; and, shortly after this, ten 3-ton steam wagons were ordered by the Government and delivered over to the Army Service Corps.

40. The War Office were so favourably impressed with the service rendered by these and other makes of self-propelled vehicles, that in 1901 they instituted a competition of motor wagons at Aldershot, offering a prize of £500 for the vehicle considered to have given

FIG. 22.—THE BRITISH ARMY'S FIRST SELF-PROPELLED VEHICLE, A THORNYCROFT STEAM WAGON OF 1899.

FIG. 23.—THE FIRST THORNYCROFT LORRY WITH INTERNAL COMBUSTION PARAFFIN ENGINE.

Built in 1904 for the War Office. An interesting feature is the funnel for expelling the exhaust gases.

the best performance ; this prize was won by a Thornycroft. Following this, the War Office placed orders for a number of Thornycroft, and also of Foden, steam vehicles, which were shipped out to South Africa and used for transport purposes during that war. In his evidence before the Royal Commission on the South African War, the late Earl Kitchener stated : "The motor lorries sent to South Africa did well ; Thornycroft's are the best."

Later, the War Office called for a 5-ton lorry driven by an internal combustion engine using petroleum ("paraffin" or "kerosene") as fuel, and, in 1904, in response to this wish, Messrs. Thornycroft produced the vehicle illustrated in Fig. 23, having steel-tyred road wheels of normal traction-engine type, with pivoted front axle.

The military authorities of that time still hesitated to allow the use of petrol for supply and ammunition transport on account of the supposed great risk of fire with so inflammable a fuel ; it will be noted also in Fig. 23 that a funnel was fitted : this was done, as it was thought the engine exhaust from the rear of the vehicle would frighten horses in the column.

41. In the summer of 1907 the Royal Automobile Club organized a 1,000-mile trial for commercial vehicles, the War Office offering special certificates for petroleum-driven vehicles deemed suitable for military purposes. Messrs. Thornycroft entered two, and obtained one of these special certificates for their performance.

For some time after the South African War it was generally considered that the most suitable self-propelled vehicles for transport were those carrying their load on their own backs, but later this opinion wavered and, in 1909, the War Office instituted a further competition for the best internal combustion tractor. Many makers entered vehicles, but the Thornycroft, illustrated in Fig. 24, was deemed the only one worthy an award and accordingly received a prize of £750. About this time, however, the rubber-tyred commercial lorry began to appear, and its promise so modified official opinion that it soon came to be regarded as the best type at any rate for service in any European war in which we might become involved, and a few orders were accordingly placed for such lorries for experimental service.

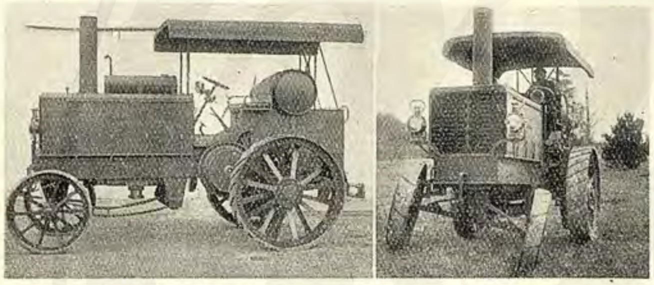


Fig. 24.—Thornycroft Paraffin Tractor.
Awarded First Prize in the War Office Trials of 1909.

42. The first batch of Thornycroft petrol lorries was delivered to the War Office on 5th August, 1914, immediately after the beginning of hostilities, and throughout the Great War the Basingstoke Works concentrated their energies on the production of this type, and supplied altogether roundly 5,000. An external view of one of these celebrated vehicles is given in Fig. 25; after four years of strenuous service, a J-type Thornycroft gained the first prize in the Rhine Army Show held at Cologne in 1919.

Owing to the practical failure of the pre-war subsidy scheme, the War Office had very few vehicles that could

be called up on the outbreak of hostilities in 1914, and they accordingly impressed a large number of lorries from private owners and makers throughout the country, mechanical transport camps being formed at various centres wherein these were collected and dealt with.

43. Mechanical transport officers who served from

Fig. 25.—One of Several Thousands of J-type Lorries Supplied for War Service.

the time the Expeditionary Force left the country in the first week of August, 1914, will vividly remember the odd collection of impressed vehicles which were brought together in Kensington Gardens and the road from London to Southampton strewn with all sorts and conditions of vehicles, many of them old crocks, quite incapable of running the 80 odd miles—others perfectly good vehicles, but smashed up by men incapable of driving them. There were, of course, many first-class drivers who joined up in the first week, but there were also many others without any knowledge or experience of driving. A good example of the latter sort was that of a driver who took his vehicle into one of the improvised depots on the road and asked them for lubricating oil because he thought his engine was running badly. On examination, the officer in charge found that he had been running, apparently for some time, with one broken connecting rod and the bottom knocked out of the crank-chamber, but he was undaunted and determined to drive his vehicle to Southampton.

The road journey to Southampton had, at any rate, the good effect of eliminating most of the "duds" before they were shipped to France.

Fortunately the leading makers at the time had fair numbers of the new subsidy-type vehicle in progress, and these were quickly impressed and formed the backbone of the first mechanical transport of the British Army.

By the spring of 1915, conditions were sufficiently fixed for the authorities to decide on an advanced repair depot at St. Omer, and repair bases at Rouen and Paris. In the early stages the transport companies and ammunition parks consisted of mixed types of vehicles, but the advisability of keeping together vehicles of the same make was soon realized.

In 1915 it was not safe to assume that the St. Omer repair depot would continue to be held, and so temporary arrangements only were resorted to; but, later on, the big jute mill there was converted into a first-class workshop, and work went on there quite happily, except when the Department of the Vedage decided to give the officers of the M.T. Mess a treat or when there was an air raid. In the latter part of the war, with the enormous number of vehicles employed, it was necessary to establish four different repair shops.

44. The work which the different companies in columns did varied very greatly, depending on the activity of the part of the line at which they were placed. Certain companies were constantly at work from railhead to the advanced positions, when, of course, all running had to be done at night. Where there was activity, ammunition columns would be constantly running, while at other parts of the line ammunition parks and columns might be acting as mobile stores for weeks on end.

While generally the speed of vehicles was restricted to about 8 miles an hour over the bad roads, on occasions it was necessary to get supplies through at any cost, and on more than one occasion the M.T. saved the situation when other forms of communication were destroyed.

The low speed at which the vehicles were ordinarily run has been referred to, but some noteworthy speed records were made from time to time when it was necessary for stores to catch some particular transport.

As an example, I may refer to a run made by three J-type Thornycrofts in the early part of the war. Certain supplies had to be shipped at Avonmouth instead of Devonport, and the Motor Transport Department were requested to make a special effort to transfer these supplies in time to catch the Avonmouth boat. Two lorries would have sufficed to take the load, but in case one should break down, three were sent in convoy from Bulford to Devonport, where two 3-ton loads were taken up and transferred to Avonmouth; the average speed maintained *throughout* was no less than 17·3 miles an hour. When running in convoy it is, of course, much more difficult to make good time than when running singly, and to average this speed, under the circumstances of this case, meant that during a good part of the running time the vehicles must have been going at fully 25 miles per hour.

45. Again, when British reinforcements were sent to the Italian front, several columns of J-type lorries were driven across France at high speeds, and a further opportunity occurred of demonstrating their capabilities when crossing the Alps.

Though the greatest part of their transport work was done on the Western front, J-type lorries were used in all the theatres of war, including India, and they even penetrated to the heart of Central Africa with the Royal Naval expedition to Lake Tanganyika.

While mainly fitted with the well-known standard W.O. lorry body for carrying a useful load of 3 tons, many J-type chassis were also mounted with anti-aircraft guns, the frames being suitably stiffened, and the load taken off the springs so as to provide a rigid platform, and resist the special stresses set up by the gun when in action.

The following brief account of the organization and normal work of a transport column, written during the war, is of interest—

46. " Each Division requires about 150 lorries for its supply column, ammunition column and ammunition park ; the supply column consists of 50–60 vehicles, which must perform their duties every day. The ammunition column and the ammunition park's work depend largely on whether the guns are in use. The whole column, as a rule, is under the command of the company officer, with various mechanical and other officers to assist him. The column has its own store wagons and portable workshop wagons. These take up a position somewhere on the route between the rail-head—which is probably somewhere within twenty or thirty miles of the Division that is being supplied—

and the supply column, and make journeys every day between the rail-head and the men's billets on the Front, the order of events being somewhat as follows—

" The lorries are loaded up at the rail-head during the early morning, the men proceed down the route to the Front to a position which is fairly well advanced, but safe from shell fire from the enemy. They will rest there during the day, and will, when it is dark, advance as close up as they can go to the men's billets. They will then be unloaded, and horse wagons will take the supplies on for the remaining mile or so. They will then return straight up to the rail-head and load up again ready to repeat the performance the next day.

" The ammunition column and ammunition park will wait for several days along the route, ready to go up when called for. They have the more dangerous work as it frequently happens that they cannot wait for darkness to get up to the Front. It is a most interesting spectacle to see in a market town, or along a stretch of road, 50 to 150 vehicles lined up with the men camping out, awaiting the advance.

" The transport men's vehicles are also their homes, and as they are able to sleep on the driver's seat, or under the tarpaulin, they really are not badly off.

" Of course, in the first few weeks of the war, and during the retirement from Mons, the transport drivers had a most trying time. They were, in many cases, working practically a week on end without sleep, and were under fire a great part of the time. It has been generally recognized that these men, who had seen nothing of fighting before, the majority of them only having joined up when the vehicles were impressed in the first week of the war, did splendidly."

47. Attached to each of our columns were motor workshops fitted with a full equipment of power-driven

tools, as illustrated in Fig. 26; by aid of these many minor repairs were readily effected, and we found them of great use on numerous occasions, though when a case such as that shown in Fig. 27 was encountered, it was felt that no further trouble need be taken.

48. The system adopted by the directors of our motor transport for keeping records of the state of vehicles in the different columns was very effective; and, as the war progressed, it became possible to forecast fairly well the numbers that would be likely to pass through the "casualty parks" to the various M.T. repair depots.

When delivered into a casualty park, a vehicle was taken over by the Inspection Staff, who examined it to determine whether a complete overhaul was required. Whenever it was decided that this was necessary, the vehicle particulars were entered in a list and notes taken also of its equipment, which was then removed and passed into store. The vehicle, minus equipment, was next passed on to the M.T. Depot and completely stripped. The engine, complete with all its accessories, the gear-box, and the back axle were taken to the "Unit Shop," the chassis number being carefully recorded, so that the unit should, whenever possible, be re-erected in its own chassis.

49. Considering the engine first, it was next completely dissembled, all parts being cleaned, and finally washed in a paraffin tank; they were then laid out in order on an inspection bench and carefully examined, replaces being "indented for" in the case of such parts as were found to be beyond repair.

The crankshaft, if worn, was reduced in diameter by either 5, 10, or 15-thousandths in a crankshaft grinder, and reamers were provided of these three standard under-sizes for the white-metal main bearing bushes.

Fig. 26.—A Mobile Workshop for War Service.

Fig. 27.—All that was Left of a Thornycroft Lorry after a Direct Hit by a German Shell

Adjoining the Unit Shop was the White-metalling Shop, wherein main bearings and big-end bearings were renewed by die-casting in special under-sized moulds, which allowed sufficient excess material for reamering-out even in the case of a crankshaft reduced in diameter by 15-thousandths.

The new bearing castings were next assembled in the crankcase, and the proper reamer passed through all three from end to end. In general, this rendered very little scraping necessary ; and in many cases it was even found that by bolting up the bearings after reamering only, the fit, though at first very tight, after being run in for a day or so (*v.* § 51), eased, and a beautiful surface developed upon the white metal ; in the author's opinion, such bearings held up better in service than the scraped bearings, due perhaps to the formation of a compressed perfectly-fitting skin by running-in under pressure, and this practice appears to be now extending in normal high-class work.

Big ends were repaired in a generally similar manner ; a jig was made in which all four connecting rods were mounted on a long gudgeon pin rove through all four eyes ; this long pin was carried by a special bracket clamped to the lathe saddle between the centres, and a reamer was then passed through all four big ends, which were subsequently dealt with as described above for the main bearings.

Camshaft bearings never seemed to require renewal merely as the result of wear ; where renewals were necessary, these were usually *in toto* as a result of the engine being hit by a shell or suffering accident from some other cause. Valves and tappets were not made, but were always drawn from store by indent.

50. For some time we had no means of re-grinding worn cylinders. When a ridge had formed, the edge of the piston crown was rounded off so as to clear the ridge. Later on, however, we set up a machine for lapping out scored or ridged cylinders by means of a dummy piston served with emery and oil, and worked up and down with a screw-like motion of about one-quarter of a turn each way to ensure the lapping being uniform. This, and other devices, were gradually evolved as the war progressed ; later, we set up our own foundry and pattern shop, and were able to cast over-size pistons and other details as required.

Gudgeon pins sometimes worked loose in the piston bosses ; when this occurred during periods of great pressure, complete new pistons were fitted ; but during easier periods, over-size gudgeon pins were made, and the piston bosses and connecting-rod eye bushes were reamered out to suit.

51. Magnetos were dealt with in a separate shop, being carefully dismantled, cleaned, overhauled, and adjusted as necessary. Whenever possible, a magneto was returned to the engine with which it had been previously associated. Engines were re-assembled under careful supervision, the men being divided into gangs, each in charge of a corporal ; a staff sergeant acted as shop foreman, and inspected all engines, before the base-chamber was bolted on, to see that adjustments were correct, nuts tight, split pins in place, etc. ; his report to the officer in charge being satisfactory, the engine was then closed and forwarded to the testing shop, where it was first belt-driven from the counter-shafting for 1 to 1½ days, in order to run the bearings in, after which it was run on petrol and tuned up until the full power output was obtained. Finally, it was labelled and forwarded to the Lorry Section for re-erection in its chassis.

52. **Gear-boxes.** These also were dealt with by sections of men working under corporals, and were carefully inspected after cleaning, all worn parts—as gear wheels, ball races, etc.—being replaced, though, even under the exceptionally severe conditions in France, it was rarely found that anything more than the gear wheels needed attention, the third-speed wheel in most cases being found considerably worn.

Replace parts were at times difficult to obtain, and numerous temporary shifts were resorted to in consequence. All sorts of patches and fake arms were put on gear-boxes on various occasions to enable vehicles to carry on.

53. **Back Axles.** When kept well lubricated—as they usually were—back axles very rarely needed any replacements beyond occasional ball races and new bushes to the road wheels, and the trouble, at first, arising from end nuts coming off when the War Office thread of 16 to the inch was used ; this was later reduced to 10 threads to the inch, and this source of trouble then practically ceased.

54. **The Lorry Section.** While engines, gear-boxes, and back axles were being overhauled in the Unit Shop as just described, the remainder of the chassis was receiving attention in the Lorry Section, in which frames, steering gears, front axles, springs, etc., were dealt with as necessary.

Frames. Any loose rivets found were cut out, holes reamered, and fitting bolts driven in, with nuts screwed hard down on to a spring washer, and the head of the bolt then riveted over the nut. In earlier vehicles with short front dumb irons, we frequently found it necessary to replace the two through rivets by bolts, with tubular distance pieces between the frame flanges, thus enabling them to be screwed up hard. In later vehicles,

an improved pattern of long dumb iron was fitted by the makers, and this gave no trouble.

55. **Steering Gear.** Reference to the ball joints of this gear has already been made in § 9 ; when the white-metal lining of the malleable iron nut housing was found to have worn loose, it was melted out and run in afresh with the aid of a jig, if time permitted ; otherwise a complete new part was fitted.

Springs. These were always taken off, and the leaves separated, any broken being replaced by new, although it often happened that completely new springs had to be fitted owing to the shortage, for some time, of separate leaves. Later, special spare leaves were stocked.

Final Running. When completely re-assembled in the Lorry Section, trials were made of the vehicle under load, after which it was examined and passed by the Motor Transport Inspection Department. In this way, vehicles on returning to their field units could be relied upon as in good order throughout.

56. **Major Strickland's Observations.** Some extracts from a valuable criticism of the J-type Thornycroft may conveniently find place here. For permission to reproduce these, I am indebted to that experienced automobile engineer and author, Major F. Strickland, who enjoyed exceptional opportunities of becoming intimately acquainted with all details of the behaviour of various types of motor lorry employed throughout the war.

Major Strickland's criticism is too long to be given here in full ; I have therefore to content myself with some extracts only from his interesting observations and conclusions.

Referring to the front axle of the J-type lorry, he remarks : " This was quite satisfactory, excepting only that there appeared to be room for improvement in the durability of both swivel pins and wheel bearings." He considers it is better to form the jaws on the axle itself rather than on the stubs, as in the latter case he is of opinion that the section must either be shallow, resulting in the bushes being near together, or the swivel pin must be placed at some distance from the wheel track, necessitating a heavy design of stub axle; and that when the jaw type of front axle is adopted, the swivel pin is better when fixed in the stub axle and working in the jaws.

57. Lubrication is admittedly difficult here owing to the small range of movement in this joint, and he points out it is commonly found that they soon exhibit indications of wear. Ball and roller bearings did not prove very successful either in swivel joints, even when used as thrust bearings, as the constant motion over a small arc soon wore the races into grooves. I observe that one of the largest carrying companies using motor vehicles has recently replaced all such bearings by plain bearing washers.

58. The front road wheels were carried on floating bronze bushes in accordance with the wishes of the War Office. On this point, he says—

"Wheel bearings were of four types, viz., floating bush, fixed bush, ball, and roller.

"Of these, the floating bush seemed to me the worst. It involved three renewable wearing surfaces, namely, the wheel centre, stub axle, and the bush. Further, all these appeared to wear relatively badly, especially where the wheel was allowed to rock and was not held square by the axle shaft. It is quite unusual in mechanics of engineering to use a metal like bronze as a convex wearing surface, and this is presumably because it has been found unsuitable, and there appears no special reason to depart from ordinary practice in the case of wheel bearings."

Some of the lorries we used had fixed bushes with oil lubrication, and these proved on the whole to be very satisfactory.

"Ball bearings were not much used, but ran very well wherever observed; but they are rather complicated if separate races are provided for the thrust, as should be the case.

"Roller bearings appeared to me to be the most satisfactory of all, but they are very heavy and presumably costly.

"A distinct advantage of roller and ball bearings is that the wearing part on the axle is renewable. With floating bushes, the stub axles and the sleeves of the live axles wore oval and eventually had to be renewed. If the wearing part on the axle is renewable, the scrapping of expensive parts is saved. This is especially important in the banjo type of back axle, as the wearing part with floating bushes is part of the main axle forging, and we have had to scrap the whole of this forging simply because it was badly scored in the bearings."

The reader is reminded that in the J-type Thornycroft lorry the back axle is not of the banjo type, but is fitted with removable sleeves, which can be renewed when worn. (*See* § 93.) He continues—

"It appears to me that it would be a great advantage in the case of plain bearings to have a sleeve to take the wear. I do not see why a case-hardened sleeve should not be put on the axle; and if this were done and fixed bushes used, running in oil, I believe they would wear a very long time and be cheap to renew, while they would be a good deal lighter and cheaper than roller bearings."

59. **Rear Axle Drive.** The rear road wheels of lorries used in the war were driven either by chains, double-reduction-gear live axle, or worm-driven live axle, the worm being sometimes straight and sometimes of the "hour-glass" type. The chain drive was always noisy and appeared necessarily to involve a lower-geared vehicle, which, as Major Strickland points out, was of use at times when "ditched" in enabling vehicles to clear themselves with somewhat greater ease than when the more usual type of drive was fitted; it may also be argued that chains give an increased road clearance and reduced unsprung weight.

Under ordinary running conditions, however, the live axles appeared on the whole to be preferable, and between the double-reduction gear and the worm drive there seemed little to choose.

60. **Petrol Tank.** The best position for this appeared to be on the dash, as in the J-type lorries; there is then, under all circumstances, a good "gravity feed." Vehicles with pressure feed gave a good deal of trouble through failure caused by joints working loose and admitting air, thus resulting in loss of pressure.

61. **Clutches.** Major Strickland points out that in the war lorries the three types principally employed were the single plate, the multiple disc, and the cone. He was favourably impressed with the single-plate type, remarking that they "took up" very sweetly and gave no trouble. The multiple disc clutches, running in oil, worked very well, but their behaviour was rather dependent upon the kind of oil used in them; some lorries were fitted with dry-plate multiple disc clutches, and these appeared in general to behave well. The cone clutches worked well also, and were readily adjustable if required.

He remarks—

"I believe the great fault of many clutches to have been that the travel of the clutch pedal was too short and the foot pressure required too great in consequence. I think that for convenience in use there should be a long travel provided so that, after the clutch is disengaged, the pedal has still to move a good long way before the clutch stop comes into action. It is easy then to be certain that the clutch is entirely free from both the flywheel and the clutch stop. This, in combination with the reduced foot pressure, would, I think, make lorries much pleasanter to drive."

On this point Messrs. Thornycroft have informed me that in all recent J-type lorries the range of motion of the clutch pedal has been substantially increased (*v.* § 21).

62. **Cylinders.** With reference to the T-headed cylinders of the J-type Thornycroft lorries, he says—

"The T head seems to me, on the whole, to have the greatest number of advantages for heavy work. It has the advantage over the L head that the engine can be made shorter for the same valve area, while at the same time ample room can be got for good water spaces round the valves.

"The pipe arrangement is also very simple, and the whole engine can be made very accessible.

"With the L head, the engine has, in practice, to be made a good deal longer, and this makes the crankshaft liable to spring and the engine to have a threshing period. Hence the shaft has to be larger in diameter, which has many disadvantages."

63. **Pistons.** (*See* § 26.) These were generally satisfactory, though, as usual, gudgeon pins in all lorries required on the whole a good deal of attention. These pins cannot be made a driving fit in the piston bosses

without risk of distorting the piston, unless very stout bosses and pistons are used, which involves the serious disadvantage of increased reciprocating masses. Major Strickland observes that a simple and effective mode of fixing the gudgeon pin was by means of a split pin through each end lying in a groove formed in the surface of the piston.

The small end joints in all engines of this type are the first to become slack in service, owing to their small movement under considerable bearing pressure, and to the difficulty of providing for really efficient lubrication through their position within heated pistons.

64. **Crankshafts.** Engines with two, three, four, and five crankshaft bearings were observed in the war lorries, and it can only be said that all appeared to behave quite well. With five bearings, the middle one usually wore most rapidly, no doubt owing to the pressures through inertia being here greatest ; in a few lorries the middle bearing was omitted, the crankshaft being then borne in four bearings ; these gave no trouble. Probably the three-bearing arrangement is, on the whole, the best for ordinary running conditions ; a few engines were fitted with two main bearings only, and these also ran quite satisfactorily when the moving parts had been carefully balanced ; with two bearings, comparatively low-bearing pressures should result, and the arrangement would appear to reduce production cost.

On the engines of a few lorries, ball-bearing crankshafts were fitted ; these held up very well, but they are costly and not easily fitted, and they were always noisy. They shorten the engine and simplify lubrication, and are probably best on two-bearing crankshafts where the smallest alternating pressures occur, and where they may be of small size and easily fitted.

Valves were either gear- or chain-driven ; the chains did not appear to last very long, and often broke without warning ; they were expensive to renew and required a lengthened crankcase ; the gear drives gave no trouble.

65. **Lubrication.** The oil pumps originally fitted to the J-type lorries gave trouble partly from their elevated position and partly from air leaks through worn bushes and end-play from wear ; in all recent vehicles these sources of trouble have been removed by lowering the pump (*v.* § 29), by bushing its body and cover, and by hardening both the spindle and the impeller. After two years or so of service, any end-play that may exist is readily taken up by facing off three- or four-thousandths from the body flange.

Major Strickland's comments on the lubrication of the engines of the various types of lorry used in the war are interesting, and I therefore give them below in some detail. He remarks—

66. " There are considerable differences in the methods of engine lubrication, four main systems being in use :

" (1) An oil feed to each bearing, the big ends being fed by a banjo frame and the oil never going through the bearing twice.

" (2) Plain splash.

" (3) Trough.

" (4) Forced.

" Of these, the first is the ordinary lubrication of an open engine, and the bottom half of the crankcase is merely a dust cover.

" Theoretically, this should be a most imperfect system, as the oil is never used twice, but is drained out when it has been run once through the bearings. In practice, it appears to work as well as any system there is, and I never heard that it was at all extravagant in oil. Also, it seldom makes the engine smoke, and presumably, therefore, should not carbonize badly.

" The bearings in this system must get far less oil than in others where the oil is continuously circulated, but they do not appear to wear any more, and this is probably due to the fact that the oil never has any dirt in it.

" Of the other systems, plain splash seemed to work excellently, but should have some definite means of keeping the oil at the right level. If this were done and each connecting rod dipped into a trough in the crankcase like the Ford, I believe that it would be as good as any, and is very simple. It has the great advantage that it never fails suddenly, as do all the pump systems, but the engine gradually gets drier and gives warning that the oil is low.

" Troughs worked well, but appear to have all the complication of fully forced, with a less plentiful supply of oil to the bearings. Also the supply to the different troughs is rather uncertain, unless a separate pump is used to each trough, and this is very complicated and expensive.

" Fully forced is theoretically right, and worked very well except for failure in detail. The only sound objection to it appears to be that the supply of oil to the cylinder walls depends on the fit of the big-end bearings, and that if enough gets on to the cylinder walls when the bearings are new, there will be an excess when the bearings get slightly worn. I think this might be avoided to a large extent by making the holes supplying the oil to the bearings very small. This would enable the pump to keep up the pressure, which very few pumps do now, and so ensure better distribution of the oil to the bearings.

" I think that in all cases there should be a settling place for dirt before the oil goes through the filter, and, further, that the area of the filter should be large and that the flow through the gauze should be upward and not downward. I think also that the overflow from the relief valve should not go back through the filter

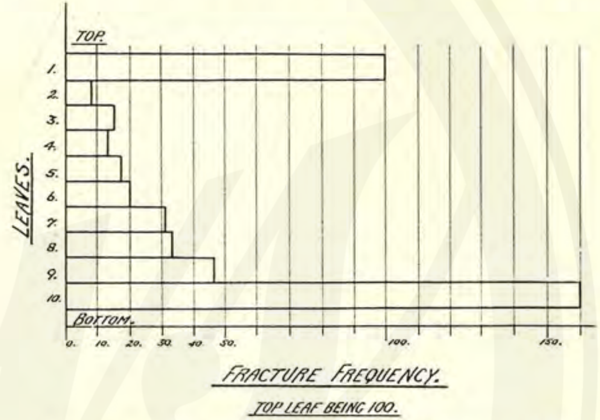


Fig. 28.—Relative Frequency of Fracture of Spring Leaves.

but back to the pump suction, so that no more oil than is necessary should be drawn through the filter."

67. Bearing Springs. With all the types of motor lorry used during the war, we had a good many cases of broken spring leaves, due to the general severity of the conditions of service, although, as already mentioned, drivers were under standing orders to drive slowly.

The spring problem is extremely complex, and no complete solution is attainable ; we have, therefore, to be contented with approximate formulæ. The matter is very ably and fully discussed by Mr. H. S.

Rowell in Part VII of his excellent paper in *Proc. I.A.E.*, 1923.

Leaf failures usually result from fatigue of the material, and Rowell gives a diagram, reproduced in Fig. 28, obtained from observations of over 500 actual fractures by Messrs. Landau and Parr ; this diagram

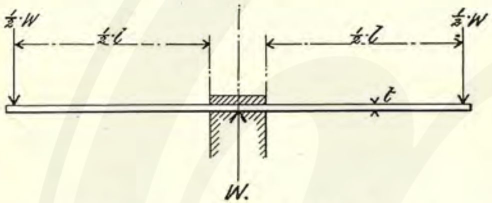


FIG. 29.—SIMPLE SINGLE-LEAF SPRING.

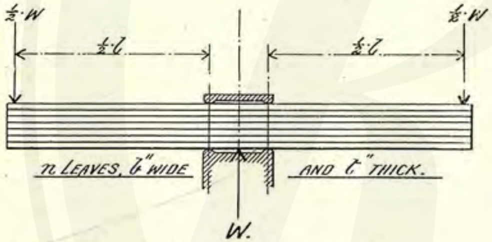


FIG. 30.—SIMPLE MULTIPLE-LEAF SPRING.

shows the liability of the several leaves to break, the topmost leaf being taken as 100. It will be noted that in these cases the top and bottom leaves were by far the most liable to break.

68. Usual Approximate Formulæ. That the reader may appreciate the nature of the approximate formulæ usually employed in spring design, I give below the steps by which the usual equations are established—

Suppose we have, first, a single leaf of perfectly

elastic material b in. wide, t in. thick, and l in. long, loaded and supported as indicated in Fig. 29. If the load W be such as to produce a small deflection only, then the Simple Theory of Bending tells us that the deflection δ will be given by the equation—

$$\delta = \frac{1}{4.E} \times \frac{Wl^3}{bt^3} \text{ inches} \qquad . \qquad . \qquad (1)$$

where E is the Modulus of Elasticity or " Young's Modulus " of the material, and may be taken at $2{\cdot}8 \times 10^7$ lbs. per sq. inch. While the maximum stress, tensile and compressive, induced in the leaf is expressed by—

$$f = \frac{3}{2} \times \frac{Wl}{bt^2} \text{ lbs. per sq. inch} \qquad . \qquad (2)$$

69. Next, let us suppose that we have n such leaves superposed one upon the other, as in Fig. 30, with no friction between them. Then each will evidently take one-nth of the load, and so we shall obtain the resultant deflection and maximum stress by writing $\frac{W}{n}$ for W in the above two equations ; and thus we get

$$\delta = \frac{1}{4E} \times \frac{Wl^3}{nbt^3} \text{ inches} \qquad . \qquad . \qquad (3)$$

and for the maximum stress—

$$f = \frac{3}{2} \times \frac{Wl}{nbt^2} \text{ lbs. per sq. inch} \qquad . \qquad (4)$$

Springs, however, are not made up of leaves of equal length, but are always, of course, as indicated in Fig. 31, which shows the rear bearing spring of the J-type Thornycroft lorry. Professor Reuleaux, taking the leaves as shortened by equal steps, found that the deflection, without friction, is in this case increased by about 50 per cent ; accordingly for a frictionless spring of n leaves diminishing by equal steps, we should have—

$$\delta = \frac{3}{8E} \times \frac{Wl^3}{nbt^3} \text{ inches} \quad . \quad . \quad (5)$$

70. Actually, in motor vehicle springs, the leaves are not merely placed in contact, but are very firmly nipped

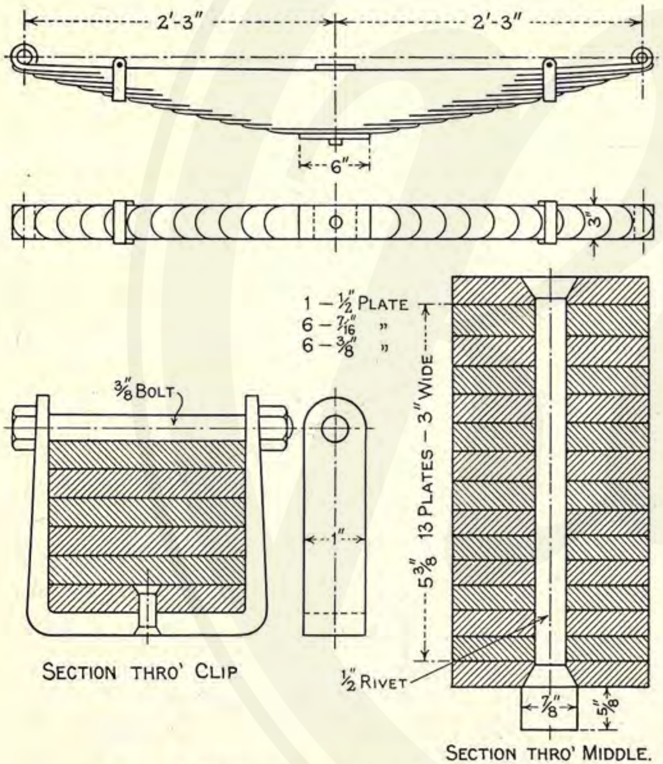


FIG. 31.—DETAILS OF J-TYPE REAR SPRING.

or clamped together, so that there is not only some initial stress in them, but also friction between them of unknown and widely varying amount. The friction resists their relative movement, and thus strengthens the spring and diminishes the deflection. Springs again are frequently made with leaves of varying thickness, and also with more than one leaf of the full length. (*See* Fig. 31.) If there be n_1 leaves t_1 inches thick, n_2. t_2, and so on, then we may modify Equation (5) to allow for this by writing—

$$\delta = \frac{3}{8E} \times \frac{Wl^3}{b\{n_1t_1^3 + n_2t_2^3 + \ldots\}} \text{ inches} \quad (6)$$

71. The inter-leaf friction is unknown in amount, and varies greatly with the condition of the leaf surfaces. Mr. Rowell says—

" It has sometimes been found in practice that springs which carried their load quite well when dry, broke very quickly when cleaned or greased."

Spring friction confers the valuable property of quickly damping out the spring oscillations, and also relieves the leaves of some stress.

To allow for friction and for differences in details of design, as, for example, the tapering of leaves in the direction of their length, etc., it is found necessary in practice to replace the constant $\frac{3}{8E}$ of Eq. (6) by a constant C, determined from actual experience of each type of spring. A good average value of C is $\frac{1}{8 \times 10^7}$; so that we obtain finally from Eq. (6) the useful semi-empirical deflection formula—

$$\delta = \frac{1}{8 \times 10^7} \cdot \frac{Wl^3}{b\{n_1t_1^3 + n_2t_2^3 + \ldots\}} \text{ inches} \quad (7)$$

72. The J-type lorry spring (Fig. 31) is now made up of thirteen leaves, each 3 in. wide and of three different thicknesses, the top leaf being $\frac{1}{2}$ in., the next six each $\frac{7}{16}$ in., and the lowermost six each $\frac{3}{8}$ in. The normal static load is 5,600 lbs.; and the effective length of the spring is $54-6=48$ ins. All leaves excepting the top one are tapered for about 4 in. from each end, and are rounded at their ends as shown in the plan view. For this spring, therefore, we have—

$$W=5600,\ l=48,\ b=3;\ \text{and}\ n_1t_1^3+n_2t_2^3+n_3t_3^3=$$
$$1\times(\tfrac{1}{2})^3+6\times(\tfrac{7}{16})^3+6\times(\tfrac{3}{8})^3=0{\cdot}944;$$

and accordingly Eq. (7) gives as the deflection—

$$\delta=2\tfrac{3}{4}''\ \text{(roundly)}.$$

Messrs. Thornycroft tell me the actual deflection is usually a little less than this, viz., about $2\frac{5}{8}$ in.; in all the circumstances the agreement between the actual and calculated figures may be considered very satisfactory in this case.

73. **Maximum Leaf Stress.** When we come to consider the maximum stress induced in the leaves under the static load, we are on somewhat more difficult ground, and indeed no exact formula is available. Equation (4) is often employed, but the values thus obtained for f can only be regarded as rough approximations to the actual stresses occurring in the leaves, owing to leaf-friction and initial stress.

74. The late A. A. Remington has given a table of figures thus deduced for motor car springs on page 253 of Vol. XVI of the *Proc. I.A.E.*; they range from 39,000 to 87,000, and he remarks that they are probably "considerably greater" than the actual stress sustained by the material."

For estimating leaf thickness, designers commonly

use Eq. (4), with a value for f of 50,000 in the case of railway springs, to about 80,000 for motor-car springs, for the static load.

Remington considered that the absolute maximum stress sustained during actual work is obtained in the case of motor-car springs by multiplication of f by from 1·75 to 2·25 for the rear springs and by from 2·5 to 3·5 for the front springs. Thus there is no doubt but that spring leaves are very heavily stressed. They are usually, in motor vehicles, made of steel oil-hardened and lead-bath tempered, and range then in ultimate tensile strength from about 150,000 to 250,000 lbs. per square inch.

75. The initial camber given to laminated springs varies a good deal in practice; Messrs. Thornycroft tell me that as the result of their extensive experience they find a spring which is nearly straight under its static load to be on the whole preferable. (*See* Fig. 31.) All their springs are tested before being put into service to a definite inverse camber in the special spring-testing machine illustrated in Fig. 32. It is perhaps of interest to remark that the value of f corresponding to any deflection δ (in inches) is readily obtained by aid of the following very simple formula which results from combining Equations (4) and (5)—

$$f=4E\,.\,\frac{t\delta}{l^2}\qquad(8)$$

For the value of E assumed here, viz., $2{\cdot}8\times10^7$, this becomes—

$$f=1{\cdot}12\,\frac{t\delta}{l^2}\times10^8\qquad(9)$$

and this is sometimes useful as giving roughly comparative value figures for different springs.

76. **Spring Eyes.** Solid-forged spring eyes, though neat in appearance, were the cause of many top leaf

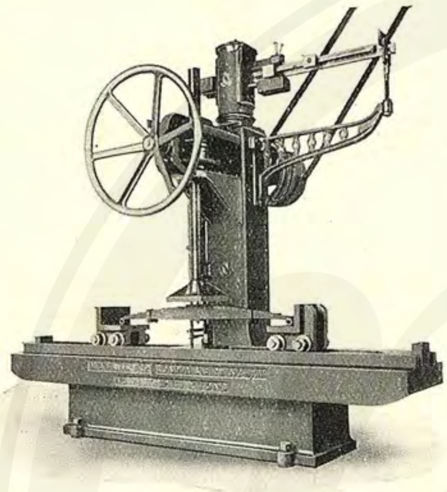


FIG. 32.—SPRING TESTING MACHINE.

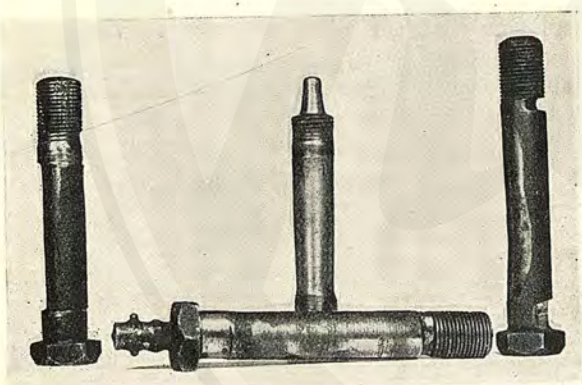


FIG. 33.—WORN SHACKLE PINS, SHOWING THE RESULTS OF ABSENCE OF LUBRICATION.

failures, probably resulting from faulty heat treatment. The better practice is undoubtedly as shown in Fig. 31, the holes after rolling being bored out true, and bronze-bushed at either one or both ends to receive the shackle pins. The shackle pins should be fixed firmly in the shackles, and be properly lubricated in the spring eye bearing. The combined effects of improper fixing and neglected lubrication are strikingly shown in Fig. 33 reproduced from a photograph of some pins taken from an American lorry after a quite limited amount of running.

The spring clips (Fig. 31) near each end of the spring keep the longer leaves in correct position laterally and assist also in preventing them from separating during recoil or "rebound." The mode in which they are fixed in the J-type Thornycroft lorry is clearly indicated in the section shown in Fig. 31.

77. Major Strickland makes the following interesting observation—

"The French lorries, which were driven very fast as a rule, had in many cases exceedingly wide-leaved springs 4 in. to 6 in. in front and 6 in. to 7 in. at the rear. Suitably proportioned, such springs can be made to have the right deflection under load with a quite low leaf stress even at maximum deflection; such springs should be practically everlasting. These advantages might, however, be better attained by making both the front and rear springs double, i.e. by fitting two narrow springs side by side."

CHAPTER IV

78. SOONER or later every motor vehicle requires adjustment and repair, and in the earlier years of automobile development the organization for carrying out repairs was, in most cases, very primitive, so that it was commonly said of a lorry that it ran quite well until after its first visit to the repair shop. The activities of motor lorry builders were fully absorbed in producing and selling new vehicles, and the setting up of adequate arrangements for effecting adjustments and repairs was regarded, if at all, as a matter for owners to take in hand themselves.

But many owners were quite non-mechanical, and I well remember several cases of small fleets of unhappy vehicles which were entirely dependent upon the well-intentioned efforts of a half-skilled though enthusiastic mechanic equipped with a rickety vice bench and a handful of old files in a leaky outhouse, assisted by the well-known type of wooden man who goes away and brings the wrong spanner. Under such circumstances, adjustments and repairs were always lengthy and usually unsatisfactory. With the large developments that have taken place in the motor vehicle movement during the past ten years, this condition of things has become much less frequently met with, and owners now can usually get their vehicles promptly and effectively dealt with in well-organized and well-equipped service depots in most parts of the country. It must be remembered that as much skill and care is necessary in adjusting and repairing as was originally exercised in constructing the vehicle if it is to continue to function properly. It should also be strongly impressed

upon owners that vehicles should be maintained always in a condition of substantial efficiency; in the course of a long experience of commercial vehicle repair work, I have been frequently struck by the heavy expenses incurred in remedying breakdowns which could have been entirely avoided by the exercise of a little systematic attention on the part of those responsible for the driving and upkeep of the vehicles.

79. **Cleanliness.** Most important is it that time should be allotted to the regular cleaning and greasing of all vehicles, as this fosters an *ésprit* in the drivers and is of the utmost benefit to the vehicles themselves; in the process of cleaning and greasing, small matters requiring attention also often come to light; the practice of the L.G.O.C. in this respect has already been referred to (§ 3). I insert here a breezy statement by a brother officer on this matter of systematic cleaning He says—

"The importance of cleaning was very forcibly brought home to me during the latter part of my service when in charge of a large fleet of heavy lorries, run in connection with the Artillery School on Salisbury Plain. The drivers, who were largely composed of unfits and conscripts, knew just enough about the machines to drive them, and naturally used them very hardly.

"At the time I took over the convoy, very little cleaning was done, except in the more obvious parts of the chassis, such as radiators and bonnets. Shortly after, however, a command order was issued to the effect that shackle-bolt heads, etc., were to be kept cleaned and *polished* if possible, and that particular attention was to be paid to this point by officers.

"I had just come home from one of the tropical side-shows, where we had been running a nondescript collection of vehicles, so few for the work they had to do that we had been working two shifts of drivers, and had hardly time to fill up with oil and petrol (much less clean), and so I thought that this polishing business was a brain-wave of some brass hat at the War Office, and was inclined to scoff at it as far as I dared under Service conditions, but nevertheless had to obey orders ; and, in my daily crawls under lorries, was surprised at the amount of trouble I saved the workshop unit by spotting such things as loose rivets in frames, loose nuts, worn shackle pins, and even bigger defects, which, if attended to at once, cost practically nothing in time and money, but left alone would have meant breakdowns and several days' loss of use of the particular machine.

" In general, these rigid inspections had a very good effect on the drivers also, who got very keen to make a good show.

" It should be remembered that these drivers were recruited from the same classes of men who are now driving commercial vehicles in civil life, and I think it very probable that some similar scheme would have the same good effect under civil conditions."

I may mention here also the excellent influence exercised upon drivers and others by the Commercial Motor Users' Annual Parade at which a cup and prizes are awarded to the most meritorious vehicles.

80. In the 1923 Parade, 350 vehicles appeared, and I observe that on this occasion the C.M.U.A. judges for the second year conferred the Challenge Cup upon Messrs. Wethered's fleet of Thornycrofts (Fig. 34), awarding them also the first and second prizes. The third prize was won by a team of Thornycrofts entered by Messrs. Shell-Mex, Ltd. I am reminded also that the credit of first instituting this annual parade is due

to Messrs. Thornycroft, who organized a parade—in early days now far off—of their steam wagons on the Thames Embankment.

Thorough cleaning before embarking upon repairs is of the first importance, but in many smaller garages and repair shops this is often not carried out, and mechanics may frequently be seen pulling to pieces an axle or gear-box still thickly coated with grease and road grit. Before a general repair or overhaul is undertaken, the

FIG. 34.—THE FLEET OF THORNYCROFT LORRIES IN THE SERVICE OF MESSRS. WETHERED'S BREWERY, GREAT MARLOW.

First and Second Champion Teams at the C.M.U.A. Parade in London, 1923.

whole chassis should be thoroughly cleaned ; if a pressure of 200 to 300 lbs. of water be available, a small jet of this will be found very effective in dislodging caked mud and grease. Not only is it economical to spend some energy in keeping vehicles clean from the running point of view, but such vehicles are also good advertisements for the firms owning them.

81. During the first part of the war, only standard-sized replace parts were stored, but a moment's reflection will show that in many cases this could not be very helpful. When, for example, cylinders became worn and lost their compression, they were scrapped,

although they could quite well have been ground out and fitted with pistons suitably enlarged ; this entailed an enormous amount of waste and, later, the imperative necessity of economizing spares resulted in the stocking of over-size pistons, but the general question of over-size parts was never properly worked out during the continuance of the war.

The early practice, still largely followed, is to stock either unmachined spare parts or spare parts roughed out only, enough material being left to enable them to be fitted as required. Thus roughly-machined spare pistons can be finished in the repair shop and fitted each to one particular re-ground cylinder ; and so in other cases. This has done very well where only small numbers of vehicles are dealt with, but on the large scale it is very desirable that a more definite system should be adopted ; and a practice now rapidly gaining ground is that of the stocking of standardized over-size and under-size replace parts, these being manufactured preferably by the vehicle builders themselves. In the latter part of the war we benefited by the adoption of this practice in certain items, as already described in § 49 in connection with crankshafts.

82. The practice adopted by one of the largest London taxicab companies is here of much interest. All important parts are used *three times*, a complete system of standardized over-size parts having been worked out to render this practicable.

For example, there are three sizes of cylinder, say, A, B, and C in order of increasing bore, and three corresponding sizes of piston, A, B, and C in order of increasing diameter.

The cylinder starts as A, and is fitted with an "A" piston. After wear, the cylinder is ground to B bore and a B piston fitted. Finally it is a second time

ground, becoming C in size, and fitted with a C piston. The piston *starts as C size*, and is first fitted to a cylinder that has been twice ground out. When worn, the piston is ground down to B size and again fitted into a cylinder corresponding. And when again worn here, it is a second time ground, finally becoming A size, and is then used in an A cylinder, after which it is finally discarded. The economy of this method of systematized procedure is apparent.

83. The supply of standardized over-size and under-size replace parts is principally of importance in connection with engine overhauls ; Messrs. Thornycroft inform me they have stocked such parts for their M/4 engines for some years past, and the table shown on p. 90 gives details of these for cylinders, pistons, piston rings, gudgeon pins, big ends, main bearings, and valves.

It will be noted that over-size cylinders 10, 20, and 30-thousandths large in the bore are stocked, with corresponding over-size pistons and rings ; piston rings over-size *in depth* are also available to fit worn piston grooves. Big-end bearings 10, 20, 30, 40, and 50-thousandths under-size are stocked ; while for main bearings, three under-sizes, viz., of 10, 20, and 50 thousandths respectively, are considered sufficient. Over-size gudgeon pins and small-end bushes are also available, and valves with stems $\frac{1}{32}$ in. large in diameter to fit worn guides after these have been reamered out. By aid of these it should be possible to maintain engines in first-rate condition at moderate cost.

84. **Dismantling a J-type Lorry.** After much experience, I have found the following a convenient order of procedure when a J-type Thornycroft lorry has to be completely dismantled :—The body having been removed and the chassis then thoroughly cleaned, it is well, firstly, to remove the wings, or mudguards, as with

these out of the way, access to the mechanism is rendered very easy. The bonnet may next be taken off together with the bonnet boards, these being attached

STANDARD OVER- AND UNDER-SIZE REPLACE PARTS FOR THE M/4 THORNYCROFT ENGINE

Name of Part.	Standard Part No.	Repair Part No.	Allowance.
Cylinder	68413	69894	+10/1000
Cylinder	68413	69933	+20/1000
Cylinder	68413	72820	+30/1000
Piston	64474	64474B	+10/1000
Piston	64474	64474C	+20/1000
Piston	64474	72825	+30/1000
Piston Ring	66217	70793	+10/1000
Piston Ring	66217	70792	+20/1000
Piston Ring	66217	72090	+20/1000 on depth
Piston Ring	70920	72822	+30/1000
Piston Ring	66217	72826	+30/1000
Piston (Scraper Ring type)	71713	72375	+10/1000
Piston (Scraper Ring type)	71713	72378	+20/1000
Piston (Scraper Ring type)	71713	72821	+30/1000
Piston Ring (use with 71713)	70920	72376	+10/1000
Piston Ring (use with 71713)	70920	72379	+20/1000
Scraper Ring	71714	72377	+10/1000
Scraper Ring	71714	72380	+20/1000
Scraper Ring	71714	72823	+30/1000
Gudgeon Pin	60957	72074	+ 5/1000
Gudgeon Pin	60957	70786	+15½/1000
Gudgeon Pin	60957	72505	+10/1000
Small-end Bush	46044	70787	+15½/1000
Conn. Rod Bearing	63699	67711	−10/1000
Conn. Rod Bearing	63699	67712	−20/1000
Conn. Rod Bearing	63699	70079	−30/1000
Conn. Rod Bearing	63699	70078	−40/1000
Conn. Rod Bearing	63699	68550	−50/1000
Main Bearing	43666	67713	−10/1000
Main Bearing	43666	67714	−20/1000
Main Bearing	43666	68548	−50/1000
Main Bearing	43589	67715	−10/1000
Main Bearing	43589	67716	−20/1000
Main Bearing	43589	68549	−50/1000
Valve	46848	46848A	+1/32" on stem

by three coach bolts on each side. The starting handle is then taken out by slacking away the clip bolt. After this, the flexible water-joint connectors between engine and radiator are removed, when the radiator can be slid off as soon as the two bolts have been taken out which secure the trunnion brackets to the frame on each side. The steering column is next taken adrift; first the control connections are removed; then the bolt in the steering tube bottom piece is slackened; the steering column and steering wheel can then be lifted out, leaving the steering-box still in position. After this, the dash should be taken off, all attached pipes and controls being first disconnected. The steering-box should next be removed to enable the engine to be taken out; this is best done by undoing the three bolts in the bracket foot, taking off the leather cover of the ball joint on the end of the steering drop arm, and casting loose the fore-and-aft steering rod. The steering-box, with its bracket, can then be lifted out.

85. The next unit to receive attention should be the rear axle. This is desirable, as with an unloaded chassis the spring camber puts the propeller shaft and its disc joints slightly in compression. The flexion of the leather discs under this condition, and presence of the shroud on the disc joint fork, make it difficult to uncouple the joints, and slide out the propeller shaft, to enable the gear-box to be lifted out. The rear axle should therefore be tackled first.

The brake rods should be uncoupled. Then take off the nuts from the four bolts which hold each rear spring on the spring palm, and lift up the back of the chassis to enable the dowel centre pins in the springs to clear the holes in the palms in which they rest. About 1 in. lift is necessary, and the axle can then be moved back sufficiently to allow the rear disc universal joint to be uncoupled. It is then a simple matter to uncouple the propeller shaft at the front end, and to remove it.

86. Attention can now be given to the gear-box. Four bolts hold this to the sub-frame, and the only obstacles to its removal, after these have been taken out, are the leather disc joint which connects it to the clutch shaft and the bearing bracket which carries the change-speed shaft. If necessary, the change-speed gate and brake quadrant and all the gear can be removed simultaneously with the gear-box, but it is better to take off the two nuts which hold the change-speed shaft-bearing bracket to the box and swing it loose, and remove the gear-box first. Before lifting it out, the foot-brake gear must, of course, be disconnected and, before dismounting the clutch, the pedal cross-shaft must, obviously, come down, and then the clutch comes out easily enough after the nuts which clamp the leaf springs to the flywheel have been removed.

Here it may be well to give a word of advice in regard to this component. It is a sound and simple fabric-lined cone clutch of robust design, but, in course of time, the fabric naturally wears. The necessary movement in declutching is allowed by the leather disc joint which couples the clutch shaft to the first reduction pinion, and up to a point this leather joint will also permit deeper engagement of the clutch cone with the flywheel, as the fabric on the former wears. Should the wear become excessive, however, it is possible for the leather joint to drag against the clutch spring and, by preventing proper engagement, cause the clutch to slip. This is easily overcome by putting packing pieces behind the leather joint; but, unless the contingency is foreseen, the cause of the clutch slip may be obscure.

The next step is to take off the flywheel; it comes off easily enough by taking out four bolts. It is better to do this while the engine is in the chassis, as it is heavy and its removal enables the engine to be "slung" with greater ease.

87. The engine can now be taken out, after uncoupling the exhaust pipe and taking out the holding-down bolts. The chief point to observe is the method of slinging. Messrs. Thornycroft have devised a simple form of sling (Fig. 35), which it is well worth while to make. There are two bars, which catch the engine under the valve pockets on either side, that on the off side having a bend in it to clear the hot air pipe. The chain from one end of the near side bar couples to the other end of the off side bar, and *vice versa*, so that the chains can be crossed on the crane hook. This enables the engine to be slung without damaging or removing any of its fittings.


Fig. 35.—Slings for Lifting Engine from Chassis.

88. The chassis is now practically dismantled, save for the front axle. Undo the spring bolts and jack up the front of the frame (as in the case of the rear axle), to enable the dowel pins to clear the holes in the spring palms. The axle can then be slid out forwards, with the fore-and-aft steering rod trailing behind it. The frame meanwhile will, of course, have been packed up on trestles. We are now left with the frame with all its brackets and the springs still in position. The latter

can be taken off, and dismantlement is then complete. Two men should be able to accomplish all this in about three hours.

89. **The Chassis Frame.** This should be looked over, though it is rare to find any cracks. All rivets may be tapped, particularly those of the sub-frame and apron plate; should a loose rivet be found, it is in general best to remove it, broach out the hole clean, and replace by a well-fitting bright bolt and nut screwed hard up and riveted over.

90. **Springs.** The condition of the springs should be examined as to camber before the chassis is dismantled. One cracked plate in a spring frequently denotes something wrong throughout. Unless a skilled springsmith is available, it is better not to attempt to repair or "set up" springs. It is a specialist's job, and they should be returned to the makers for repair, or replaced by new ones. If all plates are sound, examine spring eyes for wear. They are bushed at the front ends only, and excessive wear, if found, is practically certain to be due to neglect in lubrication. See that greaser holes are not blocked up. Examine particularly the bottom pin in the rear spring rear shackles. If that is not lubricated properly, it may seize in the shackle. The pin will then shear the dowel, which locates it in the bracket, and oscillate therein on a *narrow bearing surface.* This may cause wear and possibly the scrapping of the bracket. Examine the springs for "dryness." If necessary, remove the clips and prise apart the leaves; clean out any rust between them, and grease moderately before replacing.

91. **Rear Axle Adjustments and Repairs.** The worm-driven rear axle of the J-type Thornycroft lorries very rarely gave us any trouble, the combination of worm and wheel in particular seeming practically everlasting.

Occasionally it may be desirable to take apart a rear axle for examination with a view to adjustment, and when this is done it is necessary to exercise care in re-assembling the parts to ensure that the various clearances are correctly maintained. The back axle is very readily dismantled: by unscrewing the nuts of the hub caps and removing the bolts, not only do these caps become immediately removable, but the driving flanges also are at once withdrawable from the splined outer ends of the differential shafts. The end nuts and washers on the sleeves, which retain the road wheels in place, being next removed, the wheels may be slid off and the floating bushes examined and replaced if necessary. Study of Fig. 5 will enable the reader to see how the remainder of the axle may be dismantled, and also to understand how—if the floating bushes do not require attention—the whole of the differential and driving gear within the axle may be withdrawn for examination without even jacking up the road wheels, by simply pulling out the two differential shafts and unscrewing the nuts holding the gear housing in place.

92. Messrs. Thornycroft inform me that the following precautions must be observed when re-assembling—

"The worm and worm wheel are both marked with two grooves. It is essential that, when fitted, the two grooves on the worm should face towards the rear or thrust end of the worm shaft, and that the grooves on the worm wheel should be on the off side of the axle. An enlarged section is shown in Fig. 36.

"When fitting the worm shaft *A* to the worm *B*, a little oil should be applied to the bore of the worm and splines of the shaft; the shaft should then be entered into the worm boss—care being taken to see that the splines are in line—and driven in a short distance by a few taps with a lead hammer. The shaft is next pressed home by an arbour or hydraulic press, the pressure being applied at the end *C*.

" In mounting the worm, the distance between the face *E* of worm and shoulder *D* of shaft should be

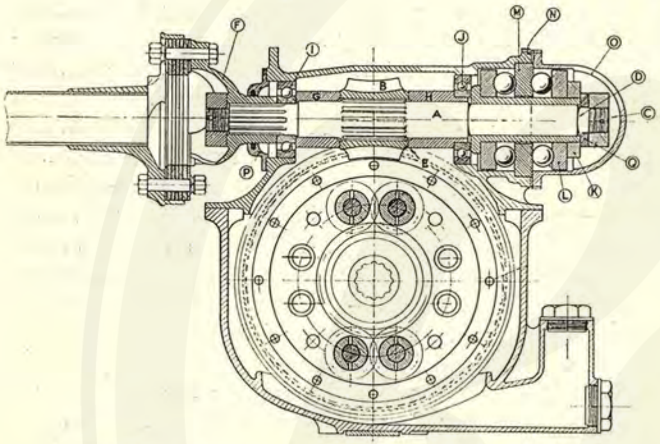


FIG. 36.—SECTIONAL DIAGRAM OF REAR AXLE WORM SHAFT.

A = Worm shaft.
B = Worm.
C and D = *See* § 92.
E = Face of worm.
F = Coupling fork.
G, H, = Distance pieces.
I J = Ball bearings.
K = Nut of ball-thrust bearing.
L = Rear ball race of thrust bearing.
M = Centre race of double thrust ball bearing.
N = Face of worm case.
O = Thrust cap.
P = Oil retainer.
Q = Washer under end nut.

9½ in. for J-type lorries : this ensures the correct draw at end of shaft for final assembling.

" The coupling fork *F* can be pressed on shaft as described above, but the fork should not be pressed on so tightly as the worm, as the fork must be withdrawn to enable the shaft to be placed in position in the worm case on final assembly. Before withdrawal, the fork

and shaft should be so marked as to ensure their being replaced on the same splines.

" The distance pieces *G* and *H* can now be placed in position, and the ball bearing *I* pressed on shaft. Ball bearing *J* should be pressed on distance piece *H* before the latter is pressed on shaft, and should be a light press fit only. Ball bearings should be let into their respective housings in top worm case, before mounting on shaft.

" Before placing the ball thrust on shaft, the race *M* should be tried in its housing, and the face of race should stand proud of the top worm-case face *N* by not less than ·010 in., which permits the thrust cap *O* to hold the race firmly. In adjusting the ball thrust nut *K*, the ball thrust sleeve should be so adjusted and locked as to permit a ·004 in. feeler being inserted between the face of ball race *L* and nut *K* ; this ensures that the ball thrust has no load due to the nut on sleeve being unduly tightened. The above points being observed, the ball thrust can now be mounted on shaft, care being taken to see that there is a draw at the shoulder *D*. Place the washer *Q* in position, screw the nut home, and hammer up tight. Put the universal coupling fork *F* on the opposite end of shaft, and nut up as described above ; the cotter holes can now be drilled in each end of the shaft.

" To place the shaft in position in top worm case, the universal coupling fork must be withdrawn and the shaft passed through the casing, so that the ball bearings just enter their respective housings ; a few blows with a lead hammer on the end *C* will then drive all home to the correct position.

The oil retainer *P* can now be fitted, the tallow-soaked felt washer being first inserted : it should be an easy fit on the universal coupling fork boss. The universal coupling fork is next finally driven on shaft, using a hollow drift, with a " hold dolly " on the end *C* of shaft ; the nut may then be finally screwed up and cottered.

" The thrust cap *O* can now be placed in position, taking care that the nut on end *C* of shaft clears it. A little " Firmaline " on the ball thrust before finally bolting on this cap will ensure ample lubrication until the oil from the axle case works up.

Owing probably to lack of lubrication, cases have occasionally occurred where the split pin in the locking nut at the end of the worm shaft has sheared and the parts have come adrift.

" We are, therefore, now fitting a *D* washer in the place of the plain washer *Q*, and whenever occasion arises to open up any axles of older type it is advisable to fit a *D* washer, which merely necessitates grinding a flat on the worm shaft itself."

93. **Rear Axle Sleeves.** Surrounding, but not touching, the differential shafts in the back axle are two " sleeves," which carry at their outer ends the floating bushes on which the rear road wheels ride (*v.* Fig. 5). When worn at their outer ends, these sleeves are readily removed and replaced by using the simple tools described, and following the directions given on the drawings reproduced in Figs. 37 and 38 herein.

As already mentioned, the floating bushes on which the road wheels are mounted were a War Office requirement, and this mode of construction involves wear both of the sleeves, the floating bushes, and the interior of the wheel hub. Major Strickland's suggestion may be referred to (§ 58), but it would appear to be difficult satisfactorily to arrange a removable case-hardened sleeve on the axle itself. I think, however, it would be an improvement if the sleeve wear could be lessened

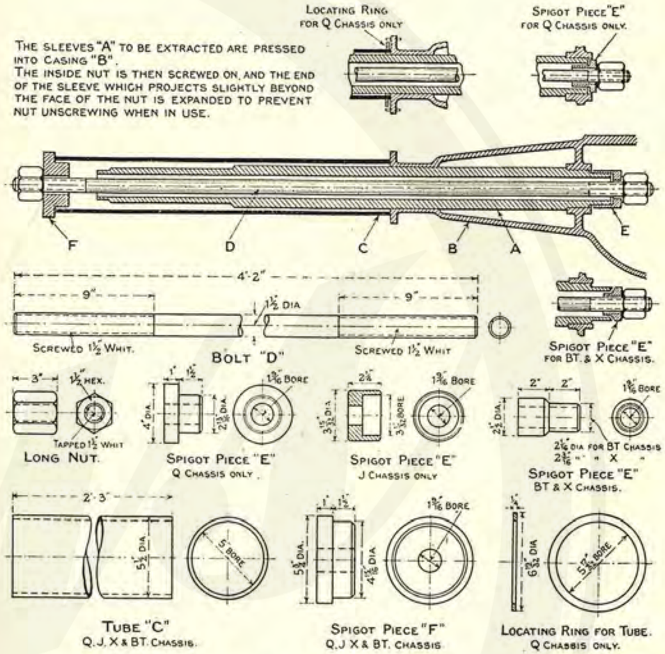


FIG. 37.—GEAR FOR REMOVING SLEEVES FROM BACK AXLE CASING.

1. Chip through and remove inside nut (except in Q chassis).
2. Slip extractor tube *C* over axle sleeve.
3. Push extractor bolt *D* through sleeve.
4. Put neck bush *E*, and nut, in position. The diameter of this bush is slightly smaller than the bore of casing.
5. Put spigot block *F*, and nut, in position.
6. Screw up nut on outer end by means of a long spanner, or spanner lengthened with a piece of pipe, when sleeve will be withdrawn from casing.

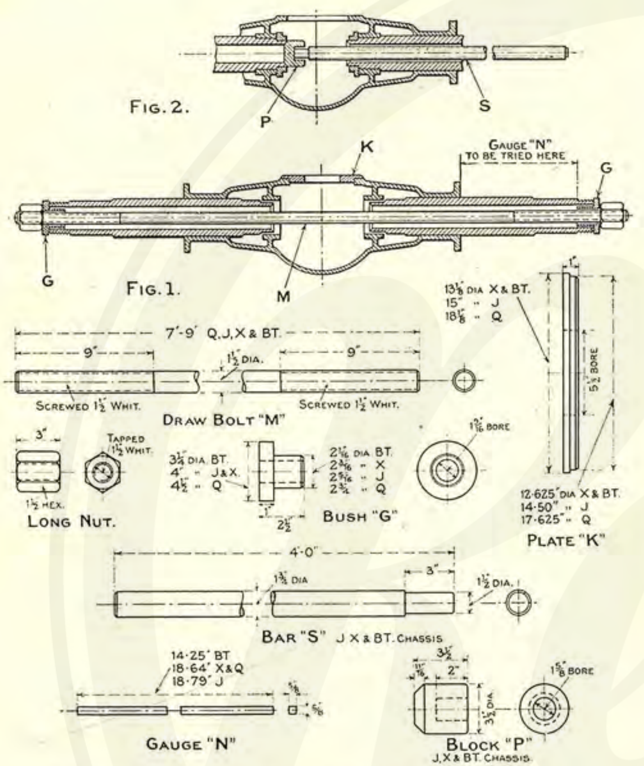


FIG. 38.—GEAR FOR PRESSING SLEEVES INTO BACK AXLE CASING.

Before assembling, liberally coat bores of casing and ends of sleeve with white or red lead paint; or, failing these, ordinary paint will do.

The sleeves should be placed in position in casing, as shown in Fig. 1 above. They will enter thus far without the use of special tools, but are pulled into final position with drawbolt and bushes used in the following manner—

1. Bolt spigoted plate *K* securely to axle in the position normally occupied by top half of worm-gear casing. This is important, as it prevents casing from buckling.
2. Place the two bushes *G* in position.
3. Push drawbolt *M* through sleeves and casing.
4. Place nuts in position and screw up both together until, in the case of sleeves with keys, both *enter their respective keyways*.

This is important and requires watching carefully. It is comparatively easy to

and this might perhaps be done by fitting the road wheel boss with a fixed bronze bush capable of withdrawal and replacement after wear.

94. **Universal Couplings.** (*See* § 10.) When fully loaded, the rear bearing springs of the J-type chassis are, as already stated, very nearly straight; the propeller shaft, through-spindle of gear-box, and worm shaft are then practically in line; and there is neither tension nor compression in a fore-and-aft direction upon the leather* rings of the second and third universal joints.

But when the vehicle is unloaded, and especially if the body be also off the chassis, the rear bearing springs have a decided camber, and in this case the rings of these universal joints are subjected to a considerable degree of fore-and-aft compression, becoming then somewhat distorted and difficult to remove or replace. It is then best to proceed in one or other of the following two ways—

(1) If the rear axle is attached to the springs and the propeller shaft alone has been removed, it is possible by the careful application of a crowbar to bring sufficient compression on the coupling rings to enable them to be got into place.

(2) But, whenever possible, it is much preferable to proceed as follows: Disconnect the rear springs at the shackles; the leather rings are then easily put in place and bolted up, after which, by means of a crowbar,

* Or fabric.

ensure one key entering correctly, and with a little care in screwing up both nuts at once, the two keys can be made to do so; if, however, one sleeve slips round so that key and keyway are not in line, by far the quicker way is to extract the sleeve and replace it in line. *No attempt should be made to turn the sleeve in axle casing to line up key and keyway.* When both keys have entered their respective keyways, each sleeve can be pulled home.

A gauge *N* is provided to show when the sleeve has been pulled in to correct distance. This gauge is the correct distance from the face of axle casing flange to end of plain portion of sleeve or face of thrust washer.

A hardened block *P* and bar *S* are used to slightly expand the end of sleeve to prevent inside nut loosening, as shown in Fig. 2 opposite.

the axle is readily prised forward into the correct position to enable the shackle bolts to be replaced. If the leather rings have to be renewed when the vehicle is

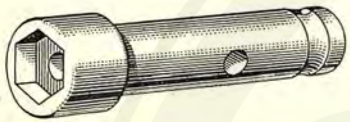


Fig. 39.—Box Spanner for Nut of Universal Joint.

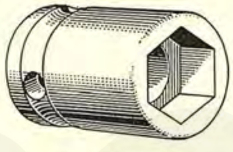


Fig. 40.—Box Spanner for Worm Shaft Universal Coupling.

loaded, the operation is simplified, as there is then little or no fore-and-aft compression to be dealt with.

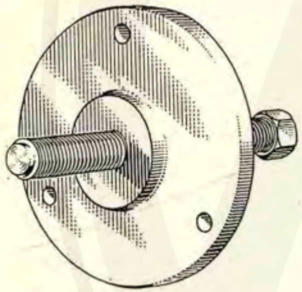


Fig. 41.—Extractor for Universal Coupling Fork.

To remove a universal coupling fork it is first necessary to unscrew the securing nut on the end of the splined shaft; this is conveniently done by aid of the special box spanners illustrated in Figs. 39 and 40, the latter being used for the nut at the worm shaft coupling.

The universal coupling fork may then be drawn off by means of the "extractor" shown in Fig. 41, by first bolting the flange to it and next screwing the central bolt hard up against the end of the shaft until the fork slacks away. As the centre of the foot-brake drum is integral with the universal coupling fork aft of the gear-box, this extractor is also used when the foot-brake drum requires removal.

95. **Lining up Gear-box.** Some cases of crankshaft breakage that occurred during the war were found, on examination, to have been caused by the gear-box having got out of line with the engine either from a settling of the frame or from faulty re-erection after overhauling. With the improved mode of suspension of the engine and gear-box, as described in § 8, this can hardly occur in later vehicles; still, it may be

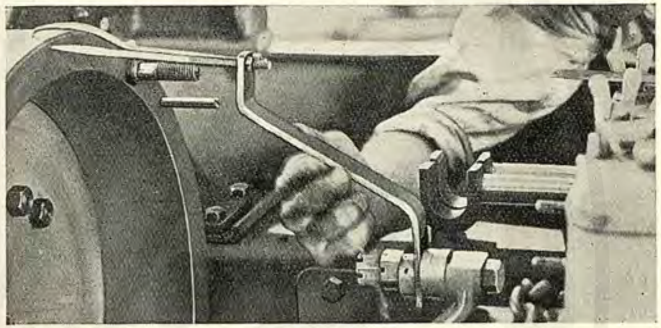


Fig. 42.—Showing Method of Testing Gear-box Alignment.

useful to describe here a simple means of testing the accuracy of the setting. The method is clearly shown in Fig. 42.

A double trammel is bolted firmly to one arm of the clutch coupling fork on the front of the gear-box. There are two pointers at the end of the trammel, one of which is adjusted to the face of the flywheel and the other to the periphery of the flywheel. The fork being rotated, the pointers will at once show whether the gear-box is out of line with the face of the flywheel or out of centre with the flywheel, when it should be packed accordingly.

Engine Repair. In Fig. 43 is shown the mode of fixing the crankcase when the main bearings require reamering out; the whole device may be mounted upon the bed of an ordinary small lathe. The fixture ensures that the crankcase is rigidly and truly held, and that the bearings are reamered accurately in line.

Fig. 44 illustrates the use of a set of four half-cylinders mounted upon the crankcase, with inspection doors removed for ascertaining that the connecting rods are in correct alignment.

Fig. 45 shows how the crankshaft is held and an extractor applied when it is desired to withdraw the timing wheel. The wheel is connected to a stout cross-head by two bolts, and is then drawn off by screwing the stout screwed rod shown hard up against the end of the crankshaft. To replace the timing wheel, it is driven on by aid of a hollow sleeve surrounding the crankshaft and bearing against the boss of the wheel.

96. **Minor Repairs and Adjustments.** By reason of its extreme usefulness and readiness for immediate service at any time, the commercial motor vehicle is one of the most heavily-worked machines in general industrial use; but the severity of even normal conditions of running renders it essential to prolonged good performance that all working parts be kept in proper adjustment. The temptation to overload the vehicle constantly arises, but should be as constantly resisted; and rigid instructions should be issued against driving at speeds in excess of that stated by the makers. The evils of excessive speed are particularly serious, as the stresses thus created in the mechanism of the vehicle increase very fast, being roughly as the *square* of speed, and not merely simply in proportion to it.

Over bad road surfaces, speed should be reduced, and

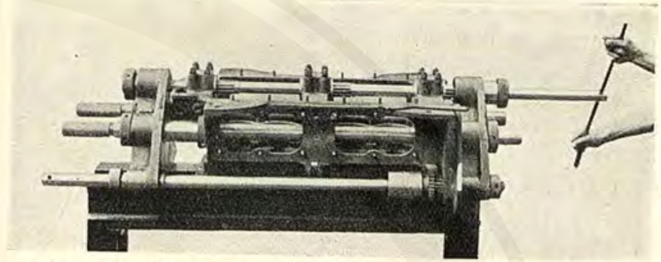


FIG. 43.—REAMERING OF CRANKSHAFT MAIN BEARINGS.

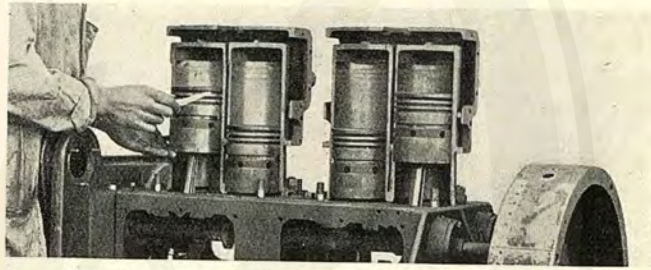


FIG. 44.—TESTING PISTONS FOR ALIGNMENT IN HALF CYLINDERS.

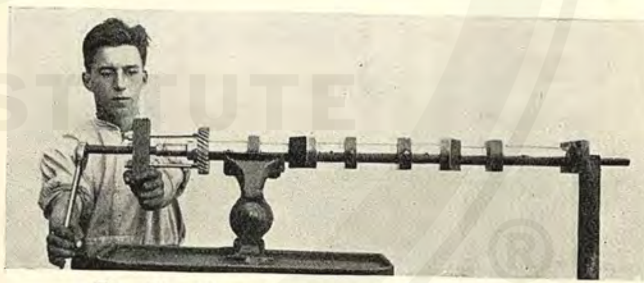


FIG. 45.—WITHDRAWING TIMING WHEEL FROM CRANKSHAFT.

under no circumstances should the governing details be tampered with in any way.

Daily Inspection. A brief examination should be made daily of all bolts and nuts on the chassis, and all working parts should be tried from time to time to see that no undue slackness has developed. It is specially desirable to give regular attention to the condition of the details of the steering gear and the foot- and hand-brakes.

I have found it an excellent practice to allot regular periods at weekly or fortnightly intervals for each vehicle to remain in the shed to enable its driver to thoroughly clean and examine all working parts and make adjustments requiring more time than can be spared on ordinary working days.

97. **Spares on Vehicle.** It is always well to carry on the vehicle, in addition to the usual tool kit, at least the following small spares: Two valves, all complete with springs, washers, and cotters; a selection of assorted bolts, nuts, and split pins; two 4-in. lengths of rubber tubing for water service connections; four sparking plugs; 2 yds. of insulated "high-tension" wire.

98. **Engine Adjustments.** The most important point in connection with the engine, to which regular attention must be given, is that of lubrication; some remarks on this are given later. (Chapter VI.)

Should a knock develop in the engine, it should be at once investigated and remedied. In most cases, it will be found that the knock arises from slack connecting-rod big-end bearings. If the bolts are slack, they must be tightened up; but if the bearing itself is worn, it must be adjusted by slightly reducing the thickness of the liners or distance pieces inserted between the big end and cap of the rod. Nothing must be taken off these liners at their inner surfaces (i.e. where they bear

against the crank pin), as this causes waste of oil from the bearing and results in over-lubrication of the piston, sooted plugs, and a smoky exhaust.

Pistons. When the engine continues to run for a short time after the ignition is switched off, and also "pinks" or knocks when pulling hard at comparatively low speed, as when hill-climbing—although the ignition has been retarded—carbonizing is indicated, and the piston crowns must then be cleansed of the deposit of carbon which has formed upon them, and which, through points or small local areas becoming red-hot during working, provide an automatic pre-ignition. A carbon deposit also forms inside the piston from the oil thrown up by the crank-pin on to the heated lower surface of the piston crown; this deposit should also be removed to prevent flakes of carbon falling from it into the crank-chamber and, in time, choking up the oil strainer.

The piston rings should also be examined to see that none is broken nor become fixed in its groove.

99. **Valves.** Access to the valves is simply obtained, as the valve caps are retained by cone-seated bayonet joints; and all that is necessary to remove a cap is to slack back the set screw and give the cap a quarter turn, when it can be lifted out. All the valves require grinding-in occasionally; if this is not done, the compression and, consequently, the power output of the engine, will progressively diminish. Leaky exhaust valves especially are quickly ruined completely by the rapidly erosive and oxidizing action of the flaming exhaust gas rushing past them. After being ground-in a valve seats rather lower than before, and hence the tappet clearance always then requires readjusting; a suitable clearance is the thickness of an ordinary visiting card (about ·008 in.). The tappet rods are

now fitted with screwed caps locked by hexagon nuts; all that is necessary to adjust the clearance is to slack back the locking nut, screw the cap until the correct clearance is obtained, and tighten up the nut. Earlier engines had tappets surmounted by steel caps, adjustment being effected by inserting thin washers between the end of the rod and inside of cap.

100. **Water-circulating Pump.** The gland should be packed with cotton grease packing, and tightened up so as to permit an occasional drop of water to pass out. Asbestos packing must not be used for this gland. When filling the radiator, the small cock on the top of the pump body should be opened to prevent the formation of an air lock. The driving belt should be kept just so tight that it does not slip; if too slack, a link may be removed, but if this shortens it too much, a half-link may be inserted. The belt should be dressed occasionally with neat's-foot oil or castor oil.

101. **Ignition.** The sparking plugs require examination from time to time; any carbon should be carefully scraped off and the plug then well washed in petrol and dried on a clean soft cloth. The spark gaps should be adjusted to a width of about $\frac{1}{32}$ in. I much prefer the high-tension leads to be well separated and carried in full view from the magneto to the sparking plugs; a defective lead is then at once noted, which may not be the case when they are carried in a bundle through a tube.

The magneto requires very little oil; only three or four drops of a good sewing-machine oil in each oil hole at intervals of, say, two weeks. Over-oiling is liable to cause failure of the magneto by setting up short-circuiting through the excess getting into the armature. The contact breaker should be occasionally examined by aid of a hand lens; the platinum points must be

kept clean and free from oil; they need occasional adjustment, which must be done with great care.

102. **The Clutch.** This has already been described and illustrated in § 21. A three-quarter front view of the clutch is shown in Fig. 46, and it is very easily adjusted by means of the nuts *A A* on two studs fixed in the flywheel rim, and which pass through the ends of the double laminated spring as shown. If the clutch

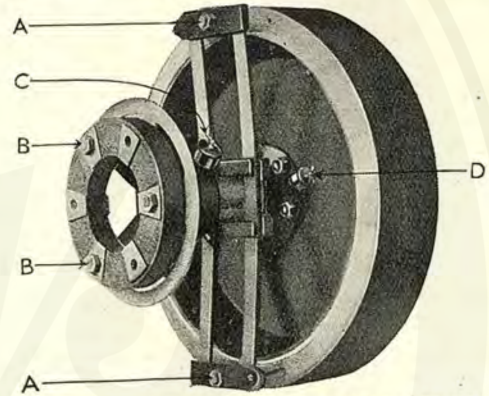


FIG. 46.—CLUTCH WITH LAMINATED SPRING ADJUSTMENT.

slips, it is only necessary to screw up these nuts and thus increase the spring pressure; but care must be taken to screw them up equally. On the other hand, should the clutch engage too suddenly or be "too fierce" as it is termed, the lining of the cone may first be dressed with engine oil; if this does not remove the "fierceness," the nuts *A A* must be screwed back a little. When the pedal is depressed and the clutch disengaged, the spring pressure is taken by a ball-thrust bearing, which is greased by means of the lubricator *C*; this should always be kept well supplied. I may point out here that the driver should not keep his foot always on the clutch pedal, as there is then a likelihood of this bearing being constantly subjected to unnecessary pressure. Drivers also often make a practice of slipping the clutch, in order to let the engine " get away " ; with these heavy vehicles this practice should be strongly discouraged, as it causes great friction and wear, and the early destruction of the clutch-lining fabric.

The bolts marked *BB* on Fig. 46, in the leather universal coupling, occasionally work slack, and should be tested from time to time and tightened when necessary.

103. **Gear-box.** In general, little attention is needed by the gear-box beyond maintaining the oil level within it up to the centre of the bottom shaft ; the same quality of oil may be used as in the engine. It is well to drain the box and wash it out with paraffin about twice a year ; in particular, if the gear is changed unskilfully and the wheels are grated, the teeth may have been chipped, in which case any steel chippings should be removed without delay to prevent them from getting into and damaging the ball bearings.

104. **Brakes.** The side brake acts directly on the rear wheels, and thus causes no stresses in the transmitting mechanism ; it should therefore be used in preference to the foot-brake, whose action is transmitted through the rear universal joint, worm, and differential gear to the rear wheels. The side brake is adjusted by means of right- and left-handed screwed rods united by shackles on both sides of the chassis ; in addition, forks, having several holes, are fitted on the brake rods, so that a wide range of adjustment is available. All working parts and joints of both brakes should be kept free, well oiled, and in correct adjustment.

105. **Motor Lorry " Service."** The general deficiency of mechanical knowledge and skill possessed by owners has resulted during recent years in most leading makers undertaking the organization and setting up of inspecting staffs and service depots, where vehicles can, whenever necessary, obtain the same degree of skilled treatment as when they were originally built. Messrs. Thornycroft have for some years past given careful attention to the maintenance of vehicles built by them, and to assist owners in keeping their fleets in good running condition have set up a complete system including (1) Instructional courses to drivers ; (2) an outside inspecting department, whence technical and experienced inspectors travel all over the country and keep in direct touch with owners ; and (3) " Service Depots " or agencies throughout the country, where full stocks of replace parts are kept, and in which repair work of any description is executed by their own workmen.

Driving Courses. Messrs. Thornycroft receive drivers at their Basingstoke works for instruction prior to the delivery of vehicles ordered ; such men are, of course, required to conform to the factory regulations while under instruction, and their expenses are paid by their own employers. An instruction book is given with each new vehicle delivered. This is simply written and amply illustrated so as to be easily understood by inexperienced drivers. An illustrated list of spare parts is also included, by aid of which any part required can promptly be obtained on application by quoting its number and preferably also its list description.

Outside Inspectors. These are experienced men who visit owners throughout the country from time to time and assist them gratuitously with advice in connection with the maintenance of their Thornycroft vehicles.

Their function is purely advisory, and they are not supposed to act as mechanics, although I have found that in cases where a trifling adjustment only is necessary they are usually obliging enough to give it their personal attention. Owners who apply for a skilled mechanic to be sent to carry out some required adjustment or repair are naturally invoiced for his services and expenses in the normal course of business.

Service Depots. Messrs. Thornycroft inform me they are so fully represented in Great Britain that owners everywhere are within reasonably easy reach either of a Thornycroft depot or an agency. In the depots, full stocks of spare parts are kept, together with a staff of skilled mechanics. The agencies maintain also adequate stocks of all usual spares, and are equipped to undertake all ordinary repairs and adjustments.

Messrs. Thornycroft have also branches of their own abroad, in addition to their foreign agencies ; in general, these are adequately equipped with competently-staffed repair shops, and are stocked with all necessary spare and replace parts.

CHAPTER V

106. **Cost of Running** :—The whole cost of running a fleet of motor vehicles is a problem which does not always receive that careful attention its importance would seem to merit. There are, of course, undertakings in which complete and carefully detailed cost records *must* be maintained, as, for example, in an omnibus or goods-carrying service, where the success or failure of the enterprise depends directly upon the question whether the vehicles do or do not pay to run. But in the very numerous cases where manufacturers or distributors use a limited number of motor lorries to transport some of their goods there are several additional considerations of value to be taken into account. Thus, there is the very important advantage in general that goods are so transferred direct from consignor to consignee without intermediate delay and cost being incurred by breakage of bulk and extra handling in transit ; there is also the saving of time and gain of reputation resulting from prompt deliveries ; and the advertisement to manufacturers and distributors arising from their name being brought prominently before the public by well-conditioned motor vehicles in the course of their daily running. Though it is impossible to estimate the precise money value of these important points, they must yet receive careful attention when the question of setting up a motor vehicle fleet is under consideration.

The total running costs of the very light delivery vans now so largely used by retail tradesmen, taking loads varying from, say, 10 to 30 cwts., are particularly difficult to estimate exactly ; yet there is no doubt but that their speed, range of action, and general convenience cause them to be found preferable to the much slower and more troublesome horse requiring constant human attention in connection with feeding, watering, stabling, grooming, shoeing, etc.

107. A few statements relating to the cost of running motor omnibuses in London have been published, and I refer briefly to these here as the results obtained may be helpful if only as furnishing a standard for comparison with other cases. Thus, in 1907 the average total running cost of the London motor omnibuses was 9·5 pence per mile ; in 1912 this had been reduced to roundly 7·0 pence per mile, this total being made up of the following items—

Typical Running Costs Details of London Motor Omnibuses in 1912.

Pence per mile.

Item.	Pence.
Driver's wages	1·251
Conductor's wages	0·847
Petrol	1·067
Tyres	1·098
Depreciation, rent, rates and taxes	0·849
Maintenance	0·240
Body upkeep	0·235
Traffic expenses	0·270
Oil, grease, and paraffin	0·117
Lighting	0·069
Trade vehicles	0·151
Clothing	0·001
Aggregate of all other expenses	0·868
Total running cost per mile	= 7·063 pence

At the end of 1912 there were about 4,500 motor buses in Great Britain, practically all petrol type. The average gross weight of a fully-loaded full-sized omnibus was at that time from 5½ to 7 tons, a maximum of about 2 tons being borne by each rear driving wheel. The average daily run in London service ranged from about 100 to 120 miles ; in country services, with inferior roads and steeper hills, the daily mileage was usually of the order of 75, and the total running cost per mile from 9·0 to 12·0 pence, compared with 7·0 to 8·0 pence in London service.

The solid rubber tyres fitted were usually guaranteed a life of 12,000 miles, but in London service, on good road surfaces, this mileage was usually materially exceeded, the average from 543 omnibuses showing a tyre life of 18,346 miles, with a maximum of 32,663 miles ; it may be taken that an all-round average of 20,000 miles may safely be assumed as the mileage life of the solid rubber tyres of London motor omnibuses at that period.

Since 1920 the Corporation of Aberdeen has operated a fleet of Thornycroft motor omnibuses. During 1923 these vehicles are stated to have earned a profit of 20 per cent on the capital outlay, the working expenses having been somewhat under one shilling per bus-mile.

108. **Commercial Lorries.** The lowest running cost per ton transported is shown by the heavy commercial lorry which runs a full journey daily, fully loaded, over good road surfaces, at its proper speed ; this ideal condition of things is, however, never realized. The nearest approximation to it is that of a vehicle running out fully loaded daily and supplying depots from a central factory or warehouse, returning partially loaded with "empties"; and, again, over good road surfaces and at its proper speed. But the most commonly occurring case is that wherein the vehicle starts out loaded and gradually disposes of its burden on its outward run, returning home light and—it is to be feared—usually at too high a speed.

In considering running costs, it is well to have clearly before one's mind a perfect case. When fleets of commercial vehicles are under consideration, it is not a question of making any profit directly out of their running, and hence the perfect case would seem to be that, having allowed for interest on purchase money, depreciation, proportion of fixed overhead charges, and all other costs whatever incurred in connection with the actual running and maintenance of the vehicles, the total shall come out less than that of any available alternative system. In this ideal case, also, all the collateral advantages conferred by the employment of motor lorries—as of convenience in dispatching goods *whenever* desired, the saving of time in delivery, etc.—are enjoyed in addition to the economy achieved by their service. But the difficulty in instituting a really exhaustive comparison of cost of transport by motor lorry and by alternative methods is so great as to be, in general, impracticable; for in all other methods there is almost invariably intermediate handling and breakage of bulk of the goods in transit, involving extra charges, increased delay in delivery, and some risk of damage and perhaps loss.

109. For the assistance of prospective owners, Messrs. Thornycroft issue a pamphlet showing some estimated running costs of their standard motor vehicles, and by aid of this I have prepared the statement given below for the case of a 4-ton J-type lorry—

ESTIMATED RUNNING COSTS OF A 4-TON J-TYPE LORRY.

1. *Standing Charges*—

Item.	Pence per week.
Interest on purchase-money @ 5% per annum	107
Depreciation @ 15% per annum	640
Insurance	120
Taxation charges	138
Drivers' wages @ £4 per week	960
Total	1,965

2. *Running Charges*—

Item.	Pence per mile.
Petrol @ 1s. 9d. per gallon	3·0
Tyres	1·2
Repairs	1·6
Oil and grease	0·29
Total	6·09

110. The total cost of operating the lorry, per week, is dependent upon the weekly mileage run, and may be set out conveniently thus—

ESTIMATED TOTAL OPERATING COSTS PER WEEK AND PER MILE OF A 4-TON J-TYPE LORRY.

Weekly Mileage.	Standing Charges in Pence per week.	Running Charges in Pence per week.	Total Cost in Pence per Vehicle-mile.	Total Cost in Pence per Net Ton-mile.
100	1965	609	25·74	6·45
200	,,	1,218	15·91	3·98
300	,,	1,827	12·64	3·16
400	,,	2,436	11·00	2·75
500	,,	3,045	10·02	2·50

The economy of maintaining a good weekly mileage is strikingly brought out in the fourth column. The figures in the fifth column are for a lorry always fully loaded; if the vehicle is fully loaded on the outward journey only, and returns light, these figures will evidently be doubled.

111. From some running cost records in my possession, the figures given below have been selected. These are average actual costs per vehicle as deduced by their owners from a fleet of six similar 4-ton motor lorries used in normal commercial service throughout the year

1922. The six lorries averaged each 225 working days during the year.

ACTUAL RUNNING COSTS DURING 1922:

Averaged from the records of six 4-ton Lorries.

Item.	Pence per week.
Depreciation	807·2
Insurance	54·3
Taxation	130·0
Wages of driver and assistant	1692·1
Petrol	1168·4
Tyres	194·5
Repairs and adjustments (material and labour)	607·1
Oil and grease	127·4
Garage expenses–	530·8
General establishment charges (proportion)	367·8
Total cost in pence per week	5679·6

The weekly vehicle-mileage averaged 316 throughout the year, so that the total cost in pence per vehicle-mile amounted to 17·9. The average load outward was 3·9 tons, and inward 1·6 tons. And the average fuel consumption was 6·4 vehicle-miles per gallon. On comparing these figures with those of § 110, it will be observed that, although no interest is charged upon the purchase capital, the depreciation allowance is so large that it probably includes the item of interest. Further, the following additional items are here debited against the vehicle—

Assistant's wages	732·1
Garage expenses	530·8
Establishment charges	367·8
Total	1630·7

If this be deducted from 5679·6, the figure 4,049 pence per week results; and this is seen to be in substantial agreement with Messrs. Thornycroft's estimate,

which is roundly 3,890 pence per week for 316 miles. The average load in this case was 2·75 tons only, corresponding to

$$\frac{5679{\cdot}6}{2{\cdot}75 \times 316} = 6{\cdot}54 \text{ pence per net-ton-mile};$$

but running costs estimated per net-ton-mile are so greatly dependent upon the nature of the service as to have no comparative and, in general, very little intrinsic interest or value.

112. Estimated in manner similar to that exemplified in §§ 109 and 110, Messrs. Thornycroft have prepared running cost statements for all their standard types of motor vehicles, and from these I have prepared the following short table giving a summary of results for an assumed weekly vehicle-mileage of 400 in all cases—

ESTIMATED RUNNING COSTS OF STANDARD THORNYCROFT LORRIES.

400 *Miles per week.*

Type.	Normal Full Load: Tons.	Pence per Week.			Pence per Vehicle-mile.	Pence* per Net Ton-mile.
		Standing Charges.	Running Charges.	Total.		
B.T.	2	1,748	1,632	3,380	8·45	4·23
X	3	1,869	2,078	3,947	9·87	3·29
J	4	1,965	2,436	4,401	11·00	2·75
Q	5	2,048	2,848	4,896	12·24	2·45
W	6	2,116	3,076	5,192	12·98	2·16

* For vehicle fully loaded throughout.

The relative economy of the heavier types in cost per net-ton-mile is clearly shown in the last column, the cost with a 6-ton vehicle being roundly only one-half that with a 2-tonner. General operating costs are conveniently recorded on forms of the type given on

Make:— Load Capacity:— Engine No:—

Week	Standing Charges					Weekly Running Costs						Total Weekly Charges	Total Weekly Mileage	Cost per Mile	Cost per Ton Mile	Petrol Used	Miles per Gallon	Remarks
Ending	Interest on Capital	Depreciation	Rent, Insurance and Licence	Wages of Driver	Total	Tyres	Petrol	Oil and Grease	Maintenance and Repairs	Miscellaneous	Total			Pence	Pence	Galls		

Form for Recording Vehicle Operating Costs.

page 120, which summarizes all expenses at weekly intervals.

113. **Organization of Drivers.** Much attention has been devoted of late, particularly in the United States, to the very important problem of reducing delivery costs by the adoption of economically sound methods, whereby drivers are encouraged both to improve their deliveries and to maintain their lorries in efficient condition at a minimum of cost.

The Chicago Motor Coach Co.* insist on an adequate technical training and education for all their drivers and other workers, and regard careful and regular inspection and recording as essential to success with motor vehicle fleets. They state they have learned four very important lessons, viz.—

(1) The value of courtesy.

(2) The importance of proper training.

(3) The necessity of care in employing and discharging men.

(4) The importance of general mechanical knowledge.

General courtesy is, of course, always a valuable asset in business, and particularly is this so in a passenger-carrying service.

The Chicago Co. point out that as most of the "available talent" is more or less unskilled, it becomes necessary to put all through a course of intensive training; this is accordingly undergone not only by drivers, but also by inspectors, mechanics, starters, and assistants.

With reference to the granting of employment, they observe that great care should be exercised in scrutinizing the past records of applicants, and they should also be examined for temperamental fitness; they remark that a sensible management realizes the average

* *Motor Transport*, 1/5/23 (New York).

man tends to be loyal, and is usually quick to respond to the right kind of leadership. And, again with regard to dismissals, they say that nothing is more wasteful than a steady stream of changes in *personnel.* To create a permanent and contented "crowd," they have thus been led to select men 25 or more years of age, and preferably married; and they consider it important to arrange that, whenever possible, promotions should be made from the ranks, so that good and keen service may look forward hopefully to a due reward.

114. On the point of mixed fleets, their General Manager is very emphatic; he says—

"A number of responsible concerns have bought a miscellaneous equipment of vehicles with the thought that in this manner it would be possible to compare readily their relative merits, but too often the very fact that the equipment is miscellaneous prevents any one type from showing to advantage, and the net result is often somewhat chaotic, and confusing, and troublesome to all concerned. . . . Seldom does an organization secure a fair degree of efficiency from mixed equipment. From our view-point we would rather maintain a second-grade fleet all of one type than one of mixed first- and second-grade vehicles."

Great stress is laid upon the importance of a properly organized inspection and recording system, as with this the mechanical condition of the whole fleet is always definitely known at headquarters, and analysis of these records reveals clearly the directions in which improvements may be made and economies effected.

Mr. W. Winkler, of Chicago, operating a fleet of twenty-two goods-carrying motor vehicles, dwells particularly upon the importance of maintaining always a high standard of cleanliness throughout; he states that

when the lorries are kept very clean and smart in appearance, their drivers manifest much more interest in them.

115. The National Oxygen Co. of Chicago have published some useful particulars of their practice.* They attach great importance to the personality of the driver, and always select men possessing some mechanical skill; they keep the same man as far as possible on the same lorry, and encourage him to make all his small adjustments and repairs, and thus keep his vehicle on the road the maximum amount of time.

The Fifth Avenue Bus. Co., of New York, with a fleet of 280 buses, state that in their system a "Bus Report Card" is filled up by the driver and conductor daily. This records any irregularities in working, or other items requiring attention, that have been noted by either during the day. At the end of the day's run this report card is handed by the driver to an inspector, and ten minutes is allowed these two to discuss it and any points arising from it. Experience shows that these ten-minute conversations each night with a skilled inspector soon give the driver a useful knowledge of the details of his vehicle. As an encouragement, the drivers are paid extra for these nightly talks, and also for verifying personally before they leave that their vehicles have been properly replenished with petrol and oil for the morrow's run.

116. The Broadway Store at Los Angeles, with a fleet of thirty-two lorries, state that by the adoption of a carefully considered system they have, within one year, reduced their parcels delivery costs by 10 per cent, reduced breakages by 15 per cent, and that they have also nearly eliminated the withdrawal of any lorries from service due to mechanical troubles.

* *Motor Transport,* 15/3/23 (New York).

The driver's daily reports show if anything needs attention; and all necessary adjustments, repairs, or replacements are done during the night. A copy of the daily report form is given on p. 125.

Engines are governed to prevent over-running, and it will be noted that the vehicles are fitted with odometers, or mileage indicators; and, in some instances, also with other special recording apparatus of accelerometer type.

In addition to these daily reports, every lorry is thoroughly inspected once monthly, and the observations made are entered upon a suitably extended form and preserved for record, any necessary action being then taken.

All lorries are washed every night; certain parts are greased nightly; and all lorries are completely greased five times monthly. A sum of 15 dollars per lorry per month is allowed by the company for body upkeep (i.e. paint, varnish, and small repairs), exclusive of washing and polishing. A "service lorry" is also maintained specially equipped to deal with any difficulties experienced by the ordinary lorries during their daily work. They say—

"Some idea of the equipment of our service vehicle may be gained from the fact that it has never taken more than 15 minutes to get any disabled lorry under way after it has arrived on the scene."

117. To encourage carefulness and reduce breakages of goods, this company has instituted a bonus system, whereby 320 dollars per month is credited to the whole fleet. This is termed the "Anti-breakage Fund," and against it all costs of replacing breakages due to carelessness of drivers is debited during the course of the month. Any credit balance then remaining is distributed equally between the thirty-two drivers; thus

BROADWAY DEPARTMENT STORE.*

Daily Truck Report.

Truck No. .... Date .... Driver ....
Run .... Helper.....................

Odometer Finish .... Tyre Charge (if any)..............
Odometer Start .... Make removed........ No. ....
.... Odometer reading ....
Mileage .... Make applied .... No. ....

Check (√) *all parts* NOT *working properly.*

Ignition	Foot brakes	Radius rods ....
Carburettor	Tyres......................	Radiator..................
Cooling	Steering gear..........	Fan..........................
Lubrication.............	Tie rod	Fan belt...................
Valves.....................	Front axle...............	Battery....................
Power......................	Wheels	Lights......................
Knock......................	Springs...................	Odometer ....
Hand brakes...........	Frame	Fenders....................

Meter Reading :	*Remarks :* ....
Finish............................	....
Start.............................	....
Consumption :	....
A. H.P.M.	....
	....

GASOLINE AND OIL.	Gallons : Gasoline.	Quarts of Oil : Medium.	Quarts of Transmission Oil.
Received by.........................			

Garage Telephone No..................

Store Telephones :

Up to 5.30 p.m................................

After 5.30 p.m................................

* Reproduced by courtesy of *Motor Transport,* 239 West 39th Street, New York, U.S.A.

a driver who has had no breakages whatever gets no more than another who has had several ; this is found to make the men painstaking for the sake of their fellows, and to encourage a spirit of co-operation in carefulness.

The drivers are all uniformed, each man being supplied by the company with two complete uniforms including puttees and a shoe-polishing outfit. The uniforms are left each night in the garage before the men go home, and before starting out on the following day each man reports in uniform and with clean puttees and shoes. No street inspectors are employed, the condition and performance of the lorries (as shown by the daily reports handed in by the drivers) being considered to render these unnecessary.

Thus, generally, it may be said that our American friends have found the best policy to consist of stimulating drivers to keep their vehicles always in smart condition throughout by granting facilities for instruction, examination, and attention ; by encouraging them with the offer of suitable rewards or small bonuses ; and by holding out the hope of advancement to persuade them to give fully and cheerfully of their best in the discharge of their duty.

CHAPTER VI

118. THE mode of lubrication of the M/4 engine fitted to the J-type chassis is described in §§ 29 and 30, and further references to this important matter will be found also in §§ 65 and 66.

Lubrication is of all things chief in importance, as the consequences of neglect may quickly involve an owner in a repair bill of the first magnitude. As good lubricating oil is somewhat expensive, a reasonable moderation in its use must be observed, but too great an insistence on minimizing oil consumption may easily prove a very expensive economy.

A good lubricating oil should satisfy the following four simple tests—

(1) A sample should not separate into strata of different shades, nor deposit any sediment after standing in a glass cylinder for several days.

(2) It should neither rust nor corrode a piece of polished steel suspended in it, nor turn blue litmus paper red.

(3) After shaking up with water, it should quickly and clearly separate, leaving no soapy emulsion.

(4) When ice-cooled, it should not become cloudy, which indicates a content of paraffin wax.

Different brands of oil should never be mixed. If a change of oil is to be made, all the old oil should be drained away and the parts cleaned with paraffin before the new is introduced ; this is of special importance in connection with the engine. The oil in the crankcase in the course of use may become diluted and thinned by unburnt fuel, which is absorbed after passing the

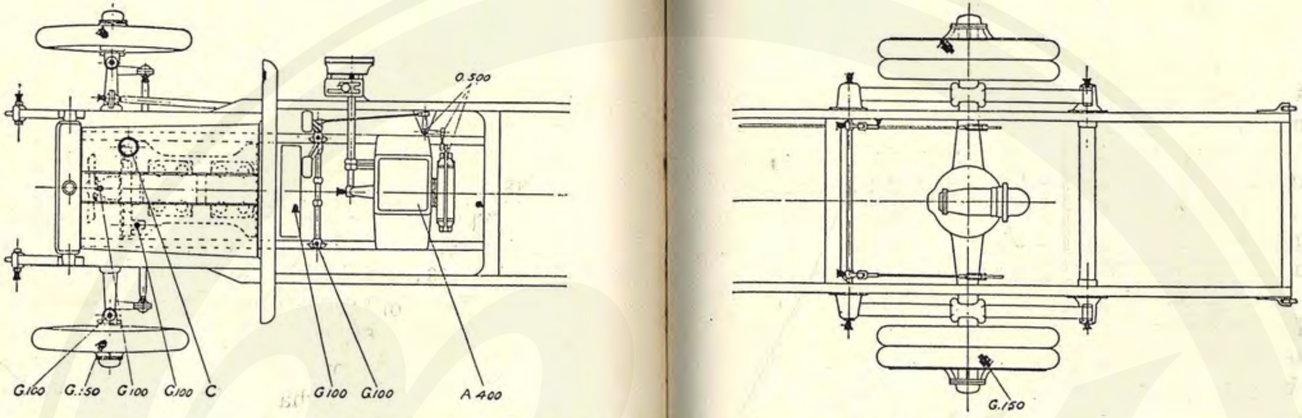


FIG. 47.—LUBRICATOR DIAGRAM FOR J-TYPE CHASSIS.

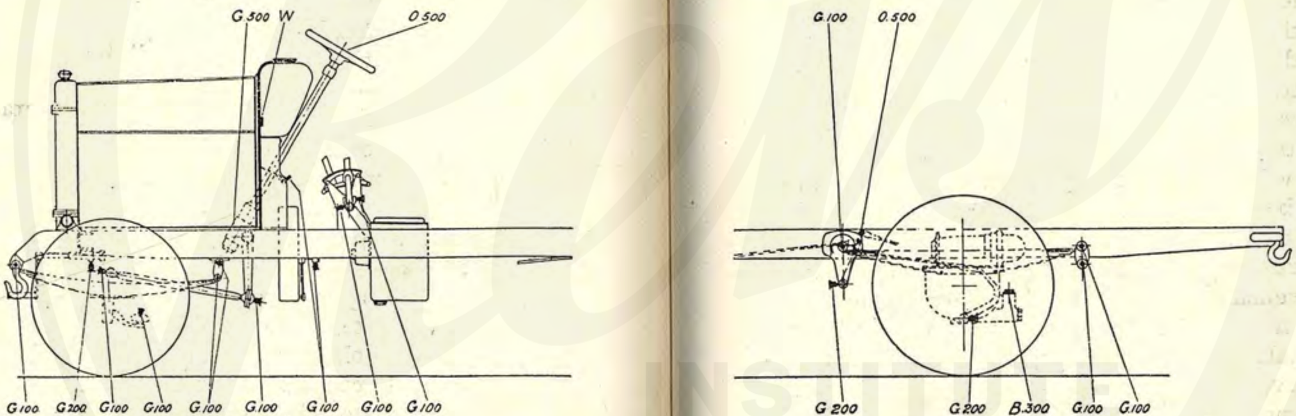


FIG. 48.—LUBRICATION DIAGRAM FOR J-TYPE CHASSIS.

A. Fill gear-box with lubricating oil to the proper level, viz., up to the centre of the bottom shaft. This should be sufficient for about 400 miles running, after which examination should be made to see it more is required.
B. Fill with amber gear oil up to the top of the filling hole: this should be sufficient for about 300 miles.
C. Fill with best quality motor oil until oil level indicator rises 1½ in. above lowest level, when, with engine running, a pressure of about 10 lbs. should be shown on pressure gauge *W*.
G: Fill up with grease and screw down caps frequently.
O. Inject a few drops of oil from oil can.
NOTE.—The figures after the several letters as *O* 500, *G* 100, etc., indicate how often the oiling or greasing is to be done (i.e. *O* 500 means oil every 500 miles, *G* 100 means grease every 100 miles, etc.).

pistons in the form of vapour; it may become contaminated by small particles of metal and of carbon; and some water may also appear in it from condensation of burnt gases which have got past the pistons. The water and contaminations together tend to thicken the oil into a "sludge," and in extreme cases this has been known to cause failure of the lubrication, with consequent damage to the engine. The oil in the engine should be maintained at, but not above, the level of the test cock fitted on the lower part of the crankcase; and when the engine is running, it should always be noted that the oil gauge indicates a pressure of 5 to 10 lbs., showing that the oil pump is acting; should the gauge show no pressure, the oil pump must be primed. If this does not succeed in stimulating it into action, it is probable that the strainer (*see* § 29) is fouled or the pipes choked; the strainer should be examined first, and its gauze thoroughly cleaned and finally washed with paraffin. In any case, the strainer should be removed and cleaned, and the oil renewed at intervals of about two months; the oil pipes also should be taken down occasionally and washed out with paraffin.

All grease cups throughout the chassis should also receive regular attention, and their ducts not be allowed to become blocked. Cups covered in mud render the grease liable to become dirty; strict cleanliness should be observed.

A lubrication diagram for the J-type chassis is given in Figs. 47 and 48, and will repay careful study.

I am indebted to Messrs. Thornycroft for the following statement embodying their recommendations relating to lubricating oils for use in their motor lorries—

119. **Oil for Thornycroft Commercial Motor Vehicles:—** "ENGINE, GEAR-BOX, AND REAR AXLE.—We prefer to

use one brand only of lubricating oil throughout our commercial vehicles. For this purpose we recommend either of the following—

Price's Heavy Gas Engine Oil ,, No. 445	Supplied by Messrs. Price's Co., Ltd., Battersea, London, S.W.
Double Shell Lubricating Oil Triple Shell Lubricating Oil	Supplied by Messrs. Shell-Mex, Ltd., Shell Corner, Kingsway, London, W.C.2.

"Anyone contemplating using any other oils on our vehicles is advised first to ascertain that their essential qualities are such as to render them equally suitable.

"Some oils carbonize more easily than others in the engine, causing an excess of carbon deposit which rapidly fouls the engine, resulting in pre-ignition and consequent loss of power. Other oils tend to lose their viscosity at running temperatures, rendering them entirely unsuitable for engine lubrication.

"The back axle having a worm drive requires a particularly good quality of lubricating oil, and an unsuitable oil in the back axle will have as disastrous results as an unsuitable oil in the engine.

"Alternative oils to those recommended above should have a specific gravity of 0·9 at 60° F., and should come within the following limits with regard to viscosity—

	Redwood.	Engler Degrees.
140° F.	140–250	4·7–8
200° F.	50– 85	1·8–3

"For those who have access to a laboratory, it will not be a very hard matter to obtain the relative viscosities at the temperatures given above. On the other hand, we are quite prepared to report on oil samples submitted by our clients, when they cannot for any reason obtain oils which we have recommended and proved to be satisfactory.

" Flash Point.—This should not fall below 330° F. by closed test.

" Congealing Point.—The oils should be in a liquid state at 25° F.

" Engine Oil Level.—When oiling up the engine, the crank-case should be filled up to the level of the try cock fitted to the sump ; this places the float stem of the oil level indicator about half-way up the guide on the crank-case between the middle cylinders.

" If the oil level is higher than this, there will be occasions when the rods may dip, either running uphill or down, with a consequent waste of lubricating oil and smoking exhaust.

" Gear-box Oil Level.—The level of the oil in the gear-box should be maintained up to the centre of the bottom shaft.

" Back Axle Oil Level.—The casing of the rear axle should be filled up to the top of the filling plug-hole.

" Engine Oil Pressure.—The oil pressure on the bearings of the engines, as fitted to types ' BT,' ' X,' ' J,' and ' Q ' chassis, should be about 10 lbs. per sq. inch, as indicated by the oil gauge when the engine is running moderately fast. If, however, the engine is very hot and the speed reduced so that the crankshaft is only just revolving, then the oil pressure may be expected to drop, say, to 5 or 6 lbs. per sq. inch.

" Cleaning.—It is a good plan to drain out and wash the engine sump, gear-box, and rear axle casing, say once every six months and fill with fresh oil.

" Rear Axle : Important.—*Grease should on no account be used as a rear axle lubricant.*"

120. **Oil Consumption.** In considering the oil consumption of heavy motor vehicles, it is, in practice, necessary to pay attention to that of the engine alone, as the oil required by the rest of the mechanism is inconsiderable. It frequently happens that, although at first the oil consumption is reasonably good, yet after considerable service, and particularly after an unskilled overhaul, the consumption is found to have substantially increased. Most usually this arises mainly from the wear of the connecting rod big ends—and to some extent that of the crankshaft main bearings also—having been carelessly taken up ; this point has already been dealt with in § 98.

Increased oil consumption also results after long service from worn pistons, which, in addition, cause loss of compression and of power, and necessitate the re-grinding of the cylinders and fitting of over-size pistons, as described in § 82.

In cases where the oil consumption is considered to be unduly large, although the bearings and pistons are in reasonably good adjustment, baffle plates may be fitted which intercept most of the oil thrown from the big ends upwards towards the pistons ; cases have occurred where the oil consumption has been halved in this simple way ; this has already been referred to in § 30.

Another cause of waste of oil is the habitual maintenance of too high a level in the crank chamber. The top of the indicator rod should not rise more than half-way up its guide, and no fresh oil need be added until it has fallen nearly to the bottom of the guide ; during this period the oil pressure gauge should show a reading varying between 5 and 10 lbs. per square inch.

Drivers very often maintain the oil at a higher level than this, and indeed seem often to consider the engine requires oiling in proportion to their own stops for meals. This practice results in rapid carbonizing and a smoky exhaust, and is wholly wasteful and undesirable.

121. Messrs. Thornycroft have carried out special experiments with various designs of piston, to ascertain how far the engine oil consumption can be reduced, and with certain pistons they have succeeded in getting as much as from 1,000 to 2,000 vehicle-miles per gallon, and this in some instances in actual everyday commercial service ; the result, of course, largely depends upon finding a type of piston that is *and remains* gas-tight. With these special pistons it is found that baffles must not be used, as the cylinders then tend to keep actually too dry.

122. **Fuel Consumption.** Fuel consumption depends not alone upon the adjustment of the carburettor, but also upon the general condition of the engine. With good compression in all cylinders, correct valve setting and functioning, no air leakages along worn valve-stem guides nor through defective inlet-pipe joints, crisp and regular firing, no pre-ignition, and unobstructed exhaust piping and silencer—the petrol consumption should be satisfactory if the carburettor be in proper adjustment.

Air leakages into the inlet manifold, even though so small as to be inaudible, are specially detrimental to economical running, as they necessitate the carburettor being arranged to give an excess of petrol, in order to furnish a rich mixture for starting and slow running ; and the mixture tends in many carburettors automatically to increase in enrichment as the engine is speeded up, although in the Thorny-Solex carburettor, as described in § 35, there is an arrangement of parts specially designed to prevent this increase.

Pre-ignition also is capable of greatly prejudicing fuel consumption, as it involves negative work in the engine. It is usually caused by over-carbonization of the walls

of the combustion chamber and piston crown, resulting in local overheating, or by an unsuitable type of ignition plug having parts which quickly become incandescent in normal running. Weak firing involves loss of work through slow rise of pressure, and misfiring means direct loss of unburnt fuel through the exhaust.

If the engine and carburettor are in order, and the quantity of fuel used yet seems unduly large, it is well to examine the various parts of the chassis in order to see if any bearings are tight or seizing, or if one or more of the brakes is constantly on.

So far as the carburettor is concerned, it is generally best to leave this alone, as it has always been adjusted carefully by the makers before delivery. The float chamber requires occasionally cleaning out, as a sludgy deposit and sometimes also a small quantity of *water* accumulates in it, and this may cause " popping back " when starting from cold. A flooding carburettor is most commonly caused by grit in the needle valve, and this is easily removed by aid of a petrol syringe. Occasionally, but very rarely, flooding arises from a punctured float ; this is easily ascertained by taking out the float and shaking it, when any petrol within will be heard. The obvious remedy in this case is to replace or repair the float.

The reader has already in § 19 been cautioned against running with too *cool* an engine.

The vehicle-mileage obtained per gallon of petrol depends also to some extent upon the capability of the driver, upon the amount of " coasting " practised, and upon the frequency of vehicle stoppages. The nature and condition of the road surfaces over which the lorry travels has an important influence upon the fuel consumed ; ordinary macadam in winter offers a resistance about double of that in summer ; modern tarred road surfaces are also prone to soften in hot weather, and the resistance to traction is then considerably increased.

In testing petrol consumption on the road, two things should be carefully noted, viz., (1) that " petrol " varies very greatly in quality, and (2) that the petrol used should be carefully and directly measured ; it is quite unsafe to assume, for example, that a 2-gallon tin of petrol contains just 2 galls. of the liquid. A satisfactory method is to have a special small accurately-calibrated petrol tank coupled up directly to the float chamber of the carburettor and run the vehicle to a stop upon a known quantity of petrol in this tank, the distance being recorded by a carefully calibrated mileage recorder or " odometer."

Consumption is often expressed in miles per gallon, but a more exact and definite method is to state it in gross-ton-miles per gallon, as this takes into account both the total weight of the vehicle and the distance travelled. The best performances are obtained in general when the total mass moved is a maximum, results slightly exceeding 100 gross-ton-miles per gallon having been attained.

123. As already stated (§§ 34–37), Messrs. Thornycroft use the Thorny-Solex carburettor in all their motor vehicles, and they have conducted a large number of tests, both with this and other designs of carburettor in order to determine the arrangements which enable the greatest economy of fuel to be achieved.

I am enabled to give here some interesting results of experiments made at their Basingstoke works with five different types of carburettor, one being the " Thorny-Solex," and the remainder designated A, B, C, and D respectively. (*See* inset.) The figures given are of much practical value, and should be carefully studied.

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Comparative Road Tests of various Carburettors on a Thornycroft Standard Type "J" Vehicle.

The same Vehicle used for the whole of the Tests. No coasting allowed.

	CARBURETTOR "A"			CARBURETTOR "B"			CARBURETTOR "C"			CARBURETTOR "D"			THORNY-SOLEX 35 mm. Choke—26 mm. Pilot Jet, 50. Main Jet—20·5 Pints (N) 2.		
	NON-STOP	STOP (1 min. at each mile)	Difference	NON-STOP	STOP (1 min. at each mile)	Difference	NON-STOP	STOP (1 min. at each mile)	Difference	NON-STOP	STOP (1 min. at each mile)	Difference	NON-STOP	STOP (1 min. at each mile)	Difference
DISTANCE (miles)	28	28	—	28	28	—	28	28	—	28	28	—	28	28	—
TIME (travelling)	1 hr. 50 min.	1 hr. 58½ min.	8½ min.	1 hr. 52½ min.	2 hrs. 0¾ min.	8¼ min.	1 hr. 53¾ min.	1 hr. 59½ min.	5¾ min.	1 hr. 53½ min.	2 hr. 4 min.	10½ min.	1 hr. 53 min.	2 hrs. 0¾ min.	7¾ min.
TIME (stopped)	—	28 min. (running light)	—	—	28 min. (running light)	—	—	28 min. (running light)	—	—	28 min. (running light)	—	—	28 min. (running light)	—
FUEL (total)	4·117 galls.	4·497 galls.	·38 gall.	4·23 galls.	4·6 galls.	·37 gall.	4·45 galls.	4·764 galls.	·314 gall.	4·27 galls.	4·8 galls.	·53 gall.	3·84 galls.	4·31 galls.	·47
GROSS LOAD (tons)	8·068	8·068	—	8·068	8·068	—	8·068	8·068	—	8·068	8·068	—	8·068	8·068	—
SPEED (M.P.H. average) (Reckoned on Travelling Time only)	15·3	14·2	1·1	14·9	13·9	1	15·03	14·05	·98	14·8	13·5	1·3	14·8	13·9	·9
MILES PER GALLON	6·8	6·2	·6	6·6	6·08	·52	6·29	5·875	·415	6·55	5·83	·72	7·29	6·39	·9
GROSS-TON-MILES PER GALLON	54·87	50·2	4·67	53·4	49·1	4·3	50·76	47·4	3·36	52·9	47	5·9	58·8	52·4	6·4
FUEL (per gross-ton-mile)	·0182 gall.	·0199 gall.	·0017 gall.	·0187 gall.	·020 gall.	·0013 gall.	·0196 gall.	·021 gall.	·0014 gall.	·0189 gall.	·021 gall.	·0021 gall.	·017 gall.	·0190 gall.	·002 gall.
TIME (per gross-ton-mile)	·486 min.	·648 min.	·162 min.	·498 min.	·658 min.	·160 min.	·494 min.	·652 min.	·158 min.	·5 min.	·672 min.	·172 min.	·5 min.	·658 min.	·158 min.
PULLING	Good	Good	—	Good	Good	—	Very Good	Very Good	—	Good	Good	—	Very Good	Very Good	—
ACCELERATION	Fair	Fair	—	Good	Good	—	Very Good	Very Good	—	Bad	Bad	—	Very Good	Very Good	—
DECELERATION or Over-running	Bad	Bad	—	Bad	Bad	—	Good	Good	—	Good	Good	—	Very Good	Very Good	—
CONDITION OF ROADS	Good	Good	—	Good—Greasy in places	Good—Greasy in places. Rain since a.m. test	—	Fair—Very greasy and muddy	Bad—Very heavy, greasy, and muddy	—	Bad—Wet and greasy	Fairly dry	—	Good	Good	—
WEATHER	Fine	Fine	—	Fine—Stiff head wind half distance	Fine—Stiff head wind half distance	—	Fine	Fine	—	Fine—But cold and foggy	Fine—Cold. Some fog	—	Fine—But cold and frosty	Fine—But cold and frosty	—

It will be noted that all these tests were made on one and the same J-type lorry, and that no coasting was permitted.

The Dewar Trophy awarded by the Royal Automobile Club for the most meritorious performance of the year, in a certified trial, was gained in 1922 by a 2-ton B.T.-type Thornycroft lorry, which attained a fuel economy of 13 vehicle-miles, equivalent to 69·3 gross-ton-miles, per gallon of petrol ; a creditable performance.

124. **Bench Test of the M/4 Engine.** I am able also to give here the results of a bench test, made in the ordinary course of production, of an engine of the M/4 type, as already described in §§ 25–32. The compression ratio was 3·56 : 1. The petrol used had a calorific value of 18,400 British thermal units per pint. The brake horse-power, revolutions per minute, and petrol consumption were directly observed. And " torque " or turning effort is estimated in lb.-ft., 1 lb.-foot being the turning effort of 1 lb.-wt. acting at the end of an arm 1 foot long.

THORNYCROFT M/4 ENGINE.

Result of Test.

Speed : Revs. per min. n.	B.H.P.	Pints of Petrol per B.H.P. per hour. C.	Brake Mean Effective Pressure. ηp.	Mean Torque in lb.-ft. T.	Brake Thermal Efficiency. %
800	29·5	·720	76·4	193	19·2
1,000	34·1	·715	70·5	178	19·4
1,200	37·0	·717	63·8	161	19·3
1,400	38·8	·720	57·4	145	19·2

In studying these results, the reader will be assisted by just a very little theory ; if d and s be the bore and stroke, both in inches, then for this type of four-cylindered engine—

Brake mean effective pressure, $\eta p. =$

$$2{\cdot}51.\ \frac{\text{B.H.P.}}{d^2 n.s} \times 10^5 \text{ lbs. per sq. inch} \qquad (10)$$

$$\text{Mean torque, } T = \frac{d^2 s}{48} \times \eta p. \text{ lb.-ft.} \qquad (11)$$

And—

$$\%\ \text{Brake thermal efficiency} = \frac{2{,}545}{18{,}400 \times C} \qquad (12)$$

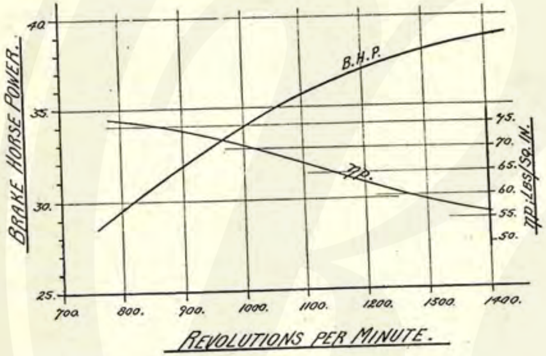


Fig. 49.—B.H.P. Test Diagram.

From measurements made of the cooling water and its rise of temperature, the whole heat evolved by the burning of the petrol used was found to be distributed thus—

In performing useful work at flywheel	19·4 %
Carried away in the cooling water	35·2 %
Lost in exhaust gases and radiation	45·4 %
	100·0 %

Curves prepared from the above table, showing the variation of B.H.P. and brake mean effective pressure with speed, are shown in Fig. 49.

It is useful to observe that, from Eq. 11, torque is directly proportional to brake mean effective pressure and for a four-cylindered engine of this type is obtained from it simply by multiplying by the factor $\frac{d^2 s}{48}$.

125. Use of Paraffin as Fuel. On account of its very much lower price, paraffin, or kerosene, is sometimes employed as the fuel for driving motor lorries, and it can be quite well used for this purpose, though not so conveniently as petrol. As paraffin is not volatile at ordinary temperatures, it is necessary to introduce between the carburettor and the inlet manifold an exhaust-heated vaporizer in order to gasify the misty spray delivered from the carburettor nozzle and so provide a true gaseous mixture to the engine. The heating thus necessitated of the working mixture increases its volume, and so diminishes the mass of the charge taken in by the engine. The somewhat heated and expanded charge requires a reduced compression, and the net result of all this is that the power output of the engine is usually reduced by 10 to 15 per cent. Perhaps the best results are obtained with "Russian vaporizing oil," though ordinary "lamp oil" or "kerosene," obtainable at any oil store, will give quite fairly satisfactory running.

A Thorny-Solex type carburettor is used with the M/4 engine, and the best running is obtained by fitting choke and jets as follow—

Main jet	150
Auxiliary jet	70 or 75
Choke	23

If at any time petrol be reverted to, these should be changed to—

Main jet	125
Auxiliary jet	65
Choke	23

When using paraffin, the engine is governed exactly as with petrol, viz., by means of a governor-controlled throttle situated in the vapour passage. (*See* Fig. 50.)

126. A diagrammatic section, showing the Thornycroft paraffin vaporizer in section, is given in Fig. 50. The device is very simple, with no moving parts or

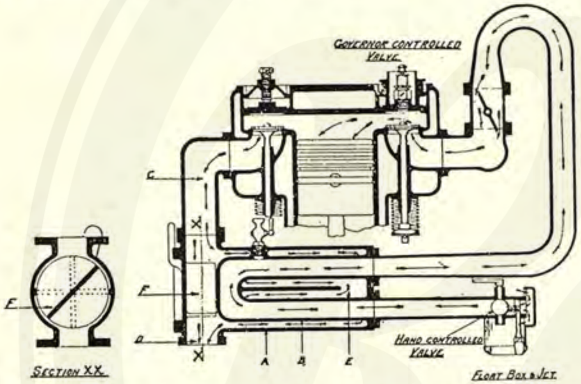


Fig. 50.—Diagrammatic View of Thornycroft Paraffin Vaporizer.

valves to get out of order. The exhaust gases, instead of being discharged directly through the silencer into the atmosphere, are first passed via the pipe *C* into a vaporizing vessel *A* containing an inner chamber *B*, within which again is a second inner chamber *E*. The heated exhaust gases pass not only around the outside of *B*, but also through *E*, as indicated by the arrows, so that the paraffin spray, mixed with air within the chamber *B*, is completely vaporized. The path of the paraffin-air mixture from the carburettor to the inlet valve of the engine is clearly indicated.

In general, it is found sufficient to pass a portion only

of the exhaust gases through the vaporizer, as otherwise the mixture becomes overheated, causing the engine to knock and the power to diminish ; the amount of exhaust so passed is regulated by a hand-operated by-pass valve *F*, of which a section is shown on the extreme left of Fig. 50. In the vertical position, all the exhaust passes directly to the silencer ; in the horizontal position it all passes through the vaporizer ; and in intermediate positions, part passes directly away and part goes through the vaporizer ; thus any desired degree of heating may be obtained. The best position is easily determined by trial for any particular quality of fuel used.

127. **Starting and Stopping on Paraffin.** When for any reason the use of petrol is objected to, starting on paraffin is effected by a preliminary heating of the vaporizer with a blow lamp. A convenient way of proceeding is to remove the by-pass valve *F*—which is readily done by unscrewing the two hexagon nuts on the end of the vaporizer—when the blow-lamp flame can be played directly upon the walls of the chamber *B* ; in about ten minutes this becomes sufficiently heated to enable an easy start to be made ; before " cranking " the engine, a few drops of paraffin are injected directly into the vaporizer through a priming cock situated on the dash-board.

It is usually more convenient, however, to start on petrol, and to facilitate this the fuel tank is provided with a special compartment, in which a small quantity of petrol is carried, while a three-way cock is fitted in the fuel supply piping enabling either petrol or paraffin to be delivered to the carburettor.

A small drain cock is fitted to the bottom of the float chamber, by means of which any paraffin may be drained away before the three-way cock is turned on to the petrol for starting ; the engine is then cranked in the usual manner, and the vehicle is run for three or four minutes on petrol, by which time everything is sufficiently warm to enable the cock to be turned over to the paraffin supply.

Should the exhaust be smoky, the vaporizer is probably not hot enough ; the by-pass valve *F* should then be adjusted. It is better for the vaporizer to be rather too hot than too cool, as, in the latter case, paraffin in liquid form may enter the cylinders and, by passing the pistons, impair the quality of the lubricating oil in the crank-chamber, with consequent risk of damage to the main bearings. As there is always some leakage of vapour past the pistons on account of this property, it is desirable, when using paraffin, to renew the crank-case oil at more frequent intervals than when petrol is used ; about once a fortnight is recommended.

When pulling hard, an engine has always a tendency to knock when running on paraffin, and hence it is desirable to change down in speed gear somewhat earlier than with petrol and also, when hill-climbing, to run with the ignition lever slightly more retarded.

The magneto setting is, however, a little *advanced* for paraffin running ; thus with the ignition lever fully retarded, firing is arranged to occur with petrol at one inch (measured on the flywheel rim) before top centre, whereas with paraffin it is set to fire at *two* inches beforehand.

When a prolonged stop is to be made when using paraffin, it is well to turn the three-way cock right off before stopping, so that the engine may use up all the paraffin in the float chamber before it stops ; the float chamber is then empty, and ready to be filled with petrol when a fresh start is to be made.

Sometimes the three-way cock is turned right over from paraffin to petrol shortly before stopping, the engine then using up the paraffin and perhaps also a little petrol, so leaving the float chamber filled with petrol in readiness for the next start ; the first method is obviously the more economical.

The best results on paraffin are obtained when long non-stop runs can be made ; if, however, the vaporizer is well heated, there is usually no difficulty in ordinary climatic conditions in re-starting on paraffin alone, even after a stop of as much as half an hour.

128. **Experimental Engine.** In order to enable experiments to be made with different kinds and mixtures of liquid fuel, Messrs. Thornycroft use the special single-cylindered experimental engine illustrated in external appearance in Fig. 51.

The cylinder has a detachable head, with a bore of $3\frac{1}{2}$ ins., while the stroke is $6\frac{1}{2}$ ins. ; the engine has been specially arranged to enable the most suitable valve setting and best value of the compression ratio to be readily determined for any particular fuel tested.

The compression may be varied from 4 : 1 to 7 : 1, while the engine is running, merely by turning the small hand-wheel *A*, which raises or lowers the whole cylinder without in any way affecting the action of the valves, which are driven by overhead shafts operated by vertical spindles with sliding connections. The volume of the combustion chamber is thus varied, leaving the stroke unchanged.

The valves are side by side, and are actuated through rockers by cams on separate enclosed overhead shafts. The spiral bevel wheels on the two vertical spindles, driven from the crankshaft, are located by screwed sleeves, which can be raised or lowered independently at *B*, *B*, while the engine is running, thus enabling the

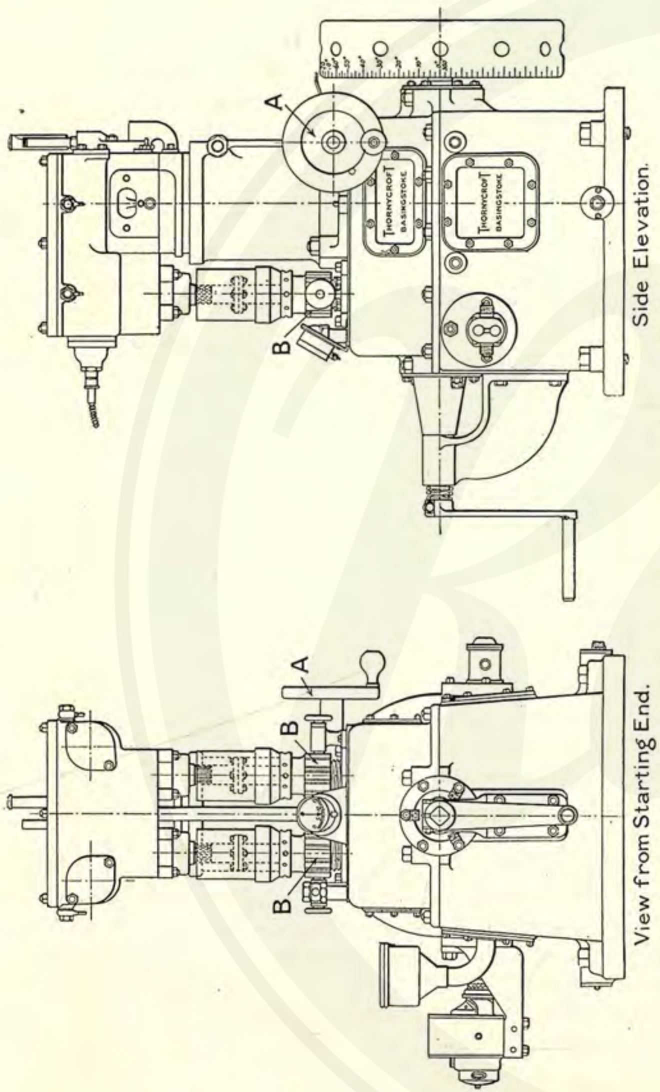


FIG. 51.—EXTERNAL VIEWS OF THORNYCROFT EXPERIMENTAL ENGINE.

A = Hand-wheel for varying the ratio of compression.
BB = Screwed sleeves for varying the valve timing.

timing of the inlet and exhaust valves to be varied separately as desired during operation.

Special carburettor arrangements enable the size of the jet and the effective choke diameter also to be readily varied, and the air supply maintained at any desired temperature by an electric heater, thus facilitating investigations into the behaviour of different fuels.

The fuel is delivered to the carburettor from a tank carried by a spring balance, whereby the consumption may be continuously observed ; in addition, a sensitive fuel flow meter is introduced between the tank and engine, which indicates the rate of flow of the fuel in pints per hour.

Arrangements are also made for measuring and regulating the rate of flow of the cooling water to the cylinders, and its temperature at inlet and outlet is observed by thermometers suitably placed ; the total heat lost in cooling is thus ascertained.

The temperature of the exhaust gases is determined by a pyrometer, and arrangements are also made for taking samples of the exhaust for analysis.

The brake horse-power is measured by an electric dynamometer direct coupled to the engine, and the combination may be run at any speed up to 4,000 r.p.m. Thus, with this engine, experiments may be made easily, rapidly, and accurately, and the effects upon performance due to changed atmospheric conditions eliminated.

The increase in brake thermal efficiency accompanying raised compression is strikingly shown in Fig. 52, which exhibits results obtained with this experimental engine using the same grade of fuel at compressions ranging from 4 : 1 to 6 : 1. At each compression ratio tested, the fuel supply and temperature were first adjusted until the best performance was obtained ;

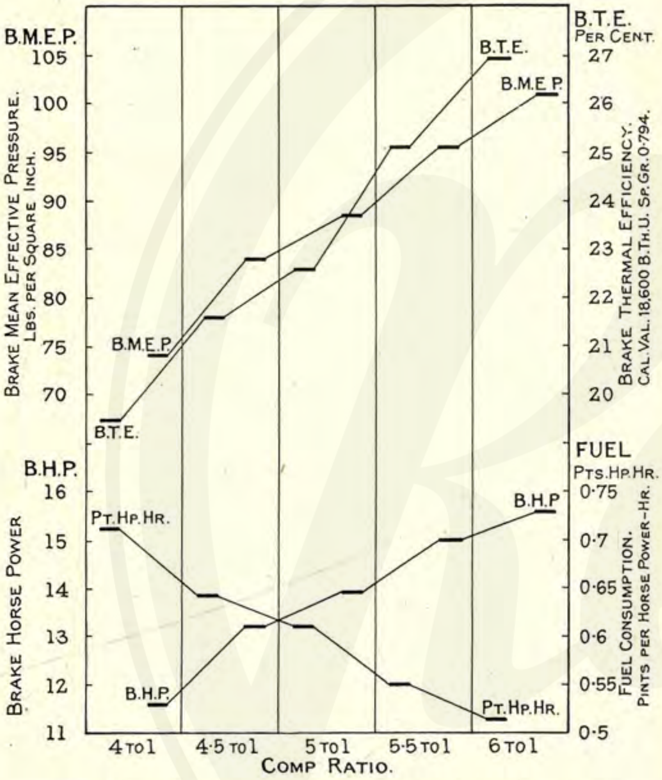


FIG. 52.—VARYING COMPRESSIONS GRAPH OF ENGINE TESTS ON BENZOL FUEL.

observations were taken as soon as everything had settled down into a steady condition. The revolution speed was the same throughout.

129. **Mixtures of Fuels.** Older motorists will recall the days of the surface carburettor, and the value we then set upon obtaining petrol of 0·68 specific gravity; we have now to be content to use a spirit varying from about ·72 to ·76 in specific gravity in ordinary services. Petrol continues an expensive fuel, and the immense and constantly-increasing world demand for it will no doubt cause supplies to become less and less volatile and to contain a larger and larger proportion of hydrocarbons of the "kerosene" type.

So far, in Great Britain, we have been more fortunate than the citizens of the United States in our spirit, as our leading qualities in general evaporate to dryness at from 190° C. to 200° C., whereas the usual spirit on the "other side" requires a temperature of about 240° C for its complete evaporation. "Petrol" is not a definite chemical compound, but a complex mixture of liquid hydrocarbons having different boiling points, so that, when distilled, portions begin coming over at quite low temperatures and continue with the temperature steadily rising until the whole is evaporated.

Very numerous experiments have been made with mixtures of liquid fuels, and particularly with mixtures of petrol and benzol and of petrol and alcohol.

Commercial benzol, though an expensive fuel, possesses the valuable property of usually curing an engine of "pinking" if present in the petrol to the extent of 20 per cent and above.

"Pinking" or "detonation" is a spontaneous explosion of the carburetted mixture in the cylinder due to the combined effects of compression and heating.

"Pre-ignition" is a firing of the mixture before the desired instant, caused by local overheating, whereby incandescent points are created on the carbon deposit covering the piston crown, or exhaust valve head, or combustion chamber, or sometimes on exposed portions of the sparking plug.

In order to prevent these two very undesirable actions, the compression pressure has to be kept rather low. But increase in fuel economy marches with increase in compression ratio, and thus it becomes of much importance to discover if the detonating tendency of ordinary petrol-type fuels can in some simple way be reduced.

130. Commercial benzol consists mainly of the three "aromatic" hydrocarbons—benzene, toluene, and xylene; and, in his experimental engine, Mr. Ricardo* has found that the highest compression can be used when employing pure toluene as fuel, and the lowest with a special petrol from which all the "aromatic" constituents had been removed. Starting with a light paraffin-petrol freed from aromatics, but conforming in every respect with the Air Ministry's specification for fuel for aircraft in 1920, he found that in best normal running conditions, the maximum compression ratio that could be used was 4·85 : 1, and that the compression at which detonation commenced was very sharply defined. By adding 20 per cent of toluene to this petrol, the compression could be raised to 5·57 : 1, which involved an increase of less than 2 per cent in the weight of the fuel, but gave an increase of thermal efficiency of 7 per cent. Further experimentation in this direction led him to conclude that compression could be raised in direct proportion to the aromatic content of the fuel used. He was thus led to suggest an empirical scale which should indicate the tendency of fuels to detonate

* *Proc. Roy. Aero. Soc.*, 16/12/20.

or "pink" by taking the aromatic-free petrol as 0 and pure toluene as 100; this furnished the following comparative figures—

Toluene: Value of Fuel.	Maximum Safe Compression Ratio. —: 1.	Indicated Mean Effective Pressure: lbs./sq. in.	Indicated Actual Thermal Efficiency. %
0	4·85	132·5	31·1
10	5·20	135·4	32·3
20	5·57	138·7	33·5
30	5·94	142·0	34·7
40	6·32	144·9	35·5
50	6·67	147·5	36·5
60	7·05	150·0	37·3

Further experimentation showed that toluene was beaten as a "pink-quencher" by alcohol, the relative values being—

Aromatic-free petrol	0
Pure toluene	100
Ethyl alcohol (99%)	166

131. Referring to alcohol, Dr. Ormandy* says—

"There is a great possibility that we can get over the difficulty (of detonation) by adding to ordinary American petrol a very small amount of very strong alcohol."

The heat value and volatility of alcohol being small relatively to petrol, it is desirable to use a small quantity only; while, in order to ensure its remaining permanently dissolved in the petrol, its strength must be great (i.e. it must contain but a very small proportion of water), and accordingly requires to be specially dehydrated.

He says, further—

"I think that if from 5 per cent to 10 per cent of

* *Proc. I.A.E.*, Vol. xvi, Pt. 2, 1921–2.

strong alcohol be added to an ordinary American or Russian petrol, its 'pinking' propensity will be reduced to about the same as that of an ordinary American petrol to which 30 per cent of benzol has been added."

That liquid of evil odour, carbon bisulphide, if added to an easily detonating petrol, will also at once stop the detonation.

Ricardo's results were obtained with an experimental engine having a very efficiently cooled combustion chamber, aluminium piston, and large valves; it must not be hastily concluded that equally high compressions could safely be adopted in *any* engine. The form of the combustion chamber and location of the valves and, sparking plug therein, have great influence on detonation, and he has given an account of his experiences in this direction, together with a valuable table embodying his results, in *The Automobile Engineer* for October, 1922, to which the reader is referred for full details.

Many experiments on various fuels, pure and mixed, have been carried out by the London General Omnibus Co. They found that alcohol alone, and mixtures of alcohol and benzol, had a corrosive action on iron and other metals, and corroded the iron fuel tanks of the vehicles; this difficulty was overcome by using "terne" plates, i.e. sheet iron coated with a lead-tin alloy rich in lead.

Messrs. Ormandy and Craven have found that the addition of a small amount of alkali neutralizes this tendency, and point out that the "pyridine" now used in denaturing commercial alcohol also tends to prevent corrosion from taking place.

The L.G.O.C. also experimented with a fuel consisting of 70 per cent alcohol and 30 per cent benzol, using a standard engine having 90 lbs. compression pressure; this mixture gave a bad fuel consumption.

The compression pressure of several engines was next raised to 126 lbs., when about the same fuel consumption was obtained as with their normal petrol. Following this, a fuel, consisting of 65 per cent alcohol, 30 per cent benzol, and 5 per cent ether was tried, and with this, at 90 lbs. compression, a lower fuel consumption resulted than in either of the preceding cases. These experiments were carried out on six motor omnibuses, each of which was run 6,000 miles in ordinary London service.

Further experiments are in hand on mixtures of alcohol and ether, and of alcohol, petrol, and ether.

Finally, I would refer to Sir Dugald Clerk's valuable method of preventing detonation in large gas engines by admitting to the inlet pipe a small quantity of cooled, inert *exhaust gases*; this has been found very effective in quenching detonation in petrol motors.

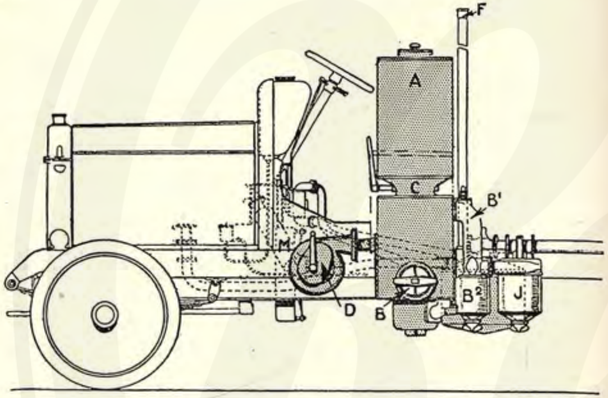
It has been found, for example, that using an aromatic-free petrol of toluene value 0, the safe compression ratio could be raised from 4·85 : 1 to 7·5 : 1 simply by the addition of some cooled exhaust gas to the fresh mixture, thus improving the economy of an engine by some 6 per cent (i.e. from about 31 per cent to 37 per cent) without affecting its power output, by the mere addition of cooled exhaust gas, costing nothing and adding nothing to the weight of the engine.

Dr. Ormandy considers there is something extraordinary in the way that CO_2 and water vapour (in the exhaust gases) act on the propagation of flame in explosive mixtures, and considers this a matter meriting further careful investigation.

132. **Paraffin or Kerosene.** Generally with paraffins, the higher the boiling point, the lower the compression pressure that must be employed; it is common experience that when using paraffin (or "kerosene") a lower

compression ratio (max. about 4·2 : 1) is found necessary than with petrol.

Many kerosenes contain a considerable proportion of heavy "aromatic" hydrocarbons, and if these be extracted they produce a fuel which can be used with a very high compression ratio without risk of detonation. Direct tests furnished results as shown at foot of page.



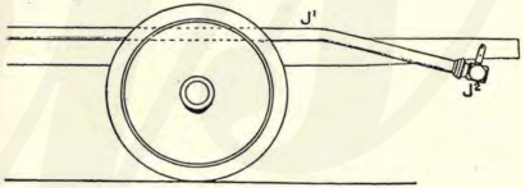


FIG. 53.—GENERAL ARRANGEMENT SIDE VIEW OF SUCTION GAS PRODUCER ON J-TYPE CHASSIS.

In both cases, the same vaporizer temperature was used, the only difference being in the compression ratios.

(RICARDO.)

Fuel used.	Specific gravity Water = 1.	Pints per I.H.P. hour.	Indicated Mean Effective Press. lbs. per sq. in.
Kerosene. . .	·812	·595	111·0
Aromatic extracts from kerosene	·884	·420	125·5

133. Use of Producer Gas. A direction of development of much interest is that of driving heavy motor lorries by aid of gas supplied by small specially designed suction producers carried on the vehicle itself, and using, as fuel, anthracite, coke, charcoal, and many other industrial refuses previously carbonized ; encouraging progress has been made in this direction, notably by Col. D. J. Smith and by Messrs. Thornycroft.

The Thornycroft gas producer is very small, and comprises a brick or corundum-lined cylinder within a square casing, which forms a jacket for heating the air on its way to the ash-pit, and serves also as a lagging to the producer.

The reader is reminded that producer gas is made by sucking a mixture of air and steam through incandescent fuel, whereby it is partly consumed, the gaseous products which issue consisting principally of nitrogen, carbon monoxide, and hydrogen, the two latter constituents being combustible. This gas, cooled and freed from dust, is then mixed with a sufficiency of fresh air, and used in the motor cylinder in place of the more usual mixture of petrol vapour and air.

The water is carried in what, in a petrol-driven lorry, would be the fuel tank, and the bulk of the steam required is generated in a boiler or muffle surrounding the engine exhaust, as indicated at *M* in Figs. 53 and 54, which show the general arrangement of the whole plant on a J-type chassis; it will be observed that it takes up but little room and interferes not at all with the general convenience of the vehicle. The engine is a standard M/4, except that the compression ratio is increased for running on gas.

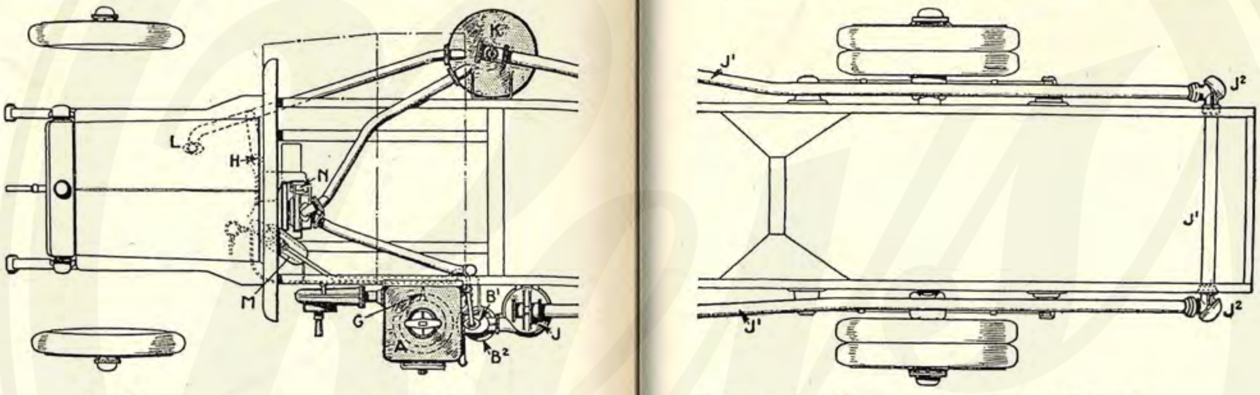


Fig. 54.—General Arrangement Plan View of Suction Gas Producer on J-type Chassis.

The fire is laid and clinker removed from time to time through a door on the producer marked *B* on Fig. 53; all manholes and cleaning doors throughout the plant are fitted with dogs or fly-nuts, and are thus very easily removed by hand when required.

The producer is surmounted by a fuel-feed hopper *A*, of a height dependent upon the nature of the fuel employed; communication with the producer is effected through a hand-operated charging valve *C*.

The hot gases from the producer pass down through the water-jacketed pipe B^1, which terminates in a

plain dust collector B^2. This removes the larger dust particles which come over with the gas. This water-cooled pipe, in addition to cooling the gases, generates some steam, which is passed into the ash-pan. From this pipe, the gases pass into the cyclone dust separator *J*, which takes out the smaller particles of dust; and is thence passed round the chassis through the cooling pipes J^1, which are arranged with cleaning doors J^2 at the corners, so that all the pipes can be cleaned.

This cooling pipe leads into the dry scrubber *K*, which is packed with wood wool or horsehair, or similar cleansing material, and finally cleans the gas before it passes to the inlet pipe of the engine marked *L*.

The steam generated by the hot gases in the water-jacketed pipe B^1 is not nearly sufficient for the satisfactory running of the producer. The variable quantity of steam required is generated in the boiler *M*, surrounding the exhaust, as already mentioned.

Messrs. Thornycroft say—

"The hand-blower for starting up, marked *D*, is accommodated under the footboard and on the driver's step, and is, therefore, in a very handy position for operating.

"The exhauster, which is used for keeping the fire in proper condition when the engine is running light, is marked *N*; it is vertically over the flywheel and

FIG. 55.—J-TYPE LORRY WITH THORNYCROFT SUCTION GAS PRODUCER.

carried from the engine itself, and is easily operated by a lever within handy reach of the driver.

"The outlet from the producer through which the gases are blown in starting up, and also when the exhauster is in operation, is shown at *F*, the height of this pipe being sufficient to take it above the cab, so that the gases are at once clear of the driver and above any other ordinary traffic which may be encountered.

"The starting-up of the plant from cold is a simple operation, usually completed under ten minutes, and requires no particular skill; and the handling of the vehicle on the road is as simple as that of a petrol

vehicle. The attention required by the plant itself depends largely upon the nature of the fuel used. If dirty or dusty, the dust extractor and scrubber will require attention more often than with cleaner fuel, but to clean the dust extractor it is only necessary to remove the doors at the bottom by slacking-back large fly-nuts; and in the case of the scrubber, since the inside can be entirely removed by taking off one fly-nut, the repacking of this with suitable straining material is almost as simple an operation. No water is used in the cleaning or scrubbing of the gases, with the result that corrosion of parts due to chemical or electrolytic action is obviated, and the cleaning operation is simplified."

During 1922, Messrs. Thornycroft ran gas-driven lorries under observation in the service of their Basingstoke works. They state that over an aggregate of 1,579 miles, including long and short runs and town and country traffic, the average consumption was 2·6 lbs. of anthracite per vehicle-mile.

In a special road trial of 28 miles on 6th April, 1922, with a gross load of 7·51 tons, an average speed of 12 m.p.h. was maintained on a consumption of 2·51 lbs. of anthracite and 1·61 lbs. of water per vehicle-mile; thus, in this test, the fuel cost was only one-fourth of that of petrol.

An analysis of the producer gases from a lorry, made at Basingstoke in March, 1921, showed that the combustible constituents amounted to 37·2 per cent of the whole volume; the gas had a gross calorific value of 130 B.Th.U. per cu. foot; and each cubic foot required for its complete combustion about an equal volume of air. The maximum heat value of the mixture-with-air was 65 B.Th.U. per cu. foot, which is about two-thirds of the maximum heat value of a petrol-air mixture; but the producer gases will stand a higher compression ratio, and are therefore probably correspondingly more efficient.

An external view of a Thornycroft War Department J-type lorry, fitted with suction gas plant, appears in Fig. 55, and shows how little the aspect of the vehicle is altered by the addition of the producer plant.

A Thornycroft producer-gas driven vehicle ran in the 1922 trials of the French War Department and Ministry of Agriculture, and was awarded the first place for its performance.

Though not yet out of the experimental stage, the prospects of this means of driving motor vehicles appear favourable; when all the practical difficulties are overcome, the great economy in fuel cost that will result must greatly benefit motor road transport of all types.

CHAPTER VII

135. We live in an ever-changing world, and thus, excellent though the service rendered by the J-type vehicles already existing, the makers continue, both in this and their other standard types, to introduce improvements in various details of the designs. Particular attention for some time past has been devoted to engines, and they have conducted careful investigations into the performance of an engine arranged (1) with valves side by side; (2) with the inlet valve above the exhaust; and (3) with overhead valves—the principal object in view being to obtain the best results possible with the heavy petrols now in general use in this country.

This engine was a four-cylinder vertical, having a bore of $4\frac{3}{4}$ ins. and a stroke of 6 ins.; the fuel used throughout the tests referred to herein was No. 3 petrol.

136. (1) With a compression ratio of 4·23 to 1, and with the valves side by side as in the very usual L-headed arrangement, satisfactory running was obtained at speeds above 1,000 r.p.m.; below this, and particularly below 800 r.p.m., troublesome detonation and pre-ignition occurred. Typical test results are given on p. 160, and these may usefully be compared with the figures of the M/4 engine as exhibited in the table of § 124; a marked improvement will be noted.

An endeavour was made to lessen the detonation and pre-ignition at low speeds by reducing the compression ratio to 4·1 : 1. This proved partly successful, but at the expense of reduced power output and lessened fuel economy.

Examination showed that the exhaust valves reached a high temperature, and it was thought to be here that the pre-ignition originated ; the highest temperature is commonly reached in the exhaust valve heads, and some makers construct these rather massively in cast-iron to facilitate the conduction of the heat away through the seats and so lengthen their working life.

The weight of this B.B. 4/1 A engine was 863 lbs. all complete, but without oil or water, corresponding to 16·9 lbs. per B.H.P. at 1,200 r.p.m.

Tests carried out, with a view to determine the heat distribution, resulted in a B.H.P. of 51·6 at 1,200 r.p.m., together with the following figures—

Item.	Per Cent of Total Heat.
Converted into useful work (B.H.P.)	20·6
Appearing in the cooling water	28·0
Lost in exhaust gases and radiation	51·4
	100·0

The mechanical efficiency was approximately determined by cutting out of action each cylinder in turn while running ; this furnished the following results—

Indicated horse-power	62
Brake horse-power	51·5
Mechanical efficiency	83·2%

THORNYCROFT B.B. 4/1 A ENGINE.

R.A.C. RATING 36·1. TEST RESULTS.

Valves side by side. Full throttle.

Speed : Revs. per minute.	B.H.P.	Pints of Petrol per B.H.P. hour.	Brake Mean Effective Pressure.	Mean Torque in lb.-ft.	Brake Thermal Efficiency. %
600	30·6	·705	94·7	267	19·7
800	40	·685	93·0	262	20·2
1,000	47	·680	87·5	247	20·3
1,200	51	·695	79·0	223	19·9
1,400	53	·720	70·2	198	19·3

137. (2) This engine, referred to as the B.B. 4/1 B., was generally similar to the B.B. 4/1 A. just discussed, but the inlet valves were placed vertically above the exhaust valves. With this arrangement, only very slight pre-ignition was experienced and, by retarding the ignition a little, quite good running was obtained down to a speed of 600 r.p.m. Examination showed that in this case the exhaust valves did not appear to become overheated.

Test results are given below—

THORNYCROFT B.B. 4/1 B. ENGINE.

R.A.C. RATING 36·1. TEST RESULTS.

Inlet valve situated above exhaust. Full throttle.

Speed : Revs. pe minute.	B.H.P.	Pints of Petrol per B.H.P.-hour.	Brake Mean Effective Pressure.	Mean Torque in lb.-ft.	Brake Thermal Efficiency. %
600	33·2	·665	102·3	288	20·9
800	43·0	·635	99·7	281	21·8
1,000	49·0	·632	91·0	256	21·9
1,200	53·0	·636	82·0	231	21·8
1,400	55·6	·645	73·7	208	21·5

The compression ratio was slightly greater than in the preceding case, viz., 4·28 : 1. And the heat distribution at 1,200 r.p.m. was found to be by special tests—

Item.	Per Cent of Total Heat.
Converted into useful work (B.H.P.)	21·65
Appearing in the cooling water	34·41
Lost in exhaust gases and radiation	43·94
	100·0

The higher heat loss to the cooling water in this case resulted from the construction of the exhaust outlet, the water-jacketed cylinder-casting forming one-half of the exhaust passage.

The weight of this engine complete, but without oil or water, was 854 lbs., corresponding to 16·1 lbs. per B.H.P. at 1,200 r.p.m. Reducing the power output by throttling down against constant resistance is stated to have given highly satisfactory fuel consumption results ; this is an important feature in the normal running of a motor vehicle.

138. (3) The third engine, referred to as the B.B. 4/1 C., was also generally similar to the preceding two, excepting that the valves were now located in the cylinder head. These overhead valves necessitated the engine being somewhat longer and heavier (910 lbs.) and the tests, I am informed, did not show such good results as the others.

139. In the table below, the performances of the M/4, B.B. 4/1 A., and B.B. 4/1 B. engines are compared at 1,200 r.p.m. and at full throttle—

THE M/4, B.B. 4/1 A., AND B.B. 4/1 B. ENGINES COMPARED.

At 1,200 *r.p.m. and full load.*

Engine.	Bore and Stroke.	R.A.C. Rating.	B.H.P.	Brake Mean Eff. Press.	Mean Torque in lb.-ft.	Pints of Petrol per B.H.P. hour.	Brake Thermal Eff. %	Weight in lbs. per B.H.P.
M/4 valves opposite	$4\frac{1}{2}\times 6$	32·4	37·0	63·8	161	·717	19·3	—
B.B. 4/1 A valves side by side	$4\frac{3}{4}\times 6$	36·1	51·0	79·0	223	·695	19·9	16·9
B.B. 4/1 B. inlet over exhaust	$4\frac{3}{4}\times 6$	36·1	53·0	82·0	231	·636	21·8	16·1

These figures show very clearly the marked superiority of the B.B. 4/1 B. engine, with the inlet valves over the exhausts, and I am informed that future "J" vehicles will be fitted with this type of engine.

140. Now that the very great importance of fostering the development of road transport is becoming realized by the authorities and the public, and our roads are being strengthened and improved, the motor lorry

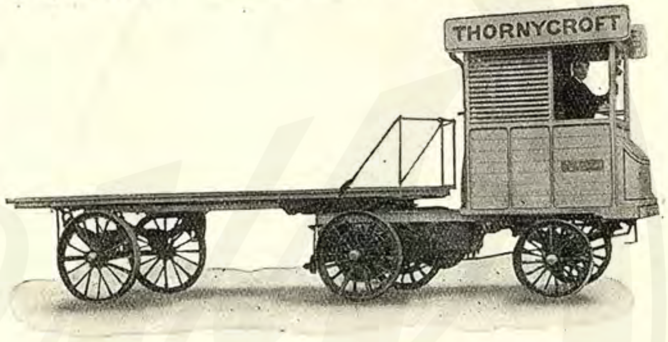


FIG. 56.—AN EARLY THORNYCROFT STEAM-DRIVEN SIX-WHEELER, BUILT IN 1898..

evidences a tendency to increase its carrying capacity ; and one direction in which developments are taking place is in the provision of six-wheelers, which enable large useful loads to be transported with little, if any, increase in wheel loading.

It is interesting to recall that Messrs. Thornycroft were very early in the field with designs of this kind. Fig. 56 illustrates a steam-driven six-wheeled lorry, for example, which was produced by the company at the end of the nineteenth century ; several vehicles of this type were constructed. The fore-part comprised a short-framed steam wagon chassis to the rear of which the goods-carrying platform was attached by a turn-table. The reader will note that this design appeared before the advent either of the solid rubber tyre or of the use of the petrol engine for commercial purposes.

In Fig. 57, one of Messrs. Thornycroft's latest designs of six-wheeler is shown, comprising a J-type chassis, as already described above, with a plain open lorry goods platform.

The extreme length of this compound vehicle is 31 ft., and its extreme width 7 ft. 2½ ins. The length

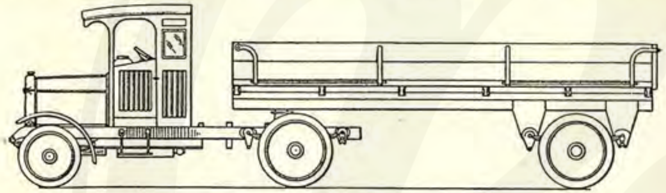


FIG. 57.—J-TYPE TRACTOR AND TRAILER ATTACHMENT FOR A LOAD OF 11 TONS.

of the lorry platform is 20 ft. 2 ins., and its height from the ground, unloaded, 4 ft. 2 ins. Solid rubber tyres are fitted throughout, the leaders being singles, and drivers and trailers twins.

These six-wheelers are found of especial value in easy country districts, and enable very large loads to be transported with great economy in fuel, experience showing that the high figure of from 80 to 85 gross-ton-miles per gallon of petrol is frequently attained in ordinary service. (Compare § 38.)

141. The J-type vehicle, as already mentioned, is designed for a normal full load of 4 tons, with an open lorry platform, but the requirements of owners vary considerably; in some cases, normal loads greater than 4 tons are available, but for the most part loads

somewhat less are commonly dealt with. Accordingly, Messrs. Thornycroft build a range of standard motor vehicles designed for full loads of from 2 to 6 tons inclusive; the leading features of these are collected in the table on page 166.

142. **The 2-ton B.T. Vehicle.** The 2-ton B.T. chassis is built in slightly varying overall lengths according to the type of body to be fitted, the longest being required when the vehicle is to be used as a passenger coach and the shortest when as an end-tipping wagon. Messrs. Thornycroft inform me they have standardized fifteen different types of body for use with all their standard chassis, and outline views of these are given in Figs. 58, 59, and 60; the company consider that practically all ordinary requirements are covered by these; special bodies are, however, supplied when demanded by purchasers.

143. From 22nd August to 1st September, 1921, the B.T. Thornycroft lorry, illustrated in Fig. 61, underwent a trial run of 1,260 miles under the observation of the Royal Automobile Club, the objects of the trial being to ascertain the petrol, oil, and water consumption, and to demonstrate the general reliability of the vehicle.

From the R.A.C. Certificate of Performance, No. 473, the following particulars are taken—

The trial occupied ten days, the average daily run being thus 126 miles; the route was from London via Chard and Penzance to Land's End; thence by Exeter, Wellington, Wigan, and Lockerbie, to Edinburgh, and back to London via Newcastle-on-Tyne.

The roads generally were in fair condition and weather fine, though rain fell on three days. The fuel used is given as "motor spirit," and the lorry did not "coast" when descending hills.

Thornycroft Standard Motor Vehicles.

LEADING FEATURES OF TYPES CARRYING FROM 2 TO 6 TONS (1923).

Type.		Engines (*all 4-cyls.*).		Vehicle Speeds in Miles per Hour, at 1,000 r.p.m. of Engine.					Tyres; All Solid Rubber; Leaders' Singles, Drivers, Twins.			Axle Weights in Tons: Fully Laden.		Overall Dimensions of Standard Chassis for Goods.	
Letter.	Full Useful Load: Tons.	Letter.	Bore and Stroke. Ins.	1st Speed.	2nd Speed	3rd Speed.	4th Speed.	Re-verse.	On Leading Wheels.	On Driving Wheels.	Fitting Size.	On Front Axle.	On Rear Axle.	Length in Feet.	Width in Feet.
B T	2	AB/4	$4 \times 5\frac{1}{2}$	4·15	8·3	14·6	—	4·15	900 × 90	900 × 90	741	1·2	3·45	19·0	6·0
X	3	M/4	$4\frac{1}{2} \times 6$	3·5	6·0	9·75	16·0	3·5	1030 × 100	1030 × 110	881	2·0	4·4	21·4	6·56
J	4	BB/4	$4\frac{3}{4} \times 6$	2·75	5·0	8·5	14·5	2·25	880 × 120	1050 × 140	720 front 881 rear	2·2	5·8	21·7	7·2
Q	5	BB/4	$4\frac{3}{4} \times 6$	2·2	4·0	6·8	11·6	1·8	880 × 120	1050 × 160	720 front 850 rear	2·6	7·2	23·6	7·33
W	6	BB/4	$4\frac{3}{4} \times 6$	2·2	4·0	6·8	11·6	1·8	880 × 140	1050 × 160	720 front 850 rear	3·45	7·45	23·8	7·33

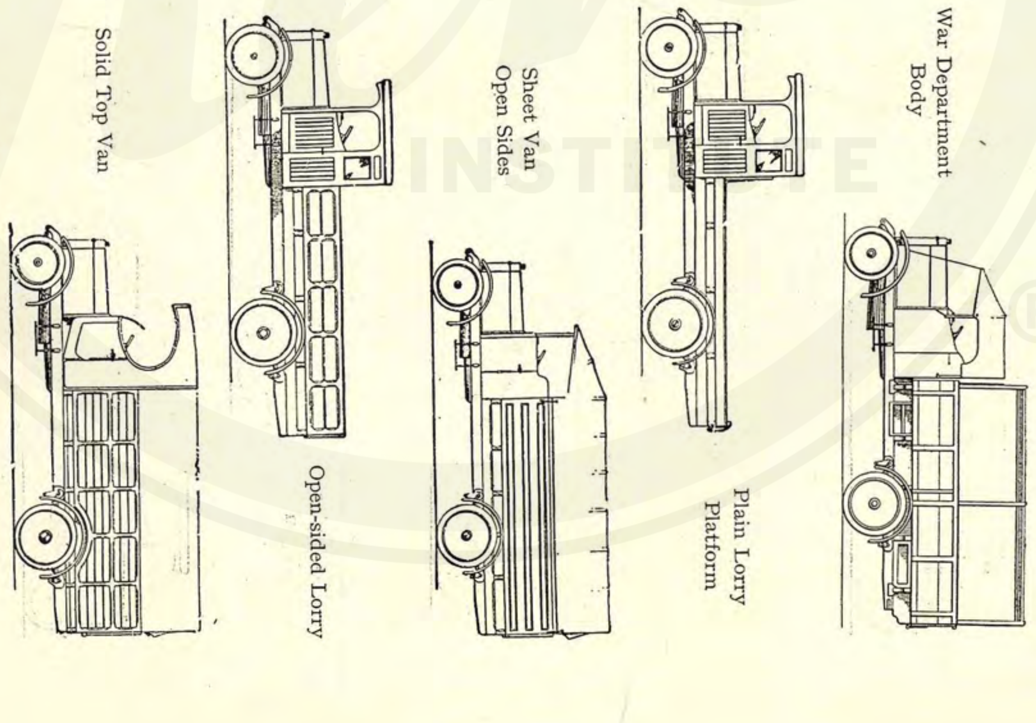


Fig. 58.—Types of Thornycroft Vehicles.

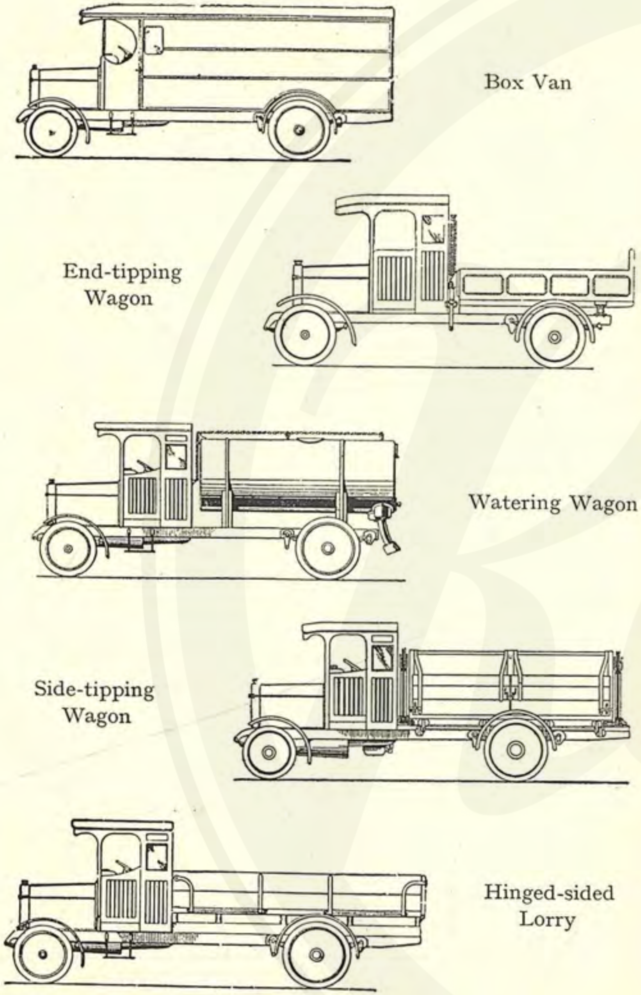

Box Van
End-tipping Wagon
Watering Wagon
Side-tipping Wagon
Hinged-sided Lorry

Fig 59.

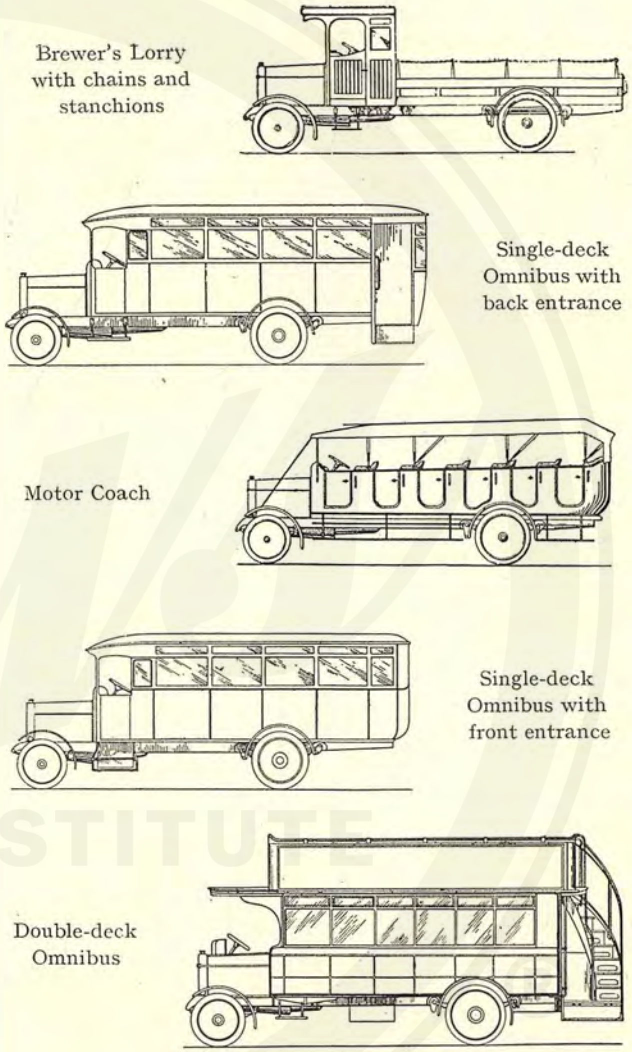

Brewer's Lorry with chains and stanchions
Single-deck Omnibus with back entrance
Motor Coach
Single-deck Omnibus with front entrance
Double-deck Omnibus

Fig. 60.

Excepting that the carburettor and petrol pipes were thrice taken down to discover the source of a shortage in the supply of petrol (which ultimately turned out to be due to dirt in the petrol cock), no work whatever other than fuel replenishment and greasing was done on the vehicle throughout the trial. No water was

FIG. 61.—B.T.-TYPE 2-TON HINGE-SIDED LORRY.

added during the run, but at the end the total amount needed to make up was found to be 1·0 gall.

The general results obtained were—

Gross moving weight	5·33 tons
Total distance run	1,260 miles
Average speed on running time . .	15·9 m.p.h.
Vehicle-miles per gallon of fuel . .	13·0
Gross-ton-miles per gallon of fuel . .	69·3
Vehicle-miles per gallon of oil . . .	504

The engine was governed, and standard throttle and ignition controls were used.

This excellent showing won for the vehicle the Dewar Trophy for the most meritorious performance of the year in R.A.C. trials.

144. The X-type Chassis. This is intermediate between the B.T. and J. types, and is designed for a useful load

of 3 tons on an open lorry platform, or $2\frac{1}{2}$ tons in a van body. It is found specially suitable for use as a motor coach or motor omnibus. Four forward speeds

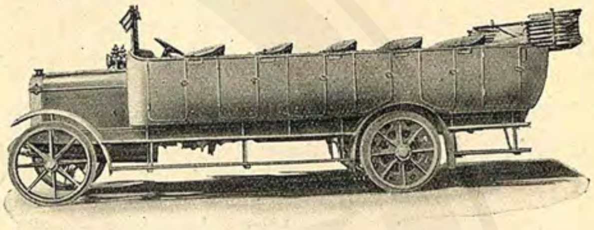


FIG. 62.—X-TYPE 28-SEATED MOTOR COACH.

are fitted, the fourth giving a vehicle-speed of 16 miles per hour, with the engine running at 1,000 r.p.m.

A 28-seated motor coach body on an X-type chassis is illustrated in Fig. 62.

FIG. 63.—Q-TYPE 5-TON PLATFORM LORRY.

The J-type chassis has already been fully dealt with, being indeed the main subject of this book.

145. The Q-type Chassis. With this chassis a useful load of 5 tons is transported on an open lorry platform, or $4\frac{1}{2}$ tons in a box van body. The top speed of the vehicle is about $11\frac{1}{2}$ miles per hour at 1,000 r.p.m. of the engine. A Q-type open lorry is illustrated in Fig. 63.

The general lay-out and details are similar to those of the J-type chassis as already described, the gear-ratios being suitably increased on account of the heavier loads dealt with and stouter driving tyres being fitted.

146. **The W-type Chassis.** This chassis is designed for the substantial load of 6 tons on an open lorry

Fig. 64.—W-type 6-ton Platform Lorry.

platform, or $5\frac{1}{2}$ tons in a van body. It is specially suitable for the service required by brewers, millers, mineral water manufacturers, and other distributors of heavy goods.

One of these large vehicles, with an open lorry body is illustrated in Fig. 64 ; the loading area provided is 17 ft. 8 ins. in length and 7 ft. in width. The top speed, with engine making 1,000 r.p.m., is roundly $11\frac{1}{2}$ miles per hour.

147. To facilitate the handling of heavy goods, cases, etc., Messrs. Thornycroft fit a special hauling gear to their lorries when desired ; this is found exceedingly

useful in loading heavy cases on a platform-type vehicle. An illustration is given in Fig. 65.

At the ends of the rear live axle are castings in the form of drums bolted to the driving flanges of the rear

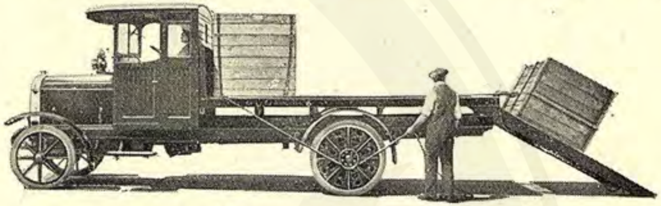


Fig. 65.—Hauling Gear in Use on 4-ton Lorry.

wheels. Withdrawal of the three connecting pins from each wheel enables these drums to be brought into operation for loading purposes, utilizing the full power

Fig. 66.—Part of the Westminster City Council's Fleet of J-type Tipping Wagons.

of the engine transmitted through either of the four available speeds. If preferred, one drum only can be used, the winding speed being then double that obtained when both drums are in use, the pull on the rope being the same.

Instead of the hauling drum shown, winding drums

L.M. and S. Rly. (North-Western Section) have over 100 " J," " X," and " B.T." vehicles.

The National Benzole Co., Ltd., have over 80 " J " and " B.T." vehicles.

Shell-Mex, Ltd., have over 200 " J," " X," and " B.T." vehicles.

Lever Bros., Ltd., have over 100 " J " vehicles.

The British Petroleum Co., Ltd., have over 100 " J," " X," and " B.T." vehicles.

FIG. 67.—VEHICLES REPRESENTING LARGE THORNYCROFT FLEETS OWNED BY WELL-KNOWN USERS.

can be fitted, to operate in a similar manner, with flanges to contain a suitable length of wire rope. This hauling gear is also sometimes of service in extricating a vehicle which may have become bogged in soft ground.

148. Thornycroft motor vehicles have for many years been used by large municipalities for street-watering, dust-collecting, etc.

In 1899 the company supplied the Highways Department of Westminster with their first steam wagon: this vehicle has run 150,000 miles, and is still (1923) in service; two other Thornycroft steamers were supplied later, and each of these has completed over twenty years' service.

In 1908 they supplied the Westminster Council with their first petrol-engined tip-wagon; this was furnished with two bodies, viz., a tipping body for cartage work by day and a watering tank for street cleansing at night; this vehicle has now completed thirteen years of 20-hour day-and-night service.

In 1921, the Westminster Council possessed a fleet of eighteen J-type tipping wagons, with interchangeable watering bodies; a view of part of this fleet, taken at the Commercial Motor Users' Parade in Lincoln's Inn Fields in 1921 is shown in Fig. 66.

149. Space does not permit me to dwell further upon the numerous and varied uses to which Thornycroft motor vehicles are applied throughout the world. A few photographs representative of large fleets have been collected, and are reproduced in Fig. 67; these will serve to give an indication of the considerable scale on which motor vehicle transport is already adopted by progressive business firms.

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