

TRIUMPH TR MAINTENANCE MODIFICATION & TUNING

by
J.L.S. Maclay

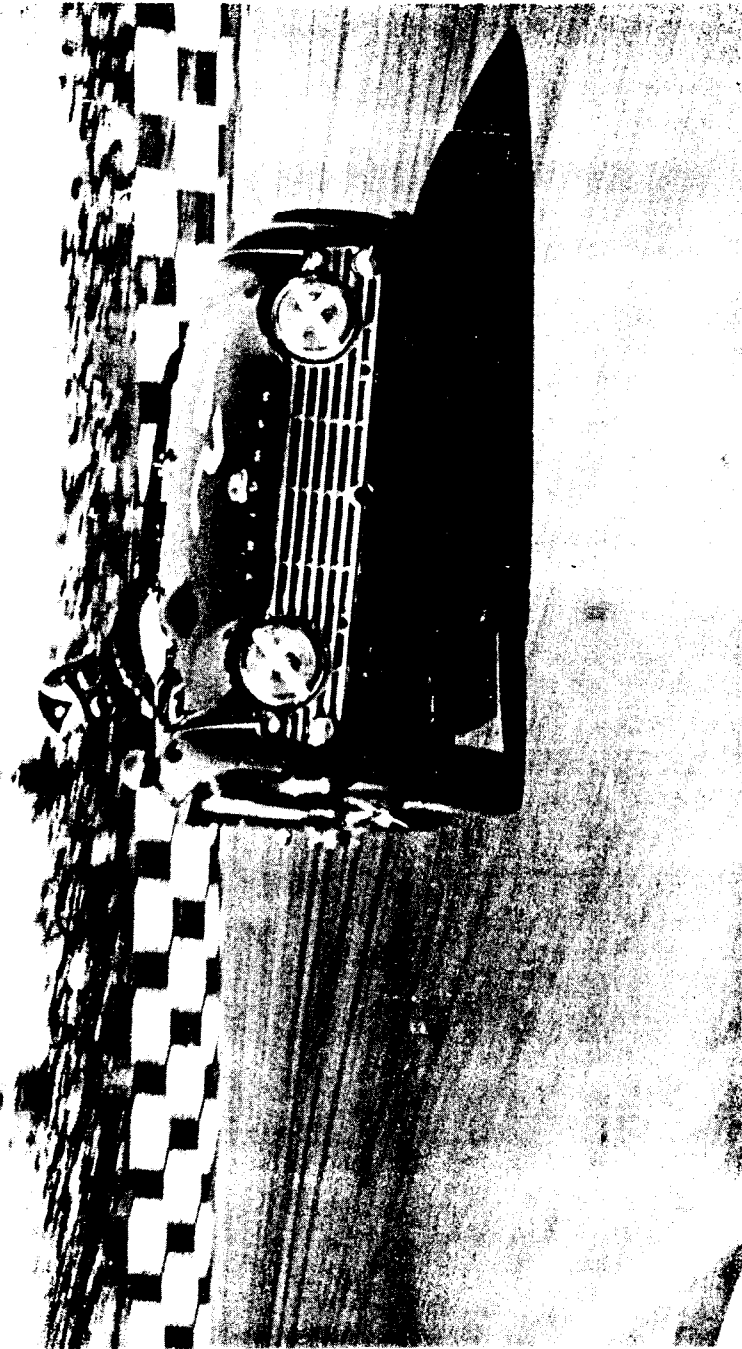


22-26 Lower Odcombe, Yeovil, Somerset

Tel West Coker 406

Photo: Michael R. Hewett
Team Dangerfield of Bristol drifting his TR1 through Paddock Bend, Brands Hatch

Plate 1



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ACKNOWLEDGEMENTS

Acknowledgements and thanks are due to the following for their help in the preparation of this manual:

Autocar.

J. W. E. Banks and Sons Ltd.
Champion Spark Plug Co. Ltd.

N. L. Dangerfield, Esq.

S. A. Hurrell, Esq.

M. R. Hewett, Esq.

L. Hughes, Esq.

Knightsbridge Publications Ltd.

C. J. Lawrence, Esq.

Motor

R. Penrice, Esq.

Standard Triumph International Ltd.
Super Sports Engines Ltd. of Acton.

INTRODUCTION

The Triumph TR2 was announced to the public at the 1953 Motor Show. Since then over 100,000 TR2s, TR3s, TR3As, TR4s, TR4As and TR4A IRS have been built. In August 1967 production of the four-cylinder engine stopped, to make way for the six-cylinder engine. This tuning and maintenance manual covers all four-cylinder TR sports cars from 1953 - 1967. It describes all details of keeping the car in really good condition through correct maintenance and overhaul, and also shows how to carry out modifications and tuning.

For a modest outlay of money, or time and work, the TR owner can improve the performance of his car to a state where it is superior to most other sports cars and comparable with the best. Apart from the advantage of increased performance, he can have a lot of fun modifying the car himself, and learn a great deal. In the TR he has a really sound basis to work on and a simple reliable engine which is an ideal starting point for the enthusiast who is new to this type of work.

Good luck.

J. L. S. Maclay.
24th August, 1967.

CHAPTER ONE

BASIC THEORY

A knowledge and understanding of the basic principles of the Triumph TR engine, its behaviour and design factors, will help the enthusiast to appreciate the desirability and effect of various modifications, and will help him differentiate between a worthwhile piece of work and valueless gadgetry. If, as is usually the case, he has a limited amount of money to spend, this knowledge will let him see where to spend that money to best advantage.

To start from scratch we must understand how the internal combustion engine works. I crave the indulgence of those readers already well acquainted with the operating principles of the I. C. engine, over the next few paragraphs.

The 'Otto' cycle is the basis of all four stroke internal combustion engines. There are four separate phases: Induction, Compression, Ignition, Exhaust. Each of these is effected by the travel of the piston from top to bottom or bottom to top of the cylinder. Starting with the piston at the top of the cylinder, as it moves down, the cylinder fills with gas which is supplied through an inlet valve. As the piston moves up the cylinder, the inlet valve is closed to contain the gas, which becomes compressed. The compressed gas is then ignited by the sparking plug, burns very fast and expands. This action provides the motive power to the engine by driving the piston down the cylinder. The exhaust valve is then opened and on the up-stroke the exhaust gases are forced out and the exhaust valve is closed. We are now back to the position at which we started. The piston has gone up and down the cylinder twice and only on one down stroke was the action driven by power. The three other strokes are powered by the inertia of the flywheel. The linear motion of the piston is turned into rotary motion by the crankshaft. The inlet and exhaust valves are operated mechanically via rocker arms and pushrods which are moved up and down by cams on a shaft. The shape of the cams on the camshaft determines the timing and duration of each valve opening.

Other basic components necessary for the operation of the engine are a source of gas, and spark. The carburettor produces the gas by mixing petrol and air during their passage into the cylinder. This may sound simple, but it has to produce the correct mixture over a wide range of conditions, such as varying speeds, varying

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degrees of acceleration, tick over, cold starting, overrun, etc. Ignition of the mixture by a spark is effected by the battery kept charged by the generator or dynamo. The intensity of the spark is increased by a coil and the spark is timed by the distributor which is driven mechanically off the camshaft, in conjunction with the oil pump.

All this equipment has to be operated and the power for this comes from the ignition stroke of the cycle. Since the ignition stroke depends on the induction and compression stroke and the spark, it is obvious that the engine has to be started independently, but once fired is self-perpetuating. A starter motor is designed so that it disengages once the engine fires. Since the source of power is the ignition and consequent burning of the gas, the function of all the other parts of the engine is designed to achieve this in the most efficient manner. By efficiency we are here taking into account a very wide range of items, not just power. The engine designer has to achieve performance, economy, smoothness, long life, quietness, easy starting, reliability and many other features. If an engine is designed with one aspect uppermost the others may suffer. A full house racing TR engine for instance is noisy, expensive and unreliable when compared with a normal TR production car engine, which will comfortably exceed 75,000 miles before reconditioning becomes necessary. Really quiet engines are expensive to manufacture. So the design of an internal combustion engine is a compromise. It may be possible to improve one aspect, but it will most probably be at the expense of another. Today most car manufacturers in this country give 12 months or 12,000 miles guarantee on their product. Into the design, therefore, go a good number of features which will safeguard the reliability of the unit and thereby save the manufacturer paying out too much money on warranty claims. The incidence of claims gives the manufacturer a very good guide as to the soundness of the design and the reliability built into the car, and corrective action can be taken where necessary. The fundamental aims when increasing the power of the TR engine are two: to increase the power exerted on the piston when the gas burns and to increase the revs. so that there is a greater number of power cycles. To increase the power exerted on the piston means getting as much gas as possible into the cylinder and then compressing it to the optimum pressure. This is normally best achieved by opening up and smoothing the path of the incoming gas and by ensuring that the inlet valve is open for as long and as wide as practical. The bulk of modifications, such as gas flowed heads, large valves, high lift camshafts or special carburettors are devoted to this aim. Increasing the compression ratio also increases the power exerted on the piston

top due to the higher pressure exerted when the compressed gas is ignited. If however, the engine has a poor induction system increasing the compression ratio is not really the first place to go to work. It is the induction system that will yield the greatest power increase, so one must carefully consider which approach is going to be the more productive. For ultimate output both should be modified. Camshaft modifications permit the timing of the valve opening and shutting to be changed and the distance the valves open to be increased. By changing the profile of the cam, the inlet valve, for instance, can be made to open earlier and quicker thereby giving an advantage at high revs, but possibly a loss of power at low revs.

Increasing the number of revs from 5,000 to 6,000 per minute means that in that minute there are 20% more power strokes. Unfortunately this does not give 20% more power, since the amount of gas taken into the cylinder decreases as engine speed increases. Power losses, stresses on the mechanical components, and heat also increase proportionately. But, before going further into this, it is helpful to have a thorough understanding of the factors that determine b.h.p. and torque. We must understand the relationship between efficiency and performance. This can be defined by saying that performance is the efficiency with which an engine performs a certain task. Performance involves all the factors concerned with engine operation such as b.h.p., torque, fuel consumption, wear and engine friction. For example, in the ten years before the first world war engine designers did not understand or concern themselves with engine performance figures. Cars such as the magnificent Grand Prix Itala produced 120 b.h.p. from a four cylinder 14½ Litre engine! Maximum speed was about 110 m.p.h. at a fabulously slow 1,200 r.p.m. If engine designers wanted more power they merely increased the capacity of the cylinders. Engines of 2 litres would produce as little as 10 b.h.p. Compare this with the 220 b.h.p. produced by a 1,600 c.c. Formula Two engine and it is obvious that enormous strides have been made.

The only measure of true power developed is brake horse power which can be calculated from the torque and r.p.m. by the following formula:

$$\text{B. H. P.} = \frac{\text{Torque} \times \text{r. p. m.}}{5,252}$$

When considering brake horse power it is important not only to think of the maximum produced, as b.h.p. is produced throughout the revolution range. It is therefore of great importance to view the b.h.p. produced by an engine at both high and low engine speeds.

The engine converts the heat energy in petrol into twisting force at the flywheel which is known as torque. Torque can be defined as

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a force applied about a centre of rotation. As an example, if a force of 10 lbs. were applied to the end of a crank with an arm 1 ft. long, one would be applying a torque of 10 lb/ft. Thus the pressure in the cylinder on the power stroke is converted by means of the piston and connecting rod to torque at the crankshaft.

To further our understanding of what constitutes performance, we must now consider the pressure variations in a cylinder during the four stroke cycle. On the intake stroke the piston travels down creating a partial vacuum and the pressure in the cylinder is lower than that of atmosphere (14.7 lbs. per sq. in.). With a fully open throttle the fuel mixture rushes in through the carburettor and inlet manifold to try and fill the vacuum. How successfully it does this depends on the r.p.m., the amount of surface friction in the manifolds and ports, the size of the valves and the choke area of the carburettor. Therefore the amount of petrol/air mixture that gets to the cylinder depends on a number of factors, and the higher the r.p.m. the greater the pressure loss. The amount of petrol/air mixture that the engine will inhale compared to its cubic capacity is termed 'volumetric efficiency'.

As an illustration, a volumetric efficiency of 80% shows that the piston is drawing in 80% of its displacement on the intake stroke, and therefore at the end of the piston's downstroke the pressure in the cylinder would be about 12 lbs. per sq. in. As the pressure inside the cylinder is still lower than that outside, the inlet valve can be left open for 40° to 60° of the compression stroke to take advantage of the partial vacuum still present, as well as the inertia of the gas flow. It will be appreciated that this overlap must be a compromise as if a camshaft is used with too great a valve overlap, at low r.p.m. the engine will be pumping out nearly as much as it is drawing in, if the piston is, say, three quarters of the way up its compression stroke before the inlet valve closes.

With the inlet valve closed the piston ascends, compressing the mixture to a final pressure that largely depends on the compression ratio. The compression ratio is the volume of the cylinder with the piston at the bottom, compared with the volume when the cylinder is at the top. The compression ratio can be expressed mathematically by the following formula, where CS is the volume of the combustion space, and TD is the total displacement of the piston:

$$\text{Compression Ratio} = \frac{\text{TD} + \text{CS}}{\text{CS}}$$

Although it may appear that the final compression pressure (b. m. c. p.) would be the pressure at the bottom of the stroke multiplied by the compression ratio (Boyle's Law), in practice this is not so, because no account has been taken of the temperature variation

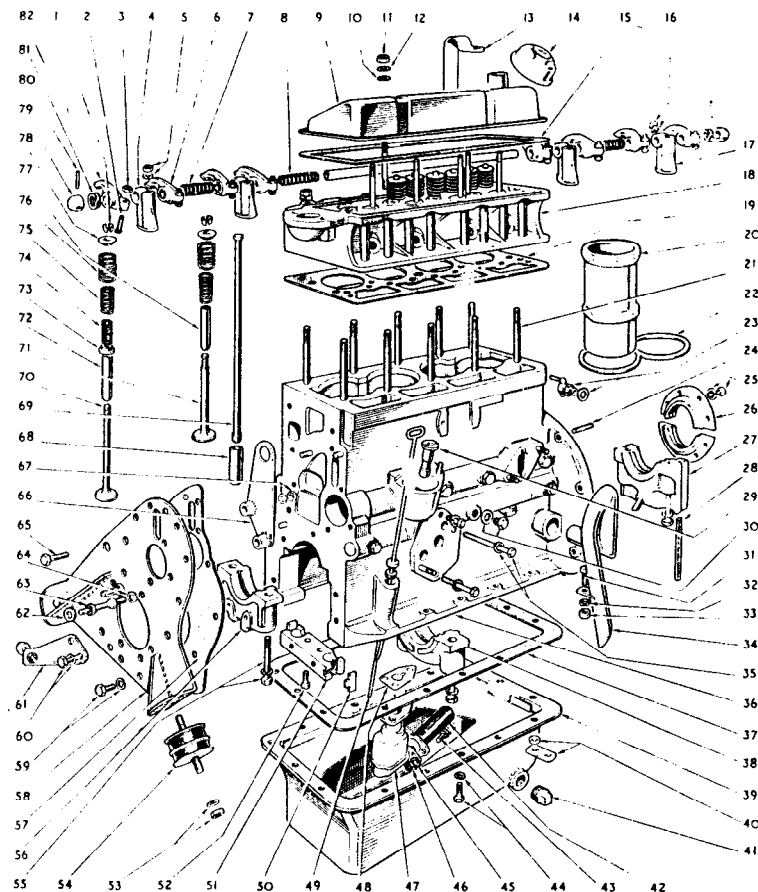


Fig. 1. Exploded view of the valve gear and main static components of the TR engine. 1 Split collars. 2 Adjusting screw. 3 Nut. 4 Rocker pedestal. 5 Nut & spring washer. 6 Rocker—R. H. 7 Spring. 8 Spring—centre. 9 Rocker cover. 10 Fibre washer. 11 Nyloc nut. 12 Plain washer. 13 Lifting eye. 14 Filler cap. 15 Rocker cover gasket. 16 Screw & shakeproof washer. 17 Rear rocker pedestal. 18 Cylinder head. 19 Cylinder head gasket. 20 Cylinder liner. 21 Cylinder head stud. 22 Liner gasket. 23 Drain tap & fibre washer. 24 Stud. 25 Setscrew & spring washer. 26 Rear oil seal. 27 Rear main bearing cap. 28 Sealing felt. 29 Distributor drive gear bush. 30 Oil gallery plug & copper washer. 31 Setscrew. 32 Spring washer. 33 Nut. 34 Breather pipe. 35 Oil filter attachment bolt & spring washer. 36 Cylinder block. 37 Sump gasket. 38 Centre main bearing cap. 39 Sump. 40 Breather pipe bracket & distance piece. 41 Sump plug. 42 Oil pump filter gauze. 43 Bolt. 44 Setscrew & spring washer. 45 Spring washer. 46 Nut. 47 Oil pump. 48 Oil pump gask. t. 49 Dipstick. 50 Sealing piece. 51 Front sealing block. 52 Screw. 53 Nut & spring washer. 54 Engine mounting. 55 Main bearing cap bolt & spring washer. 56 Front main bearing cap. 57 Gasket. 58 Front bearer plate. 59 Setscrew & spring washer. 60 Setscrew & spring washer. 61 Torque reaction arm & buffer. 62 Fibre washer. 63 Shouldered stud. 64 Spring washer. 65 Bolt. 66 Lifting eye. 67 Nut & spring washer. 68 Tappet. 69 Pushrod. 70 Exhaust valve. 71 Inlet valve. 72 Exhaust valve guide. 73 Collar. 74 Auxiliary valve spring. 75 Inner valve spring. 76 Outer valve spring. 77 Inlet valve guide. 78 Valve collar. 79 Rocker shaft end cap. 80 Mills pin. 81 Spring. 32 Rocker—L. H.

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of the mixture. Compressing a gas raises its temperature (note how hot the base of a bicycle pump becomes when blowing up a tyre). The increase in temperature of the gas in the cylinder is so rapid that it has not time to be absorbed through the cylinder head and walls, and therefore the pressure at the end of the compression stroke is far greater than it would have been if the mixture had been at a constant temperature. The pressure increase due to heat build-up is known as 'polytropic' compression and means that the normal pressure in the cylinder at 2,000 r. p. m. would be about 120 lbs. per sq. in. instead of about 90 lbs. per sq. in. if the temperature of the gas had remained constant.

The petrol/air mixture does not explode when ignited by the sparking plug, but burns relatively slowly, and in fact requires about 60° of crankshaft rotation to burn fully. This means that the spark must be advanced to ensure that maximum power and economy are obtained by timing the ignition and expansion of the gas at the best possible period of crankshaft rotation. During the 60° of crankshaft rotation while the mixture is still burning, the cylinder pressure in a normal engine rises to about 800 lbs. per sq. in. Following combustion comes the actual power stroke, and at the end of this stroke the pressure in the cylinder is still at about 75 lbs. per sq. in. which is far higher than atmospheric pressure. As this high pressure would hold back the piston on its exhaust stroke, the exhaust valve is opened before bottom dead centre and to assist cylinder scavenging is held open several degrees after top dead centre.

The pressure in the cylinder is transmitted by way of pistons, connecting rod and crankshaft to torque at the flywheel. During this process mechanical losses take place because of friction, and pressure losses because the piston has to move against a partial vacuum during the inlet stroke, and a pressure during the exhaust stroke. The normal engine with the accelerator held wide open will deliver at 1,000 r. p. m. about 90% of the power produced in the cylinder. Engine friction, and pressure and vacuum losses rise with increased r. p. m. so that at 5,000 r. p. m. the engine is only delivering about 70% of its true power at the flywheel. With a partially closed throttle the situation becomes worse as for any given r. p. m. the total losses are practically the same irrespective of throttle opening.

The only way the amateur can determine the effect of his modifications on his engine is to do one modification at a time and then test the car on the road or on a rolling dynamometer to determine the result. The professional has a large advantage as he can use a proper engine dynamometer, which is a machine for measuring

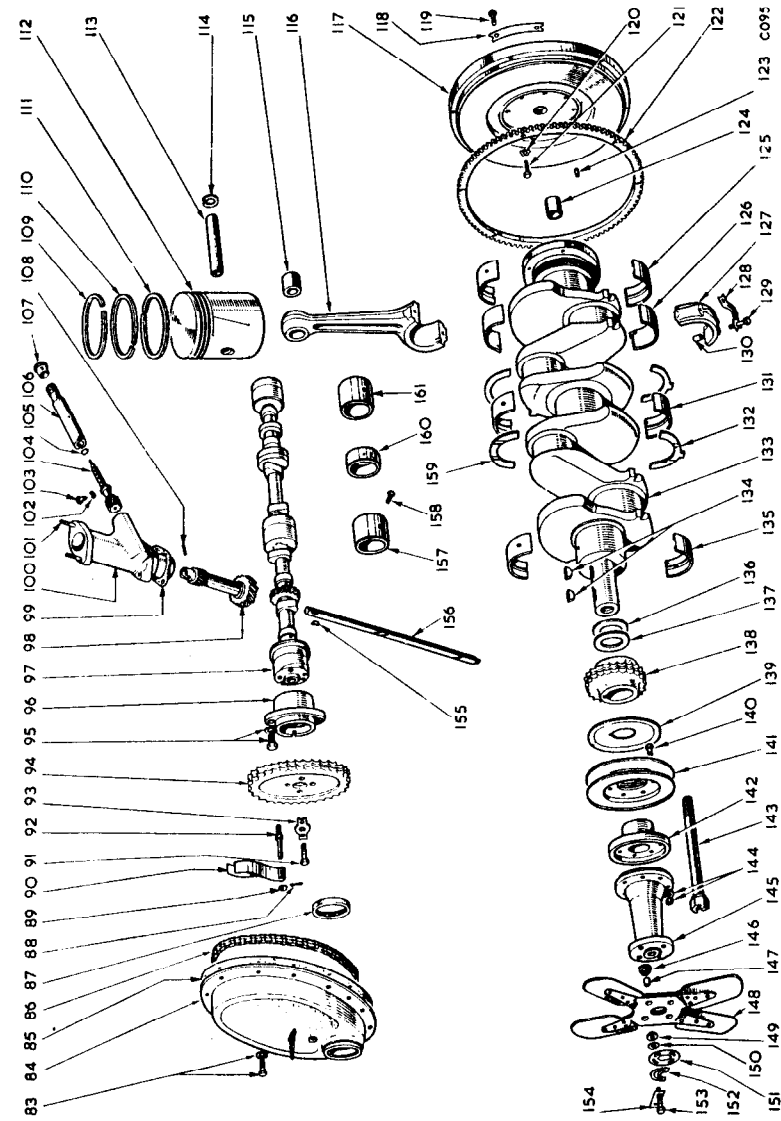


Fig. 2. Exploded view of the main moving parts of the engine

and absorbing torque. If the amateur requires accurate measurement of any gains in power without the expense of removing the power unit from the car, the obvious answer is to find a local garage with a 'rolling road' dynamometer. This machine measures the amount of torque passing through the driving wheels, all that it is necessary to do being to drive the car onto a special platform, with the driving wheels resting between two large rollers. The engine is then started, and the car put in top gear. The power shown will be less than the true power being developed by the engine due to transmission friction losses. As a means of seeing the comparative effect of different modifications and getting maximum performance by tuning adjustments, this is a very good method. However the equipment is expensive to purchase and not very many garages possess 'rolling road' dynamometers. The normal or ordinary dynamometer used extensively in this country is the Heenan and Froude hydraulic unit which loads the engine by the friction of water in a turbine. The amount of load is regulated by valves. The normal procedure for testing an engine for torque is to bolt it down to the test stand, connect the oil, petrol and water lines, and attach the exhaust pipe. The engine is then started, and torque readings taken at various r.p.m. The maximum torque being produced at any given r.p.m. is determined by the load put on the engine by the dynamometer. The load is slowly increased to the maximum that the engine will hold at that r.p.m. From the torque produced the b.h.p. can be calculated as has already been shown.

Brake mean effective pressure is also a true measure of an engine's efficiency as it indicates the pressure that the engine is working at. The higher the pressure the more power the engine will develop. B.m.e.p. is closely related to torque and can be determined by the following formula:

$$\text{B. m. e. p. (lbs. per sq. in.)} = \frac{\text{Torque} \times 2473}{\text{Cubic capacity}}$$

R.p.m. can be regarded as the rate that the engine performs its work. Providing the torque is maintained the faster the engine spins the more power it will develop in a specified time. Piston speed is not now so important as it used to be, but speeds in excess of 2,500 ft. per minute still mean that there must be considerable pressure pumping losses. Generally speaking the slower the pistons have to travel the better.

From the foregoing it can be seen that to improve the efficiency and performance of the engine we must increase the torque and b.h.p. and try to maintain them over a larger revolution range. The methods that can be used to achieve this are shown in detail in Chapter 2.

CHAPTER TWO

STAGES OF MODIFICATION

Five main factors control the increase of power and torque in any internal combustion engine, and can be summarised as follows:

1. The maximum r. p. m.
2. The cubic capacity.
3. The mechanical efficiency.
4. The weight and volume of the mixture drawn into the cylinders.
5. Combustion efficiency.

A single modification can have an effect on several of the factors listed above at the same time. As an illustration, a modification that increases the weight of the mixture drawn into the cylinders will also increase the revolutions, which represent the rate at which work is being performed. It is therefore of great importance to know both the main and side effects of making different modifications, and what will be their total contribution to the engine's performance in terms of increased b.h.p. and torque. In many instances an astute cheap modification will be of far better value and give a far better result than an uninformed expensive one. In this chapter will be shown the modifications that give the best results, in terms of actual performance gained for money spent.

It is now necessary to go into slightly greater detail and consider what modifications can be done under each of the five main headings we have already listed for increasing power output. Some of the modifications will have secondary effects but we will not be concerned with this at the moment.

The maximum revolutions of the engine per minute can be increased by:

1. a) Altering valve springs so that valve bounce occurs at higher r. p. m.
- b) Accurately balancing all reciprocating engine components.
- c) Lowering the weight of reciprocating parts such as valves, push-rods, connecting rods, pistons, etc.

The cubic capacity can be increased by the following methods:

2. a) Boring the cylinder bores oversize.
- b) Boring the cylinders oversize and fitting larger cylinder wall liners and new pistons.

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The mechanical efficiency can be improved in the following manner:

3. a) Increasing the piston and bearing clearances.
- b) Raising the oil pressures.
- c) Using a high viscosity oil.

The weight of the fuel/air mixture drawn into the cylinders can be improved by:

4. a) Increasing the total carburettor choke area.
- b) Lengthening the period during which the inlet and exhaust valves remain open.
- c) Making greater the flow path area of the manifolds and ports.
- d) Smoothing out the flow path in the manifolds and ports.
- e) Increasing and smoothing the flow path around the inlet valve head in the combustion chamber.
- f) Supercharging.
- g) Increasing the valve discharge area.
- h) Drawing cool air into the carburettors.
- i) Making the petrol/air mixture richer than standard.

The combustion efficiency can be improved by the following ways:

5. a) Raising the compression ratio.
- b) Increasing the exhaust scavenging and improving cylinder filling by pressure wave tuning of inlet and exhaust systems.
- c) Increasing turbulence within the cylinder.
- d) Ensuring that the spark is properly timed and of sufficient power to fire at all revolutions.

From the foregoing it can be seen that some of the modifications will be fairly easy to make and could be performed by a competent mechanic, while others would require the use of specialised machinery, and skilled craftsmen.

Consideration should be given to the correct sequence in which to make modifications to the TR engine to get the maximum increase in power for the lowest possible cost. The majority of individuals have their own idea of the modifications that they consider will give the greatest increase in power for cash spent, and they vary from straight through free flow exhaust systems to gadgets stuck on the end of the exhaust pipe. Disregarding personal opinions, the modifications listed will be those that have been proved on a dynamometer. By doing this it will be possible to relate cost to true performance increase and not just theory, which in practice sometimes proves to be incorrect because of unknown or disregarded factors.

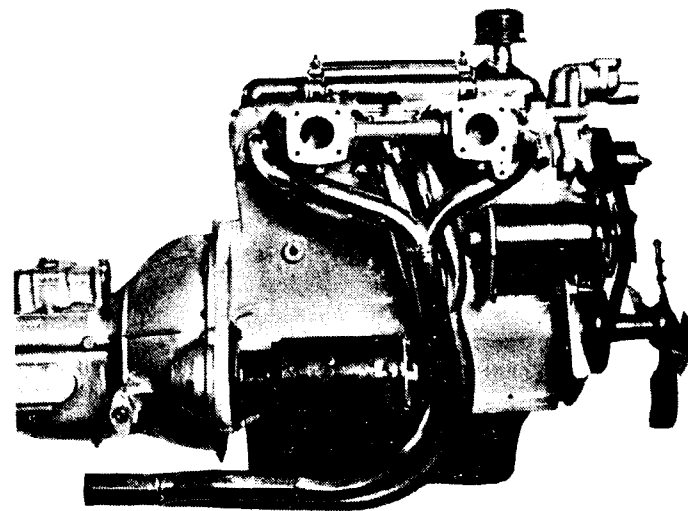


Fig. 3. The 135 b.h.p. TR engine. Note the special exhaust manifold

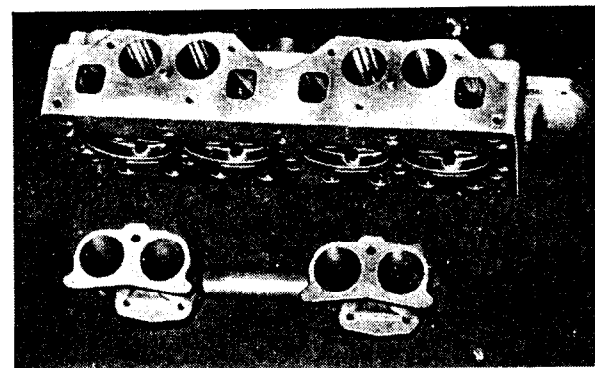
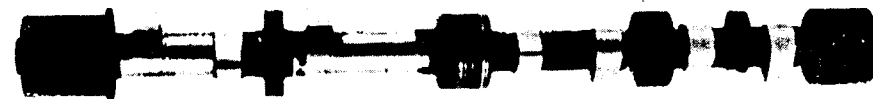


Fig. 4. Above. The gas flowed, polished, and modified cylinder head and inlet manifold fitted to the 135 b.h.p. engine

Fig. 5. Below. The special wide overlap S.A.H. touring camshaft also used in this engine



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In practice some of the modifications listed above either are not necessary or not worth the cost. On TR engines there is no real requirement to reduce the weight of the reciprocating parts of the valve gear as these engines are only rarely revved above 6,000 r.p.m. Lightening the connecting rods and pistons is not worth the trouble or the risk of weakening them. The means for increasing mechanical efficiency are not really applicable to TRs and no-one uses superchargers on TRs nowadays. Otherwise all the modifications are worthwhile and can be carried out successfully.

Before getting too involved in modifications it should be pointed out that on a worn engine, or one that has not been regularly or properly maintained, substantial power increases may be found by just getting the engine to function properly. Good points and plugs, properly ground valves, or a decarbonised head all work very much better than tired and worn components. The same applies of course to other components such as liners, pistons, piston rings and the bearings at the bottom end. The normal stages of modification of TR engines are shown below though the sequence is usually related to the owner's purse and the accommodation and facilities at his disposal at the time.

	Approx. Cost Owner fitted & modified	Approx. Cost Garage fitted
Stage 1. Gas flowed head (stage 1) Free flow exhaust pipe and silencer	£15. 0. 0.	£40. 0. 0.
Stage 2. Gas flowed head (stage 2) Free flow exhaust Extractor type exhaust manifold	£35. 0. 0.	£68. 10. 0.
Stage 3. Gas flowed head Free flow exhaust pipe Extractor type exhaust manifold Modified camshaft (touring) Two DCOE Weber carburettors Two special inlet manifolds and carburettor linkages	£125. 0. 0.	£168. 0. 0.
Stage 4. Gas flowed head Free flow exhaust pipe Extractor type exhaust manifold Modified camshaft Two DCOE Weber carburettors Two special inlet manifolds and linkages		

STAGES OF MODIFICATION

Oil cooler kit	
Lightened flywheel and stronger clutch	
Special main and big end bearings	
Balanced crankshaft, pistons, rods, clutch and flywheel	£165. 0. 0. £216. 10. 0.

Approximate power increases at the rear wheels are:

Stage 1.	10 b. h. p.
Stage 2.	22 "
Stage 3.	40 "
Stage 4.	40 "

Though stage 4 does not give any increase in power over stage 3, an oil cooler, lightened flywheel and special bearings are included, as well as balancing of the unit. These modifications will reduce wear and increase the life of the engine. The benefits of flywheel lightening are discussed on page 53. The b.h.p. increase figures quoted represent net b. h. p. gain compared with a standard unmodified TR4A, and are actual dynamometer readings.

Stage 1 is designed to be a simple inexpensive improvement to performance. The cylinder head is nearly always the first part of an engine to be modified. By this I mean that there are more cars with modified heads than modified camshafts. If the owner is going to fit a modified camshaft, he will probably do the head as well. The reason for this is simple - accessibility. A cylinder head can be changed quite easily, but to change a camshaft is a major operation involving engine removal, stripping, retiming ignition and valves and takes some knowledge and time. In stage 1 the cylinder head modifications are a raised compression ratio, enlarged and polished inlet and exhaust porting, re-shaped and balanced combustion chambers, and matched inlet manifolds. The stage 2 head is as stage 1 but with all new valves, and special springs, to permit higher revs.

The aim of these modifications is straightforward. They are designed to make the passage of the gases into the cylinder as direct and easy as possible. The big valve S.A.H. cylinder head has special large inlet valves and a 10.7:1 compression ratio (on 2.2 litre engine). The improvements to the exhaust system are designed to ease the job of the piston when it is pushing the exhaust gases out of the cylinder. It would be wrong to think that it is only the piston that pushes the gases out, for with the valves closed there is considerable pressure in the cylinder even when the piston is at the bottom of its bore. Opening the exhaust valve lets the exhaust gases out but the piston, on its way up the cylinder, still has to push the remainder out. By opening up and removing any restrictions in the

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exhaust gases passage through the valves, ports, manifold, pipe and silencer the power losses in the engine are reduced and an incidental gain is a fruity exhaust noise, much treasured by many enthusiasts! Stage 3 involves much more work than stages 1 and 2. The main reason for this is that a modified camshaft is fitted. Also for stage 3 two twin choke DCOE Weber carburettors and inlet manifolds are included. These are usually the most expensive items on a modified engine. If one is modifying the car to obtain extra power for road use only, the Weber carburettors are not really necessary. The twin S.U. carburettors, or on later cars Strombergs, do a very good job. The Weber gives better ultimate performance than these but for road use, in my opinion, the increase in performance is hardly worth the cost. When it comes to competition work there is no doubt that Webers are the best bet, unless you are thinking of going over to fuel injection or supercharging. The chief advantages of the Weber carburettor lies in the streamlined, relatively uninterrupted passage the air travels through, and the fact that Webers give more accelerative power, because of the enriching device that operates whenever the throttle is opened suddenly. If one wants one choke per cylinder, two twin choke Webers would be cheaper to buy than four S.U.s. The Webers probably give 5 - 6 b.h.p. more at maximum power than S.U.s or Strombergs. At low to normal revs the S.U.s and Strombergs give more torque and use less petrol.

As explained in Chapter One, valves do not open or close when the piston is exactly at top or bottom dead centre. By opening early or closing late one can fill or empty the cylinder more efficiently. The speed at which the gas is travelling, or alternatively at which the engine is turning, affects the ideal timing of the valves considerably. This means that a camshaft can be designed to give power at high revs, low revs, or, as on production cars, a relatively even amount of power over the anticipated rev range. On a racing engine low revs are not used and the valves are timed to give more power at high revs, but at the expense of low rev power.

The valve timing of standard camshafts is compared with an SAH and a Lawrence tune camshaft:

	TR4s	TR2s/3s	SAH	Lawrencetune
Inlet valve opens b. t. d. c.	17°	15°	23°	42°
" " closes a. b. d. c.	57°	55°	64°	72°
Exhaust valve opens b. b. d. c.	57°	55°	64°	78°
" " closes t. d. c.	17°	15°	23°	38°



Fig. 6. An oil cooler is essential if near maximum power is to be used for any length of time

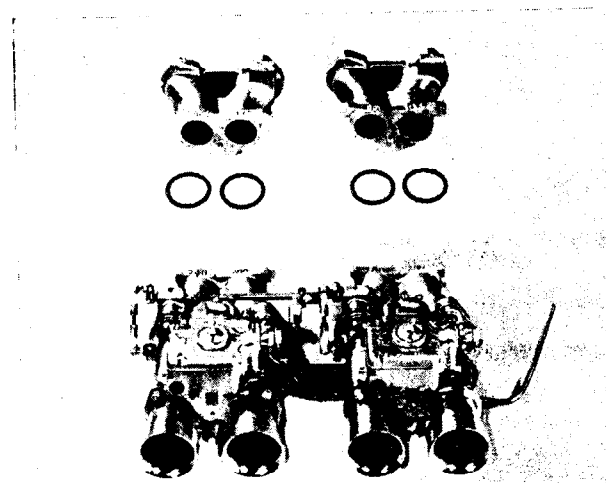


Fig. 7. Two twin-choke Weber carburettors will give a worthwhile gain in both torque and maximum b.h.p.

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In stage 4 we find an oil cooler kit. Improved induction and increased revs lead to higher temperatures since more gas is burnt. The water cooling system is adequate to deal with this, but there is a risk, if high revs are maintained, that the oil will get too hot and cause engine damage. The majority of reputable mineral and castor oils are safe to 160°C Centigrade. Above that temperature the oil film breaks down and they oxidise at a higher rate. However, before this temperature is reached the bearings will fail, 145°C being the maximum figure at the bearings. This means that the maximum sump temperature permitted is 110 to 120°C as the oil will be further heated as it passes through the pump, oilways, and down the crankshaft to the bearings. On the TR engine an oil cooler is definitely necessary for competition or for high speed cruising, but for normal use it is not so important.

Balancing the engine reduces wear and the risk of component failure due to increased load. If the pressure exerted on the pistons is equal (achieved by careful tuning and ensuring that combustion chamber sizes are identical and that all the rotating parts are balanced) the unit will run more smoothly which will put less stress on the rotating parts. The advantage of balancing increases as engine revolutions rise since the stresses increase at a greater rate than revs. The man who modifies his engine for a modest power increase and who does not plan to rev it any higher than normal will probably not need to have his engine balanced. The benefits at normal revs would be so small that they would probably not be noticeable, whereas if higher revs, say 6,000 r.p.m. or more are used, it is very worthwhile. Though it reduces the chance of mechanical failure it cannot prevent it.

Special bearings are available which give a longer life than others. The most important aid to long bearing life is an oil cooler. Depending on how the engine is used, a reasonably long life should be expected. For road use observing a normal rev limit of 5,000 r.p.m. with very occasional surges to 5,500 r.p.m., changing the bearings every 30,000 miles is sensible. Using 5,500 revs regularly in competitions, it would be advisable to change the big ends every 15 races. At higher revs, the period must be correspondingly shorter.

Stage 4 is the normal limit to tuning the TR engine. For racing purposes some people go much further. They spend very much more money, time and effort than the normal enthusiast and are taking much greater risks of failure or engine 'blow-up' as it is usually called.

A stronger clutch is desirable and the author always used a Daimler SP 250 clutch which is designed to cope with 140 b.h.p. in

STAGES OF MODIFICATION

everyday use on the SP 250, and so is well suited to a hot TR engine. It bolts straight onto the flywheel without modification.

Reliability is one of the advantages of the TR engine, but with one proviso: being a comparatively long-stroked engine high revs do not suit it. 5,000 r.p.m. should not harm it, 5,500 r.p.m. on a balanced engine is fairly safe, but when 6,000 r.p.m. is used regularly, failure is being risked. Having personally raced a 2138 c.c. TR4 engine for three seasons I would recommend changing the crankshaft after a season's racing or, say, 10,000 road miles if 5,500 revs are consistently used. The most common failure seems to be the crankshaft, but only when consistently used beyond the makers recommendations. When they do go, they usually snap a connecting rod and hole the side of the crankcase. The rods, in my experience, don't often fail, though big end bolts do, and these should be changed at the same time as big ends. Continual use of high revs obviously will wear the engine much quicker than normal use. Apart from balancing there are other ways of checking and protecting against failure. Crack testing will tell if there are any cracks at the time of the test. This has its uses but is of limited value since a component may run for hundreds of hours without developing a crack, but the time between a crack appearing and actual failure may be a matter of minutes. Cracks and failures often start where there is a scratch or machining mark on the metal. One way of strengthening crankshaft webs and connecting rods and their caps is to file off any marks and then polish the metal. This helps to develop a 'skin' on the metal which strengthens it. Another way of achieving this is by shot peening. This involves putting the component in a machine which fires hundreds of little metal shot at the metal. Bearing and other finely machined areas have to be protected from the shot. According to an advertisement shot peening is a very successful way of increasing life. Though the advertiser was naturally biased he quotes: "Crankshaft life increase of 900 per cent" attributed to J. O. Almen, Research Dept., General Motors; "Connecting rods 1,000 per cent life improvement" attributed to American Machinist; "1,400 per cent life increase on rocker arms" attributed to American National Defence Research Committee.

CHAPTER THREE

STRIPPING AND REBUILDING THE ENGINE

If the engine is badly worn, then stripping and rebuilding it will automatically result in an increase in power. If the unit is modified while in pieces even further power will result.

The few differences that there are in the different models of TR engines do not affect stripping and assembly. These instructions apply to all TRs, though a few minor details may differ. When assembling an engine always try to put back an item where it came from. For instance put a valve back in the same seat as before. This means laying components out on a bench carefully or marking them. Scratching marks on them is not advised as this may weaken them. Masking tape that can be written on is recommended. Examples of items that should be replaced where they come from are valves, valve springs, connecting rods, connecting rod caps, gudgeon pins, pistons, etc.

CYLINDER HEAD REMOVAL

1. Drain the cooling system by opening the tap at the bottom of the radiator.
2. Disconnect the ancillaries:
 - (a) petrol pipe by pulling the rubber connection off at the float chamber.
 - (b) carburettors) by undoing the 8 retaining nuts.
 - (c) exhaust manifold)
 - (d) plug leads - just pull them off.
 - (e) water hoses by undoing the jubilee clips at either end of the heater hose and on the top hose to the radiator.
 - (f) rocker cover by undoing the 2 nuts on the top of it.
 - (g) temperature gauge capillary or cable where it goes into the thermostat housing.
3. Undo the 4 nuts holding the rocker shaft in place, each a little at a time, and remove the shaft and pushrods. Do not disturb the cam followers.
4. Easing each nut a little at a time, undo the 10 cylinder head holding nuts in the order shown in Fig. 11. If not done in the correct order there is a risk of distortion of the cylinder head.

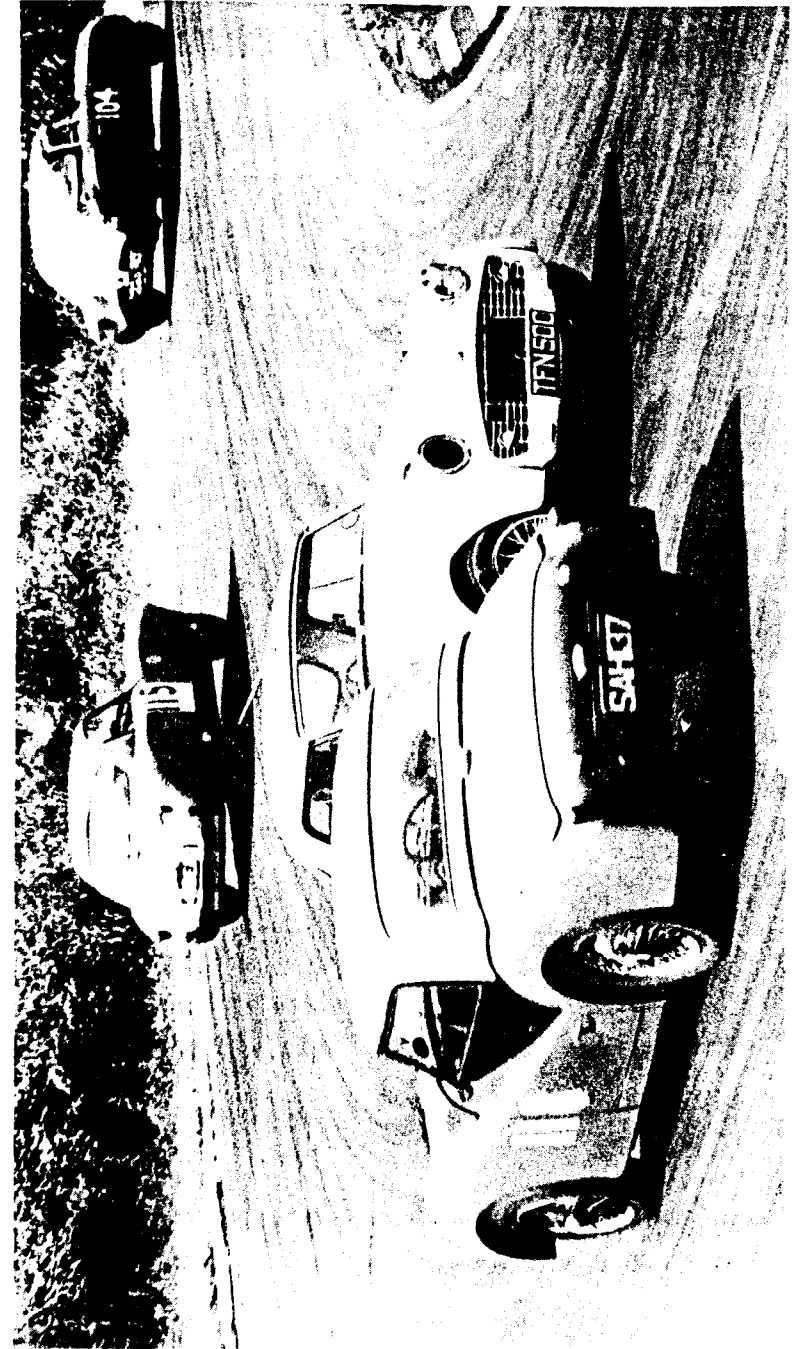


Plate 2
TR's waltzing round Druids Bend at Brands Hatch - luckily neither made contact

Photo: Michael R. Hewett

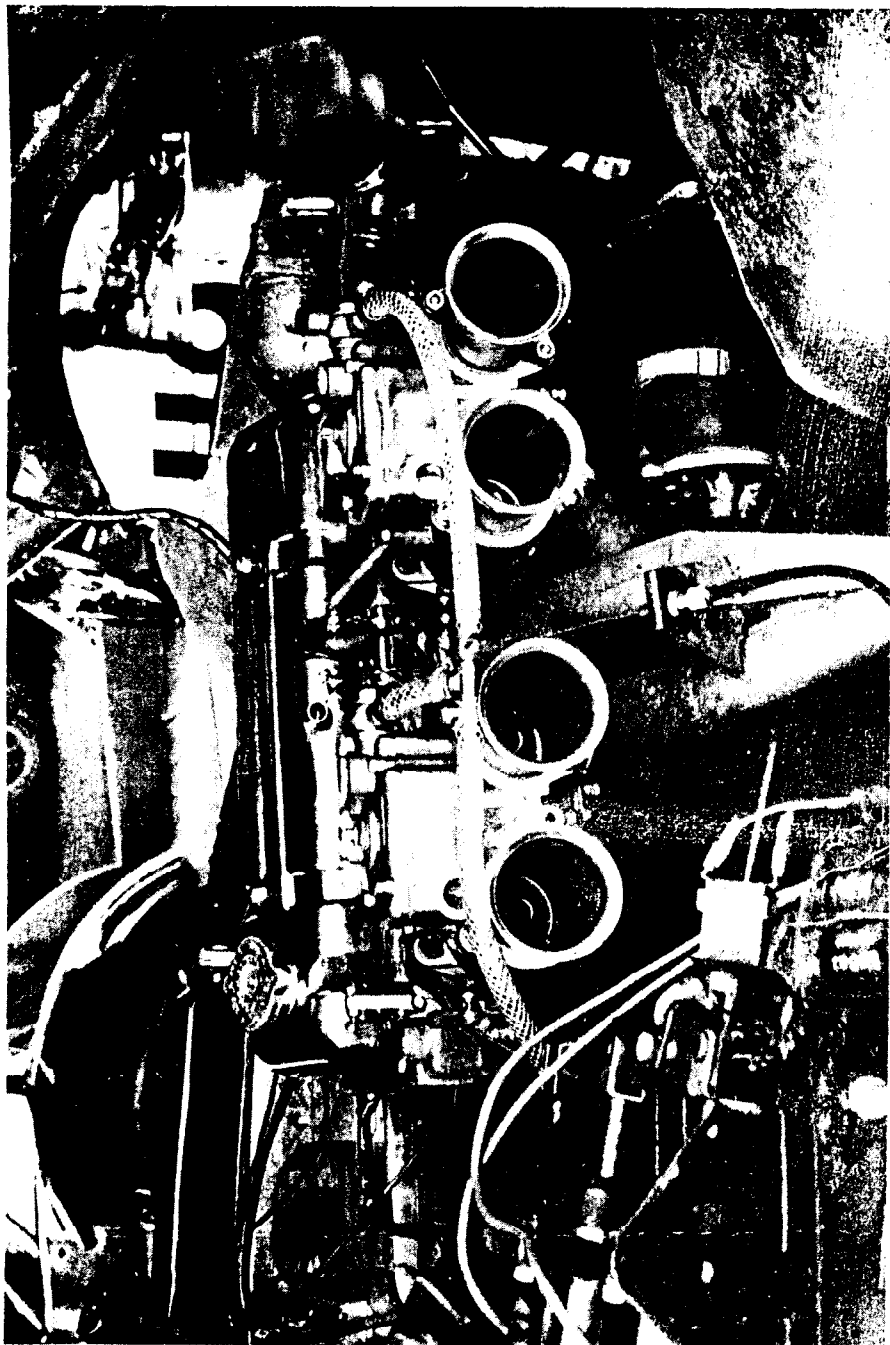


Plate 3
A fully modified racing TR engine complete with twin-choke Webers
Photo: J. MacLay

STRIPPING & REBUILDING THE ENGINE

5. Ease the cylinder head off the block. If it proves hard to move rocking or judicious tapping with a wooden mallet may help.
6. Do not turn the engine over. The wet liners are held in position by the cylinder head and if the engine is turned over, or a piston is moved in its bore, there is a very good chance that the liner will move and break the seal at the bottom of the liner. This seal prevents the water coolant from getting into the oil. Should this happen the lubrication effectiveness of the oil is ruined. Always change oil if there is any water in it. If the liners are moved, they must be removed and new figure of eight joints put in. If it is desired to turn the engine over or extract the pistons, the tops of the liners should be held down in position with retainers bolted down by the cylinder head studs.

CYLINDER HEAD OVERHAUL

Compress the valve springs with a valve spring compressor, remove the collets and take out the valves. Either lay out the valves in order or mark them so that they are returned whence they came. Remove all carbon from the combustion chamber and ports and thoroughly clean the head. Check valve guides for wear by inserting a new valve, lifting it $\frac{1}{8}$ in. and rocking it sideways. Movement of the valve head should not exceed 0.020 in. Before grinding the valves into their seats make sure that the stems and valve guides are clean and oiled. Grinding is easiest done on a machine but can be done as well by hand. Smear a little grinding paste on the seat or valve face and with a valve grinding tool rotate the valve to and fro, changing position frequently, until more grinding paste is necessary or you think that a perfect finish has been achieved. All pitting marks must be gone and there must be a gas-tight seal all round the seat. To test, smear a little engineer's blue on the valve face and rotate $\frac{1}{8}$ in. to and fro on the seat. If there is not a circle of blue all round the valve seat, further grinding is necessary. A gas-tight seal is very important or else there is a risk of valve burning. This is specially applicable to exhaust valves. Another test is to put liquid round the seat, insert the valve and then direct a high pressure jet of air into the port. If there is a leak it will show in the form of bubbles. If perfection is the aim, assemble the valves and springs, lay the head on a bench the right way up and fill the parts with paraffin and leave overnight. If any paraffin leaks into the combustion chamber the seal is imperfect.

CYLINDER HEAD REFITTING

Cleanliness is important, since dirt on the top of the block or face of the head will prevent a proper seal, and dirt in the valve

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

guides will cause excessive wear leading to heavy oil consumption. Dirt in the inlet ports could be sucked into the cylinders and score the walls, leading to less efficient compression and increased oil consumption. Lightly coat a new cylinder head gasket with sealing compound: Wellseal is very good: and tighten the cylinder head holding nuts down a little at a time in the sequence shown in Fig. 11. to a final torque of 105 ft/lbs. with a torque wrench. Replace the pushrods and rocker shaft and set the valve clearances as described on page 58. Reconnect the various ancillaries. After a few miles the cylinder head should be tightened down again to 105 ft/lbs. when hot and the tappet clearances checked.

ENGINE AND GEARBOX REMOVAL

1. Drain the cooling system by opening the tap at the bottom of the radiator and the drain tap on the nearside of the block, and the engine and gearbox sumps by unscrewing the sump plugs.
2. Remove the battery by disconnecting the two leads and the battery locators.
3. Disconnect:
 - (1) oil pressure pipe where it comes off the rear of the block by unscrewing the retaining nut.
 - (2) fuel pipes at the float chamber.
 - (3) tachometer drive by unscrewing the retainer at the base of the distributor.
 - (4) distributor vacuum drive by undoing the single nut which attaches the vacuum pipe to the front of the distributor.
 - (5) coil SW cable by undoing the nut which holds it to the top of the coil.
 - (6) temperature gauge cable where it goes into the thermostat housing.
 - (7) horns and cable (TR4 only).
 - (8) fan belt by loosening the adjuster bolts on the dynamo.
 - (9) engine earth strap from front engine bearer plate by undoing the bolt holding it in place.
 - (10) heater control wire which is held by a locking nut and the hoses held by jubilee clips: the heater hoses and engine cooling hoses.
 - (11) choke cable where it joins the rear carburettor underneath it, by slackening the clamp bolts and nuts which hold both the outer and the inner cable.
 - (12) accelerator linkage at the front of the front carburettor by undoing the ball cup retaining nut.
 - (13) exhaust pipe flange by undoing nuts.
4. Lift out the carburettors.

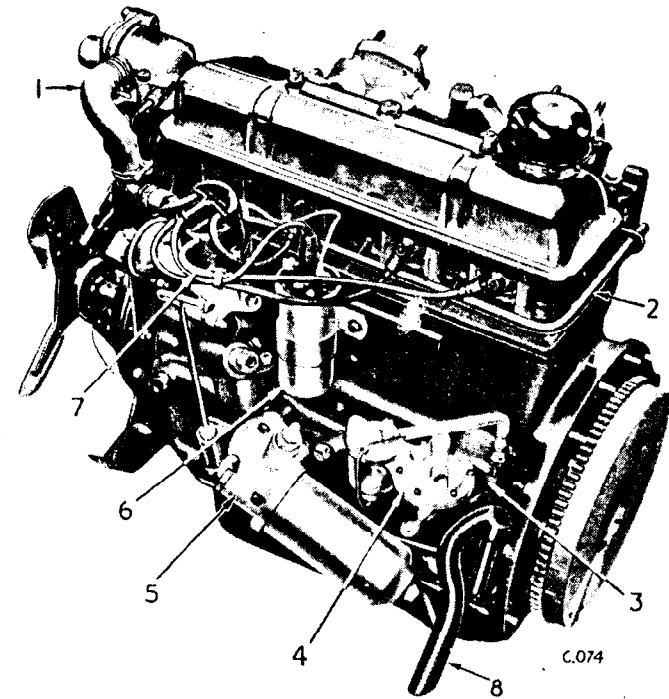
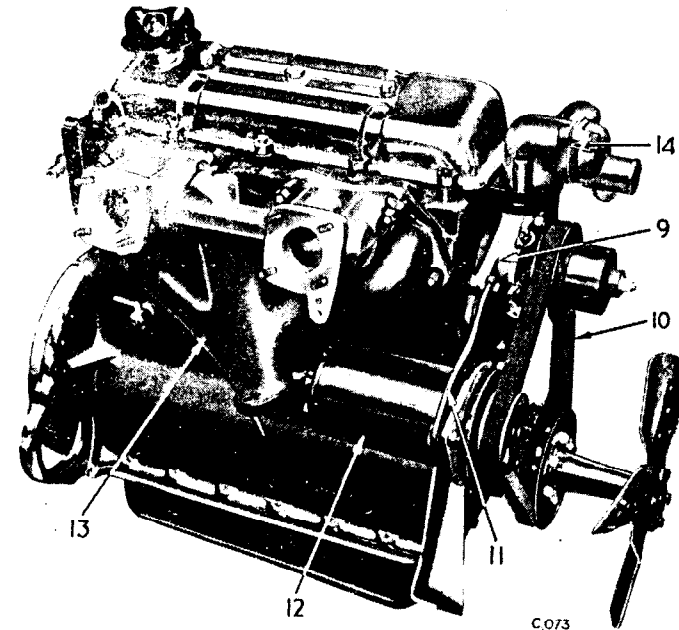


Fig. 8. Above. Left-hand view of the engine. 1 By-pass hose. 2 Heater pipe. 3 Oil pressure pipe. 4 Fuel pump. 5 Oil filter. 6 Ignition coil. 7 Distributor. 8 Breather pipe

Fig. 9. Below. Right-hand view of the engine. 9 Water pump. 10 Fan belt. 11 Adjusting link. 12 Generator. 13 Exhaust manifold. 14 Thermostat housing



TRIUMPH MAINTENANCE, MODIFICATION & TUNING

5. Move the steering nut as far forward as possible by undoing the coupling and the two 'U' bolts.
6. Remove the front cross-member support between the suspension units by undoing the bolts.
7. Remove:
 - (1) starter motor by undoing the two bolts holding it in place and the brass nut which holds the electric cable connection.
 - (2) bonnet. On TR2s/3s the bonnet is hinged at the rear and held by two nuts at either side. On TR4s it is front-hinged with three bolts either side.
 - (3) air deflector (where fitted) by undoing the retaining screws.
 - (4) radiator by removing the stays on each side and the bolts at the base.
 - (5) engine torque re-actor at the front of engine.
 - (6) clutch pipe by slackening the locknut and unscrewing the pipe.
 - (7) seat, cushions and carpets.
 - (8) gearbox cover.
 - (9) speedometer cable from gearbox.
 - (10) propeller shaft bolts where it joins the gearbox.
 - (11) overdrive solenoid cables (if overdrive is fitted).
 - (12) gearbox cover top by undoing the bolts and lifting it off. Once off the opening must be carefully covered to prevent any dirt getting into the box during the lifting operation.
8. Attach lifting gear in a way such that the engine will lift at the front at an angle of 35°-40°, see Fig. 10.
9. Disconnect the front engine mountings by undoing the single bolt on the top of the rubber mountings at each side and the gearbox rear support cross-member mounting bolts.
10. Lift the engine, tilting it up at the front, and manoeuvre it clear of the vehicle.
11. Proceed to the nearest public house and sink at least 3 pints immediately!

INSTALLATION OF ENGINE AND GEARBOX (together)

This is approximately the reverse of removal, and so the procedure is listed below without lengthy descriptions as to how many and where the bolts, etc., are.

1. Lift engine into vehicle using lifting gear so that the engine is tilted at 35°-40° rearwards.
2. Refit:
 - (1) gearbox support cross-member and rear mounting.
 - (2) front engine mountings.
 - (3) torque reaction arm, and adjust to take up any clearances.
 - (4) gearbox cover.

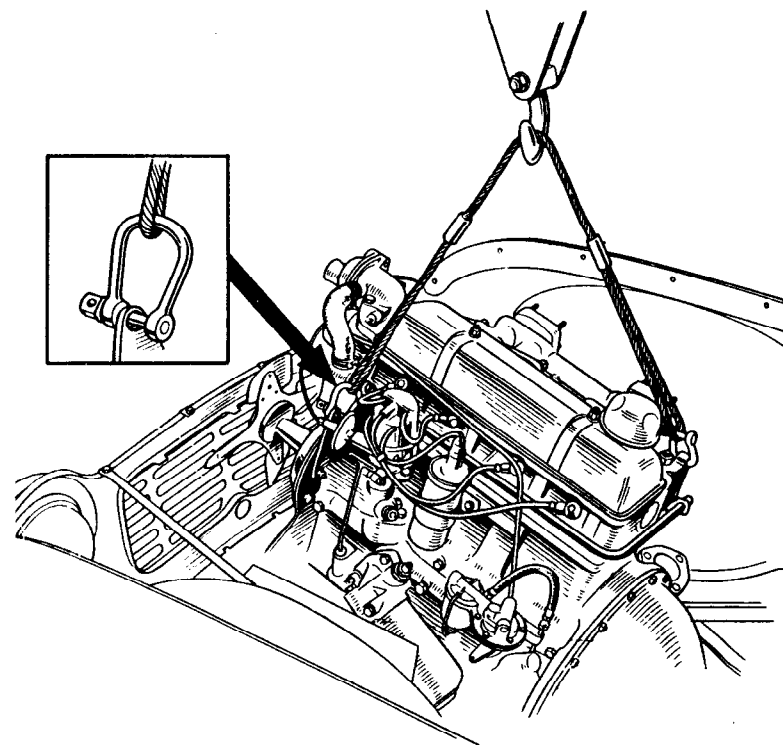


Fig. 10. Removing the TR engine from the TR4 with the aid of a sling

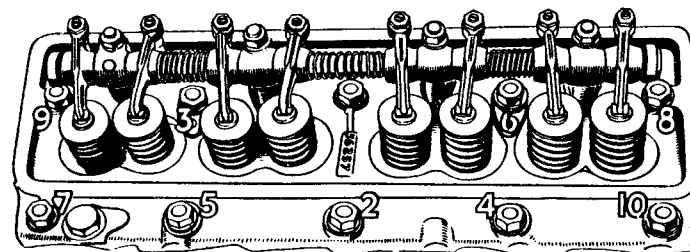


Fig. 11. The correct sequence in which to tighten the cylinder head nuts

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

- (5) propeller shaft.
 - (6) speedo drive.
 - (7) overdrive solenoid cables (if fitted).
 - (8) gearbox cover.
 - (9) seat cushions and carpets.
 - (10) clutch slave cylinder and adjust as described on page 76.
 - (11) steering unit and its 'U' bolts and coupling.
 - (12) front crossmember.
 - (13) starter motor.
 - (14) radiator and air deflector (where fitted).
 - (15) exhaust pipe flange.
 - (16) engine earth strap.
 - (17) horn cables.
 - (18) temperature gauge cable.
 - (19) vacuum pipe.
 - (20) fuel pipes.
 - (21) tachometer drive cable.
 - (22) oil pressure pipe.
 - (23) coil SW cable.
 - (24) carburettors.
 - (25) accelerator linkage.
 - (26) choke cable.
 - (27) heater hoses.
 - (28) heater control.
 - (29) exhaust pipe.
 - (30) bonnet.
 - (31) battery.
3. Refill: the radiator with water,
the engine with oil,
and the gearbox with engine oil, also.
 4. Start the engine.
 5. Check the fluid levels.

ENGINE DISMANTLING

1. Remove the gearbox by undoing the nuts and bolts attaching it to the engine. Pull the gearbox straight backwards; if there is any bending strain on it it will not slide off easily due to friction on the splines connecting the front input shaft to the clutch driven plate.
2. Remove the clutch by undoing the bolts that attach the pressure plate to the flywheel. If the unit is balanced the bolts should be numbered and replaced exactly where they came from, and similarly with any moving part. When the bolts holding the pressure plate to the flywheel are removed the driven plate

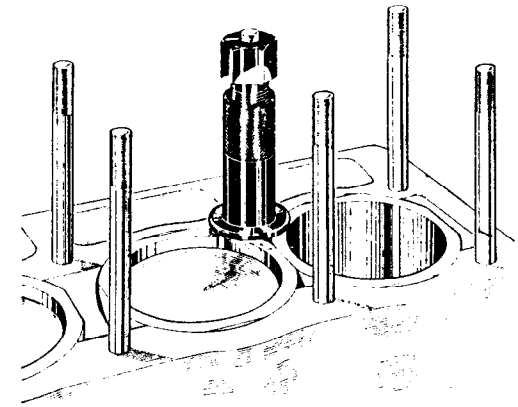


Fig. 12. To hold the cylinder liners in place use two of tool S.138

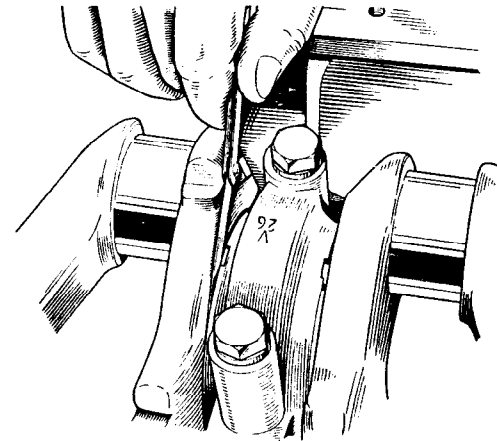
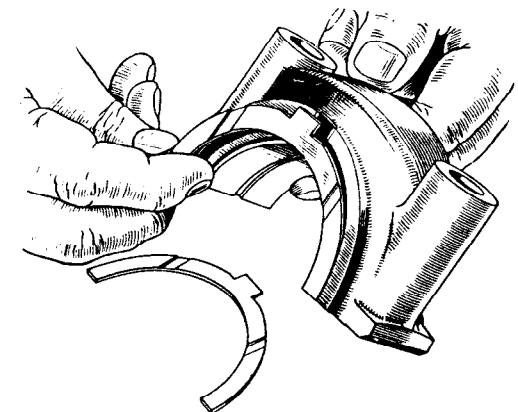


Fig. 13. A feeler gauge must be used to check crankshaft end float

Fig. 14. Fit the thrust washers to the centre main bearing cap with the grooves facing outwards



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will fall out as the pressure plate is lifted clear.

3. Ancillaries, remove:

- (1) remaining water hoses.
- (2) coil, which is attached to the offside of the block by 2 bolts.
- (3) oil filter, which is held to the block by 4 bolts of varying length.
- (4) fuel pump, 2 bolts.
- (5) distributor, by undoing the 2 bolts that hold the clamp at the base of the distributor down to the pedestal.
- (6) distributor pedestal, by removing 2 bolts.
- (7) H. T. leads and lift off distributor cap.
- (8) crankcase breather pipe which is a push fit.
- (9) water pump, held by 3 bolts at the front of the cylinder block.
- (10) dynamo, 2 bolts underneath and the adjuster bolt on top.
- (11) inlet and exhaust manifolds (if not already removed) by removing the 8 retaining nuts.
- (12) thermostat and its housing, held by two bolts on the top of the cylinder head at the front.

4. Cylinder head:

- (1) remove rocker cover, and the rocker shaft, easing each of the 4 bolts at a time.
- (2) lift out pushrods.
- (3) undo the 10 cylinder head holding nuts a little at a time and strictly in the order shown in Fig. 11.
- (4) lift off the head, and remove the gasket and hurl it far into the darkness of the night. Do not use it again.
- (5) using a valve spring compressor, remove the valves, marking them so that they can be returned to the same position.

5. Cylinder block:

- (1) lift out distributor drive.
- (2) lift out cam followers.
- (3) remove the dipstick.
- (4) unbolt the flywheel, marking it so it can be replaced exactly as it was.
- (5) fan, by unbolting.
- (6) pulley assembly. If stuck try hammering, and if unsuccessful use a puller.
- (7) timing chain cover which is held by bolts and nuts.
- (8) unbolt the camshaft sprocket and remove the chain, disc, shims, front bearing and the camshaft itself.
- (9) unbolt the front engine plate and lift clear.
- (10) unbolt the sump and remove the oil pump.
- (11) undo the connecting rod bolts, remove the caps and push the piston and connecting rods out of the top of the bores.

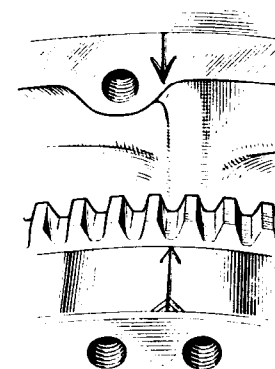


Fig. 15. The T.D.C. marks on the flywheel and cylinder block

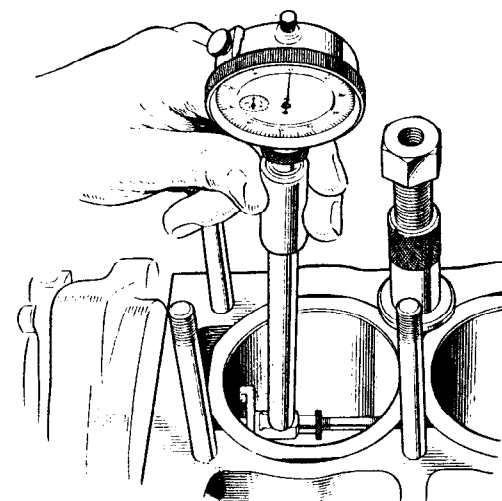


Fig. 16. Measuring the cylinder bores for wear

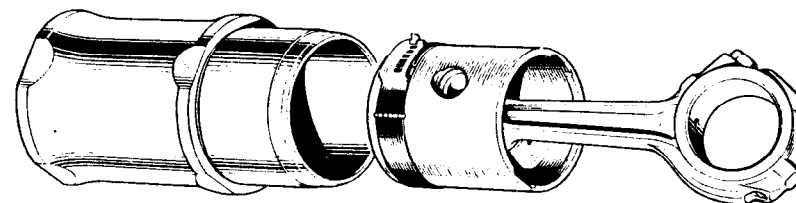


Fig. 17. Fitting a piston into a liner

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- (12) the liners should lift out quite easily, but may require a gentle tap from the bottom with a wooden mallet.
- (13) unbolt the rear oil seal, held by 8 small bolts.
- (14) unbolt the 3 main bearing caps and remove.
- (15) lift out crankshaft and remove thrust washers from block.

ENGINE ASSEMBLY

This is very approximately the reverse of dismantling but a number of points must be made.

When rebuilding, cleanliness is vital. This cannot be overstressed. Fortunate people have access to a trichlorethylene degreasing plant, but for those of us who do not, a plentiful supply of rags, petrol and oil will be very useful.

Use of new gaskets, lock plates and spring washers is recommended.

Jointing compound is recommended, but should be used with judgement and not splashed on too liberally.

A torque wrench should be used and the correct torques listed on page 117 must be strictly adhered to.

All moving parts should be oiled on assembly.

CRANKSHAFT

1. Main bearing cap bolts must have spring washers.
2. The centre main cap will only go on one way round.
3. Crankshaft end float must be between 0.004-0.006 in. measured at the centre main with a feeler gauge. Excess end float can be overcome by purchase of oversize thrust washers. In cases of too little end float the back (not bearing) side should be rubbed down on emery paper.
4. The rear oil seal felt strips should be soaked in Wellseal jointing compound and pressed home into their slots as hard as possible. Poor oil sealing at the rear of the crankshaft leads to oil on the clutch and resultant slip.
5. The front oil seal should be coated with jointing compound.

LINERS

The wet liners can very easily be lowered into position by hand. At the bottom of them are figure of eight joints to stop any leak of water into the oil. These are delicate joints, having a coating on the metal, which once compressed must not be disturbed. If disturbed, they must be replaced, or there is a risk of leaking. If removed, and wear is insufficient for a rebore, it is turning each liner through 180° so that wear may be equalised.

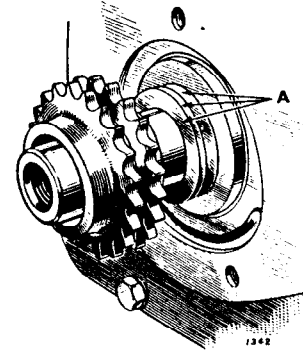


Fig. 18. Add shims behind the crankshaft sprocket wheel at 'A' so a straight edge lies flush on both camshaft and crankshaft sprocket wheels

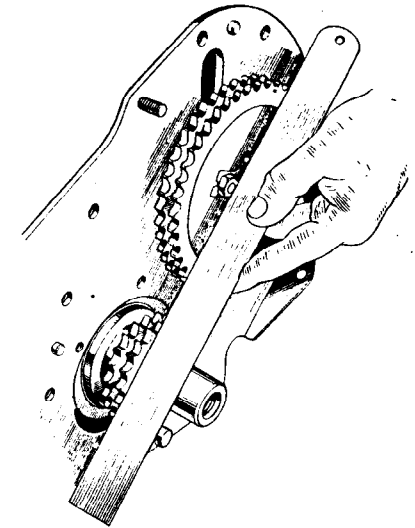
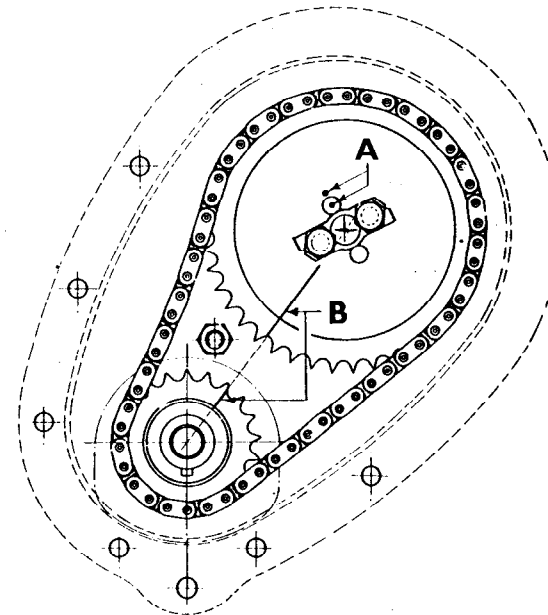


Fig. 19. Ensure the two lines cut in the gearwheels at 'B' are adjacent and in line with each other



TRIUMPH MAINTENANCE, MODIFICATION & TUNING

PISTONS AND PISTON RINGS

Once the engine is dismantled it is worth installing new rings. If this is done it is recommended to hone the liners if the original liners are to be used. Pistons should be gently heated in boiling water to ease fitment to the connecting rod. Gudgeon pins must be secured with circlips. A piston clamp should be used when fitting pistons to their liners. Most other systems of fitting risk damage to the rings.

FLYWHEEL

This must be reassembled in the same way as it was before dismantling, if the T. D. C. mark is to be accurate.

CAMSHAFT

End float should be 0.003-0.0075 in. The camshaft should be timed by lining up the punch marks on the camshaft end and on the camshaft sprocket. One punch mark is near a hole near the centre of the sprocket and the other should be visible through this hole. Once this sprocket is bolted to the camshaft, the other mark (on the outside edge of the sprocket) should be lined up with the mark on the crankshaft sprocket. When the sprockets are not marked a different procedure has to be adopted. Set No. 7 and 8 tappet clearances to 0.040 in. and set these valves at the point of balance. The point of balance is when one valve is just opening and the other just about to close, and where the tappet clearances are the same. With No. 1 piston at T. D. C. the camshaft is correctly timed. The camshaft sprocket must now be removed and the chain fitted, but great care must be exercised not to move the camshaft setting. If the sprocket bolt holes do not exactly line up with the tappet holes in the camshaft, reverse the sprocket because the holes are offset and this will allow accurate fitment.

DISTRIBUTOR TIMING

With No. 1 piston at T. D. C. position the slot in the top of the distributor drive gear so that it points at No. 1 pushrod tube. The slot is offset and should be nearer, rather than further from, the cylinder block. The exact timing of the spark is covered on page 60.

FAN BELT ADJUSTMENT

This should be adjusted so that the belt can be moved sideways about 1 in. at its longest point between pulley wheels.

STRIPPING & REBUILDING THE ENGINE

CYLINDER HEAD

The cylinder head holding bolts must be tightened in the correct sequence, see Fig. 11. Adjustment of tappet clearances is described on page 58. Decarbonising and valve grinding is described on page 25.

ENGINE RECONDITIONING - a few notes

CRANKSHAFT

Measure the diameter of the journals and crankpins at a number of positions. Sizes and wear limits are listed on page 113. If wear exceeds the limits, the crankshaft should be reground or replaced, and undersize bearings fitted.

CAMSHAFT BEARINGS

A special pulley is required to remove these. If removed and renewed, the oil feed holes in the bearing and block must be aligned.

REAR OIL SEAL

Both the fabric seals and the circular metal seal should be renewed.

CONNECTING RODS

Small end wear can be reasonably gauged by hand. If there is any apparent wear the bush and gudgeon pin should be renewed. This requires special tools and is probably best left to specialists.

OIL PUMP

Clearance between rotors must not exceed 0.010 in. Clearance between the outer rotor and body should not exceed 0.004 in. The end plate should be perfectly flat.

FLYWHEEL

Localised starter ring wear can be overcome by rotating the ring through one or two bolt holes.

VALVE GUIDES

Wear should be measured by lifting a new valve $\frac{1}{8}$ in. from the seat and rocking it sideways. Rock should not exceed 0.020 in.

VALVE SEATS

Test each seat by putting a little engineer's blue on the valve face and rotate about $\frac{1}{8}$ in. in each direction. If there is not a complete circle of blue on the seat further grinding is necessary.

CHAPTER FOUR

GAS FLOW

Gas flow to and from the combustion chamber is the most important single item when modifying the engine to produce more power. What happens outside the cylinder is more important than what happens inside. Machining and grinding the cylinder head will increase power to some extent, but carburettor, manifold, port and camshaft modifications are more important. For instance in the S.A.H. stage 1 which features a gas flowed head and a straight through silencer system, a 10 b.h.p. increase at the rear wheels is recorded. With extractor exhaust manifold, high lift camshaft and Weber carburettors and manifolds in addition, the power increase is 40 b.h.p., or four times the original increase.

Reprofiling a camshaft requires the use of specialised machinery and knowledge, and the amateur is advised against trying to do this himself. It will be better to buy an exchange reprofiled camshaft from S.A.H. or Lawrencetune who have the experience, knowledge and facilities to do a proper job. Choice of camshaft depends on the use to which the engine is going to be put. Briefly, the greater the overlap (within reason) the more power will be developed at high revs, but the power at low revs may suffer and the engine will lose flexibility. TR2s/3s valve timing is: inlet valve opens 15° B.T.D.C. and closes 55° A.B.D.C., exhaust valve opens 55° B.B.D.C. and closes 15° A.T.D.C. On TR4s the 15° figures are increased to 17° and the 55° figures to 57° . A typical touring camshaft, S.A.H.'s for example has timing of: inlet opens 23° B.T.D.C. and closes 64° A.B.D.C., exhaust opens 64° B.B.D.C. and closes 23° A.T.D.C. The timing changes are mild and are designed to give a modest power increase without reducing flexibility or sacrificing low rev power. On the full race Lawrencetune camshaft the timing is: inlet opens 42° B.T.D.C. and closes 72° A.B.D.C., exhaust opens 78° B.B.D.C. and closes 38° A.T.D.C. This is designed only with racing in mind. The inlet valve is open for 294° of the 720° of crankshaft rotation. Imagine now an engine turning over very slowly indeed, at 10 r.p.m. As the piston rises on the exhaust stroke, pushing burnt gases out of the exhaust valve, with the full race Lawrencetune camshaft the inlet valve would open 42° before the piston reached top dead centre. At such a slow engine speed it would in fact push exhaust gases out

GAS FLOW

through the inlet valve. At high speed however, when the engine is inhaling gas into each cylinder 3,000 times a minute at 6,000 r.p.m., there is a constant flow of gas interrupted by the valves opening and closing, and at this speed the inertia of the gas moving at speed through the inlet manifold and carburettor injects the gas into the cylinder even though the piston is still moving upwards. This is, of course, purely theoretical as our engine could not work at 10 r.p.m., 500 r.p.m. being the normal tickover minimum, but it does illustrate the relationship between valve overlap, engine speed and efficiency.

When the incoming mixture flows from the carburettor through the inlet manifold and ports, its pressure at the valve will always be less than that at the mouth of the carburettor, because the friction between adjacent layers of the petrol/air mixture moving at different speeds will create pressure losses through heat, which travel out through the mixture to the port and manifold walls, though a fair proportion is retained in the incoming gas. This lowers its weight per cubic centimetre and decreases its density. Pressure and frictional losses are also caused by projections and sharp angular bends, which also create undesirable turbulence. Thus the two main losses as far as manifolding and porting are concerned are caused by friction and turbulence. Although it is not possible to determine exactly by mathematical methods the total amount of pressure losses that occur, because such losses are based on the roughness of the port and manifold walls and various other incalculable factors, the science of fluid dynamics shows us quite clearly that if we wish to reduce the energy loss due to friction and turbulence as much as possible, we must get the walls over which the mixture passes perfectly smooth, and straighten out any curves to the maximum possible radius, at the same time reducing or streamlining any items (such as the valve stem guides) that project into the inlet port and disturb the air flow. Further study of fluid dynamics shows that the energy losses increase as the square of the rate of flow. It is therefore obvious that by adding another two chokes we reduce the gas flow through each inlet manifold by half, thereby reducing our energy losses by a quarter.

We have shown that the flow rate can be halved by adding two extra chokes and therefore the pressure losses reduced to a $\frac{1}{4}$, but this is only up to the ports. Therefore the pressure losses from just the port to the combustion chamber are approximately 90% of the total losses when twin carburettors are fitted and no attention given to the ports. It is therefore of considerable importance that the inlet ports be modified before another carburettor is purchased, as there is a sharp limit to the power that can be ob-

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tained by just adding a further carburettor. More power can be gained by opening and smoothing the ports, regrinding the camshaft, balancing the combustion chambers, etc., than by just adding 'go faster' carburettors and exhaust systems. That the latter can and do increase the power output is not denied, but greater increases in power can be found by attention to the internal parts of an engine rather than the 'outside' ancillaries. It is quite possible to do your own gas flow testing on the cylinder head by using the following system that has been practised with success by Bill Blydenstein when he was attempting to get more b.h.p. from his Borgward Isabella. The water test rig, as he called it, consisted of two one gallon oil cans, with their bottoms removed and then soldered together to form a long two gallon container with an inlet hole at the top and an outlet hole at the bottom. The apparatus should be suspended at a fixed height over any receptacle, such as a sink or bath, capable of allowing the water to drain away. Place the cylinder head right way up (valve stems up, heads down) on two blocks of wood, so that there is room for the valves to drop, and close one of the valves in one of the inlet ports. Two small holes should be drilled in the receptacle, one at the top, and one near the bottom, and the outlet on the container connected by a large rubber pipe to the inlet port. The actual test is performed by shutting the free inlet valve, filling the container with water, and then dropping the inlet valve to its fully open position, and timing the period taken by the water to stop flowing from the top and bottom holes. The fully open position of the valve should be previously obtained by noting how much of the valve stem disappears into the guide, marking the stem, and then fully opening it the predetermined amount when connected to the flow test rig.

Opinions on cylinder head modifications vary from person to person. The work described here will result in very good performance, and is the type of modification that can be undertaken by the amateur. More extreme modifications are possible, such as Lawrence's inclined valves, but since these are beyond the capabilities of the average enthusiast they are not discussed. A power drill with a flexible shaft is needed for grinding and selective abrasive stones, which are available from Black and Decker.

The high port cylinder head was introduced on TR3s with an 8.5:1 compression ratio. On TR4s the compression was raised to 9.1. The high port head is the better one and the latest type is to be preferred. 0.070 in. should be ground off the face of the head which, in conjunction with the grinding described below, will give a compression ratio of $10\frac{1}{2}$:1. After the 70 thou. has been removed, the head should be thoroughly cleaned before work is commenced and

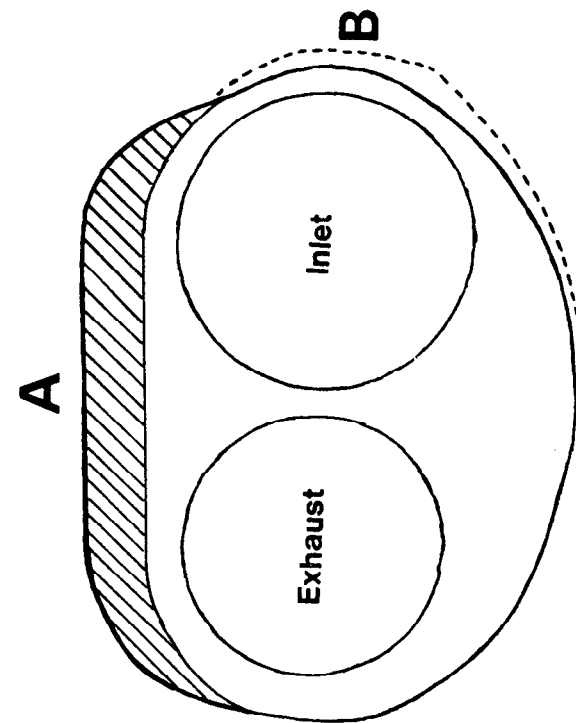


Fig. 20. The TR combustion chamber. A Area to be ground away to give a straight line taper.
B Extension of the channel round the inlet valve up to the plug

the area to be ground should be chalked and the combustion chamber scribed using a new cylinder head gasket. As shown in Fig. 20. 5/16 in. should be measured and scribed back from the original squish area for as far as is possible consistent with nicely radiused curves blending into the shape of the chamber at either end. Metal should be ground away to give a straight line taper down to the level of the valve heads with an 1/8 in. radius edge top and bottom. Clean out and smooth the concave section round the inlet valve head and extend this channel tapering upto the sparking plug. On the unmodified head this channel does not go as far as the plug but is only around the valve. Inlet ports should be opened out over their length to maintain their diameter at the face and should be smoothed and polished. The exhaust ports should also be smoothed and polished and may be opened out to match the gasket size. The inlet manifold must be matched to the inlet ports and this is best done by smearing one face with engineer's blue, mating them and grinding accordingly. The final finish should be to a high polish for best results. Though these modifications are described briefly, the amount of work involved is considerable and patience is required.

Before the final polish, but after the modifications have been made, the combustion chamber volumes should be checked to ensure that they are equal. If they are not, different compression ratios in different cylinders will be encountered. The best way of doing this is by measuring paraffin from a burette into each chamber with the valves closed and sparking plugs in position, and bringing the volume of the chambers out to that of the largest by careful grinding. The chambers should all have the same volume to within a tenth of a cubic centimeter. Do not remove metal outside the area of the combustion chamber, which can be indicated by the gasket. The central (i. e., smaller) exhaust valve spring should be removed when a high lift camshaft is used or it may become coil bound.

Compression ratio is of considerable importance, since by raising the compression we increase the compression pressure, which in turn increases the effective cylinder pressure during the expansion stroke, which increases both torque and b. h. p. A compression ratio of 10.5:1 can be used safely providing that the unit is in good condition and that 100 octane fuel is always used. It is possible to determine the theoretical power increase by applying the following formula, where CR is the compression ratio:

$$\frac{CR^{1.3} - CR}{CR - 1}$$

A further advantage of increasing the compression ratio is that it will decrease the fuel consumption because combustion has been improved and made more efficient. In other words at any given road speed the accelerator is more closed, and the engine therefore consumes less petrol because the increased compression gives greater b. h. p. for any given r. p. m. There are disadvantages of using a high compression ratio, as it involves very accurate ignition setting to avoid knocking. Further, at maximum torque r. p. m. with a wide open throttle, the fuel can pre-ignite, which will wreck an engine if run for long in this state. A high compression ratio also increases the wear on the crankshaft, bearings, pistons, rings and cylinder walls, and will generally make the engine feel rougher. Using normal oils the engine will wear a quarter more quickly with a compression ratio of 10.0:1 than with a compression ratio of 8.3:1. This brings us to an interesting aspect concerning lubrication, for which we might be permitted to digress for a moment.

Wear occurs in an engine where there is metal to metal contact. This form of contact is caused by the oil film breaking down, so anything to increase the oil film strength in a tuned engine will prolong its life considerably. Castor based oils such as Castrol R have fantastic film strength properties when compared to ordinary mineral oils, but unfortunately castor based oils tend to gum and block important oilways. Equally good as castor oils are modern Molybdenum disulphide additives which, although not actually increasing the film strength of the oil, do provide boundary lubrication when the oil film has broken down. This property has been displayed most convincingly on several occasions; cars being driven with no oil in the engine for distances of fifty miles or more, under R. A. C. supervision, after the engines have been treated with a MoS2 additive.

Having got the mixture into the cylinder as quickly as possible and having ignited it, it is now necessary to get it out as quickly as possible. As far as gas flow is concerned there is some scope for improvement by reducing back pressure through fitting a straight through silencer, and ensuring that the tail pipe is of the same diameter as the rest of the exhaust system. With engines developing their ultimate in power output, the inlet and exhaust systems should be tuned so that over a certain revolution range an extractor effect can be obtained, which will not only help in getting the exhaust gases out quickly, but will also assist the entry of the incoming mixture. To understand this more fully it should be realised that as soon as the exhaust valve opens, the pressure in the cylinder of 70 to 80 lbs. per sq. in. causes a puff of gas to enter the exhaust system under high pressure, which is immediately followed by the remainder of

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the spent gas, pushed out by the ascending piston. The important point is that when the rising piston slows down towards the end of its stroke and starts to descend again the slug of gas continues to travel down the exhaust pipe at the same speed, and therefore creates a vacuum extractor effect in the cylinder, providing that the exhaust valve is still open. If the inlet valve is also open it can therefore be seen that although the piston has not reached T. D. C. on the exhaust stroke, by suitable valve timing, and correct exhaust pipe design and length, a pressure of as low as 6 lbs. per sq. in. may be present in the exhaust port, which will induce the fresh charge to enter the cylinder much more quickly, even though the piston has not yet begun its induction stroke. Exhaust pipe length and diameter are all-important as the reverse pressure wave that travels back up the exhaust pipe should be so timed as to arrive at the exhaust port just before the piston reaches T. D. C. This effect is only present over a limited revolution range, and is determined by exhaust pipe length. A pipe length of four feet is recommended for TRs, measured from the manifold. A full length system running to the rear of the car will give benefits at low revs and less noise in the driving compartment though at marginal expense of high rev performance. The normal straight through production silencer does a good job and is recommended.

FUEL INJECTION

In 1967 fuel injection in this country was only to be found in Formula 1 and 2 and a few club racing cars. It can be cheaper than Weber carburetors and theoretically gives greater power, but the greater reliability and simplicity of carburetors are probably the factors which most appeal to the average man. On the TR5 Tecalemit Jackson fuel injection is fitted as standard equipment, so this in itself shows that fuel injection has at last been developed to be quite sound and reliable. For this reason we go into the subject more closely below. For practical experience however, advice should be sought from Tecalemit Jackson, Lawrencetune or S.A.H.

The advantages of fuel injection include better engine breathing through the elimination of the carburettor venturi. This leads to higher maximum power. Better fuel distribution provides better fuel consumption. The engine inlet manifold can be designed for maximum power without sacrificing low speed torque because, with fuel injection, fuel flow is not dependent upon air velocity. Further benefits are better throttle response because fuel flow is controlled directly by throttle opening, better flexibility through better fuel distribution and finer fuel atomisation, freedom from fuel surge problems in tight cornering.

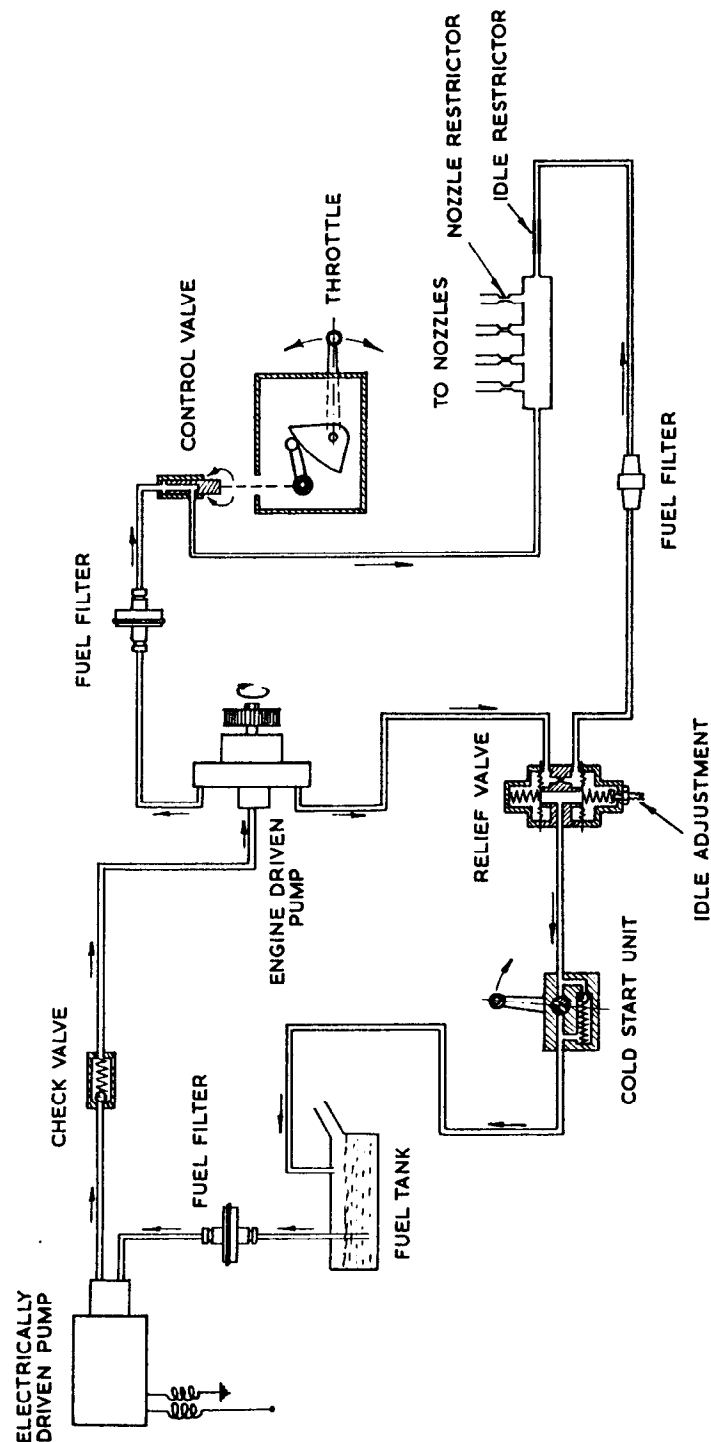


Fig. 21. Layout of the Tecalemit-Jackson TR fuel injection system

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Most fuel injection systems used in racing and in expensive production cars are timed systems, in which fuel is only injected during the engine induction stroke. The T.J. equipment differs in that fuel is supplied at an appropriate rate continuously while the engine is running. Dynamometer testing on many engines has proved that power and fuel consumption with the T.J. system are always as good, and often better than with timed injection. The reason for this lies in the longer time available for intimate mixing of fuel with air in the induction system.

THE T. J. SYSTEM - GENERAL DESCRIPTION

From the diagram Fig. 21, showing the schematic layout it can be seen that an electric pump specially designed for the system, draws fuel through a filter from the tank and passes it through a check valve into the injection circuit. The electric pump is of the eccentric vane type with five sliding vanes made from ball bearing steel fitted in a Meehanite rotor which operates in a hardened steel housing. A carbon face seal prevents external leakage. The pump motor requires 4 amps at 12 volts.

Fuel enters the end cap of an engine driven pump where it passes through a built-in filter to the pump inlet. At this point a take-off connection allows fuel, delivered by the electric pump and surplus to the engine's requirements, to by-pass, through a relief valve, back to the tank. The relief valve is specially designed to operate at a constant pressure and embodies a spring loaded diaphragm bearing on a stainless steel seating. Fuel pressure acting on the diaphragm lifts it against the spring load and allows surplus fuel to escape past the seating and so back to the tank. The large area ratio between the diaphragm and the seating ensures that only negligible changes in fuel pressure are caused by fuel line surges in acceleration and braking. The relief valve is factory set to operate at 18 p.s.i. and this pressure is maintained as the minimum throughout the metering system to avoid fuel vaporisation under high temperature conditions.

The engine driven pump comprises a toothed rotor running in a housing, one face of which has, sunk into its surface, a discontinuous groove. This is shown in Fig. 22. The action of the toothed ring driving fuel around the groove results in a pressure rise which reaches a maximum at the end of the groove where the pump outlet connection is placed. This pressure rise varies with speed up to about 100 p.s.i. at 6,000 r.p.m. The rotor is mounted on a spindle running in bearings and a synthetic rubber lip seal prevents external leakage. The pump is driven by a toothed reinforced rubber belt from a pulley mounted on the nose of the engine crankshaft. The

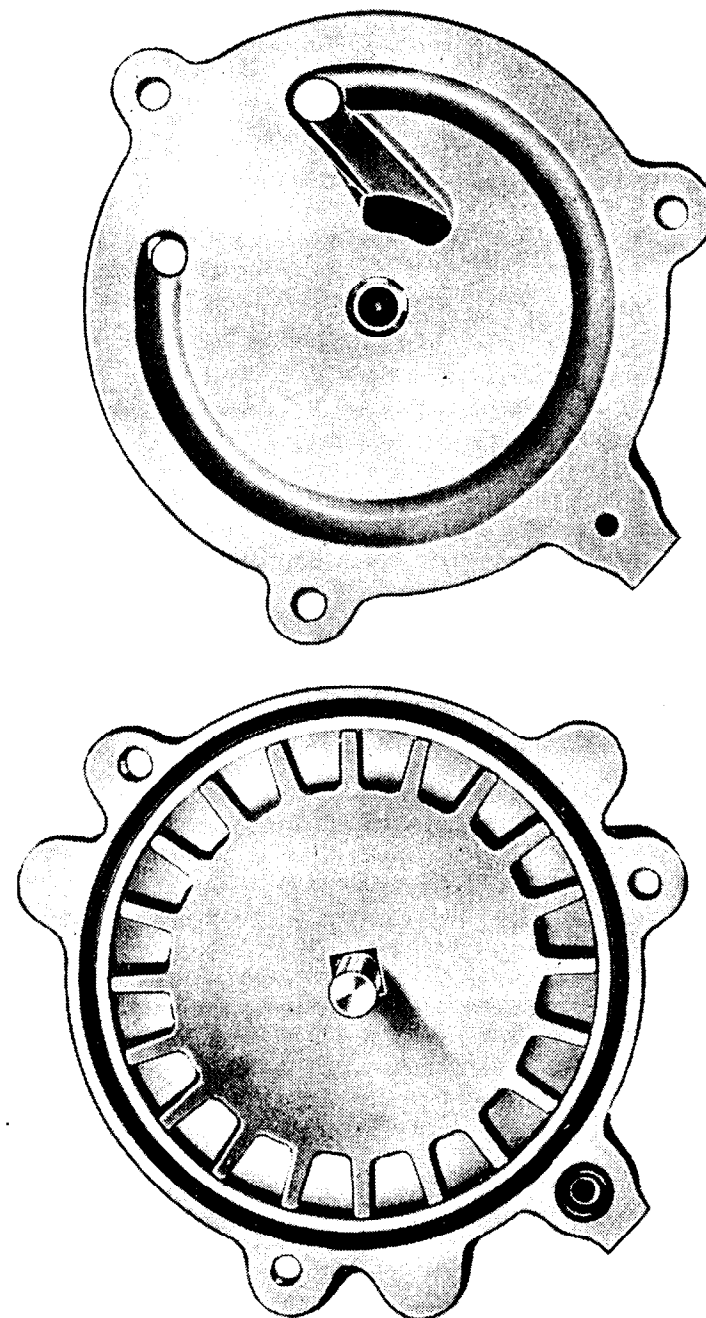


Fig. 22. The engine driven pump dismantled to show the rotor and the groove in the end-face of the housing

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pulley ratio is arranged to produce a pump speed of 6,000 r. p. m. when the engine speed is at its maximum value.

From the outlet connection of the pump, fuel is led through a filter to the control unit Fig. 23, where it is metered according to the engine's requirements by a valve shown in Fig. 21. The valve spindle is hollow and has, cut into its wall, a V-notch of special shape. When the spindle is operating inside its mating sleeve, the V-notch is in axial alignment with a rectangular port cut through the wall of the sleeve, thus as the spindle is rocked in the sleeve, a V-shaped orifice is put in the path of the fuel entering at the open end of the hollow spindle and passing through the orifice to an external connection. An extension of the spindle carries a lever at the other end of which is a pin carrying a roller. A cam, coupled to the throttles by a special linkage, operates on the roller and causes the valve spindle to take up a different position for each throttle opening. Thus there is a V-shaped orifice corresponding in size to every degree of throttle opening.

Fuel, now metered according to speed by the engine driven pump and according to throttle opening by the control valve, is passed to a distributor block. Here the fuel flow is divided into a number of equal parts, one for each engine cylinder, by restrictor units made from precision-drawn stainless steel tube.

At this point metered fuel is available for each injector nozzle and the pressure of 18 p. s. i. which was imposed to prevent fuel vaporisation has to be removed. At the same time the fuel must be injected into the intake ports of the engine in an atomised condition. The nozzles, Fig. 24, are designed to use the energy released in removing the pressure to atomise the fuel. A stainless steel needle, with a highly finished point, engages a stainless steel seating on to which it is pressed by a spring acting through a diaphragm. Incoming fuel acts on the diaphragm lifting it against its spring and allowing the needle valve to release fuel in a fine spray. The opening pressure of the nozzle is important and is factory adjusted to be accurate within 1% of its rated pressure. Each nozzle is fitted with a porous metal filter.

The circuit so far described comprises all that is required for racing applications. For road cars it is necessary to provide for good idling and this requires some simple additions to the equipment.

Reference to the diagram shows that, in the relief valve, there is a central wall with a bleed orifice in it. A second diaphragm and seating combination controls the pressure in the lower compartment and a connection to the distributor block, through an idling restrictor, provides idling fuel.

In both racing and road applications the control valve cam is

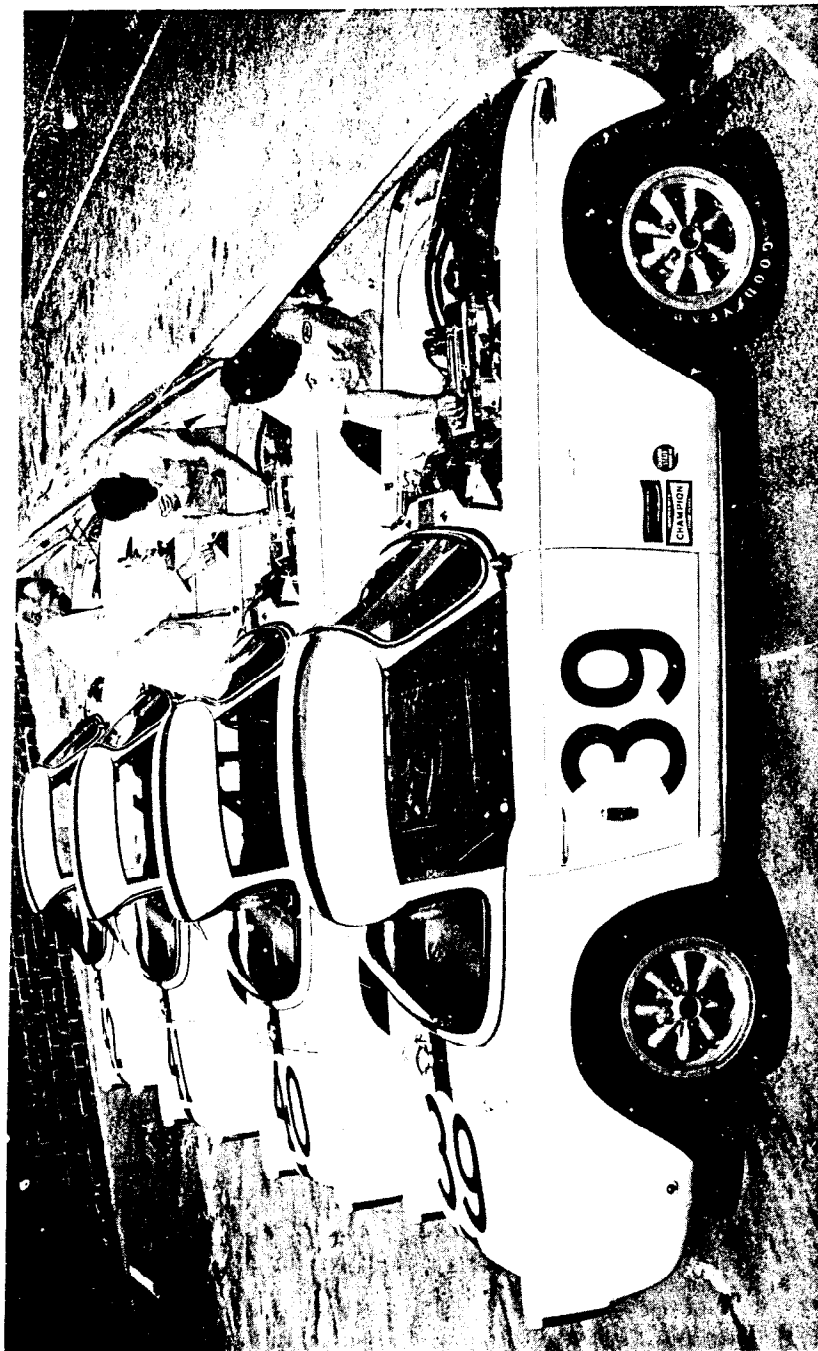


Plate 4
The immaculately prepared team of TR4s prior to their successful showing in the 1966 Sebring sports car event
Photo: Bill Watson

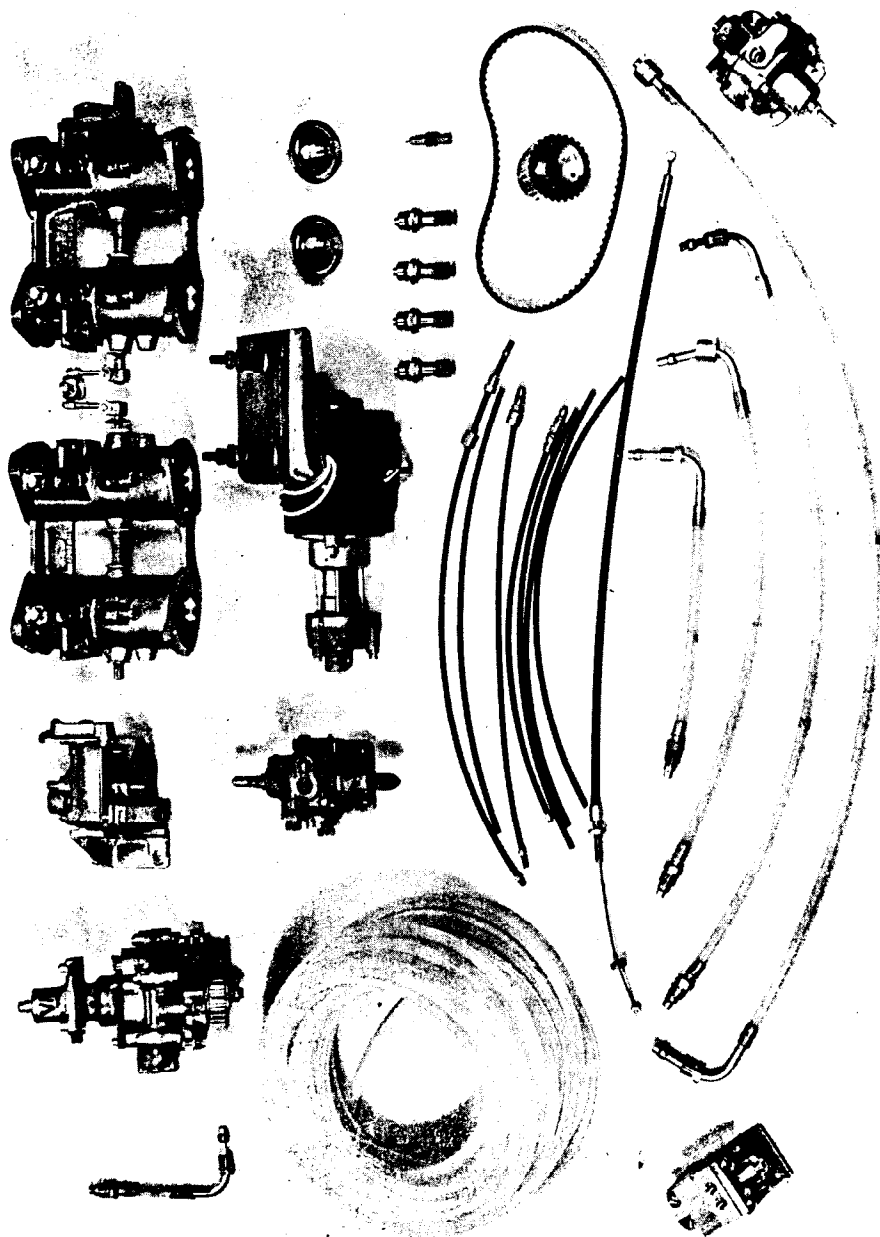


Plate 5
The Toccalentit-Jackson fuel injection system prior to being fitted to a TR3A

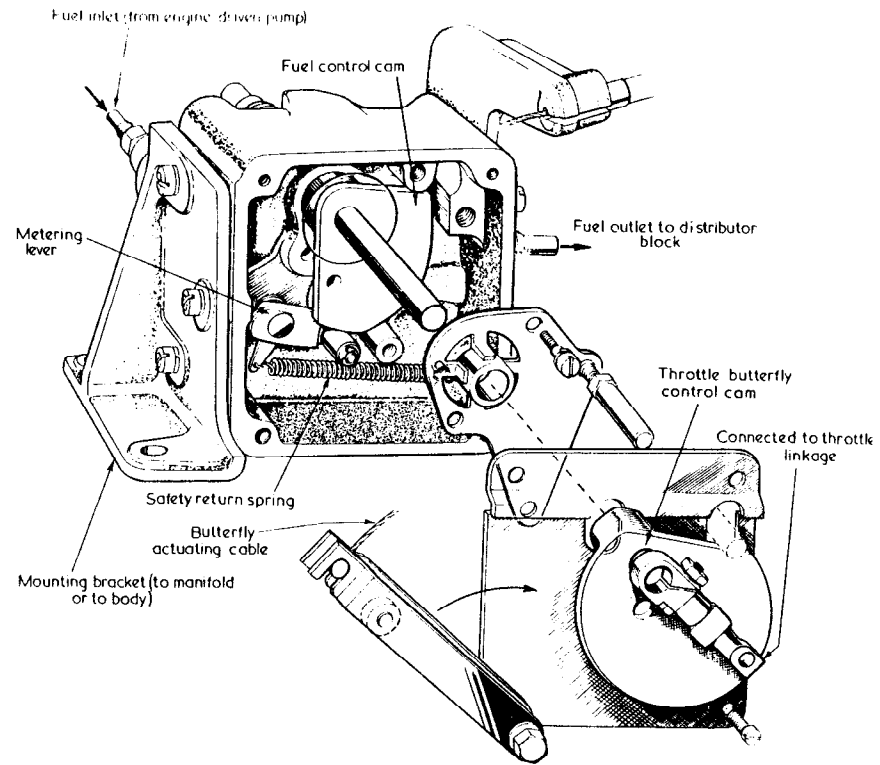


Fig. 23. The fuel metering control unit exploded to show its workings. The metering lever controls the V-notch opening and governs the amount of fuel fed out from the control body to the distributor block

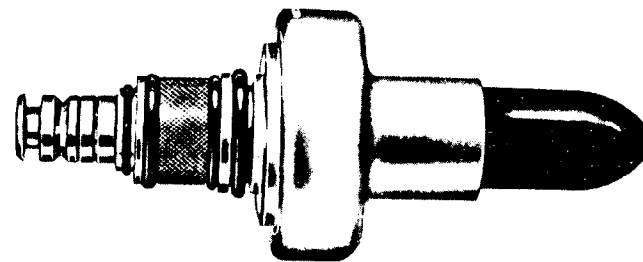


Fig. 24. The self-atomising injection nozzle

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shaped so that when the throttles are closed, or at their idling setting, the V-notch valve is closed. The only fuel then passing to the nozzles is that coming through the idle circuit. This is constant irrespective of engine speed so avoiding excessive fuel delivery under over-run conditions. The idle flow is adjustable by a screw acting on the lower diaphragm spring.

For cold starting a choke unit is provided in the return line from the relief valve. This is a simple device which, when in operation, forces the by-pass fuel to travel through a check valve and so raises the pressure in the relief valve circuit.

An electric relay is provided and this is wired to the ignition switch, the starter solenoid and an oil pressure switch, so as to ensure that the electric pump only runs either when the starter motor is energised or when the engine is running.

For European cars a standard range of throttle bodies is available. These are directly interchangeable with double carburettors and can be readily fitted to all inline engines. Crankshaft pulley adaptors are available for most engines, as are pump mounting brackets which utilise existing bolts on the engines. The throttle bodies carry mounting arrangements for the control unit and standard linkage between the control unit and the throttle are supplied. Nozzle mountings are built into the throttle bodies.

All fuel pipes are made from Tecalemit nylon tubing, which is already used on most British cars for fuel lines and is particularly suitable for fuel injection applications because of its flexibility coupled with a large margin of safety in bursting strength.

It is necessary for the components of the T. J. injection system to be matched to a particular engine type by dynamometer testing. This work is carried out either by Petrol Injection Ltd., or by the Performance Specialists who have the necessary facilities.

The T. J. system is covered by Patents registered in all motor manufacturing countries.

CHAPTER FIVE

THE BLOCK AND RECIPROCATING COMPONENTS

The Americans have a saying "There is no substitute for cubic inches". When they want more power they build bigger engines. In this country we generally have smaller engines and when more performance is required, the engine is usually developed into a more sophisticated unit. There is a preference for small, developed, high-revving engines. The reasons for this are the high price of petrol in this country compared with the U. S. A., and the old system whereby cars were taxed in relation to engine size and traffic congestion which encourages the use of small cars. Increasing the capacity of the engine is one of the best ways of increasing power. On TR2s/3s this is very simple, since TR4 pistons and liners can be fitted without any modifications to the engine. This gives a useful increase of 147 c. c., by raising the capacity from 1991 c. c. to 2138 c. c. The great advantage of increasing the bore of an engine is that as well as giving greater ultimate b. h. p., torque is also greatly increased. For competition work, many people bore out the TR4 2138 c.c. 86 mm. liners to 87 mm., giving a capacity of 2196 c. c., and fit solid skirt pistons. Standard pistons will take the extra performance of a modified engine, but may in time fail to stand up to the increased combustion pressures and revs. For serious racing solid skirt pistons are necessary. 88 mm. pistons and liners can also be used without modification to the block, but at that size the liners are getting very thin and they should be kept for out and out competition work. The 2196 c. c. 87 mm. pistons and liners cost £29.10.0. and can be fitted without removing the engine from the car. With the head and sump removed, and the big end bolts disconnected, the liners and pistons can be tapped out from below. Great care must be taken that none of the dirt and rust from the waterways gets into bearings or oil-ways when the liners are lifted. New figure of eight joints must be used when the new liners are fitted. For the man who is taking his racing really seriously Lawrence & Turner offer special pistons and liners which are so large that the block has to be bored out to accommodate them, and special gaskets have to be made. The sizes are 2480 c. c. and 2598 c. c. and are designed for use in conjunction with a special crankshaft and special cylinder head if their real potential is to be achieved.

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TR engines are reasonably well balanced in manufacture and 6,000 r. p. m. can be used without immediate disaster. If regular use of 6,000 r. p. m. is envisaged, balancing reduces the risk of failure and prolongs the life of moving parts. The forces set up by the rotating and reciprocating parts are enormous and a difference of 1/4 oz. from one piston to another is magnified thousands of times at high revs. For example the effective weight of a piston when it is decelerating at the top of the stroke at 6,000 r. p. m. prior to reversing its direction of travel is more than the weight of the car.

Presuming the engine to be already stripped, we must start by balancing the pistons. This is because the forces generated by piston inertia are considerable, and conformity can easily be achieved by reducing the weight of all the pistons to that of the lightest one. This is performed by using a pair of Chemist's scales to select the lightest, and then by removing metal from inside the skirt of the remaining three pistons with a rotary file. The objective is to get all the pistons within 1 gramme of the lightest one. As an indication of the accuracy necessary there are approximately 28 grammes to an ounce.

Attention should then be turned to the connecting rods, and these should be first tested for surface cracks using the Ardrex method. It is unlikely that there will be any internal cracks, but for peace of mind the rods can be X-rayed. There are three aspects of balance applicable to connecting rods, as not only must the overall weight be the same, but the weight of the big ends must be equalised as must the weight of the small ends. This is performed by selecting the lightest rod, and then the lightest big end, complete with nuts and bolts.

Frequently the lightest big end is not found on the lightest rod, and the lighter rod must be reduced in weight to bring its big end down to the lower figure. The same process must be applied to the little ends. It is not necessary to take the shell bearings into consideration as these are already dimensionally accurate and will weigh the same. To weigh each big and little end is difficult and a special rig must be set up so that one end of the rod rests in the pan of the scales, while the other is supported at exactly the same centre height quite freely. Again the standard to work to is that all three weights, weighed separately should be within 1 gramme of each other. Metal can be removed from obvious spots, such as irregular casting lumps, or from the side of the bearing caps, but on no account should the shank of the rod be touched where it meets the big end, as this is the critical strength region. The rods can also be polished to reduce oil drag and slightly increase the surface strength. Shot peening is also recommended for improving the strength of the surface.

The crankshaft must be balanced both statically and dynamically, and this is best entrusted to a reputable engineering firm with a Repco, Avery or similar electronic balancer, which can balance the shaft very quickly down to quite fine limits. The flywheel and clutch should also be balanced. As well as balancing the flywheel, thought should be given to lightening it, as the improvement in engine acceleration with a lightened flywheel is quite considerable. This is very interesting as it is not generally realised that the torque required to accelerate the crankshaft, and the reciprocating components including the flywheel, is equivalent to adding some 30% to the car's total weight, when in bottom gear. Of this acceleration loss the flywheel amounts for about 45%. Lightening the flywheel should be left to specialist firms as there is a risk that if it is not done properly the flywheel can fly to pieces at speed and has on occasion made a right mess of the driver's ankles!

The increase in acceleration seems out of all proportion to the weight that has been saved with the lightened flywheel, but, if we look into this matter a little more deeply we shall soon see why. The same law that applies to force, mass and acceleration, when a body is moving in a constant direction applies equally to a rotating mass, though in this case it is the angular acceleration, force and inertia that are related. Force is not only required to accelerate the basic weight of a car and its co upants but also to spin the rotating parts faster. Under this heading of rotational parts come wheels, tyres, gears and half shafts, as well as the more obvious engine components. If we do not relate power, mass and acceleration in accordance with Newton's second law of motion we see that "The force acting on a body is equal to the rate of change, with respect to time, of the momentum of the body". It is therefore possible to see that we can allow for the effect of the rotational acceleration by presuming that the weight of the car is increased by an amount dependant on the inertia of the rotating parts. This addition to weight is dependant on the sum of the inertia, multiplied by the square of the overall gear ratio, of every single rotating part between the wheels and in the engine, and in addition the sum of the inertia of the wheels.

The standard crankshaft when balanced, should give a season's racing if 6,000 r. p. m. is used, but of course this cannot be guaranteed. If this rev limit is not exceeded, then the standard crankshaft is adequate. Where higher revs are used, perhaps in conjunction with the Lawrencetune alloy head, then the special crankshaft offered by Lawrencetune is recommended. An oil cooler is essential for high speed work and will preserve the crankshaft and bearings. High speeds maintained for long periods or competi-

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tion work without an oil cooler will lead to bearing trouble. Complete oil cooler kits cost about £18. , and are well worth the money. When used for racing big end bearings should be checked every 10 - 15 races. Having disturbed them by looking at them they should be discarded and new ones fitted. Large capacity alloy sumps are not the solution to oil temperature, though they will help.

Another American saying on engine performance that comes to mind: "if it doesn't go, bore it, if it still doesn't go stroke it, and if it still doesn't go, chrome it and put it in a museum".

CHAPTER SIX

TUNING THE ENGINE

There are few things in motoring that are more depressing than the realisation that your TR is no longer the smooth running, accelerative, high revving machine that used to give so much pleasure. If out of tune, it will not only run badly, but will be difficult to start, lack power and revolutions, develop an excessive fuel consumption, be slow to accelerate, and will probably idle very roughly. When these conditions are prevalent and the engine is definitely off tune, one to two hours careful work will not only restore the car's performance and accelerative ability, but will make the engine smoother, easier to start, and generally much more responsive. If you have just bought a used car with a much modified engine, a pleasant surprise may be in store, as when the engine is properly tuned you will probably find it will give much more performance than you thought it capable of. With a car in daily use, the performance falls off so gradually that it frequently passes unnoticed. It is therefore a very good idea to tune up your car regularly, once a month being a reasonable period.

Tuning your engine will reveal many things about its condition. A good engine that is badly out of tune will respond quite remarkably to the tuning procedure. Similarly when an engine is tuned regularly, small defects that require minor repairs will be shown up early in their life, before they have had a chance to cause much damage. Taking your car to a garage to have it tuned is a chancy business that depends entirely on the ability of the mechanic involved. If he is skilled he will do just as good a job as can be done by a garage using modern 'Sun' or 'Crypton' electric test equipment. If through lack of time you wish to have your engine tuned by a garage, and you do not know if any of the mechanics are sufficiently interested or skilled to be able to tune your engine really well, then patronising a garage that uses electronic test service equipment such as the Crypton 'Motorscope' Electric Engine Tester is a way of ensuring your engine is properly tested and tuned. The Crypton Engine Tester can make a complete test of your engine in ten to fifteen minutes. The test results are shown clearly on a multi-pattern cathode ray oscilloscope screen. The machine tests for spark plug voltages, wide plug gaps, fouled plugs, worn plug electrodes, secondary re-

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sistances, broken plug leads, shorted coils, leaking condensers, high condenser resistances, poor breaker points, misaligned points, weak spring tension, point bounce, dwell angle, lobe wear, air/fuel ratio, carburettor mixture, air cleaner condition, generator output, voltage regulation, battery and starter charging system, valves and rings, gaskets and manifolds. The actual adjustments have to follow the test, of course.

It is not at all difficult to successfully tune your engine yourself for a minimum outlay of money. By doing the work yourself you also ensure that the adjustments are made not just 'close' but are set precisely to the manufacturers specifications. With a much modified engine fitted with proprietary tuning equipment it is very likely that the manufacturers specifications will have to be changed and here it is of imperative importance to obtain the new settings that are required from the manufacturers of the equipment. If new settings are not required then presumably the modification was a fairly simple one, but if for example, an alloy cylinder head has been fitted, then quite different ignition timing will be required.

To tune the car properly a certain amount of essential tools are required and these have been listed below. The items marked with an asterisk are not absolutely essential, but are necessary if you want to do a really professional and accurate job.

1. Screwdrivers, spanners, pliers.
2. A box spanner to fit the sparking plugs.
3. Set of feeler gauges.
4. Small oil can filled with engine oil.
5. Ignition file or emery paper.
6. A good extension light*.
7. Compression gauge*.
8. Timing light*.
9. Carburettor Vacuum Gauge*.

The set of tools listed above will only cost a little more than a couple of good tune-ups by your local garage. So it can be seen that this equipment will pay for itself many times over, and will provide the essential information which is so necessary if tuning is to be performed intelligently and is to be a success. As well as the items listed above, it is advisable to obtain a small stock of certain frequently used parts. These consist of items that it will be necessary to replace occasionally during the tuning process. The cost of these spares is small and if they are to hand the job will proceed much more smoothly. They can also be used as an emergency kit in case your car breaks down. It is advised that the following items be purchased.

1. A replacement contact breaker and condenser kit.
2. A spare set of distributor advance weight springs.
3. A spare set of clean and properly gapped sparking plugs.
4. Valve cover gasket.
5. Box of sparking plug gaskets.
6. A yard of ignition cable.
7. A yard of normal electrical cable.

It is not absolutely necessary to follow a definite sequence when tuning but some components on the engine must be tuned before others. As an illustration it is of no use to make carburettor adjustments if the valve clearances are incorrect, or the ignition system has not been properly checked. Generally the correct sequence to follow is as follows:

- (a) Road test the car.
- (b) Carry out valve adjustments.
- (c) Check the cylinder compressions.
- (d) Change the sparking plugs.
- (e) Adjust and check the ignition and timing.
- (f) Adjust and check the carburettor system.
- (g) Road test the tuned car and note the improvement.

The car should be road tested over the same piece of road on every occasion. All that is required is a stopwatch, two predetermined permanent roadside marks about half a mile apart, an assistant and a stretch of clear road. The test consists of accelerating the car to maximum revolutions in each of the gears and completing the set distance in the shortest possible time. Your assistant should start the stopwatch as you move off from the first mark, and stop it as you pass the second. Comparison of your times both before and after tuning will show what sort of improvement has been made. If a suitable stretch of road is not available, record the time taken to accelerate from 30 m.p.h. in top gear, and then from 20 m. p. h. to 60 m. p. h. in third gear. This latter method is more practical and is really the more accurate of the two (providing the same stretch of road is used) as no gearchanges are involved and strain is not placed on the transmission by having to make a racing start. The time you record for each test should be the average of three runs.

The valve adjustments can be made with the engine either hot or cold. The importance of correct rocker arm/valve clearances cannot be overstressed as they vitally affect the performance of the engine. If the clearances are set too open, the efficiency of the engine is reduced as the valves open later and close earlier than was intended. If on the other hand the clearances are set too close there is a danger that the stems will expand upon heating and not

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allow the valves to close properly, which will cause burning of the valve head and seat, and possible warping. It is not necessary to check the valve clearances every tune-up. Once every 3,000 miles is adequate and there is no harm in leaving them to once every 5,000 miles. When this job is tackled it should be performed before any attention is given to the ignition or carburetors.

Valve clearances - cold	TR4s	TR3s	TR2s
Inlet normal	0.010"	0.010"	0.010"
competition	0.018"	0.018"	0.018"
Exhaust normal	0.010"	0.012"	0.012"
competition	0.018"	0.018"	0.018"

Remove the rocker cover by releasing the two holding down nuts. It is important that the clearance is set when the tappet of the valve being adjusted is on the heel of the camshaft (i.e., opposite the peak). This can be effected by carrying out the adjustments in the following order (which also avoids turning the crankshaft more than is necessary).

- Adjust No. 1 rocker with No. 8 valve fully open.
- Adjust No. 3 rocker with No. 6 valve " "
- Adjust No. 5 rocker with No. 4 valve " "
- Adjust No. 2 rocker with No. 7 valve " "
- Adjust No. 8 rocker with No. 1 valve " "
- Adjust No. 6 rocker with No. 3 valve " "
- Adjust No. 4 rocker with No. 5 valve " "
- Adjust No. 7 rocker with No. 2 valve " "

The correct valve clearance is obtained by slackening the hexagon locknut with a spanner while holding the ball pin against rotation with a screwdriver. Then still pressing down with the screwdriver, insert a feeler gauge in the gap between the valve stem head and the rocker arm and adjust the ball pin till the feeler gauge will just move in and out without nipping. Then still holding the ball pin in the correct position tighten the locknut. An alternative method is to set the gaps with the engine running. This is quite possible though it is necessary for two people to work on the job. One holding the locknut and ball pin, while the other manipulates the feeler gauge.

Next comes the cylinder compression check. Again it is not necessary to make this check every time the engine is tuned, but it should be made at least once every 5,000 miles. The compression check will tell you the condition of the pistons, rings and the valves. Make it when the engine is at normal operating temperature and do it in the following way. Remove No. 1 sparking plug, then insert

the compression gauge in the spark hole and turn the engine over half a dozen times by the starter motor. Replace the sparking plug and repeat the procedure for the other three cylinders noting the readings. If the compression readings are about 110 p. s. i. to 120 p. s. i. and do not differ more than 5 p. s. i. between cylinders then you are assured that your pistons, rings and valves are in good condition. On the 10:1 compression ratio heads the compression readings should be 140 - 150.

If a low compression reading is obtained in one or more cylinders this indicates piston, ring or valve trouble. To determine which, squirt some oil into the cylinder and then take the reading again. If valve trouble, the compression pressure will show no change and still be low. If ring trouble, the reading will be high, showing that one or more rings are broken or worn. If a low compression is indicated on two adjacent cylinders it is probable that the cylinder head gasket between them has blown. If any of these troubles is present it must be rectified before further tuning is attempted.

The sparking plug has a tremendous job to do in that it must be capable of developing 12,000 to 18,000 volts across its gap, and to do this under high pressure many times a second.

At the same time there are many factors at work in the combustion chamber trying to make the plug short. For example the engine is frequently run at slow speeds before it has had time to reach its normal operating temperature. This causes deposits to build up on the insulator, and later, when the car is driven hard the heat in the combustion chamber melts these deposits which can then cause a misfire. With a modified cam it may be that the heat range of the plug is not suitable for, or capable of, dealing with the additional power and heat that is being developed. The sparking plug has also to provide a good heat flow path to the cylinder head (which means that the sparking plug threads should be clean to give good metal to metal contact) and must also form a good gastight seal, which means a good gasket must be used. Therefore, to achieve proper ignition it is essential to use a good sparking plug, perfectly clean, with no cracks in the insulator, a properly set gap and a good gasket. Sparking plugs are best tested and cleaned at your local garage in a special machine that sand blasts the electrodes and lower insulator to free them from carbon, and then tests them for efficiency. Any plugs that refuse to spark regularly above a pressure of 85 p. s. i. should be removed. The plug can be observed through a small window in the machine, and a small control knob will allow the air pressure to be increased at will. As it is frequently inconvenient to do this during the tuning process carry a spare set of plugs already cleaned and properly gapped, and exchange them

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with the plugs in the engine whenever you tune it. The latter set of plugs can then be cleaned and regapped at your convenience. Remember to fit new plugwashers. They are not expensive and a bag of 100 will only cost a shilling or so.

Plug recommendations:

	Factory	S. A. H.	Lawrencetune	Author
High Speed Touring	Lodge HN	NGK B7H	Champion L87Y	HN P
Competition Use	Lodge 2HN	NGK B7HC	Champion L58R	L57 R

The gaps should be set to 0.025 in.

When you remove the plugs from the engine, (preferably after a hard run), note their colour as this is a good indication of the carburation condition. A plug that has an oily deposit on its points indicates that the bores are worn, or the rings have collapsed, while a plug that is covered with a black sooty deposit indicates an over-rich mixture. If the mixture is too weak the plug will be whitish in colour. The correct colour is a dark grey. When you replace the sparking plugs, first clean the sparkplug seats. Do not tighten down the plugs too hard, especially in an aluminium alloy cylinder head as threads strip very easily.

Having changed the plugs move onto checking the ignition and the timing. It is true to say that by far the greatest number of breakdowns occur through faults in the ignition system. Frequent inspection of the wiring will prevent some of the more usual ignition troubles. Inspect the sparking plug leads for loose connections, and for cracks, and for signs of burning where the leads come close to or touch the engine. Two separate circuits are used to ensure that there is a spark of sufficient voltage to jump the sparking plug gap at the right time in the cylinder with fuel mixture ready for combustion. These circuits which function together to provide ignition are known as the primary circuit, and the secondary circuit. The primary circuit increases the battery voltage to approximately 15,000 volts, this actual increase taking place in the coil. Once the high tension voltage has been generated it is the task of the secondary circuit to distribute the voltage to the proper sparking plug at the right moment in the engine cycle. The voltage is switched to the correct plug by means of the distributor. Attached to the top of the distributor shaft is a rotor arm which rotates with the shaft. As it turns it carries the high voltage to the four terminals located in the distributor cap, which in turn carry the current to each of the four sparking plugs. Located below the rotor arm on the rotor shaft is a cam which makes and breaks the contact points so controlling the

TUNING THE ENGINE

high voltage charge. When the ignition is correctly timed, the amount the points open and the precise time that they open and close in relation to the engine cycle is of great importance. Obtaining the correct timing is achieved by adjusting the distributor to ensure that the contact points open and close the correct amount, and at the correct time.

Remove the distributor cap and clean it inside and out with a dry cloth. It is unlikely that the four terminals are badly burnt or scored, but if they are the cap will have to be renewed. Also renew it if it is cracked or there are signs of tracking. Push the carbon brush in the top of the cap in once or twice to make sure it moves freely. Examine the contact breaker points to ensure they are free from oil and dirt and then measure the point gap by turning the engine over till the contact breaker arm is on the peak of one of the four cam lobes. Measure the gap between the points with an 0.015 in. feeler gauge. If the gap varies from this amount slacken the contact plate securing screw and adjust the contact gap by inserting a screwdriver in the notched hole at the end of the plate. Turning clockwise to decrease and anti-clockwise to increase the gap. The distributor shaft has been known to bend, due to its length. To check this, measure the contact breaker gap in the four possible positions and if the gap varies this will be due to a bent shaft. Tighten the securing screw. If the points are pitted or burned they must be cleaned and filed smooth. They can be removed by releasing the nut which secures the end of the spring, removing the wire terminals and lifting off the lever complete with spring. With a carborundum stone or a very fine ignition file, clean and smooth the points till all signs of pitting or burning have been removed. Alternatively fit new points. Then replace the points and gap them to 0.015 in. as has already been described. Once every 5,000 miles trace a smear of oil or grease on the distributor arm, and a drop of oil on the contact breaker lever pivot. Two drops of oil should be passed through the hole in the contact breaker base plate through which the distributor shaft emerges, and two drops of oil on the head of the screw in the distributor shaft, exposed by pulling off the rotor arm. Use engine oil. It is most important not to overlubricate the distributor. Refit the distributor head.

Accurate and correct ignition timing is vital to the proper operation of the engine. The whole efficiency of the engine and the power developed by the purchase of expensive tuning equipment is wasted if the timing is out. On a standard engine advance should be 4°. With a fully tuned engine 10° is recommended. There are various ways of setting the timing and all will be described. The system recommended in the workshop manual is as follows. Check

Index to Fig. 25

- | | | |
|----------------------------|-----------------------------------|---|
| 1 Fibre washer | 53 Split pin | 64 Cork gland washer |
| 2 Damper assembly | 34 Choke cable connector | 65 Top half jet bearing |
| 3 Suction chamber | 35 Washer | 66 Washer |
| 4 Screw | 36 Nut | 67 Choke/throttle inter-connecting link |
| 5 Gasket | 37 Jet link & choke cable support | 68 Split pin |
| 6 Air cleaner | 38 Clevis pin | 69 Vacuum union |
| 7 Nut | 39 Washer | 70 Lever cam |
| 8 Throttle lever | 40 Shouldered washer | 71 Split pin |
| 9 Pinch bolt | 41 Washer | 72 Double spring washer |
| 10 Nut | 42 Float chamber attachment bolt | 73 Shouldered bolt |
| 11 Link rod coupling | 43 Fork end | 74 Throttle stop |
| 12 Link rod coupling | 44 Nut | 75 Throttle spindle |
| 13 Plain washer | 45 Jet control connecting link | 76 Pin |
| 14 Split pin | 46 Jet adjusting nut | 77 Stop adjusting screw |
| 15 Relay lever | 47 Jet head | 78 Spring |
| 16 Link rod assembly | 48 Clevis pin | 79 Throttle butterfly screw |
| 17 Cap nut | 49 Split pin | 80 Butterfly |
| 18 Washer | 50 Clevis pin | 81 Throttle connecting rod |
| 19 Front chamber cover | 51 Split pin | 82 Coupling |
| 20 Fuel pipe coupling | 52 Jet lever | 83 Gasket |
| 21 Fuel pipe | 53 Jet lever link | 84 Insulator |
| 22 Joint washer | 54 Loading spring | 85 Gasket |
| 23 Needle valve | 55 Jet locking nut | 86 Carburettor body |
| 24 Float | 56 Washer | 87 Needle |
| 25 Fork | 57 Bottom half jet bearing | 88 Anchor plate |
| 26 Hinge pin | 58 Sealing ring | 89 Return spring |
| 27 Float chamber | 59 Cork washer | 90 Pivot lever |
| 28 Split pin | 60 Cork gland washer | 91 End clip |
| 29 Clevis pin | 61 Copper gland washer | 92 Needle locking screw |
| 30 Jet lever return spring | 62 Spring between gland washer | 93 Piston |
| 31 Split pin | 63 Copper gland washer | 94 Piston spring |
| 32 Jet lever | | |

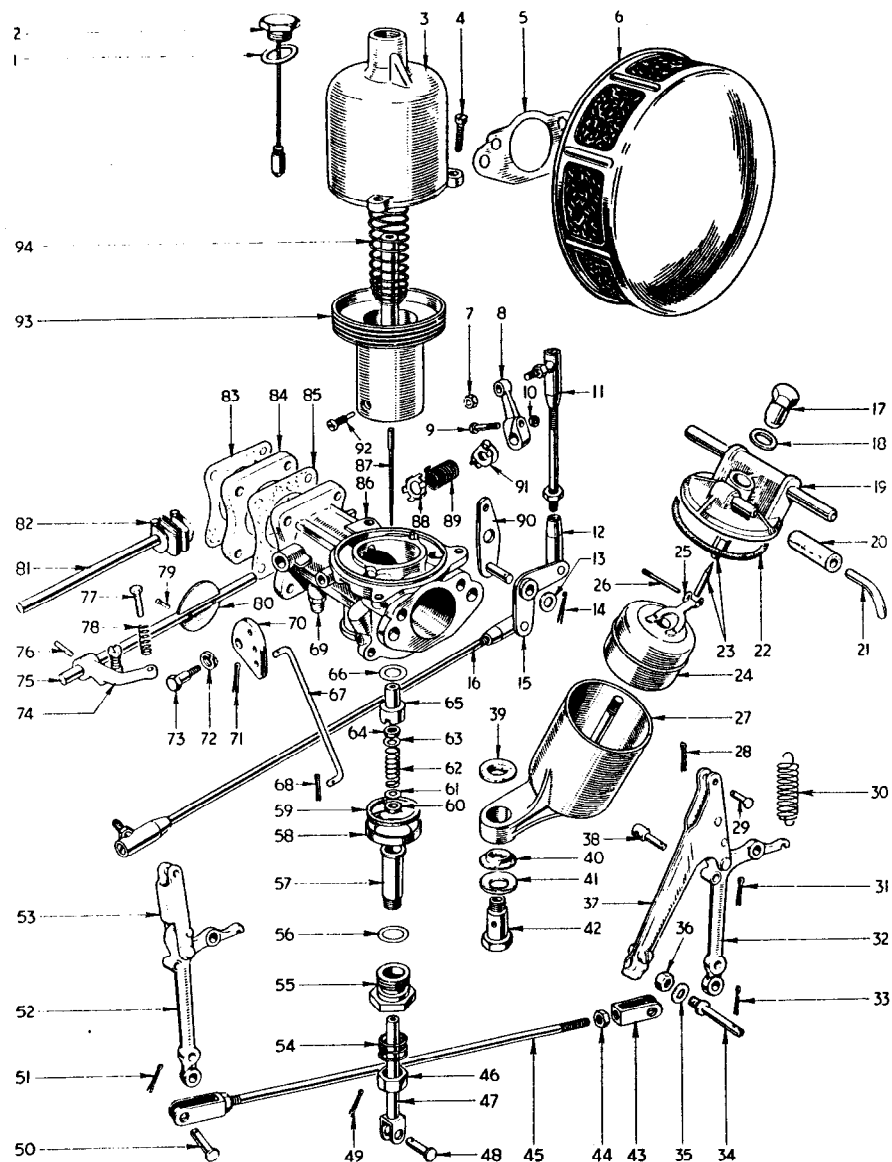


Fig. 25. Exploded view of the S.U. Carburettor

that the points are set at 0.015 in. and set No. 1 cylinder at top dead centre (TDC) on the firing stroke. This is done by lining up the small hole on the rear of the crankshaft pulley with the pointer on the timing chain cover, and checking that the rotor arm is pointing at the lead which goes to No. 1 (front) plug. Set the vernier adjustment in the centre of its scale. Adjust the distributor until the points are just beginning to open. Tighten the clamp bolt and advance the adjuster screw until one extra division appears on the vernier scale. One division is equal to 4° advance. For 10° advance adjust two and a half divisions. Since the spark occurs when the points open, an alternative way is to set the crankshaft to the required degree of advance and then set the distributor to the point at which the points open. Since one knows where TDC is on the pulley one can calculate how far 4° or 10° is round the pulley. 10° for instance would be one thirty sixth of the distance round the circumference of the pulley wheel. This can then be marked with chalk or paint, and set against the pointer. By connecting up a suitable bulb between the distributor low tension terminal and earth one can tell more exactly when the points open because the bulb will light up at this point. Another way, and the one most favoured by garages, is to use a stroboscopic light with the engine running, which flashes as No. 1 plug fires, and the flash illuminates the timing mark on the pulley wheel, and one can establish whether or not the timing is correct. All these systems set up the timing at tick-over. One assumes that the automatic advance and retard is working properly. In competition the timing at high revs is most important. A system used by many people is to set the engine to 4,000 r.p.m. or thereabouts and then adjust the advance/retard until the engine runs fastest.

On the TR2, 3, 3A and some 4As S.U. carburettors were standard equipment. On late TR4s and some TR4As Strombergs were fitted, and then there was a change back to S.U. To tune either type of carburettor proceed in the following manner. Once the engine has reached its normal operating temperatures detach the carburettor intake cleaners. Disconnect the throttle linkage between them by loosening the small nut on the folded metal clamp. This is to allow individual adjustment of each carburettor. Disconnect the choke cable at the carburettor end. Only two adjustments are provided. Idling speed is governed by the throttle adjusting screw, and mixture strength by the jet adjusting screw. The carburettors are correctly adjusted for the whole of the engine revolution range when the idling mixture strength is correct, and the idling suction equal on both instruments. With a single carburettor, only mixture strength and idling speed are adjusted. Presuming two S.U.s are fitted, remove the hydraulic piston dampers and unscrew the screws that secure

the suction chamber to the carburettor base. Clean the pistons with a dry rag and check that the shoulder of the jet needle is flush with the base of the piston. If it is not, release the clamping screw and adjust the needle accordingly. Take great care not to knock the needle, as to do so could bend it which would prevent it centralising properly in the jet hole. Check that the petrol filters located at the top of the float chambers are clean. Replace the suction chamber, complete with the return spring. Test the piston in each carburettor for freedom of movement by lifting each piston about half an inch and then letting it fall. They should fall freely and smoothly without sticking or any sign of jerkiness. If one of the latter conditions is present, then wash down the suction chamber wall and the piston in petrol, dry, smear lightly with oil, and try again. Top up the hydraulic piston dampers with engine oil to 1/4 in. below the start of the thread.

To adjust the throttle for synchronisation it is best to use a vacuum synchronising device such as the Motor Meter synchrotester. If this is not available it is possible to obtain fairly accurate synchronisation by listening through a tube to the hiss made by the air flow into the intake throats of each carburettor. The aim is to adjust the throttle butterfly disc so that an equal amount of air enters each carburettor. Listen to the hiss from each carburettor and if a difference in intensity is noticed between them, then unscrew the throttle adjusting screw half a turn at a time on the carburettor with the lower hiss, and screw up the adjusting screw on the other carburettor, until the hiss from each carburettor is the same. With a vacuum synchronisation device, all that is necessary is to place the instrument over the mouth of each carburettor in turn and adjust the adjusting screws until the reading on the gauge is identical for both carburettors. The mixture strength can be checked by lifting the piston of each carburettor in turn approximately 1/32 in. (8 mm.) with a thin wire spoke or small screwdriver so as to disturb the air flow as little as possible when if:

- (a) The speed of the engine increases the mixture is too rich.
- (b) The engine speed immediately decreases the mixture is too weak.
- (c) The engine continues to run with no change of speed then the mixture is correct.

It may be necessary to repeat the above procedure to each carburettor as they are both interdependent. To enrich the mixture strength rotate the adjusting screw in an anti-clockwise direction, i.e., downwards, and to weaken the mixture rotate the jet adjusting screw in a clockwise direction, i.e., upwards. Only turn the jet

Index to Fig. 26

- | | |
|-----------------------|--------------------|
| 1 Damper | 29 Lever |
| 2 Screw | 30 Spring |
| 3 Cover | 31 Clip |
| 4 Return spring | 32 Fulcrum pin |
| 5 Washer | 33 Washer seating |
| 6 Diaphragm air valve | 34 Needle valve |
| 7 Air valve | 35 Float assembly |
| 8 Locking screw | 36 Float chamber |
| 9 Clamping screw | 37 Adjusting screw |
| 10 Spring | 38 "O" ring |
| 11 Butterfly | 39 Screw—short |
| 12 Screw | 40 Screw—long |
| 13 Insulating washer | 41 "O" ring |
| 14 Joint | 42 Bushing screw |
| 15 Screw | 43 Jet |
| 16 Retaining ring | 44 Spring |
| 17 Starter bar | 45 Washer |
| 18 Spindle | 46 "O" ring |
| 19 Spring | 47 Jet bush |
| 20 Spring | 48 Washer |
| 21 Lever | 49 Gasket |
| 22 Nut | 50 Body |
| 23 Screw | 51 Needle |
| 24 Lever | 52 Clip |
| 25 Nut | 53 Spring |
| 26 Lever | 54 Pin |
| 27 Nut | 55 Retaining ring |
| 28 Nut | 56 Screw |

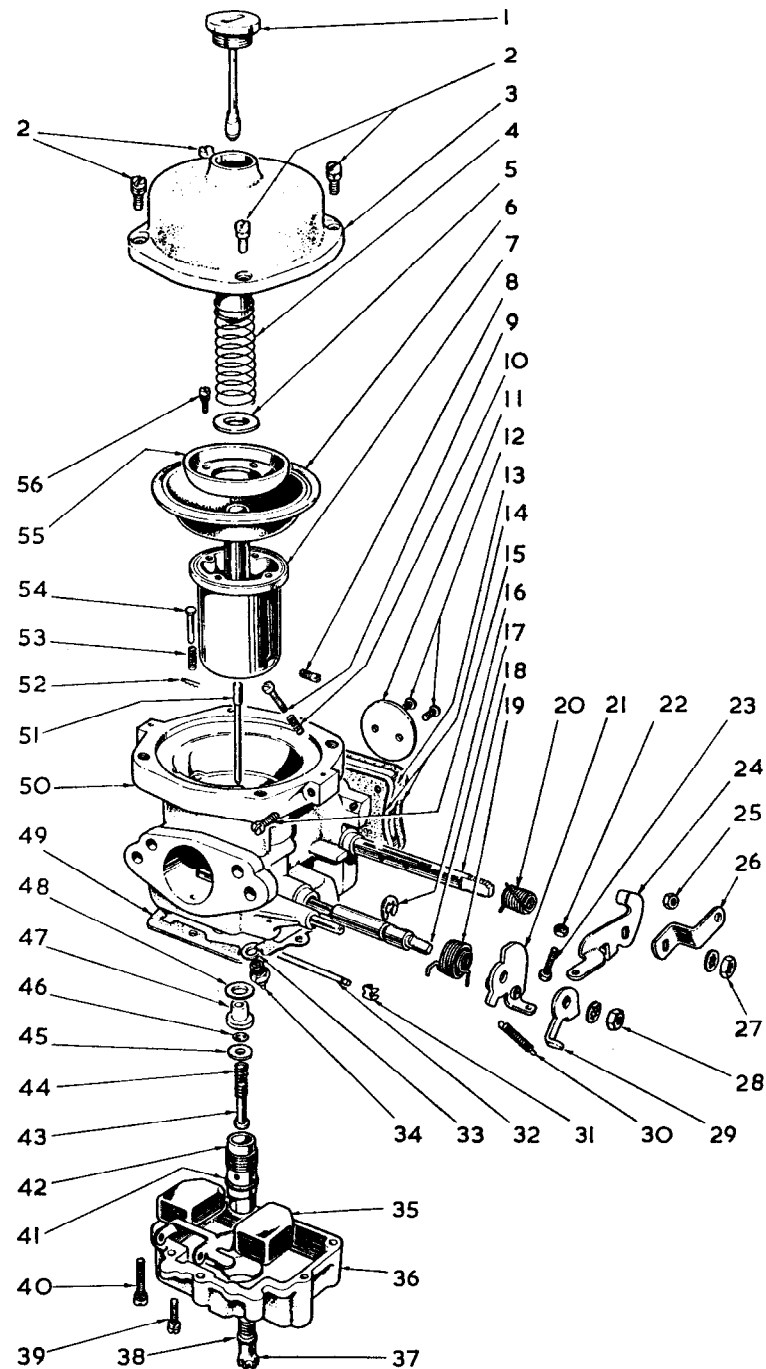


Fig. 26. Exploded view of Stromberg Carburettor

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adjusting screws a flat at a time and check the mixture strength between each turn. It is likely that there will be an increase in engine r. p. m. after the mixture adjustment has been made, so the throttle adjusting screws should both be turned an identical amount to reduce the revolutions to 750 r.p.m. As a final check repeat the test with the vacuum synchroniser device, or check aurally to ensure the hiss is still the same from each carburettor. Tighten the screw on the folded clamp to connect the throttle disc of the two carburettors together, at the same time holding down the throttle adjusting screws against their idling stops. Finally, check that there is no dirt in the bottom of the float chambers, and there is no dirt in the needle valve orifice.

When the carburation and timing are correctly set up ensure that you are using the right grade of sparking plug by a road test to 'read' the plugs. If you are going to use your car in competition this is even more important as a plug that is too 'cold' will cause voltage drop and misfiring; and one that is too hot can create pre-ignition. To test whether you are using the correct grade of sparking plug, warm the engine thoroughly on the road. Then, at maximum power in top gear (usually 500 to 1,000 r. p. m. below maximum revolutions) cut the ignition and coast to a standstill. On no account run the engine after you have switched off until you have had a look at the plugs. If the insulator nose of the sparking plug is clean and white with no deposits, then the plug is too hot. (A hot plug transfers heat away from the electrodes slowly - a cold plug transfers it away quickly). If the insulator nose is covered with black, wet deposits, or black, dry, fluffy deposits then the plug is too cold. If the insulator nose is covered with light tan to greyish brown deposits, they you are using the correct grade of plug. Fuller details on plugs are given in Chapter 8.

Once correctly jetted Webers need virtually no adjustment. The only adjustment is to the idler jets, and the aim is to get the sucking sound and the 'pop pop pop' sound as similar as possible.

Lawrencetune recommend for the 42 DCOE:

Choke	35
Main jet	145
Emulsion tube	F16
Air correction	190
Pump jet	35
Idling jet	45F9

CHAPTER SEVEN

SUSPENSION AND BRAKING

The design of production cars is a compromise. Ultimate performance is sacrificed to achieve economy, reliability, flexibility, etc., and in the case of suspension comfort and in braking, ease of operation. TR2s had Lockheed hydraulic drum brakes all round and these were changed to Girling discs at the front and drums at the rear on TR3s and later models. These brakes are adequate for normal use and are designed for stopping the car from normal speeds. They utilise comparatively soft, high friction lining material and are not designed for competition use or for high speed descents of Europe's steepest passes. Such use will induce fade on the drum brakes and loss of efficiency of the discs. The reason for fade is that the energy of the moving vehicle is converted into heat at the brake linings and if the linings are soft they will be unable to cope with the excess heat generated. The high temperatures created by the linings in contact with the drum or disc gradually cause the linings to lose their frictional grip.

Disregarding wear life, lining performance is measured by comparing its co-efficient of friction against temperature. When speaking of normal production linings the higher the co-efficient of friction the more likely is the material to lose efficiency when really hot. This is acceptable for normal road use when these temperatures are not reached, but in competition they are often exceeded and hence the need for special linings. Not only must the linings be able to cope with the extra temperature without loss of friction, but the co-efficient of friction should not change over the entire temperature range likely to be encountered. The anti-fade advantages of competition linings are offset to some extent by a lower co-efficient of friction and higher pedal pressures, but most competition drivers are happy to press a bit harder on the brake pedal, knowing that they will not fade. If the high pedal pressures are found to cause discomfort a servo unit can be fitted. A servo does not make brakes more powerful, it only reduces the required pedal pressure. Servo units utilise induction manifold suction to move a large diaphragm when the brake pedal is pressed, which drives a master cylinder similar to the one operated by the brake pedal and so provides pressure to the brake cylinders. Most servo units are very reliable and can reduce pedal pressure by up to 50%.

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

The best known competition linings are Ferodo D.S.11 pads and V.G.95 drum linings. The D.S.11 material is used almost universally and has a co-efficient of friction which does not change significantly over a temperature range of some 900°C. The V.G.95 co-efficient of friction increases with temperature until it falls off again at high temperature, but only to a small extent and is vastly superior to normal linings. The Mintex M20 lining is preferred by some, but the author has no experience of this material. S.A.H. offer Mintex linings M48 or M51. These linings are best suited to modified cars which are not used for competition. They will take the extra performance with only a modest increase in pedal pressure. For competition work the D.S.11 and V.G.95, or M20, are better but require higher pedal pressure. On cars with discs at the front and drums at the rear, it is very important to get the braking ratio front to rear balanced, and the way to do this is to alter the sizes of the operating pistons either in the calipers or in the drums to increase or reduce braking effort. When competing in the Guard's 1,000 mile race at Brands Hatch in 1965 the author's Triumph powered Morgan had D.S.11 pads at the front and V.G.95 linings at the rear which had not been properly bedded in, and in addition there was too much braking effort on the rear drums. In the race the V.G.95s wore very fast due to the extreme heat generated. Because we did not fancy burning our fingers or wasting time in a routine pit stop, we did not adjust up the rear shoes but pumped up the system with the left foot before corners. The result of this was that after 4½ hours racing, (and fortunately for me when my co-driver was at the wheel!) one of the rear pistons popped out of its cylinder causing complete brake failure and giving my co-driver the fright of his life. Not only that but he nearly ran the author over when he came into the pits! The moral of this little story is that the correct ratio is important, it is vital to adjust up worn linings, and bedding in should be carried out properly. The harder the lining the longer it will take to bed-in. Bedding-in instructions are given on page 76.

The handling and cornering power of TRs can be improved spectacularly by the use of competition springs, special shock absorbers, an anti-roll bar at the front, wheel spacers, wide wheels and different tyres. This is not to say that the car in standard form has poor cornering and handling, but that these can be improved, though at the expense of some comfort. Competition suspension, designed and manufactured by Standard Triumph, is available through S.A.H. and Lawrencetune. Lawrencetune also have their own ideas on suspension modifications and will supply to customer's order. The factory competition front springs are harder and shorter, giving less roll and lower the front of the car. They are designed for

SUSPENSION & BRAKING

racing and should be used in conjunction with special shock absorbers and an anti-roll bar. Though they can be used for rallying they have the drawback that they reduce ground clearance. The rear springs are also flatter and harder than standard, giving the same effects as the competition front springs. Competition rear springs are only available off-the-shelf for TR4s and if they are required for TR2s/3s or the TR4A IRS, they would have to be made specially. An anti-roll bar is the most important suspension modification, giving a much flatter ride round corners and also preventing the inside near wheel from lifting when accelerating hard while cornering.

Armstrong and Koni adjustable shock absorbers, as listed in Chapter 12 make an important contribution to good handling. The owner can adjust the firmness of ride to suit himself and his type of motoring. Konis, in particular, have built up a tremendous reputation based on better handling characteristics and unusually long life. Though they are more expensive than normal shock absorbers the extra expense is well worth while. The factory specifically determines the bump and rebound forces for each model, and they are supplied correctly set up. The way to change the setting or to take up wear on Koni is: the shock absorber must be fully compressed, and the dust cover turned slowly to the left (anti-clockwise) until the adjuster teeth are felt to engage. Continue turning the cover to the left until rotation stops, then, keeping it compressed and the teeth engaged, make two half turns to the right. The maximum adjustment is six half turns. On all TRs special brackets are required for the rear and these cost £6 per pair. Importers of Koni shock absorbers are J.W.E. Banks and Sons Ltd., Crowland, Peterborough, who will supply full details, but cannot supply direct as they must distribute through the trade.

There is a trend towards wider and lower tyres at present, which in turn dictates the use of wider wheels. Whereas a couple of years ago 5½ in. rims were about the widest used, it is not unusual to see 9 in. rims used in club racing today. There seems to be no limit to the cornering benefits to be had from putting more rubber on the road and tyres are getting wider and wider as a result. The subject can become quite complex since for a given tyre width one may have to accept a profile which will upset the overall gearing ratios, or may foul bodywork. On racing tyres one will find that for a given treadwidth, the profiles of Dunlop, Firestone and Goodyear are all different. There are various rubber mixes for each make and they are changed and developed frequently. Availability is not always good. Despite the difficulties, for circuit racing the wide tyres definitely give better lap times. The author has experimented with wide tyres and a two second improvement was achieved at Brands



Plate 8

The TR4A is an excellent car for continental touring. The one here is shown outside a typical French village

Photo: J. MacLay

CHAPTER EIGHT

GENERAL MAINTENANCE

LUBRICATION

Regular and thorough lubrication makes a great difference to the rate at which moving parts wear and deteriorate. Irregular or inefficient servicing leads to accelerated wear and overall is more expensive than the cost of regular services. The recommended interval between services is different between models. For instance on TR2s, intervals are 1,000 miles, 5,000 miles and 10,000 miles, and on TR3s/4s are 1,500, 6,000 miles and 12,000 miles. The greater intervals on the later models are due to improved oils and greases and also to better filters and seals. It is advisable therefore, to keep to the manufacturer's recommendations. Although the superior lubricants are being used, the earlier filters and seals may be inferior and dirt more likely to get in. Fig. 37. covers TR2s/3s lubrication and Fig. 38 TR4s. Pages 122, 123 show recommended lubricants. On the TR4A IRS there are two additional greasing points on the rear suspension.

BRAKES

TR2s had drum brakes all round but subsequent models had discs at the front and drums at the rear.

Brake adjustment.

Disc brakes are self adjusting and need no attention as the pads wear. To adjust drum brakes:

1. Jack up the front of car.
2. Remove the wheels.

TR2s

3. Line up the hole in brake drum with the adjustor inside the drum.
4. Turn the slot until the shoes touch the drum then turn back one notch. Test free rotation of drum and adjust back further if the drum is binding on the linings. Repeat on the other adjustor (the front drums are the two leading shoe type).
5. Repeat on the other front wheel.
6. Repeat for rear wheels, but there is only one adjustment per wheel, since there is only one cylinder.

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

TR3s/4s

7. On TR3s/4s the adjustment to the rear brakes is done by rotating a square adjustor which protrudes out of the back of the back plate.

Brake Bleeding.

If any sponginess is felt in the brake pedal it is likely that there is some air in the system and that it needs bleeding. Bleeding is also necessary when any part of the hydraulic system has been dismantled.

1. Check that the reservoir is full of hydraulic fluid throughout the operation.
2. Work in the order of the wheels furthest from the master cylinder first. This is the correct order: nearside rear, offside rear, nearside front, offside front.
3. Fit a flexible tube over the bleed nipple and put the other end into the bottom of a jar containing some hydraulic fluid.
4. Unscrew the nipple approximately a $\frac{1}{2}$ turn and give as many pumps on the brake pedal as are necessary until the fluid has no bubbles in it.
5. Tighten the bleed screw with the brake pedal fully depressed.
6. Do each wheel in turn and check carefully afterwards. If the fluid reservoir runs out of fluid at any stage, the whole procedure will have to be repeated.

Brake lining renewal - drum brakes.

1. Jack up and remove the wheel and brake drum.
2. Remove the two shoe locating pins and springs.
3. Lift the shoes out of the adjustor, remove the springs and lift the shoes clear.
4. Check over the system and clean the drum.
5. Assembly of the shoes with new linings is the reverse procedure but the leading edge of the new linings should be filed away slightly and the shoes must be put on the correct way round. The lining, being shorter than the shoe, is attached to it closer to one end than the other. The end having the greatest amount of shoe showing is the toe, the other end the heel. On the leading shoe, the toe is next to the piston and the heel on the adjustor. On the opposite shoe the position is reversed.

Disc brake pad renewal.

Jack up the front of the car, remove the wheels, remove the pad locating pins and their spring retainers and withdraw the old pads. Since the new pads will be thicker than the old one the pistons will have to be pushed back into their cylinders. Insert the new pads,

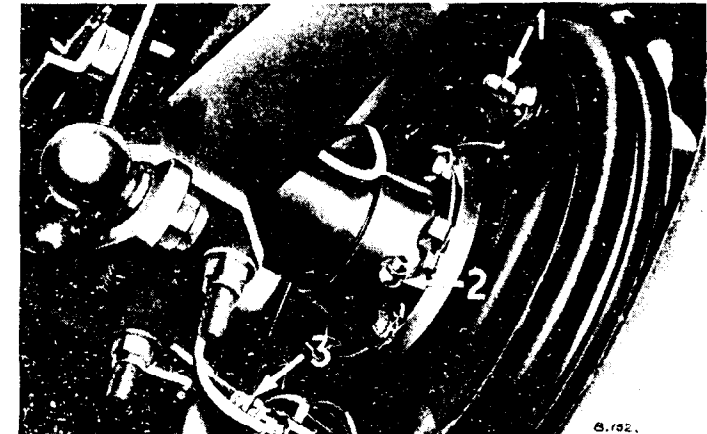


Fig. 27. The rear hub and brake backplate. 1 Brake adjuster. 2 Hub greaser. 3 Bleed nipple

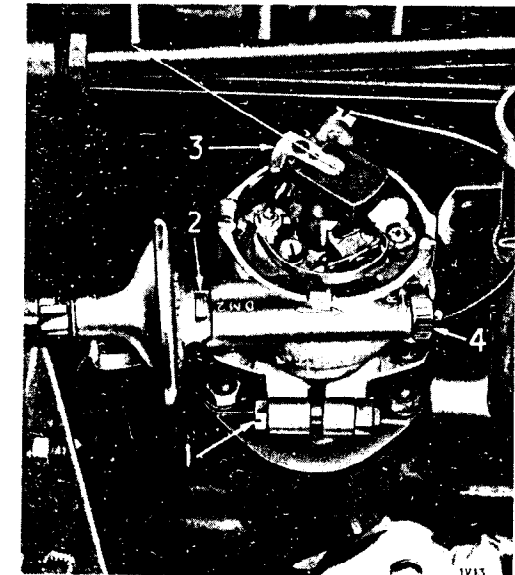


Fig. 28. The Ignition Distributor
1 Clamp bolt
2 Adjusting scale
3 Rotor arm
4 Thumb screw



Fig. 29. When piston Nos. 1 & 4 are at T.D.C. a small hole in the fan pulley is aligned with a pointer

Index to Fig. 33

- | | |
|--------------------------------------|------------------------------------|
| 1 Upper inner fulcrum | 40 Rubber bush |
| 2 Rubber bush | 41 Split pin |
| 3 Upper wishbone arm—rear | 42 Rubber seal |
| 4 Rubber bush | 43 Nyloc nut |
| 5 Washer | 44 Stud |
| 6 Split pin | 45 Spring pan |
| 7 Slotted nut | 46 Serrated washer |
| 8 Bolt | 47 Slotted nut |
| 9 Nyloc nut | 48 Damper attachment bracket—rear |
| 10 Plain washer | 49 Damper attachment bracket—front |
| 11 Grease nipple | 50 Bolt |
| 12 Upper ball joint | 51 Spring washer |
| 13 Rubber gaiter | 52 Nut |
| 14 Plain washer | 53 Nyloc nut |
| 15 Nyloc nut | 54 Fulcrum bracket |
| 16 Caliper bracket end vertical link | 55 Rubber seal |
| 17 Bump rubber | 56 Thrust washer |
| 18 Rubber seal | 57 Steel sleeve |
| 19 Bolt | 58 Nylon bush |
| 20 Spring washer | 59 Lower wishbone—front |
| 21 Lock stop collar | 60 Thrust-washer |
| 22 Lower wishbone arm—rear | 61 Rubber seal |
| 23 Lower trunnion bracket | 62 Bolt |
| 24 Grease nipple | 63 Damper |
| 25 Rubber seal | 64 Washer |
| 26 Thrust washer | 65 Rubber bush |
| 27 Bolt | 66 Sleeve |
| 28 Rebound rubber | 67 Rubber bush |
| 29 Bracket | 68 Washer |
| 30 Bolt | 69 Nut |
| 31 Spring washer | 71 Locknut |
| 32 Nyloc nut | 72 Rubber collar |
| 33 Plain washer | 73 Upper wishbone arm—front |
| 34 Nyloc nut | 74 Spring |
| 35 Grease nipple | 75 Rubber collar |
| 36 Bush—nylon | 76 Distance piece |
| 37 Thrust washer | 77 Bolt |
| 38 Bolt | 78 Bolt |
| 39 Tab washer | |

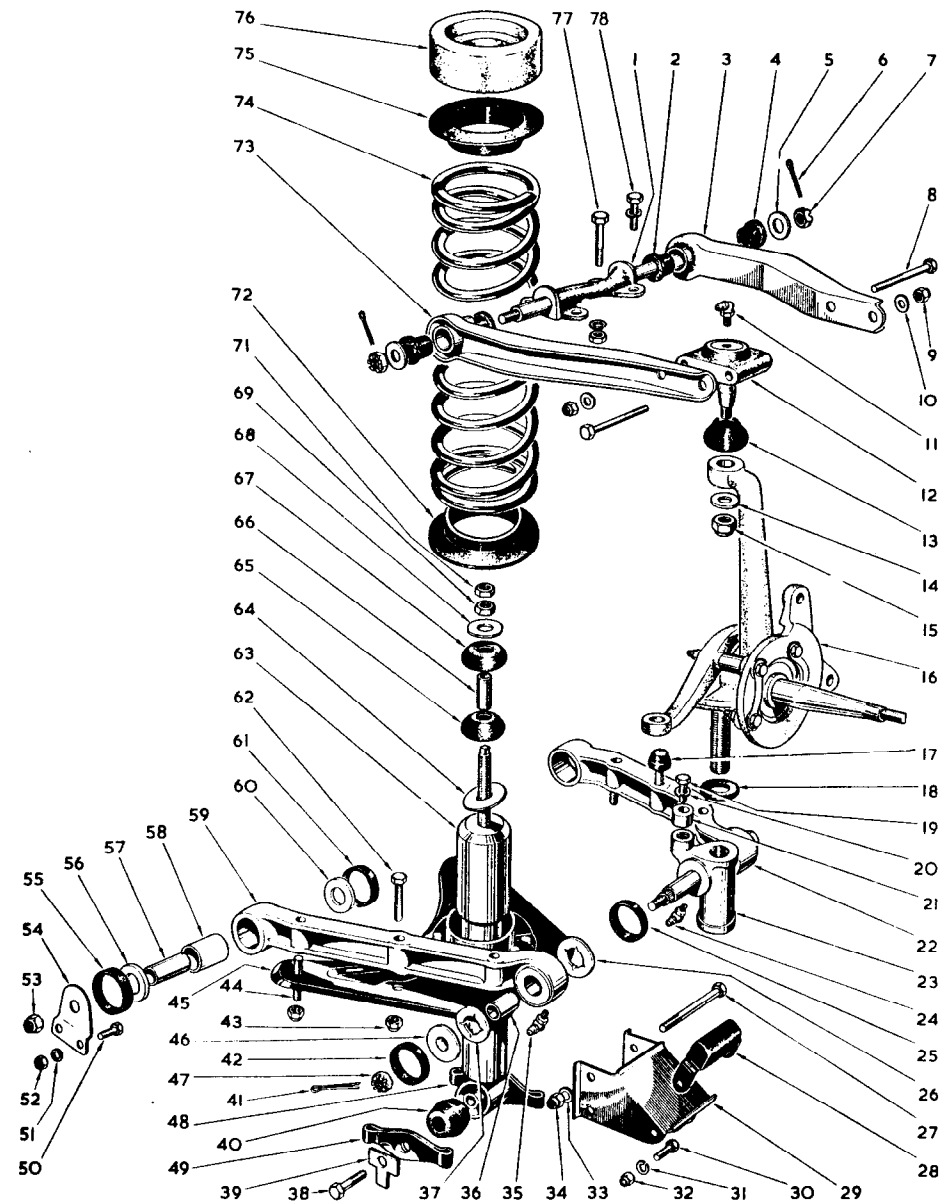


Fig. 33. Exploded view of the Front Suspension

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

FRONT HUB ADJUSTMENT AND LUBRICATION

To remove front hub.

Jack up the car, remove the wheel and grease retaining cap (disc wheel only), withdraw the split pin and remove the castellated nut and washer. Where disc brakes are fitted, undo the two bolts holding the caliper assembly and lift clear. The hub can then be lifted off the stub axle. If difficulty is experienced in getting the split pin out, a short cut is to hammer the correct sized socket over the castellated nut. By doing this the ends of the split pin are pushed out of the way and by using a tommy bar the castellated nut can be undone and the remains of the split pin should be knocked out of their hole near the end of the stub axle. This system is useful on cars with wire wheels, as the hubs make the split pins inaccessible.

Lubrication.

Wash all old grease away and pack the hub and bearing with fresh hub grease, making sure that plenty of grease gets into the bearings.

Adjustment.

Reassembly is the reverse of removal, but remember that with splined hubs and wire wheels the hubs must be returned to the side they came from. If they are not, the hub will be rotating in the opposite direction to that which it should, and there is a considerable risk that the hub nut will work loose and a wheel will come off. The tightness of the castellated nut is critical, for if too loose you will get wheel wobble and if too tight the bearing will run too hot and could seize. Tighten the nut until there is some resistance in hub rotation, then undo the nut about one flat and insert a split pin. The nut should be tightened to a stage where there is no resistance to rotation and no slack, so that the wheel rim cannot be moved to and fro.

Bearing removal.

When the hub is removed from the stub axle the bearings can be lifted out and replaced if necessary.

SHOCK ABSORBERS

The telescopic front shock absorbers are not adjustable and cannot be topped up. When they are no longer functioning satisfactorily they should be discarded and new ones fitted. The rear piston-type shock absorbers can be topped up with fluid, but if this is done the arm should be pumped to remove any air that may have got into the system.

GENERAL MAINTENANCE

FRONT WHEEL ALIGNMENT

Toe-in should be 1/16 in. - 1/8 in. The alignment should be checked with suitable equipment with the wheels pointing forward and on level ground. To adjust, slacken the locknuts on the tie-rod ends and twist the tie-rod until toe-in is correct. Roll the car forward one half turn of the wheel and check. If there is any variation take an average of the two. Tighten the locknuts - do not forget.

TYRES

Maintenance of correct pressures contributes to long life of the tyres. Changing the tyres round every 3,000 miles also helps. Diagonal changing of wheels (front left to right rear, etc.) is probably the best way of equalising wear. Radial tyres should be used on all four wheels, if used at all, and not mixed with non-radials.

Tyre Pressures

		Normal Road Use	Motorway	High Speed
Goodyear Grand Prix	... front	20	20	24
	... rear	24	24	28
Goodyear G. 200 wire boulter 165-15	... front	24	24	24
	... rear	32	32	32
Goodyear G. 800 165-15	... front	24	24	24
	... rear	28	28	28
Dunlop Gold Seal 5.50 and Goodyear Allweather Rib	... front	20	26	Not
	... rear	24	30	Recommended
Dunlop Gold Seal Nylon 5.50-15 and Goodyear Allweather Rib Nylon	... front	20	20	26
	... rear	24	24	30
Dunlop RS5 5.50-15 and Go- odyear Motorway Special	... front	20	20	20
	... rear	24	24	24

Two of the most popular tyres used on TRs are the Michelin XAS and Pirelli Cinturato. Racing pressures are a matter of personal preference but should not be less than 35 p. s. i. irrespective of the tyre used. From personal experience I recommend 40 p. s. i. all round for both Dunlop racing and Cints, but if the car understeers drop the rear pressures 4 p. s. i.

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

		Front	Rear
TR3	Cinturato	22	24
	Michelin XAS	24	28
TR4	Cinturato	20	24
	Michelin XAS	22	32
TR4	(Late models) XAS	22	38
TR4A	Cinturato	22	28
	Michelin XAS	19	23

STEERING COLUMN ADJUSTMENT

On TR4s there is a clamp which allows the steering column to be adjusted to suit the driver and which also acts as a safety device in the event of an accident by letting the steering column move forward under impact. To adjust, slacken the clamp behind the fascia, one clamp near the bulkhead and the clamp locknut which is inside the engine compartment together with the $\frac{1}{8}$ in. AF socket head screw. After adjustment the two clamps should be tightened up but the socket head screw must only be tightened finger-tight and then locked, or the steering column will not react correctly if involved in an accident.

GENERATOR

Lubrication.

Every 12,000 miles a few drops of SAE 30 oil should be injected into the end of the bearing at the commutator end. On early models there is a cap which should be removed and a felt pad lifted out. The cap should be half-filled with high melting point grease and reassembled.

Brush renewal.

Brushes wear in use and need replacing when their depth, i. e., the amount of brush left measured from the contact side, is down to $1\frac{1}{32}$ in. To renew the brushes remove the band of metal that covers the brushes and commutator, lift up the spring and extract the brush and its wire. Insert new brushes. connect up and check that they move freely in their slot.

STARTER MOTOR

Brushes should be replaced when worn down to $\frac{5}{16}$ in. To do this involves withdrawing the old brushes and unsoldering or cutting off the old connectors and re-soldering the new brushes' connectors in. Check spring tension and if the tension is very low fit new ones. The correct tension is about 35 oz.

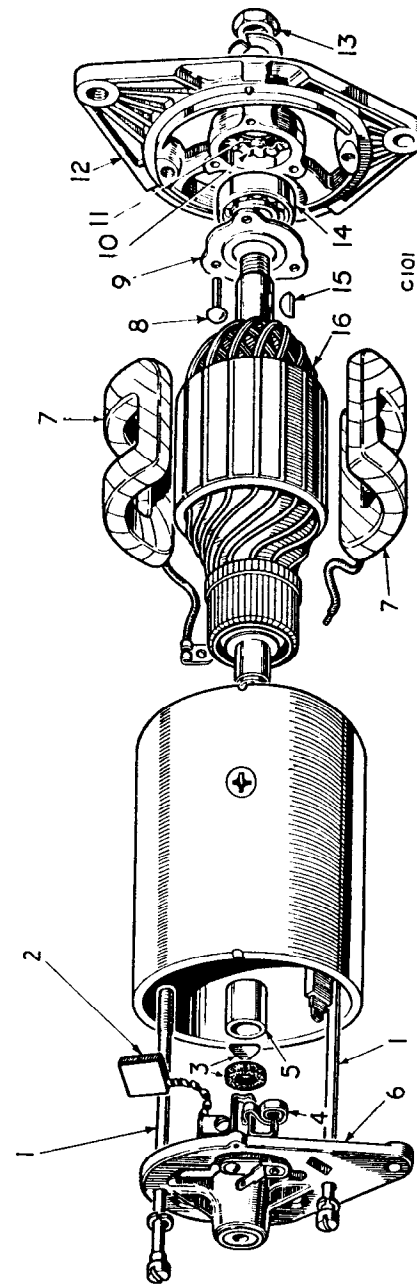


Fig. 34. Exploded view of the dynamo. 1 Bolts. 2 Brush. 3 Felt ring & aluminium sealing disc. 4 Brush spring. 5 Bearing bush. 6 Commutator end bracket. 7 Field coils. 8 Rivet. 9 Bearer retaining plate. 10 Corrugated washer. 11 Felt washer. 12 Driving end bracket. 13 Pulley retainer nut. 14 Bearing. 15 Woodruff key. 16 Armature

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

DISTRIBUTOR

Burned or pitted points are simply and quickly renewed by removing the nut which secures the end of the spring, the insulating sleeve and the wire terminals, then lifting the spring off and the fibre washers underneath it. Remove the adjustor screw and lift out the other half of the contact. Reassembly is the reverse procedure. Make sure the contacts are clean and set their maximum opening to 0.015 in. See Chapter 6 page 61 for further details.

PLUGS

A knowledge of the factors affecting choice of plug is useful and will help rectification of any problem that may arise. The higher the performance of an engine, the greater the need for choosing exactly the right plug. If the heat range is not right power can be lost. A 'hot' plug transfers heat away from the firing end slowly, and the temperature remains fairly hot. Similarly, a 'cold' plug is one that transfers heat away from the firing end rapidly and stays relatively cool. If too cold a plug is used, deposits build up on the insulator nose. These deposits bleed away voltage and can cause a plug to misfire. In severe cases the plug may not fire at all. If the plug is too hot you may encounter pre-ignition. The glowing tip of the insulator ignites the fuel before the plug actually sparks. This wastes power and can cause severe engine damage, see Plate 10. The general rule on selecting heat range is this: the lower the combustion chamber temperatures, the hotter the plug should be. As conditions cause combustion chamber temperatures to rise a colder plug is needed. There are nine major factors which have some effect on combustion chamber temperatures:

1. **Compression Ratio.** The higher the compression ratio, the higher the combustion chamber temperature - and the 'colder' the plug should be.
2. **Fuels and Fuel Blends.** Fuel blends that have special power-producing additives result in higher temperatures and have a lower pre-ignition temperature, and thus demand a 'colder' plug.
3. **Carburation.** A weaker fuel/air mixture tends to increase temperatures. The weaker the mixture, the 'colder' the plug should be.
4. **Ignition Timing.** In normal spark advance range, advancing timing increases combustion temperatures, requiring a 'colder' plug.

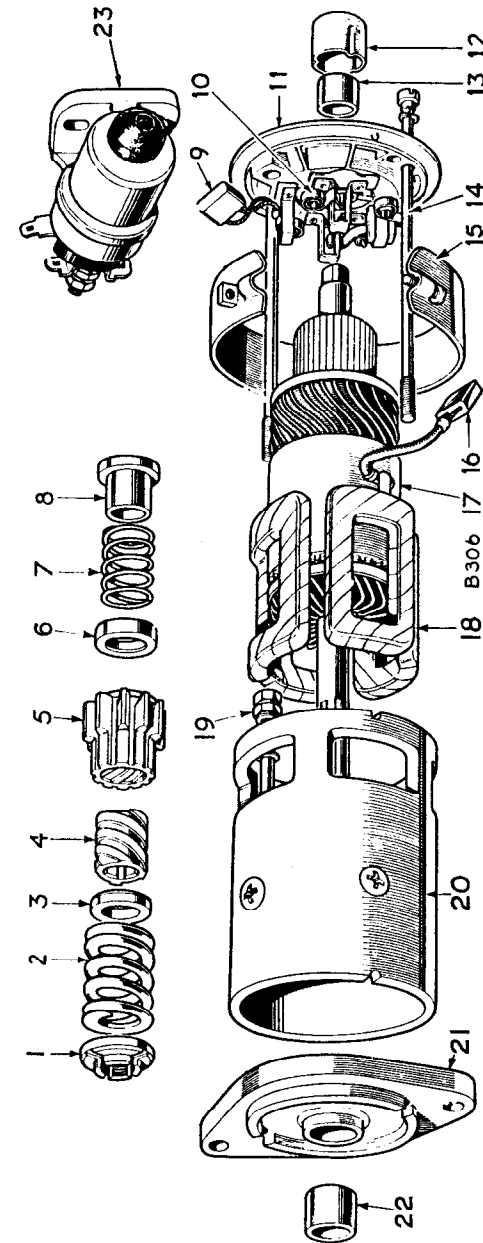


Fig. 35. Exploded view of the starter motor. 1 Starter drive nut. 2 Starter drive spring. 3 Thrust washer. 4 Screwed sleeve. 5 Pinion. 6 Thrust washer. 7 Spring. 8 Collar. 9 Brush. 10 Brush spring. 11 Commutator at y end bracket. 12 Cover. 13 Bolt. 14 Bolt. 15 Brush cover. 16 Brush. 17 Field coil connection. 18 Field coil. 19 Terminal. 20 Yoke. 21 Drive end cover. 22 Bush. 23 Starter solenoid

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

5. Gear Ratios. Higher gear ratios tend to load the engine. This subjects spark plugs to higher temperatures, calls for a 'colder' plug.
6. Atmospheric Pressure and Altitude. Higher atmospheric pressure and/or lower altitudes tend to weaken the fuel/air ratio, demanding a fuel/air ratio adjustment or colder plug. Lower atmospheric pressures and/or higher altitudes cause the fuel/air ratio to become richer, again demanding adjustment or a 'hotter' plug.
7. Supercharging. Supercharging increases combustion chamber pressures and may increase temperatures, requiring a 'colder' plug.
8. Type of Competition. In a sprint race you are only on the throttle for a few seconds. The combustion chambers do not have a chance to build up nearly as much heat as they would in a 100 mile race, for example. Thus with other conditions equal, a car being prepared for a sprint race would take a 'hotter' plug than the same car being prepared for a long run.
9. Manifold Design. This can be a complicating factor. Poor manifold design may cause poor fuel distribution, creating different mixtures in different cylinders. This results in different temperatures in the various cylinders and should be corrected.

To read the plugs, drive the car in the manner in which it will be used and cut the ignition. Do not re-start until you have examined the plugs. If used for sprints, make a sprint-like run and cut the ignition as you cross the line. Or if the car is going to be used for long distance racing, do a few fast laps and cut the ignition at speed.

After a test run.

If the insulator nose of the spark plugs shows slight brown to greyish tan deposits, you have the correct heat range.

If the insulator nose is clean, white and dry - with no deposits - the plug is too 'hot'. Try a 'colder' plug.

If the insulator nose has accumulated either dry, black, fluffy fuel deposits or wet oily deposits, the plug is too 'cold'. Try a 'hotter' plug.

Remember - you want a spark plug that is 'hot' enough to keep excessive deposits from forming and causing misfire, yet 'cold' enough to avoid the danger of going into pre-ignition, which causes power loss and can damage the engine.

CHAPTER NINE

BUYING A SECONDHAND TR2 or TR3

With the arrival of the Triumph TR2 in January, 1954, fast-motoring enthusiasts got one of the best bargains of their lives.

Although the early versions revealed a just-perceptible ancestry in several previous Standard-Triumph products, the overall job was truly a sports car, in performance as well as in appearance.

Throughout the run of the TR2 and subsequent TR3, the chief modifications - such as a hard-top and lockable doors - embellished and added personality to the car and kept the bodywork in line with improvements to the virtually unburstable two-litre engine.

BODYWORK

Carried on a conventional chassis frame, the body is likely to be free from splits and similar wear resulting from stress loading.

Look for a rubber grommet in either of the rear side panels. This will indicate that an aperture has been cut to get at the forward shackle in order to renew the spring. This is the only way to do the job and lack of grommets could mean that the original springs are still at work. Renewing them is a skilled job and the cost might well take the gilt off an otherwise good bargain.

A sump guard (part 301,644) was introduced in November, 1954, as an optional extra and modifications were made to strengthen the rear shock absorber brackets (from TS4,699) while stiffer springs (part 301,017) were available at the same time.

The impact of dirt and water at the higher-than-average TR speeds attacks the lower body edges. Rain leaks through the hood can be stopped with PVC sealing lacquer (part 552,895) and an improved rubber seal (part 603,257) was introduced in January, 1955, to cure door leaks.

THE ENGINE

Major changes to the 1,991 c. c. engine included the adoption for the TR3 of twin 1³/₄ in. choke H6 S. U. carburettors in place of the 1¹/₂ in. H4s. Engines between TS9,350E and TS10,036E were subject to a flat spot when pulling at low r. p. m. This is cured by replacing the TE-type jet needle with an SM (part 504,028) - standardised at TS10,037E. All TR3s from TS9,721E had flexibly mounted float chambers, which can be fitted to earlier models.

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

Manifolds fitted from TS9,350E with the H6 have a larger bore to align with the bigger throat area of the high-port combustion head also brought in at this time.

Vandervell shell bearings were introduced to support the second, third and rear journals of the TR3 high-lift camshaft. Earlier camshafts ran direct in the block and the two are not interchangeable. With TS12,564E, new-type aluminium alloy rocker pedestals were incorporated and, at No. TS12,650E, a new full-flow oil filter was fitted.

This filter can be used on earlier engines but its main purpose was to work in conjunction with a special crankshaft modification involving cross-drilling of the four big-end journals to improve the oil feed volume to the thrust faces of the big-end bearings. Lead-indium bearings were also introduced at this time.

While an earlier TR2 crankshaft can be drilled and brought up to date, a factory replacement would almost certainly be a better investment.

Apart from the availability of a compression plate for use with low-octane fuel no change was made to the standard 8.5:1 c.r. through the TR2/3 run.

As a rule the engine is good for 70,000-75,000 miles, or even more depending on usage. Oil thrown out of the breather (and heavy consumption) indicates bore wear but a unit with the cross-drilled crankshaft can usually be fitted with new pistons or rings as an intermediate measure.

THE GEARBOX

The four-speed gearbox was originally equipped with overdrive for top gear only. To accommodate mechanisms for overdrive in second and third gears a new top cover (part 502,411) was introduced and became standard with TS6,280.

Top-only overdrives made from then onwards can be converted and this cover used but converting earlier models involves scrapping the old cover. In conjunction with Laycock, the factory operate an old-for-new part exchange service.

SITTING IN THE CAR

Excessive TR3 pedal brake movement, caused by air in the system, which persists after topping up of fluid and bleeding may be rectified by a 1958 modification incorporating an alternative type of master oil seal.

The trouble occurred particularly on cars between TS28,000 and TS34,311, the master cylinders of which were assembled between February 14 and July 4, 1958. The correct type of seal is part 504,843.

BUYING A SECONDHAND TR2 OR TR3

Wobble in the steering column indicates a slack support bracket: it is accessible from beneath the car, not far back from the steering box.

ON THE ROAD

Reasonable tappet noise and piston rattle when cold are part and parcel of a well-used TR. Drum-type front brakes on TR2s and early TR3s cannot easily be replaced by Girling discs. The conversion costs over £100, so an elderly bargain with bad front brakes will be worthwhile only if the new owner is content to refettle the original drum brakes.

Very hard rear suspension may point to a seized shackle; repairs are difficult and expensive. Collapsed coil springs at the front are rare and replacement is not easy without the special Churchill compressor tool M50.

High-speed rally work will probably have written-off the ball journal rear-wheel bearings on a TR2. These cannot be replaced by the TR3 taper roller variety.

Wear in either type is usually audible and may arise even in a taper-roller assembly through neglect of the rear hub grease nipple, seen facing downwards just behind the brake backplates of a TR3. Watch out for slack brake backplate bolts.

Steering bias, left or right (betrayed also by unevenly worn front tyres), is difficult to rectify. Advanced wear, usually due to neglected lubrication in the vertical link top ball joint assembly, in the idler assembly or the rubber-bushed centre track-rod may be suspected.

But the rest of the steering is 'built-in' to the chassis and adjustable only for toe-in, so if all these items are spot-on, suspect the chassis.

Gears persistently jumping out of engagement after lengthy mileage are best corrected by fitting a replacement box. Annoying but not serious is the 'sizzling' chatter of a TR2 gear lever when the car is at speed. The later gear lever, modified in June, 1955, with heavier spring-loading for the end plunger, can be fitted and the nuisance further abated by packing the plunger housing with heavy grease.

Failure of the overdrive is almost sure to be due to a burnt-out solenoid caused by inaccurate setting of the operating shaft. This means that the 20-amp. actuating current has been kept 'on' when, in fact, only about 2-amp. is required to hold the mechanism engaged.

Renew the solenoid and get a repairer to reset the unit as recommended by the Standard-Triumph workshop manual, Section E, paragraph 35.

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

GENERAL

Spares are available through official Standard-Triumph stockists. The Motorists Bookshop, 24 Lower Odcombe, Yeovil, can supply handbooks and workshop manuals for all models. The chassis number (referred to by the makers as the commission number) is found on a plate attached to the bulk-head beneath the bonnet. It has the prefix 'TS' and it is important to quote this when ordering spares. The body number is stamped on an oval plate in the centre of the bulkhead: it has six numerals and the engine number, prefixed 'TS' with a suffix 'E' is on the block casting below No. 3 plug.

NEW PERFORMANCE

When fully run-in Triumph TR2/3s were capable of the following performances.

MAXIMUM SPEED

TR2, 197 m. p. h. TR3, 109 m. p. h.

TOURING FUEL CONSUMPTION

TR2, 34 m. p. g. TR3, 34 m. p. g.

ACCELERATION

20-40 m. p. h. (overdrive). TR2, 11 sec. TR3, 13 sec.
20-40 m. p. h. (direct). TR2, 9 sec. TR3, 10 sec.
0-50 m. p. h. through gears. TR2, 8.5 sec. TR3, 9 sec.

BRAKES FROM 30 M. P. H.

TR2, 30 ft. TR3, 30½ ft.

IDENTITY PARADE

The following modifications were made during the production run and they help to date the various versions.

JANUARY, 1954: TR2 Sports Roadster introduced starting at chassis No. TS303.

SEPTEMBER, 1954: Hardtop model introduced with TS3451.

SEPTEMBER, 1955: TR3 introduced with bigger S.U. carburettors; cellular grille in front air intake; scuttle ventilators; occasional rear seat optional extra with TS8637.

NOVEMBER, 1955: TR2 discontinued at TS8636.

BUYING A SECONDHAND TR2 OR TR3

OCTOBER, 1955: Girling disc brakes at front, new rear axle and taper roller hub bearings at TS13431.

AUGUST, 1957: Export only TR3A with combined sidelights and trafficators; faired headlamps; external lockable handles for doors and boot introduced at TS22014.

JANUARY, 1958: TR3A announced for home market with TS25633.

APRIL, 1962: Sports Roadster discontinued at TS82345. Hard-top Coupe discontinued at TS82337.

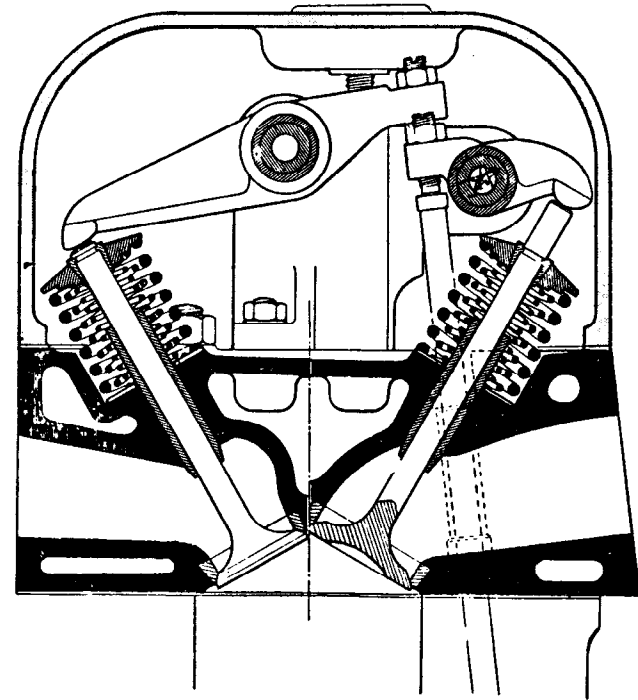


Fig. 36. The very special Lawrence-Tune crossflow cylinder head.

See page 111 for further details

CHAPTER TEN

BUYING A SECONDHAND TR4 or TR4A

Few sports cars have had more effect on the fortunes of their makers than the Triumph TR range. The first of the line was regarded as something of a joke when it appeared on the Triumph stand at Earls Court in October 1952. In the outcome, this model was never produced which is why, so far as the public is concerned, there has never been a TR1.

What happened was that Sir John Black, then chief of Standard-Triumph, wanted something to compensate for the unexpected lack of success of the Phase I Vanguard in the U.S. (it was too much like a small American car) and decided that the real way into the American market was via the sports-car field. His engineers were hastily summoned and ordered to produce a sports model for the forthcoming Motor Show. For reasons of both time and economy, this had to use as many existing Standard-Triumph parts as possible. The outcome was a blend of Standard Ten chassis parts with a Vanguard two-litre engine and a new sports body.

As others have since found, the sports-car market is not one that can be entered light-heartedly by a big manufacturer because the people who buy sports cars have their own strong likes and dislikes which mass producers seldom appreciate; and certain details of the new Triumph sports car did not please. Fortunately, Sir John Black had engaged the services of sports-and-racing-car expert, Ken Richardson, who very soon sorted out both the offending items and certain initial weaknesses in handling, with the result that when the car finally went into production the following summer it was a very different vehicle. Its factory code number, TR2, was never intended as an official title but the public got hold of it and the name stuck - the more so as the new model cemented its hold on the market by an outright win in the 1954 RAC Rally.

Although various important detailed changes were made during the run of the TR2 and subsequent TR3 models the basic design remained unchanged and the biggest alterations came with the introduction of the TR4 which was announced for the Motor Show of 1961. This not only had a completely new body which was wider, longer and more luxuriously appointed, but the engine was stepped up slightly in size and power, the gearbox redesigned to include

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BUYING A SECONDHAND TR4 OR TR4A

synchromesh on all four gears, the track widened at both front and rear and the separate chassis stiffened at the front where rack-and-pinion steering was adopted. All this caused a weight penalty of approximately 1/2 cwt., but the increased power took care of this and the makers' claim of a maximum speed of 110 m.p.h. was matched fairly closely on test.

Three-and-a-half years later came the TR4A, which not only included more comfort and luxury, but a chassis modified to accommodate independent rear suspension of the type which had already proved successful on the Triumph 2000. For the U.S. and Canada, however, it was also possible (and still is in these markets only) to buy a TR4A with a rigid axle to cater for a special North American demand which continues for this feature. To forestall a question which is sometimes asked it is NOT possible to convert a car with semi-elliptic rear springs to i. r. s. or vice versa.

Other points which distinguish the TR4A from the TR4 include slight modifications to the front grille, an increase in engine power output of 4 b. h. p. as a result of fitting new carburettors and completely new induction and exhaust systems, the fitting of an 'anti-smog' valve and a general improvement in the furnishing and all-weather equipment. With the TR4A, the hood fabric remains permanently attached to the irons for easier erection and folding, and an improved form of fitting to the screen has been adopted.

In all, 40,253 TR4 models were produced and the TR4A is now in its 28th thousand. These figures, coming after the long ancestry of TR2 and TR3 models, mean that later types are particularly well developed and remarkably free from faults. This also accounts for the fact that changes during the production runs of the '4' and '4A' have been both few and trivial.

SPARES

It is the manufacturers' policy to maintain spares for 10 years after production and both minor and major components are available on an exchange basis. Examples are an exchange engine at £64, a gearbox at £32. 10s., TR4 rear axle at £26. 10s. and TR4A rear axle assembly at £27. Smaller items available on an exchange basis include such things as disc brake calipers, distributors, dynamos, oil pumps, petrol gauge units, rev counters, shock absorbers, steering units - and very many others.

BODYWORK

In the showroom, the bodywork is likely to come under inspection first. The body is of pressed steel and rust-proofed so that, if the car has been well maintained, it should be in good shape and free from rust. At the same time, it is worth pointing out that the TR

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is the sort of car that is likely to have been driven fast over indifferent surfaces so that the inevitable bombardment of small, sharp stones may have penetrated the finish under the door sills and wheel arches. If the car has been well looked after the owner will have kept an eye on these points and touched up any bare spots before rust has had a chance to get a hold. Otherwise, rust deterioration may be difficult to eradicate.

For the rest, there are no points calling for special mention although buyers would be well advised to inspect the hood which, as with all open cars, is more susceptible to the effects of time and careless usage than most parts. A point worth mentioning is that hoods which have remained unused for long periods (as may happen if an owner has been in the habit of fitting a hard top for the winter months) may display minor leaks due to the stitching acting like a wick and carrying water through the joints. This can easily be cured by treating the stitches, but it is important to use only the approved stitch sealer, which is obtainable from Triumph dealers, as use of an unsuitable preparation can ruin the PVC material.

ENGINE AND TRANSMISSION

Looking at the engine in the showroom will do little more than give a hint of whether the car has been well cared for but as the engine is not one which is normally prone to oil leaks, their presence could indicate possible trouble. A dirty engine should, therefore, be regarded with a certain amount of suspicion and the seller asked to clean it down; if this is done and the engine inspected again after the test run, the extent and source of the leaks should become apparent.

One spot where an oil leak might well be serious is under the clutch bell housing as this could indicate a faulty rear main-bearing or its oil seal or a defective gearbox front bearing or oil seal - any of which could be relatively expensive to cure. A blocked crankcase breather, however, will produce similar effects by causing oil to be forced out at these points, even though the bearings and seals are not defective.

Both the TR4 and TR4A engines are very robust and stand any amount of hard driving. Properly maintained and intelligently handled (with 5,000 r. p. m. strictly observed as the sustained limit of revs.) they may well reach six-figure mileages before replacement becomes necessary. They have, incidentally, replaceable cylinder liners. If properly adjusted, the valve gear should be reasonably quiet and the same goes for the timing. In the latter case, however, a certain amount of noise need not be regarded too seriously because noise, in itself, does not determine the life of

BUYING A SECONDHAND TR4 OR TR4A

the timing gear.

On a test drive the first point which will be noted will be the action of the clutch. It is most unlikely that this will judder but, if judder should be present, possible causes are misalignment, oil or grease on the linings, uneven wear of the linings or a bent shaft or driving plate. None of these can be checked by a quick inspection, so the buyer will do best to fear the worst and bargain with the salesman on the basis that a clutch overhaul could cost £16-£17. There is, however, one other occasional cause, namely faulty engine mountings which allow the whole engine-gearbox unit undue freedom of movement. If this should be the trouble the cure is, of course, much less expensive.

No excessive noise should be present in the gearbox and the change should work both smoothly and positively. If the car has overdrive this should operate reasonably sweetly and without any undue slip on upward changes, but it is worth remembering that, generally speaking, a change out of overdrive on a closed throttle is likely to be more obtrusive than any upward changes.

ON THE ROAD

Normally, the TR is sensitive to the steering and there should be no excessive movement of the steering wheel. If there is, the cause is likely to be wear in the rack, the ball joints or the vertical link - all of which should be obvious from inspection. There is a shim adjustment for the meshing of the rack and pinion.

So far as the brakes are concerned, application will give a good indication of their condition, but the degree of wear present in the pads and linings can be ascertained only by inspection. A good thing to do, however, is to ask the seller if he can produce the maintenance voucher book. If he has been sensible and looked after the car well he will not only have had the normal 6,000 and 12,000-mile services carried out at the right periods, but will have had the fact entered up on the counterfoils by the dealer. This gives conclusive proof of regular servicing and is undoubtedly the best quick guide to the way the car has been looked after.

PERFORMANCE

Maximum Speed (in overdrive top): 109 m. p. h.

Acceleration: 0-50 m. p. h. through gears: TR4, 7.9 sec. :
TR4A, 8.4 sec. :
20-40 m. p. h. in direct top: TR4, 7.3 sec. :
TR4A, 9.3 sec.

Fuel Consumption: TR4: Overall, 24.0 m.p.g.: touring, 28.7 m.p.g.

TR4A: Overall, 22.5 m.p.g.: touring, 31.9 m.p.g.

Braking from 30 m. p. h. : 30 ft.

CHAPTER ELEVEN

TWO ROAD TESTS OF MODIFIED TR4s

John Blunsden of 'Sports Car' magazine tried Neil Dangerfield's Triumph TR4 on road and circuit in July 1962, and found that Sid Hurrell's modifications made it a thoroughly tractable 130 m. p. h. two-seater - a weekday shopping car and a weekend race winner. He went on to write the following.

In these days of sprint-tuned production engines and lightweight racing trailers, it is a change to find a car that serves as a town hack from Mondays to Fridays, and then, with little more than a service and a 'paraffinoverhaul', wins a motor race at the weekend.

The well-known white Triumph TR4 owned and driven by Neil Dangerfield, and prepared and maintained by Sid Hurrell, is such a car. Tractable enough to trickle along with only 800 r. p. m. showing on the rev counter, yet with sufficient power to reach a road speed of 130 m.p.h. in overdrive top with the aid of a clear motorway.

FAMILIAR NUMBER

Its registration number SAH 137 has been a familiar sight on British circuits for several years, and it has always been associated with a more than averagely successful car. Sid Hurrell used to carry it when he was racing his own TRs, and Neil Dangerfield has inherited it for what is - from a mechanical standpoint - virtually a Hurrell works entry.

As such it acts as a guinea pig for new items of performance equipment, and in one or two respects it is a little different from the normal run of Hurrell-modified TRs. The compression ratio, for example, is approximately 10.2:1 instead of the 9.5:1 of the 'production' modified engine. But as Hurrell makes a point of offering nearly all his performance equipment as separate items, as well as in a 'package deal', a TR owner can have his car modified to virtually any specification.

The conversion of the Hurrell-Dangerfield car can be divided into three parts - the engine, the suspension, and the bodywork. The engine is boosted in power from 105 to 135 horsepower, and a stronger clutch and an oil cooler are fitted. The suspension is modified at both ends for competition use, and work on this is continuing in an effort to improve the handling. The use of glass-fibre

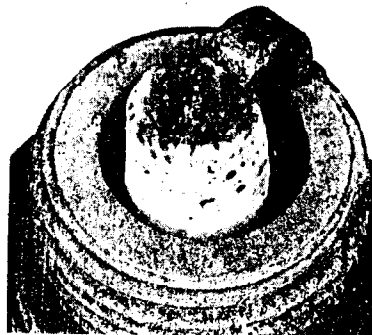
Plate 9. Sparking plug condition analysis photograph. Photo: Champion Ltd.



Plug too hot - white deposits



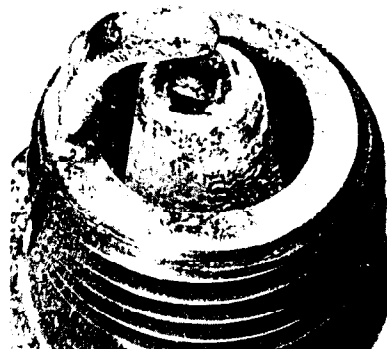
A chipped electrode



Typical damage caused by pre-ignition



Plug too cold - dry black fuel deposits



Badly burnt electrodes



A normal plug with light tan deposits



Plate 10
A slipper piston from a racing engine which blew up due to detonation

TWO ROAD TESTS OF MODIFIED TR4s

panels for the unstressed body parts has helped toward the total saving in weight of some 124 pounds. Dangerfield, therefore, is able to take full advantage of the 5 per cent reduction in catalogue weight allowed at scrutineering.

CONVENTIONAL CONVERSION

The triumph TR engine is a tough unit, and Hurrell has found it unnecessary to resort to highly elaborate and costly modifications in order to achieve the required power. In fact, the conversion is fairly conventional, although a lot of care is taken over the detail work, and this no doubt contributes considerably to the successes earned by the modified engine.

Apart from the raised compression ratio, the cylinder head has reshaped and highly polished combustion chambers and ports, the latter being matched to polished ports of the inlet manifold. Hurrell strongly recommends S. U. carburettors with the 'hot' TR engine, as they appear to give a more progressive power curve and better fuel consumption than alternative set-ups. The twin H6s have special needles, giving a fairly rich setting, but otherwise they are unchanged. No air filters are fitted on Dangerfield's car, and despite this induction roar is modest.

The S. A. H. four-branch extractor-type exhaust manifold has proved a great success, and this item is now being offered as a factory extra by Standard-Triumph, and should soon be homologated. Triumph testers have found that it offers a useful bonus of eight horsepower over the standard manifold. The four branches blend into twin parallel pipes, which in turn are joined into a single outlet ahead of the 18-inch Servais straight-through silencer.

VALVE TIMING

Although standard-size valves are used, they are fitted with competition springs, and are operated from a camshaft giving a higher lift, but not being so 'hot' that low-speed torque is sacrificed noticeably. The modified cams open the outlet valve 23 degrees before TDC, and close them 64 degrees after BDC, while the exhaust valves open 64 degrees before BDC, and close 23 degrees after TDC. This timing compares with 15, 55, 55, and 15 degrees, respectively, from the standard camshaft, while the valve lift is increased to .428 in. with a clearance of .018 in.

Sid Hurrell strongly recommends the converted engine in 2,138 c. c. form, as on the 1,991 c. c. unit the lack of torque at the bottom end is more noticeable. The Dangerfield car, of course, has the larger-capacity liners, and this conveniently moves it out of a class often dominated by 'hot' Bristol engines in ACs, and TR units in lightweight Morgans!

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The engine is fully balanced, with a lightened flywheel and special Glacier bearings, and the standard Borg and Beck clutch is fitted with a Mintex competition centre plate. The oil cooler kit incorporates a modified full-flow filter, and the engine is cooled by a Kenlowe electrically operated and thermostatically controlled fan.

HIGH GEARED

Production TR4s have a 3.7:1 axle, or a lower 4.1:1 ratio if the optional Laycock de Normanville overdrive is fitted. When Dangerfield wanted his TR4 no overdrive cars were available, so he took a normal model, with the 3.7 axle, and Hurrell subsequently fitted the overdrive without altering the axle. The result is a highly geared car, offering really effortless high-speed cruising, and a useful top speed on the faster circuits. Instead of the flick switch extending from the steering column, the overdrive is operated from a tumbler-type switch fixed to the right-hand steering wheel spoke. Apart from this, the Smiths racing rev counter, which replaces the production type, and the glass-fibre racing seat - fully padded and trimmed in black vynide to match the rest of the upholstery - the cockpit looks just like that of any other TR4, although a growing collection of 'Passed by Scrutineer' labels hanging from the fascia discloses its competition history.

Unlike the Hurrell glass-fibre body panels for the TR2 and TR3, the conversion for the TR4 follows the same profile as on the standard model. Outwardly, therefore, the racing TR4 looks little different apart from the lack of bumper bars. A close inspection, however, reveals a plastic front section, saving 25 pounds in weight, front wings (9 pounds less each), rear wings (6½ pounds less each), and boot lid (15 pounds lighter).

Special 60-spoke centre-lock racing wheels are fitted, and the suspension modifications when the car was tested included stiffer front springs, Variflo adjustable dampers all round, and a 7/8 in. anti-roll bar at the front. Even with the dampers on their softest settings the car was tailored for fast motoring, a harsh ride being offered at low speeds. At the same time, when the car was put on a circuit (Brands Hatch) it revealed too much understeer, and a considerable effort was necessary to prevent it running out of road on left-hand bends.

The Dunlop RS5 tyres were tried at 32 pounds front, 37 pounds rear at first, as recommended, but subsequent adjustment to a more balanced pressure between front and rear seemed to offer a small improvement in handling. However, before the car's potential performance could be used to the full, a considerable improvement in handling would be desirable. Dangerfield has spun off several

TWO ROAD TESTS OF MODIFIED TR4s

times in his efforts to kill the understeer, and subsequently has not been driving 'ten-tenths'. With the handling sorted, therefore, he should really go!

SUSPENSION MODS

It is difficult to pinpoint the trouble, but a thinner front anti-roll bar, softer springs and firmer damper settings might be a worthwhile line of experiment. This handling problem highlights the difficulty of tailoring a car satisfactorily for road use and for racing, and indicates the difference between fast road driving and actual racing. Normally, of course, racing tyres are fitted for track use, and since the car was tested a modified front wheel set-up has been tried, giving a castor angle of 3°. It is likely, therefore, that Dangerfield's car will be handling well by the time these words are read.

The Hurrell engine conversion has been an unqualified success in that it has turned the TR4 into a competitive racing model without reducing its docility as city transport. The engine is remarkably flexible at low speed, so that the resonant exhaust period between 2,500 r.p.m. and 3,000 r.p.m. is no embarrassment when motoring in built-up areas, the m.p.h. per 1,000 r.p.m. figure being in excess of 24 for overdrive top.

There is no carburation lumpiness at low speed, and the unit will tick-over indefinitely, even though throughout the period of the test the choke was not used once. Obviously the mixture (100 octane fuel) was on the rich side, so that the all-in figure of between 20 and 21 m.p.g. was very reasonable. The only suspicion of plug-wetting occurred when the accelerator was opened wide after a long session at low speed; then there were a few seconds of unevenness as the revs built up.

6,000 R. P. M. ON TAP

Further up the scale, there is a second resonant period beyond the 4,000 r.p.m. mark as the engine gets into full song, and at first it seems that peak revs are about 5,500 r.p.m. There is a slight rough patch at this point, but if the acceleration is sustained it evens out again at 5,700 r.p.m., and the engine goes on crisply to 6,000 r.p.m. without any indication of being overstressed.

Normally, of course, it is not necessary to use these revs, and Dangerfield usually comes in after a race with the tell-tale somewhere near the 5,500 r.p.m. mark - unless he has been in a dog-fight! For maximum acceleration a change-up is called for at about 5,000 r.p.m. Sustained high engine speed failed to drop the oil pressure and water temperature readings from their normal posi-

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tions, and only once was there any running-on after the ignition was cut.

The car cruised happily at 4,500 r.p.m. in overdrive top - 110 m.p.h. - and a best reading of 5,300 was obtained with the aid of a run-up of several miles on M1, corresponding to 130 m.p.h. Using 5,000 r.p.m. in the gears, the maximum speeds available in each ratio are: 1st, 31 m.p.h.; 2nd, 50 m.p.h.; 3rd, 76 m.p.h.; overdrive 3rd, 93 m.p.h.; top, 100 m.p.h. Naturally, these speeds can be improved by ten per cent if the revs are allowed up to 5,500 r.p.m., and by 20 per cent if the occasion demands the use of 6,000 r.p.m. No maximum speed has been given for overdrive second because the unit would not take full engine power; in any case, this ratio would not be used during normal motoring.

The car's soft top withstood top speed well, and of course with the facia air vents it is possible to drive the car with the side windows up. Above 100 m.p.h. there was some wind buffeting around the front of the car, the air seeming to swirl around the headlamp shields and cause the plastic body panel to vibrate. Although it is quite a noisy car at high speed, the TR4 is very stable, and when an unexpected large 'bump' was hit at between 110 and 115 m.p.h., it took off momentarily, and landed squarely, without a lot of drama.

The brakes were up to the extra engine performance, the only deficiency being an occasional lagging of the left front pads behind the right front pair, resulting in an initial pull to the right on a light application. The brakes smelt 'hot' after continual pounding, but did not lose their power. The clutch transmitted the power satisfactorily, although the pedal was adjusted to the point of slip, and had to be operated accordingly.

Of the big attractions of this car is that, although it has an impressive performance and is well able to see off many a more 'rorty' sports car, it also has the docility of a family saloon, and can be driven in a similar manner. The vivid acceleration and the healthy exhaust crackle can be saved for when it is really needed, and when this happens these are the figures which are likely to be obtained:

0 to 30 m.p.h.	...	...	3.0 seconds
0 to 40 m.p.h.	...	...	4.8 seconds
0 to 50 m.p.h.	...	...	6.6 seconds
0 to 60 m.p.h.	...	...	8.6 seconds
0 to 70 m.p.h.	...	...	11.2 seconds
0 to 80 m.p.h.	...	...	14.0 seconds
0 to 90 m.p.h.	...	...	17.6 seconds
0 to 100 m.p.h.	...	...	22.8 seconds

Approximate cost of the extra performance; £120 for the engine

TWO ROAD TESTS OF MODIFIED TR4s

conversion; £68 for the body parts; £22 for the suspension conversion; and £70 for the racing wheels.

The staff of Autocar had the following to say about the Lawrence-tune Triumph TR4 which they tested in March 1963.

In its standard form the Triumph TR4 is a tough and beefy sports car, in the traditional British idiom. The large, four-cylinder engine is not the smoothest of power units, and its long stroke limits the maximum regular r.p.m. to 5,000. To increase its performance without transforming the car into a rorty competition beast must, therefore be a formidable task, but Lawrencetune Engines Ltd., 69A Avenue Road, London W.3., have a wealth of experience in tuning this engine. The works Morgans successfully entered in international sports car races have been prepared by them.

The car we tested was fitted with a Lawrencetune road conversion, comprising a modified cylinder head with the usual attention to ports and combustion chambers, a branched exhaust manifold and touring camshaft. In addition, a pair of dual-choke Weber carburetors took care of fuel mixing, whilst an oil-cooler enabled us to cruise at sustained r.p.m. near the red sector on the rev counter without anxiety for the bearings. To increase the controlability, a front anti-roll bar was fitted together with Koni adjustable dampers on the front alone. The total cost of the engine modifications (including £50 for the Webers and inlet manifolds) is £129. 10s. plus £24. 10s. fitting, whereas the front suspension modifications amount to £16. 10s. plus £10 fitting. In all, £180 had been spent on the test car.

It is not as easy as usual to draw comparisons with the standard car, as the one we tested over a year ago did not have the optional overdrive that was fitted to the Lawrencetune car. However, the final drive ratio was the same on both, so the accelerations on the direct gears are a true guide to the improvements in performance. For the standing start acceleration tests the seven ratios available were used progressively, the maxima in the gears being 1st, 32 m.p.h., 2nd, 52 m.p.h., O.D. 2nd, 64 m.p.h., 3rd 80 m.p.h., O.D. 3rd, 90 m.p.h., Top 100 m.p.h. These speeds correspond to 5,300 r.p.m. for the lower four ratios, but for O.D. 3rd and top it was found advantageous to change up at 5,000 r.p.m. By using only the direct gears the time for the standing quarter-mile was increased slightly from 17.0 sec. to 17.2 sec. These times could have been improved slightly had the clutch had more 'bite' to it. Air in the hydraulic system gave it a rather spongy action, which lost a little time during take-offs and gear lever changes. The change up into overdrive was exceedingly fast.

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A good indication of the level delivery of torque that the touring camshaft enables the engine to give can be seen in the acceleration figures for O.D. 2nd. The three highest 20 m.p.h. speed ranges covering 20 to 60 m.p.h. all returned identical times of 4.1 sec. Another fact which verified this was that the four runs in opposite directions we carried out over the standing quarter-mile all took a consistent 17.0 sec.

In traffic the car displayed no temperament and could be made neither to foul its plugs nor pink on super premium fuel. Nearly all the mileage of the test was either on motorways at speeds around 100 m.p.h. or taking acceleration times at the M.I.R.A. test track, so an overall figure of 19.0 m.p.g. carries no shame.

Handling of the car was improved, and it was only near its maximum speed that the characteristic front-end wavering became noticeable. One is constantly made aware of all that is going on, both in the engine compartment and under each road wheel. Induction roar and exhaust noise levels are high, and an engine vibration between 2,500 and 3,000 r.p.m. caused an unpleasant groaning throughout the car. But the true enthusiast will deem these a small price to pay for the improved performance.

PERFORMANCE DATA - LAWRENCETUNE TR4 (Note - The figures in brackets are for the standard TR4 tested in Autocar of 5th January, 1962.)

Standing quarter-mile: 17.0 secs. (17.8 secs.)
Maximum speed: 117 m.p.h. (104 m.p.h.) 118 k.p.h. (167 k.p.h.)

ACCELERATION THROUGH THE GEARS

0 - 30 m.p.h.	3.1 sec. (3.7)	0 - 70 m.p.h.	12.5 sec. (14.7)
0 - 40 m.p.h.	5.1 sec. (5.8)	0 - 80 m.p.h.	16.0 sec. (20.9)
0 - 50 m.p.h.	7.0 sec. (8.3)	0 - 90 m.p.h.	21.5 sec. (28.2)
0 - 60 m.p.h.	9.0 sec. (10.9)	0 - 100 m.p.h.	28.9 sec. (46.3)

TWO ROAD TESTS OF MODIFIED TR4s

M. P. H.	Third	O.D. Second	Second
	4.9 to 1	6.09 to 1	7.43 to 1
10 - 30	7.0(6.4)	5.5	4.0(4.0)
20 - 40	5.9(5.8)	4.1	3.4(3.8)
30 - 50	5.3(5.8)	4.1	4.0(4.1)
40 - 60	5.2(6.2)	4.1	-
50 - 70	5.6(6.7)	-	-
60 - 80	6.3(-)	-	-

Overall fuel consumption for 370 miles:

19.0 m.p.g. , 14.9 litres/100 km. (22.5 m.p.g. , 12.6 litres/100 km.)

M. P. H.	ACCELERATION TIMES		O.D. Third 4.02 to 1
	O.D. Top 3.04 to 1	Top 3.7 to 1	
10 - 30	-	-	-
20 - 40	-	8.7(8.2)	7.8
30 - 50	-	8.3(8.5)	7.2
40 - 60	10.5	7.0(8.8)	6.6
50 - 70	10.0	7.1(9.4)	6.8
60 - 80	11.3	8.4(10.3)	6.8
70 - 90	12.9	9.5(12.7)	8.3
80 - 100	16.7	13.4(25.4)	-

CHAPTER TWELVE

CONVERSION EQUIPMENT

Lawrencetune Ltd., of 14 Astwood Mews, London, S. W. 7, and S. A. H. Accessories Ltd., of Linslade, Leighton Buzzard, Bedfordshire are the two principal suppliers of performance equipment for TRs. Few other firms supply equipment for TRs, and those that do specialise in some other made, model or business, whereas S. A. H. and Lawrencetune specialize in TRs.

S. A. H. ACCESSORIES

Sid Hurrell (S. A. H. Accessories) is the only official Standard Triumph International distributor of conversion equipment and he offers a very wide range of performance equipment for TRs and other Standard and Triumph models. He also sells a range of accessories. Sid Hurrell has a splendid competition background having raced TRs with success and has prepared many cars, notably Neil Dangerfield's TR4, before it was special-bodied. Here is a list of some equipment his firm can supply and what it costs at the time of going to press.

	Price
S. A. H. -26 stage 1 camshaft - exchange	£17. 10. 0.
S. A. H. 47X stage 2 " - "	£20. 10. 0.
Modified cylinder head - A - exchange	£25. 10. 0.
- B - "	£27. 0. 0.
- C - "	£30. 10. 0.
High efficiency exhaust system	£17. 5. 0.
Servais straight through silencer	£ 4. 0. 0.
Dual rear silencer kit - TR4s	£15. 0. 0.
Set 2138 c. c. pistons and liners	£27. 10. 0.
H. 6. S. U. carburettors and inlet manifold exchange against H. 4s.	£23. 16. 6.
45 DCOE Weber carburettors per pair	£51. 0. 0.
Weber inlet manifolds per pair	£12. 0. 0.
Throttle linkage for Webers	£ 2. 5. 0.
Oil cooler kit complete - TR2	£18. 0. 0.
Oil cooler kit complete - TR3s/4s	£18. 10. 0.
Heavy duty oil cooler for above - extra	£ 4. 0. 0.
Set Glacier recticular tin con-rod bearings	£ 1. 19. 0.

CONVERSION EQUIPMENT

	Price
Lightened flywheel - exchange	£ 3. 15. 0.
Crown wheel and pinion - 3. 7	£10. 0. 0.
- 4. 1	£10. 0. 0.
- 4. 55	£10. 5. 0.
Power-Lok limited slip diff.	£33. 0. 0.
Anti-roll bar - TR2s/3s	£ 6. 0. 0.
- TR4s	£ 5. 12. 6.
Competition front springs per pair	£ 8. 0. 0.
Competition rear springs - TR4s only	£ 5. 10. 0.

COMPETITION SHOCK ABSORBERS

Armstrong adjustable, front - TR2/3/4	£ 9. 18. 0.
" fixed, rear - " " "	£ 8. 6. 0.
" " front - " " "	£ 6. 12. 0.
" " " - TR4A	£ 6. 18. 0.
" adjustable, front - "	£ 9. 18. 0.
" fixed, rear - "	£ 9. 17. 0.
Koni front - TR2/3/4	£ 9. 15. 0.
" rear - " " "	£ 9. 15. 0.
Koni conversion brackets	£ 6. 0. 0.
Koni adjustable, front - TR4A	£10. 15. 0.

COMPETITION BRAKE LININGS

Mintex M. 20 exchange shoes 10" per pair - TR2/3	£ 3. 6. 0.
" " " " " " " " " " " " " " " " "	£ 2. 8. 6.
" " " " " " " " " " " " " " " " "	£ 1. 16. 6.
Ferodo VG. 95 " " " " " " - TR4	£ 2. 4. 3.
Ferodo pad for disc brakes	£ 2. 6. 3.
Kit to convert front drum to disc brakes - fitted	£60. 0. 0.

OTHER EQUIPMENT

Stanpart factory exchange reconditioned engine	£64. 0. 0.
Alloy oil sump	£12. 5. 0.
Bendix fuel pump, high output	£14. 10. 0.
Kenlowe electric fan kit	£13. 14. 6.
Lucas sports coil	£ 2. 1. 6.
Transistorised ignition	£14. 14. 0.
New crankshaft	£22. 18. 6.
Balancing of crank, flywheel, clutch, pistons, fan, conrods.	£ 8. 15. 0.
Reconditioned gearbox, exchange	£30. 0. 0.
Overdrive kit	£62. 10. 0.
Factory reconditioned overdrive, exchange	£30. 0. 0.

CONVERSION EQUIPMENT

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		Price
WHEELS		
Wire wheel conversion kit, with 5 60 spoke 4 1/2"		
J. Dunlop wheels, hubs and hub caps complete ...	£68.	15. 0.
Minilite magnesium wheels 5/5 1/2/6/6 1/2, from ...	£17.	5. 6.
Wire wheel conversion kit as above, but with		
5 1/2" J. wheels ...	£76.	5. 0.
Chrome 60 spoke wire wheels, each ...	£19.	10. 0.
Girling Powerstop brake booster kit ...	£13.	10. 0.
Alfin drums 10" and 9" ...	£ 9.	0. 0.
Stanpart streamlining undershield (metal) ...	£10.	10. 0.
S. A. H. " " (fibreglass) ...	£ 4.	0. 0.
Steel skid plate for rallying ...	£ 2.	2. 6.
New hoods TR2s/3s ...	£15.	0. 0.
Tonneau cover, from ...	£ 9.	0. 0.
Stanpart hardtop TR2s/3s ...	£46.	10. 0.
Crashbar - TR4s only ...	£12.	10. 0.
Interior silent travel - TR4s ...	£ 9.	10. 0.
Tow bar kit, from ...	£ 4.	10. 0.
Lamp and badge bars, from ...	£ 4.	5. 0.
 GLASS FIBRE BODY PARTS		
Front apron - TR3A ...	£13.	0. 0.
Bonnet TR2s/3s ...	£10.	0. 0.
" TR4s ...	£13.	0. 0.
Boot lid ...	£ 7.	0. 0.
Gearbox tunnel cover ...	£ 5.	0. 0.
Front wing - TR2s/3s ...	£ 7.	0. 0.
Front wing - TR4 ...	£ 6.	5. 0.
Rear wing - TR2s/3s/4s ...	£ 6.	10. 0.
Door - TR2s/3s ...	£ 5.	10. 0.
Hardtop - TR4s, from ...	£33.	0. 0.

The stage 1 camshaft is designed for road and touring use and the stage 2 S.A.H. 47X is designed for fully modified engines. With the S.A.H. 47X, the most effective rev range is 3,500 r.p.m. to 6,000 r.p.m. The timing is as follows:

	Standard	S. A. H. 47X	
	TR2s/3s	TR4s	
Inlet opens BTDC - degrees	15	17	23
Inlet closes ABDC "	55	57	64
Exhaust opens BBDC "	55	47	64
Exhaust closes ATDC "	15	17	23

Lift is 0.428 in. and valve clearances for both inlet and exhaust must be 0.018 in. To get the best from this camshaft it should be used with the modified high-compression and flowed head and inlet manifold and the four branch extractor exhaust.

S.A.H. offer three stages of modification to cylinder heads. Type A and B are TR2s/3s/4s cylinder heads, type C is the TR3A and TR4A heads. The type A head features a compression ratio raised to 10:1, enlarged and polished inlet and balanced combustion chambers and matched inlet manifolds. Type B has the same modifications as type A but is fitted with new standard inlet and exhaust valves, special valve springs, cotters and valve caps. Approximate increase in power output is 27% on the TR3/4 head and 17 - 20% on the TR2 head, with standard exhaust system. The type C head has the same modifications as the others but has a higher compression ratio of 10.7:1 (on 2.2 litre engines) and larger inlet valves which are 1/8 in. larger in diameter than standard inlet valves.

The special four branch extractor type exhaust manifold for the high port head is claimed to give an increase of 8 b.h.p. and had been used on works rally cars. The rapid extraction of exhaust gases enables a greater volume of mixture to be drawn into the cylinders. S.A.H. offer the standard TR4 2138 c.c. pistons and liners and these can be fitted to 1991 c.c. engines, giving a very worthwhile increase in power and torque. S.A.H. do not bore out to greater sizes, since they do not think that the results justify the extra cost.

S.A.H. prefer the 45 DCOE to the 42 DCOE Weber for racing, and since the 45 can be choked down to 42 mm. with the 45 you have the best of both. The inlet manifolds for Webers are cast aluminium and have grooves on the carburettor side flange for fitting rubber 'O' rings. 'O' rings make a good airtight seal between carburettor and manifold and also stop some of the engine vibrations from reaching the carburettor. Some people say this is useful, others say it makes no difference. The author has never used them and so cannot offer an opinion.

The oil cooler is recommended by the works, who used them at Le Mans. The oil is taken to the cooler by unions welded into the body of the oil filter. S.A.H. say it gives a temperature drop of some 35% from the 120° which is quite a common reading attained by the sump oil on any TR engine even when used at medium touring speeds at a climatic temperature of around 75/80°F.

Sid Hurrell has found that Glacier reticular tin bearings are best and when racing he used to check big ends every 8 races and renew them as a precaution. He changed crankshafts every second year, and says that engines should be safe to 6,000 r.p.m. if fully mod-

TRIUMPH MAINTENANCE, MODIFICATION & TUNING

ified, balanced and fitted with an oil cooler.

The alternative axle ratios are reasonably priced and the speeds they give are shown on page 115.

In addition to the listed equipment, S.A.H. offer Tecalemit Jackson fuel injection, the price of which is not yet fixed.

The anti-roll bar is the most important single modification to the suspension and gives a great improvement to the roadholding and cornering power, and stops the inside rear wheel lifting on severe cornering. No drilling, welding or other alterations to the chassis are required, and it can be fitted easily by anyone with two spanners.

The Girling 'Powerstop' brake booster is a vacuum servo unit. Fitting is straightforward. The arrangement of the output piston allows free flow of fluid through the unit when it is at rest; the hydraulic valve is actuated by the pressure from the master cylinder and reacts to the boosted pressure supplied to the brakes; the control pistons allow an exact proportion of power to be supplied at all times; because of the 'suspended vacuum' piston large amounts of air are not suddenly drawn into the engine.

The arguments for the use of electric fans such as the Kenlowe are convincing. In traffic congestion the Kenlowe fan works at 2,300 r. p. m. whereas the conventional fan runs at 500 r. p. m. or whatever tick-over speed is. It follows therefore, that if the conventional engine-driven fan is efficient at low revs, it must consume large amounts of b. h. p. at high revs. When the engine is turning at any speed other than tick-over, the car is presumably proceeding forwards and air flow over the radiator is created by the ram effect of forward movement. It is said that the fan of a well known sports car (not identified) consumes not less than 18 b. h. p. at 5,000 r. p. m. The thermal control is set to cut in the fan when temperature rises to 87°C. Other settings may be specified. Electric cooling fans are standard equipment on Bristol 407/408, Facel Vega, Jaguar 'E' Type and others.

The lightened flywheel, the advantages of which are discussed on page 53 saves seven pounds on the weight of a standard one.

There is a swing to wide wheels and fat tyres today. It has been proved on racing circuits that cornering power is increased with wider tyres. On a production car the limiting factor is body or chassis clearance, and the maximum rim width one can go to on the TR4/4A is 6 in. Wire wheels are available in 4½ in. J. and 5½ in. J. and the Minilite wheels are available in 4½ in. J., 5 in. J., 5½ in. J. and up to 6 in. J. Though expensive, the Minilite magnesium alloy wheels have the advantage of lightness, being one quarter the weight of steel and two-thirds the weight of aluminium; and strength, with twice the strength to weight ratio of steel.

CONVERSION EQUIPMENT

Fibreglass body parts save a lot of weight, with consequent acceleration and cornering advantages, are often cheaper than the standard part, and of course cannot rust.

LAWRENCETUNE

Chris Lawrence is best known for his work on and exploits in Morgans powered by TR engines. His successes are numerous including wins on the continent, many wins in British club racing, the Freddie Dixon trophy and of course his best known achievement, winning the 2 litre class at Le Mans. His knowledge of racing the TR engine is probably unequalled. The majority of his tuned TR engines go into Morgans but he also does a lot of work for Triumph owners and prepares Neil Dangerfield's very successful special-bodied TR4. Because of these associations with racing, Lawrence-tune offer a fair amount of equipment which is highly sophisticated and is designed with racing only in mind. Lawrence offers conversion equipment which is suitable for road and track, but the out and out racing equipment would not be usable on the road. So do not buy the full-race camshaft or the £195 cross flow alloy cylinder head if you only want just enough extra urge to outdrag your neighbour's Mini Cooper from the traffic lights. If going in for the really high performance equipment with a view to competition work, it would be as well to discuss your plans and requirements before deciding what you want to modify.

Listed below is some of Lawrencetune's equipment: they do offer more, but it would be to special order.

	Price	Fitting
Touring camshaft.	£20. exchange	-
Full race camshaft	£20. "	-
Modified cylinder head	£20. 10. 0.	£ 8. 0. 0.
High efficiency exhaust manifold	£16. 16. 0.	£ 5. 0. 0.
Oil cooler complete	£18. 10. 0.	£ 5. 0. 0.
Oil cooler take off block	£ 5. 0. 0.	-
Oil cooler pipes per pair	£ 5. 0. 0.	-
Heavy duty oil cooler	£10. 0. 0.	-
Competition valve springs	£ 2. 0. 0.	-
Weber inlet manifolds per pair	£12. 10. 0.	-
Set 2196 c. c. liners and pistons	£29. 10. 0.	-
Set 2598 c. c. liners and pistons	£65. 0. 0.	-
42 DCOE Weber each	£29. 18. 0.	-
Lawrencetune alloy cylinder head	£195. 0. 0.	-
Tecalemit Jackson fuel injection equipment, inlet manifolds and throttle linkage, etc.	£75. 5. 0.	£15. 0. 0.

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	Price	Fitting
Anti-roll Bar	£ 9. 0. 0.	£ 1. 10. 0.
Koni shock absorbers -front	£ 9. 15. 0.	£ 3. 0. 0.
" " " -rear with brackets	£16. 5. 0.	£ 3. 0. 0.
Hard top - TR2/3	£26. 15. 0.	£ 5. 0. 0.
" " - TR4	£35. 0. 0.	£ 5. 0. 0.
Competition Mintex M. 20 Brake Linings.		
TR2 linings all round.	£ 7. 1. 0.	£ 3. 0. 0.
TR3 disc pads, front.	£ 5. 12. 6.	£ 2. 0. 0.
TR4 disc pads, front.	£ 4. 13. 0.	£ 2. 0. 0.
TR3/4 linings, rear	£ 3. 10. 0.	£ 1. 0. 0.

In addition to this equipment, Lawrencetune do cylinder heads with special offset large valves. The prices will be quoted at the time of enquiry, but a rough indication is given. Four large inlet valves 1 11/16 in. with standard exhaust valves, about £55, and large inlets with large exhaust 1 7/16 in., about £75. Both heads are fully gas flowed and have re-shaped combustion chambers.

Sets of special Vandervell VP 3 lead indium main and big end bearings are offered at £7. 10. 0. per set. Also offered is a special crankshaft in EN40C steel with nitrided journals, the price of which is in the region of £80. Special big end bolts of 80 ton cold rolled steel are offered. Lawrencetune have also developed their own distributor advance springs.

That completes the list of Lawrencetune's regular range of equipment, but they will of course undertake development work. To go into detail on the equipment offered.

The touring camshaft is designed for road use and does not sacrifice low rev performance for ultimate output at high speed. The full race camshaft with its wilder timing is not suitable for road use and has little power at low revs. Inlet valve lift is 0.438 in. and the timing:

Inlet opens 42° BTDC
Inlet closes 72° ABDC
Exhaust closes 38° ATDC
Exhaust opens 78° BBDC

Standard bore on the 1991 c. c. engine is 83 mm. This can be brought up to the 2138 c. c. size by a straight change of pistons and liners of 86 mm. While spending this money you might as well go to 2196 c. c. and fit the 87 mm. solid pistons. 88 mm. pistons and liners are available, but are best kept for racing. Lawrencetune also offer special pistons and liners to their own design and manu-

CONVERSION EQUIPMENT

facture giving engine sizes of 2480 c. c. and 2598 c. c. These are intended for serious competition work in conjunction with the Lawrencetune alloy cylinder head, special crankshaft and fuel injection. Fitting these very large pistons and liners involves machining the cylinder block, since they are too large to fit the normal space in the block, and special gaskets have to be made. These engines rev safely to 6,900 r. p. m. with the special crankshaft.

The cross-flow head designed and developed by Lawrencetune is cast in light alloy and is pushrod operated. The valves are opposed at 60° and seat on bronze inserts. The block has to be relieved around the top of the pushrod passages because they operate at a different angle from standard. Because of the distance between the pushrods and the inlet valves, unusually long rockers have to be used for the inlet valves, whereas very much shorter ones are used for the exhaust valves. The combustion chambers are oval and give good swirl and turbulence characteristics. 10 mm. sparking plugs are used. On 2.2 litre TR4 engines with Webers and special camshafts these engines have given 154 b. h. p., but with big pistons and fuel injection the power is up into the 180 b. h. p. bracket.

After these excitements, let us return to the standard cast iron head. The normal gas-flowed head at £27. 10. 0. exchange has a compression ratio of 10.5:1. It features new standard valves and guides, gas-flowed ports and re-shaped combustion chambers. The combustion chambers are opened out considerably, and up to 0.140 in. is taken off the head. If the normal combustion chambers are retained, a maximum of 0.060 in. can be taken off the head to give a compression ratio of about 10.5:1, but there is a risk of pre-ignition at full ignition advance. The more advanced cast iron cylinder head modifications with offset valves involve drilling out the guides, and fitting larger special guides in which the valve is positioned at an angle as opposed to the standard vertical valves. The drilling for the new guide pierces the water-jacket, and is quite a major piece of work.

Bearing life is to some extent dependant on oil temperature. If sump temperature reaches 90°C., meaning of course that in other parts of the engine the temperature is considerably higher, trouble can be expected with bearings. TR engine bearings are very reliable so long as oil temperature is kept down to 80°C. The Lawrencetune oil cooler kit will do this. The take-off is a drilled alloy block which is placed between the cylinder block and the Purolator filter. This necessitates longer studs.

Chris Lawrence estimates that the life expectancy of the standard TR crankshaft to be about 2,000 racing miles plus or minus 500 miles using 6,000 r. p. m. when a fatigue failure can be expected.

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The author's experience has been consistent with this, though hardly as heroic as Lawrence's 24 hour excursion round the Le Mans circuit. The special steel crankshaft is obviously a good investment if very high revs, as with the alloy head, are envisaged.

Fuel injection is becoming increasingly popular. Its superior performance and relatively cheap cost explains this popularity. Fuel injection has a theoretical 7-8% power advantage over Webers and is cheaper. A few power output figures are appropriate here. The most Lawrence-tuned got out of the 1991 c.c. engine with Webers was 128 b.h.p. With 88 mm. pistons bringing the engine to just over 2.2 litres 131 b.h.p. was available with Webers and 138 b.h.p. with fuel injection. The cost of the complete Tecalemit Jackson fuel injection equipment for a TR is £75. 5. 0. The cost of Webers comes to more:

2 X 42 DCOE Webers at £29.18.0. each	... £59. 16. 0.
2 manifolds	... £12. 10. 0.
Fuel line and linkages	... £ 5. 0. 0.
Bendix fuel pump	... <u>£11. 14. 0.</u>
	<u>£89. 0. 0.</u>

The Bendix fuel pump is necessary with Webers as the standard pump will not deliver enough fuel, whereas with the fuel injection kit a fuel pump is provided. As regards Webers, Lawrence prefers the 42 DCOE to the 45 DCOE as it gives better torque and pickup at low revs.

Lawrence uses ignition timing advance of 12° static and 46° full advance and the rate of advance over the rev range is accurately timed with his own advance springs.

Neil Dangerfield's Lawrence-tuned car must be the ultimate in performance and modification on a TR4. For 1967 it featured 2598 c.c. pistons and liners the special steel crankshaft, steel connecting rods, the alloy cylinder head, fuel injection, transistorised ignition, light-weight Borrani offset wheels, 7½ in. rims at the front and 9 in. rims at the rear, Koni shock absorbers, special springs and the special Williams and Pritchard SLR body. The body, which cost £600 without windows and untrimmed, reduces frontal area some 15% and saves a lot of weight, the car weighing 1.15 cwt. on the starting grid.

APPENDIX I

ENGINE SPECIFICATION

	TR2s/3s	TR4s
Type:	4 cylinder in line O. H. V. pushrod operated	
Bore:	3.268" (83 mm.)	3.386" (86 mm.)
Stroke:	3.622" (92 mm.)	3.622" (92 mm.)
Cubic capacity:	1991 c.c. (121.5 cu. in.)	2138 c.c. (130 cu. in.)
Compression ratio:	8.5:1	9:1
Firing order:	1, 3, 4, 2	1, 3, 4, 2
Location of No. 1 cylinder:	Front	Front
Piston area:	33.5 sq. in.	36.0 sq. in.
Piston speed at 100 m.p.h.	2898 ft/min.	2898 ft/min.
Ignition timing:	4° Advance	4° Advance
Max. b. h. p.		TR2 90 TR3,3A 95 TR4 100 TR4A 104

Block.

Bores F	3.2673 - 3.2676"	3.3854 - 3.3857"
G	3.2677 - 3.2680"	3.3858 - 3.3861"
H	3.2681 - 3.2684"	3.3862 - 3.3865"
Rings	2 compression, 1 scraper	
Ring gaps in position	0.003" - 0.010"	0.010" - 0.015"

Crankshaft.

Crankpin diameter	2.0860 - 2.0866"
Main journal diameter	2.4790 - 2.4795"
Undersize main bearings	0.010, 0.020, 0.030"
End float	0.004 - 0.006
Undersize big end bearings available	0.010, 0.020, 0.030"
Ovality limit	0.002"

Camshaft.

Cam lift (max.)	0.230"
End float	0.003 - 0.0075"

Valves.	TR2s/3s	TR4s
Head diameter - inlet	1.56	1.56
- exhaust	1.30	1.30
Seat angles - valve		45°
- head		44 1/2°
Springs per valve - inlet	2	2
- exhaust	3	3
Free length of springs -		
exhaust inner	1.54	1.55 - 1.57
- inner	2.08	1.88 - 1.90
- outer	1.98	1.94 - 1.96
Valve clearance cold		
- inlet	0.010	0.010
- exhaust	0.012	0.010
Lubrication.		
Release pressure at 70°C and 2000 r. p. m.	70 lb/sq. in.	70 lb/sq. in.
Capacities. (drain and refill)		
Engine	10 pints	10 pints
Gearbox (without overdrive)	1 1/2 "	1 1/2 "
Gearbox (with overdrive)	2 3/4 "	2 3/4 "
Rear axle	1 1/2 "	1 1/2 "
Cooling system with heater	14 "	14 "
Fuel tank	12 1/2 galls.	11 1/2 galls.

APPENDIX II

TRANSMISSION, GEARING, ROAD SPEEDS, DIMENSIONS

	TR2s/3s/4s
Transmission	
Clutch	Borg and Beck 9" 8 1/2 in. dia. on single dry plate TR4A
Rear axle ratio	3.7 or 4.1
Gear ratios - overdrive top	0.82
(3.7 axle) - top	1.0
- overdrive 3rd	1.09
- 3rd	1.325
- overdrive 2nd	1.65
- 2nd	2.00
- 1st	3.38
- reverse	4.28
Overall ratios	
(3.7 axle) - overdrive top	3.034
- top	3.7
- overdrive 3rd	4.02
- 3rd	4.9
- overdrive 2nd	6.1
- 2nd	7.44
- 1st	11.61
- reverse	11.93
Overall ratios	
(4.1 axle) - overdrive top	3.36
- top	4.17
- overdrive 3rd	4.46
- 3rd	5.44
- overdrive 2nd	6.76
- 2nd	8.24
- 1st	12.87
- reverse	13.21

Engine speed at 10 m. p. h.

	6.95-15 G. P. tyres or 165-15 S.P. tyres		Using Michelin 165-15 tyres	
	Axles		Axles	
	3.7	4.1	3.7	4.1
Overdrive top	415	458	409	452
Top	506	560	498	552
Overdrive 3rd	551	611	541	601
3rd	669	742	660	731
Overdrive 2nd	833	924	820	910
2nd	1,016	1,126	1,001	1,110
1st	1,588	1,759	1,563	1,733
Reverse	1,629	1,807	1,605	1,779

Chassis dimensions.

	TR2s/3s	TR4s
Wheelbase	7'4"	7'4"
Track-front	3'9"	4'1"
- rear	3'9 1/2"	4'0"
Ground clearance (laden)	6"	6"

Overall dimensions.

	TR2s/3s	TR4s
Length	12'7"	13'0"
Width	4'7 1/2"	4'9 1/2"
Height	4'2"	4'2"

Weight.

Dry	2,009 lbs.	2,128 lbs.
Kerbside	2,135 lbs.	2,240 lbs.

APPENDIX III

Torques (lb/ft.)

Engine.	TR2s/3s/4s
Cylinder head	100 - 105
Connecting rod caps	55 - 60
Clutch	20
Camshaft front bearing	16 - 18
Dynamo attachments	16 - 18
Distributor	8 - 10
Engine mounting plate	12 - 14
Flywheel to crankshaft	42 - 46
Fan	16 - 18
Manifold	22 - 24
Main bearing caps	85 - 90
Oil pump attachment	12 - 14
Retrol pump attachment	12 - 14
Rocker pedestal	24 - 26
Rocker cover	2
Sump	18 - 20
Starter Motor	26 - 28
Timing cover	12 - 14
Camshaft sprocket	24 - 26
Water pump	26 - 28

Ref.	Items	Details	Mileage Intervals
9	Tyre Pressures		Weekly
3	Radiator Water Level	Top up	Weekly
6	Battery	Top up	Monthly
14	Steering Swivels (4 nipples)		3,000
14	Steering	Grease Gun	3,000
	Outer Tie Rod Ball Joints (4 nipples)		3,000
	Slave Drop Arm Pivot		3,000
14	Lower Wishbone Outer Bushes (4 nipples)		3,000
21	Propeller Shaft	Three or Four Strokes Gun	3,000
	Splines (1 nipple)		3,000
	Universal Joints (2 nipples)		3,000
19	Hydraulic Brake and Clutch Reservoirs	Top up Fluid Level	3,000
5	Carburettor Dashpots and Control Linkages	Oil as Recommended Oil Can	3,000
16	Engine	250 Miles	Top up Oil Level Drain and Refill with New Oil
20	Gearbox		Top up Oil Level
23	Handbrake	Cable (1 nipple)	Grease Gun
24		Compensator (2 nipples)	3,000
7	Clutch Cross Shaft Bearings (2 nipples)		3,000
1	Engine Water Pump (1 nipple)	Grease Gun	6,000
11	Hubs—Rear (2 nipples)		12,000
15	Ignition Distributor		6,000
8	Handbrake Lever	Oil Can	6,000
	Door Locks, Hinges, Bonnet Safety-Catch, Boot and Wheel Locks		6,000
	Generator		12,000
	Oil Filler Cap	Wash	6,000
25	Rear Axle	Drain and Refill with New Oil	6,000
13	Steering Unit	Grease Five Strokes	6,000
4	Air Cleaners	Oil as Recommended	6,000
17	Oil Filter	Renew Cartridge	6,000
18	Fuel Pump	Clean out Filter Bowl	6,000
2	Hubs—Front	Remove and Re-pack	12,000 or 24,000
22	Rear Road Springs	Clean and Oil	12,000

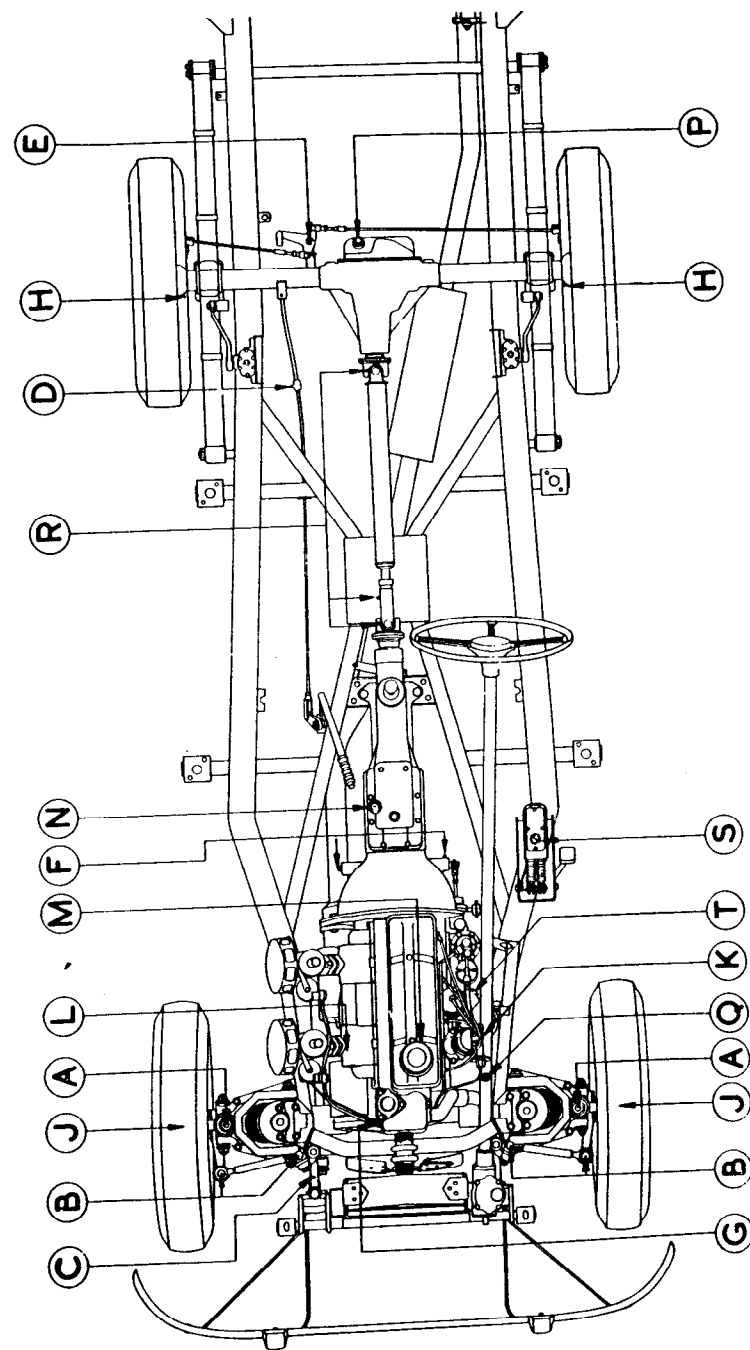


Fig. 37. Triumph TR2, 3, & 3A Lubrication Chart

Key to the TR4 & TR4A Lubrication Chart

Ref.	ITEMS	DETAILS	Mileage Interval (Thousands of Miles)
A	Steering Swivels (4 nipples)	THREE OR FOUR STROKES	1
B	Outer Tie Rod Ball Joints (4 nipples)		1
C	Steering Slave Drop Arm Pivot (1 nipple)		1
	Lower Wishbone Outer Bushes (4 nipples)		1
D	Cable (1 nipple)	FIVE STROKES	5
E	Handbrake Compensator (2 nipples)		5
F	Clutch Shaft Bearings (2 nipples)		5
G	Engine Water Pump (1 nipple)		5
H	Rear Hubs (2 nipples)		5
J	Front Hubs (2 nipples) Fitted up to Commission No. TS. 5348 only		5
K	Ignition Distributor	OIL AS RECOMMENDED	5
	Handbrake Lever		5
	Carburettor Dashpots and Control Linkages		5
	Door Locks, Hinges, Bonnet Safety Catch, Boot and Spare Wheel Locks		5
L	Dynamo		10
M	Engine Sump	TOP UP OIL LEVEL	2½
		DRAIN & REFILL WITH NEW OIL	
	Oil Filler Cap	WASH	5
N	Gearbox	TOP UP OIL LEVEL	5
		DRAIN & REFILL WITH NEW OIL	10
P	Rear Axle		5
Q	Steering Gearbox	TOP UP OIL LEVEL	5
R	Splines (1 nipple)	THREE OR FOUR STROKES WITH OIL GUN	5
	Propeller Shaft Universal Joints (2 nipples)		5
	Road Springs	CLEAN AND OIL	5
	Air Cleaners	OIL AS RECOMMENDED	5
S	Hydraulic Brake and Clutch Reservoir	TOP UP FLUID LEVEL	5
T	Oil Cleaner	RENEW CARTRIDGE	10

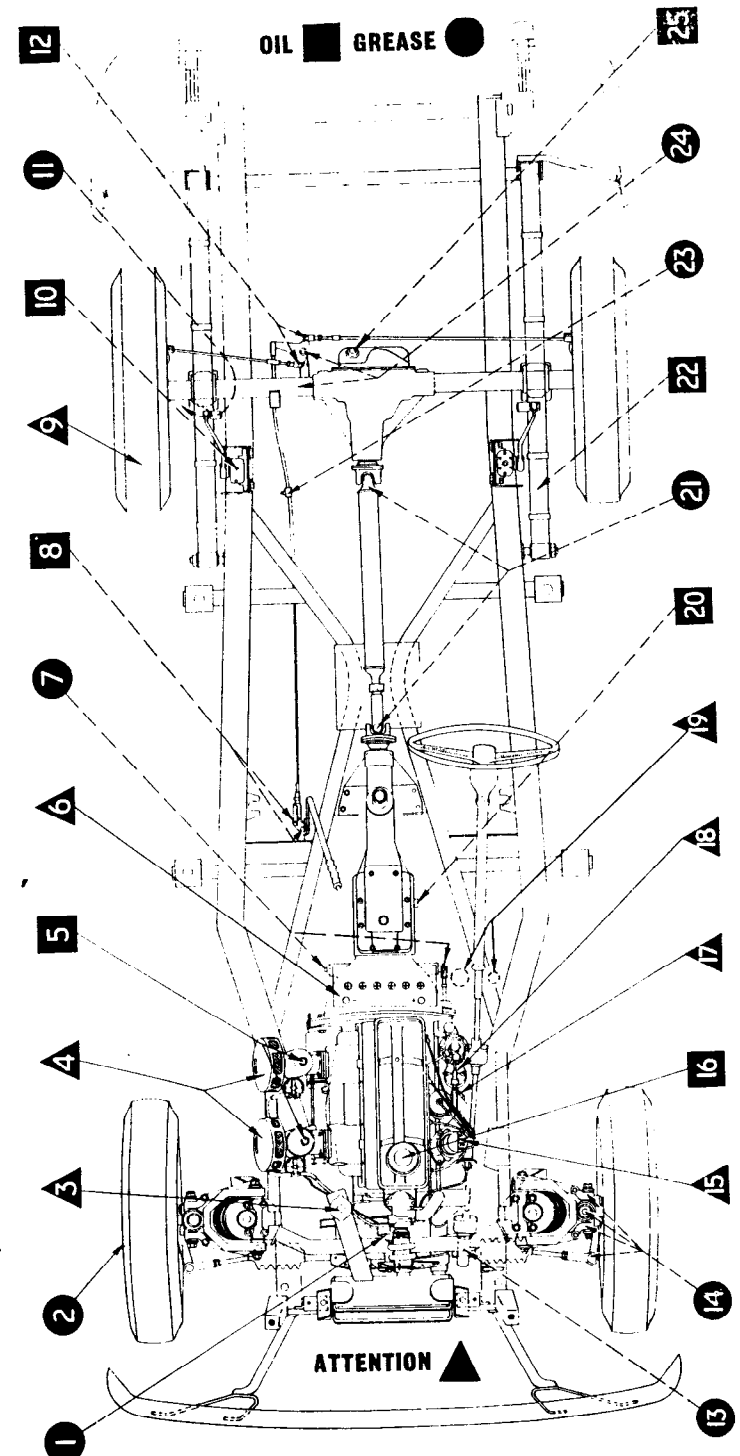


Fig. 38. Triumph TR4 Lubrication Chart

The Recommended Lubricants for the Triumph TR2, 3, & 3A

BRITISH ISLES

COMPONENT	SHELL	ESSO	DUCKHAM'S	VACUUM	WAREFIELD	B.P. ENERGOL	
ENGINE	Summer	Shell X-100 30	Essolube 30	Duckham's NOL "Thirty"	Mobiloil A	Castrol XL	Energol S.A.E. 30
	Winter	Shell X-100 20/20W	Essolube 20	Duckham's NOL "Twenty"	Mobiloil Arctic	Castrolite	Energol S.A.E. 20
	Upper Cylinder Lubricant	Shell Donax U	Essomix	Duckham's Adcoids	Mobil Upperlube	Castrollo	Energol U.C.L.
GEARBOX	Shell X-100 30	Essolube 30	Duckham's NOL "Thirty"	Mobiloil A	Castrol XL	Energol S.A.E. 30	
REAR AXLE	Shell Spirax 90 E.P.	Esso Expee Compound 90	Duckham's Hypoid 90	Mobilube G.X. 90	Castrol Hypoy	Energol EP S.A.E. 90	
STEERING GEARBOX	Shell Spirax 140 E.P.	Esso Expee Compound 140	Duckham's NOL EPT 140	Mobilube G.X. 140	Castrol Hi-Press	Energol E.P. S.A.E. 140	
PROPELLER SHAFT JOINTS	Shell Spirax 140 E.P.	Esso Expee Compound 140	Duckham's NOL EPT 140	Mobilube G.X. 140	Castrol Hi-Press	Energol E.P. S.A.E. 140	
FRONT WHEEL HUBS	Shell Retinax A	Esso High Temperature Grease	Duckham's L.B.10	Mobilgrease No. 5	Castrolcase W.B.	Energol C3	
REAR WHEEL HUBS and ENGINE WATER PUMP (Hand Gun)		Esso Grease	Duckham's H.B.B.	Mobil Hub Grease	Castrolcase Heavy		
CHASSIS. Grease Nipples (Hand or Pressure Gun)	Shell X-100 20/20W	Essolube 20	Duckham's Laminoid Soft	Mobilgrease No. 4	Castrolcase CL	Energol S.A.E. 20	
Oil Points (Oil Can) Body and Chassis			Duckham's NOL "Twenty"	Mobil Handy Oil	Castrolite		
REAR ROAD SPRINGS	Shell Donax P	Esso Penetrating Oil	Duckham's Laminoid Liquid	Mobil Spring Oil	Castrol Penetrating Oil	Energol Penetrating Oil	
ALTERNATIVELY USE REAR AXLE OR ENGINE OIL							
HANDBRAKE CABLES	Shell Retinax A	Esso Graphite Grease	Duckham's Kennol KG 16	Mobil Graphited Grease	Castrolcase Brake Cable Grease	Energol C3G	
BRAKE RESERVOIR	GENUINE LOCKHEED HYDRAULIC BRAKE FLUID						

The Recommended Lubricants for the Triumph TR4

COMPONENT	MOBIL	SHELL	ESSO	B.P.	CASTROL	DUCKHAM'S	REGENT
ENGINE SUMP*	Mobiloil Arctic or Mobiloil Special	Shell X-100 20W or X-100 Multigrade 10W/30	Esso Extra Motor Oil	Visco Static Energol Motor Oil 20W or Visco Static Longlife	Castrolite	Duckham's Nol 'Twenty' or Duckham's Q20/50	Havoline 20/20W or Havoline Special 10W/30
CARBURETTOR DASHPOTS	Mobiloil A	X-100 30	Esso 30	Energol Motor Oil 30	Castrol XL	Nol 'Thirty'	Havoline 30
			Esso 20	Energol Motor Oil 20W	Castrolite	Nol 'Twenty'	Havoline 20/20W
GEARBOX AND OVERDRIVE REAR AXLE	Mobilube G.X. 90	X-100 20W	Esso Gear Oil GP.90/140	Energol S.A.E. 90 E.P.	Castrol Hypoy	Duckham's Hypoid 90	Universal Thuban 90
			Esso Multi-Purpose Grease H	Energol L.2	Castrolcase L.M.	Duckham's L.B.10	Marfak Multipurpose 2
STEERING UNIT GREASE	Mobilgrease M.P.	Shell Spirax 90 E.P.	Esso Multi-Purpose Grease H	Energol S.A.E. 20W	Everyman Oil	Duckham's General Purpose Oil	Havoline 20/20W
FRONT WHEEL HUBS	Mobil Handy Oil	Shell X-100 20W	Engine Oil	Energol S.A.E. 20W	Everyman Oil	Duckham's General Purpose Oil	Havoline 20/20W
OIL CAN	Mobil Handy Oil	Shell X-100 20W	Engine Oil	Energol S.A.E. 20W	Everyman Oil	Duckham's General Purpose Oil	Havoline 20/20W
REAR ROAD SPRINGS	OLD REAR AXLE OR ENGINE OIL						
BRAKE CABLES	Mobilgrease Special or Mobilgrease M.P.	Shell Retinax A	Esso Multi-Purpose Grease H	Energol L.2	Castrolcase Brake Cable Grease	Duckham's Kennol K.G.16	Marfak Multi-Purpose 2
CLUTCH AND BRAKE RESERVOIR	CASTROL GIRLING BRAKE AND CLUTCH FLUID TO S.A.E. 70 R3 SPECIFICATION		LOCKHEED SUPER HEAVY DUTY BRAKE FLUID		WHERE THE PROPRIETARY BRAND IS NOT AVAILABLE, OTHER FLUIDS WHICH MEET THE S.A.E. 70 R3 SPECIFICATION MAY BE USED		
	GIRLING SYSTEM		LOCKHEED SYSTEM				

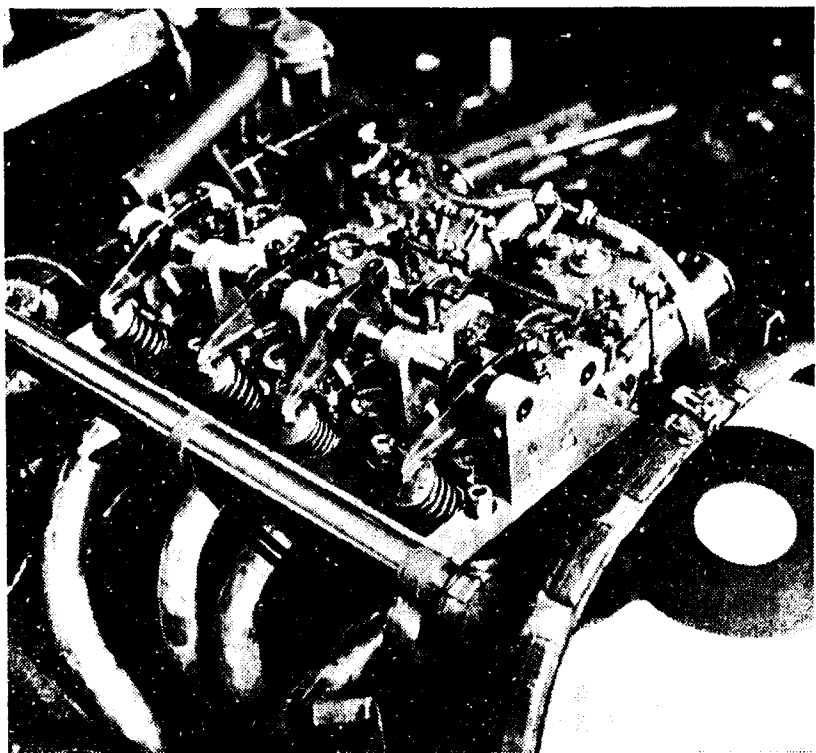


Plate 11
The Lawrence-Tunc crossflow cylinder head shown with the rocker cover removed

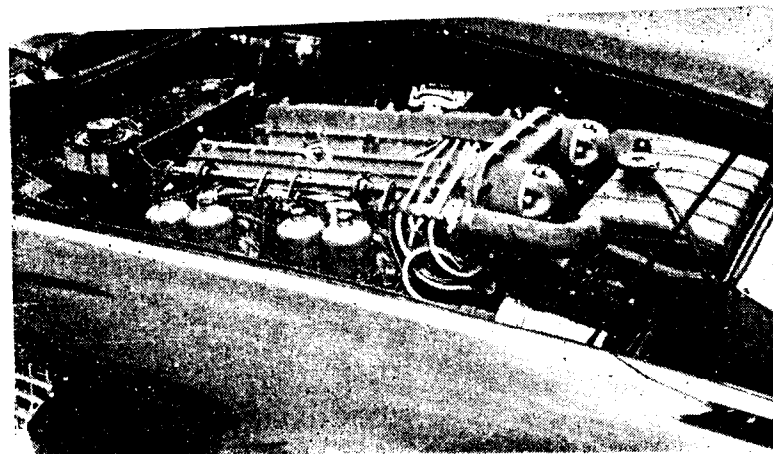


Plate 12
A very exciting twin cam engine was fitted to the TR4 prototypes for Le Mans 1961.
Output was 156 b. h. p.



Plate 13
The TR4 prototypes made use of rack and pinion steering which was retained in the production versions