2.2 Prototype and Non-Production Engines

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TEST OF A THREE-CYLINDER TWO-STROKE

High Acceleration Coupled with Even Firing and Freedom from Lubrication Troubles are Features of a Scott-designed Power Unit

By Laurence Pomeroy

Readers may recall the controversy in *The Motor* some time ago on the relative merits of two and four-stroke engines. Both sides raised some interesting points, but from a practical standpoint a difficulty arose. Whereas there were many four-strokes to take as examples, the only two-stroke car that could be cited was one of foreign origin, which also included other unorthodox features such as front-wheel drive and unusually low frontal area. Obviously wanted, as a means of putting the matter to the test, was a normal car in which a two-stroke engine had been substituted for the orthodox four-stroke.

One might have thought it impossible to find a car of this type, but it came to my knowledge that the very thing was being run for experimental purposes by the Scott Engineering Co.

The fame of Scott in the motorcycle world is legendary, but the company is now engaged on a large number of specialized engineering products, many of them of first-class importance.

However, some time prior to the war, in fact, as far back as 1934, they designed a 1-litre engine which was intended to run at a constant speed of about 2,700 r.p.m. and to drive an electric generating set. This engine was quite different from anything they had previously produced for motorcycles, and as the generating plant did not come to fruition, they decided to try the engine in a car. A light sports type was purchased, normally fitted with an engine of 1.2-litres, and this was taken out and the Scott engine of .98-litre installed.

This unit is not all that the Scott people think a car engine should be. It was not designed for an automobile in the first place: it has merely been adapted for road use so as to get experience and data. Nevertheless a road test, carried out over a considerable distance and including a famous Northern hill, shows the performance to be highly satisfactory.

One of the best ways of gauging performance is by means of the Tapley meter, which is an accurate method of determining acceleration. The higher the Tapley "Q" figure, as it is termed, is shown on the instrument, the more rapid the acceleration. A really large car with superlative top-gear performance will give a figure of, say, 300, whereas a normal 1-litre model will give about half that value.

Knowing the weight, gear ratio and engine size of any given car, the normal "Q" figure in acceleration can be calculated, and in the car under review the top gear was 4.5 to 1 (making 50 m.p.h. equivalent to 3,000 r.p.m.), the weight with driver 14½ cwt., and the capacity approximately 1 litre.

This should give a "Q" figure of 150, so having rigged up my instrument I was interested to see what the realized figure would be on the road. The car started up readily, and having been led to expect a high performance, I was at the beginning to be disappointed to find that the acceleration at 30 m.p.h. was only the calculated average. This, however, seemed to be due to an incorrect carburettor adjustment at low speeds, for as the r.p.m. rose the performance increased until at 40 m.p.h. the acceleration was over 40 per cent. better than might be expected, and this remarkable improvement was maintained right the way up to the high speed range.

With the normal engine the car has a maximum speed of approximately 70 m.p.h., but this becomes a comfortable cruising speed with the three-cylinder engine. Furthermore, so great is the power of the latter at around 3,000 r.p.m. that it will actually take the car up a 1 in 16 gradient at a timed 60 m.p.h., whilst accelerating from 40-60 m.p.h. it takes only 11.5 secs., a figure which is only normally achieved by cars having a far superior capacity to weight ratio.

These extraordinarily good top-gear figures are, of course, reflected in the lower ratios. Northern motorists will, I think, be interested to know that Holm Moss was climbed from the Holmfirth side at a steady 35-40 m.p.h. in third gear, which is 6.3 to 1, i.e., with the engine holding 3,000-3,300 r.p.m. The source of these high speeds is clearly evident from the power curve.

It will be seen that over the greater part of the speed range the output is higher than one can expect from even a first-class four-stroke incorporating such refinements as hemispherical head with inclined valves. The two-stroke gains little in respect of maximum power, and this bears out the impression I have had for many years that for sheer ultimate horse-power the four-stroke is supreme. The effective valve opening of the two-stroke is not sufficient for really for really high r.p.m., but it is, as the curve shows, quite adequate to permit a very useful improvement in the middle part of the speed range.

It is just in this part of the speed curve that the utmost power will be required for future cars, particularly of the sports type. Streamlining will make, say, 45 b.h.p. amply sufficient for 90-100 m.p.h. on a small car, but in order to maintain such speeds with reliability, top gears must be raised and acceleration must suffer unless the power can be increased in the lower part of the speed curve.

From the evidence of the Scott, it is apparent that a well-designed two-stroke can make a useful contribution in this direction. Thus, whereas at 2,000 r.p.m. a normal 1-litre engine will be doing well to develop 18 h.p., it will be seen that the Scott develops 23 h.p., a gain of 27 per cent.

Now let us see if this gain in power is achieved at undue cost. Does it involve difficulties in maintenance, for instance, special methods of driving, or charge the owner with the responsibility of mixing oil with the petrol?

Lubrication has often been the bugbear on two-stroke engines, resulting in uneven firing, a smoky exhaust and the complication of mixing up oil and fuel together before filling the tank. In the Scott design these problems have been tackled by radical departures from normal practice. One fills the sump with oil in the manner normal to a four-stroke engine, petrol is supplied to the carburetter by a mechancially driven fuel pump, but this is by no means normal.

Various types are being developed by Scott, but each one incorporates the principle of being a double-acting pump, taking up, at the same time, fuel from the petrol tank and oil from the sump. The pump mixes these in the required proportions before passing them into the carburettor. I say "required proportions" because the ratio of oil to petrol is not kept constant but is increased as the demand for petrol increases rises and loads go up. Thus, little oil is passed into the engine under part throttle conditions when there is danger of plugs oiling.

The unorthodox characteristics of the lubrication system are not, however, confined to this method of supplying the required oily mixutre. The compression chamber into which the charge is initially drawn is separate from the sump, and, of course, there is one chamber to each cylinder, the crankcase being divided off into separate compartments, as it were.

The fuel, having been compressed by the down-going piston, travels up the transfer port into the cylinder but in so doing is taken round through a sharp angle which centrifuges the oil from the petrol-air-mixture and traps it in a small trough which is above the level of the crankshaft. From this trough there are drilled passages into the crankshaft. When the piston comes down again on the firing stroke and pressure is built up in the crankcase, the adjacent piston is rising and there is a depression in the next-door pumping chamber. As a result, the oil starts to travel down the crankshaft by reason of the pressure difference, and in doing so lubricates the main and big-end bearings, eventually being returned by gravity to the sump. It will thus be seen that as compared with the normal two-stroke engine the oily charge is not fed right through the cylinder, and this eases the life of the plug and greatly retards the building of carbon around the exhaust ports.

I found that Lodge HD14 plugs stood up perfectly well, and in the course of driving through Northern industrial areas as well as at high speeds on the open road I suffered from neither plug wetting nor pre-ignition. The cooling of the engine has indeed been very carefully attended to. A light alloy head is used with carefully designed water passages, and there are even drilled passages put through the bars on the exhaust ports, these bars being, of course, necessary in order to prevent the piston ring springing out as it passes the port.

A point I was not able to check was whether the oil in the sump becomes diluted by its constant association with the ingoing charge. But I was assured that this was not so, as the crankcase normally runs at a fairly high temperature—round about 65 degrees C., which is sufficiently high to evaporate any left-over fuel.

This new method of lubrication seemed to me to be a very important step towards making the two-stroke engine a satisfactory unit for normal public consumption. It relieves the driver from any new obligations, for he is already trained by four-stroke practice to look after the sump level and refill the petrol tank.

So far as maintenance is concerned the three troubles most commonly associated with two-stroke engines, apart from the elementary one of lubrication (to which I have referred) are piston seizure when running hard, sticking of piston rings and carboning of the exhaust ports. As I have remarked, the latter should be greatly reduced by the separation of the oil from the petrol, whilst the former has been entirely abolished by careful cooling and by good piston design. The sticking of piston rings has been overcome by using the modern type of taper rings with the side faces machined at a slight angle.

There seems, therefore, no reason why an owner should be involved in any difficulties of maintenance. Rather the contrary. There are no valves to need grinding or adjustment, decarbonizing is as easy as on a side-valve unit, and judging by results obtained on other two-cycle engines cylinder wear should be virtually nil.

The most serious disadvantage is undoubtedly the comparatively high fuel consumption. Whereas one would expect a car of the type tested to do about 30 m.p.g., the figure I actually attained was about 25 m.p.g. I grant that this was with really hard driving, but even so it would seem fair to assume consumption would normally be at least 25 per cent. greater with the two-stroke unit. This means that with petrol at 2s. a gallon a mileage of 15,000 p.a. involves an extra cost of approximately £10 per year. Against this can be set a reduction in repair charges, elimination of cylinder rebores, etc.

My experiences with this particular unit do not encourage me to suppose that the three-cylinder engine is a very satisfactory type as such. The inevitable out of balance couple gave rise to considerable vibrations at certain speeds, although it is fair to add that above and below these speeds it was very smooth. There would, however, be no difficulty in producing a four-cylinder design, and this would achieve normal standards of balance coupled with the even torque flow usually associated with a straight-eight. Whether the Scott Co. will produce such an engine in post-war years I cannot tell. Certainly their war-time commitments make it impossible to produce any new engines at the present time. The performance of the present job on the road, however, does show that for acceleration and hill-climbing the two-stroke has very real merit. Additionally, it is simple, reliable and durable, whilst the patented Scott fuel-oil pump, coupled with the pressure lubrication, seems a highly satisfactory method of overcoming a chain of difficulties which have, in the past, done much to impair its popularity.

THE SCOTT G.P. ENGINE

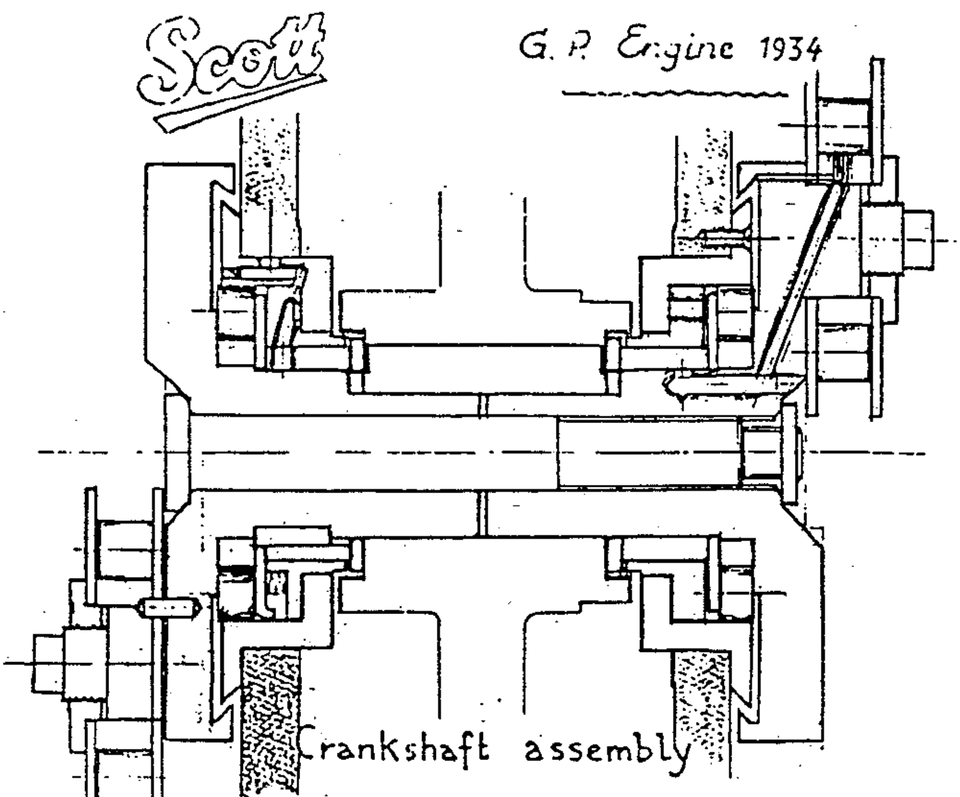
This article has been prepared as the result of the kind loan of an engine (GPY 4034) by Philip Bewley (a new member of our Club) who succumbed to the temptation, which I had previously resisted, to bid for a "box of bits" at Sotheby's Auction at this year's Classic Bike Show at Stafford.

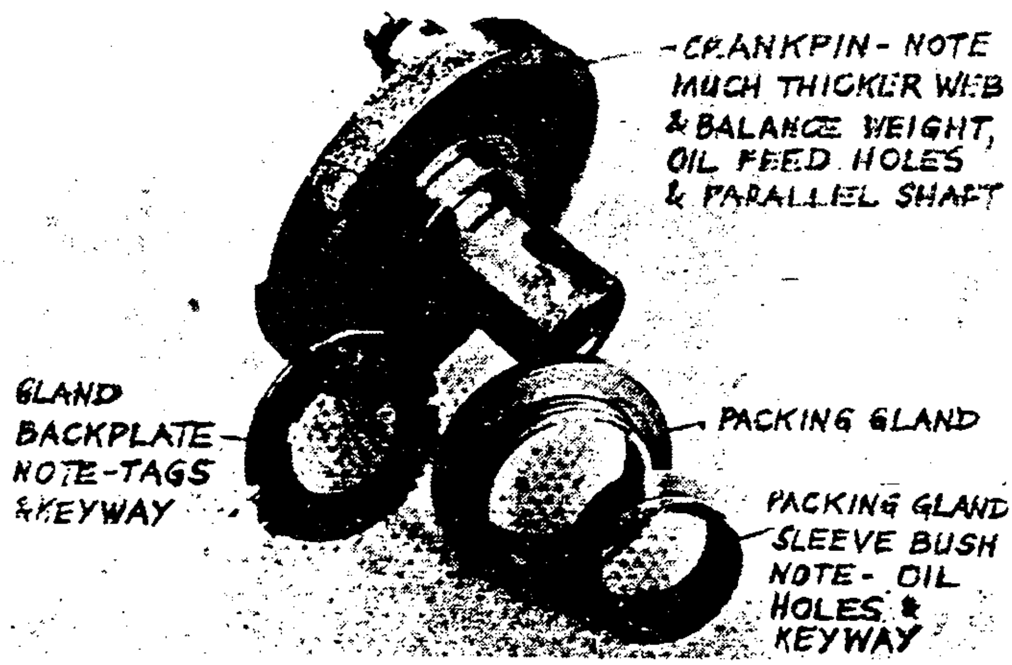
The Scott Grand Prix engine introduced in 1934, and intended for fitment to the T.T. Replica model, was appreciably different to the conventional Scott engine as a study of the accompanying photographs and sectioned drawing will show.

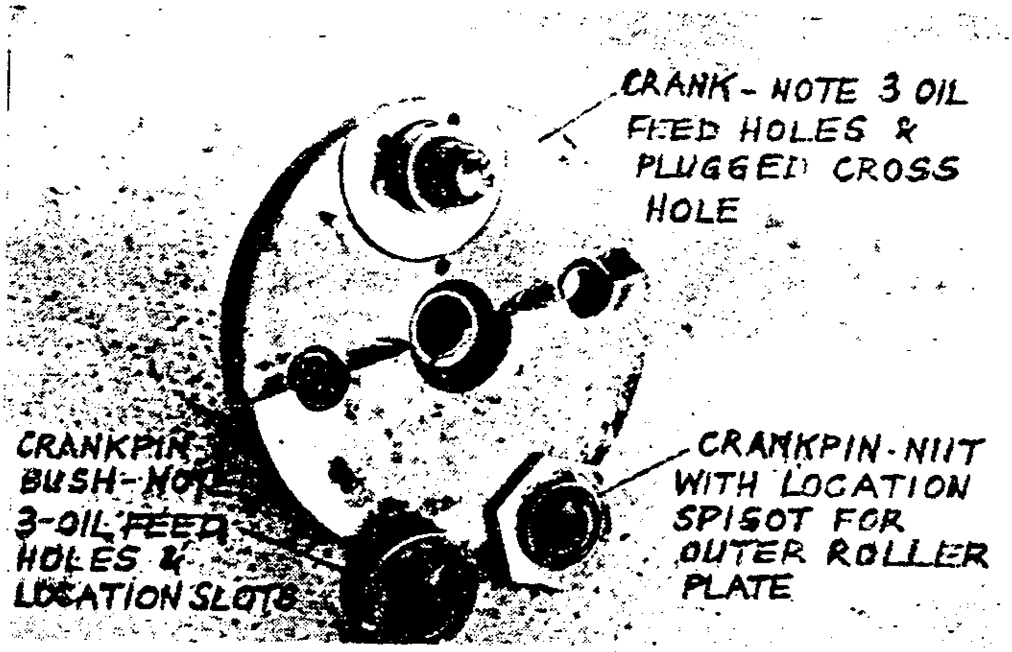
In relation to the 'bottom end' of the engine; one of the main differences was the adoption of parallel fitting of the cranks to the central flywheel, although the reasons for the change from the tapered fitting, which had been employed successfully since 1908, is not known. There were also differences to the flywheel; the gearbox drive sprocket having a flange and spigot location secured by six bolts, tab-washered in positions from the opposite side (behind the magneto drive sprocket) screwed into the flange. On the opposite side the magneto drive sprocket was located on a spigot register up to a shoulder, and secured with a single screw. I have seen photos of similar machines having a bevel gear-driven magneto mounted on the nearside crankcase, but his particular engine was arranged differently. The flywheel had the usual central key for location of the cranks.

Apart from the change to parallel fitting, there were other major differences in the cranks where it was obvious that the designer (Bill Cull?) had wrestled with the problems of lubrication to glands, main bearings and big-ends and also fracturing. The cranks and all the related components, with the exception of the main bearing bush, were special, and the majority of the components were handed R.H. or L.H. The crank itself was stiffened up considerably with thicker web and balance weights into which were two tapped holes, presumably for extraction purposes.

Lubrication to the big-ends was via two holes drilled from the outer face to the vee undercut recess at the back of the crank disc, through two matching holes in the inner roller plate, which was trapped behind the crankpin bush which also had two matching holes drilled halfway connecting to two holes at 90° to the crankpin bearing diameter. To ensure alignment of these holes, the inner roller plate and crankpin bush were located by two small projecting pegs. In addition a third oil hole was drilled angularly from the crankpin to meet another hole drilled horizontally at a small radius (plugged on outer side of crank disc) to connect with another hole and groove adjacent to the main bearing bush. Another radial hole in the crankpin bush mated up with this angular hole so that the big-ends were supplied (hopefully) from

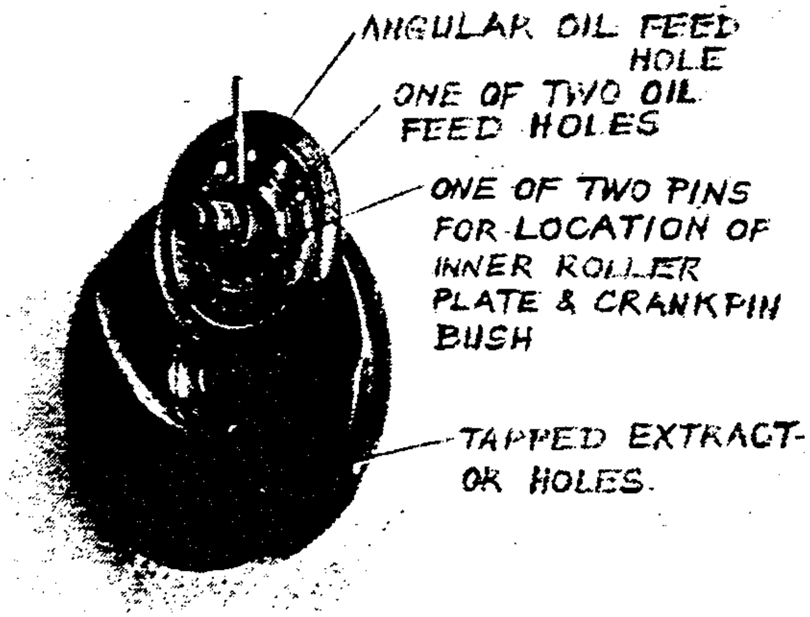


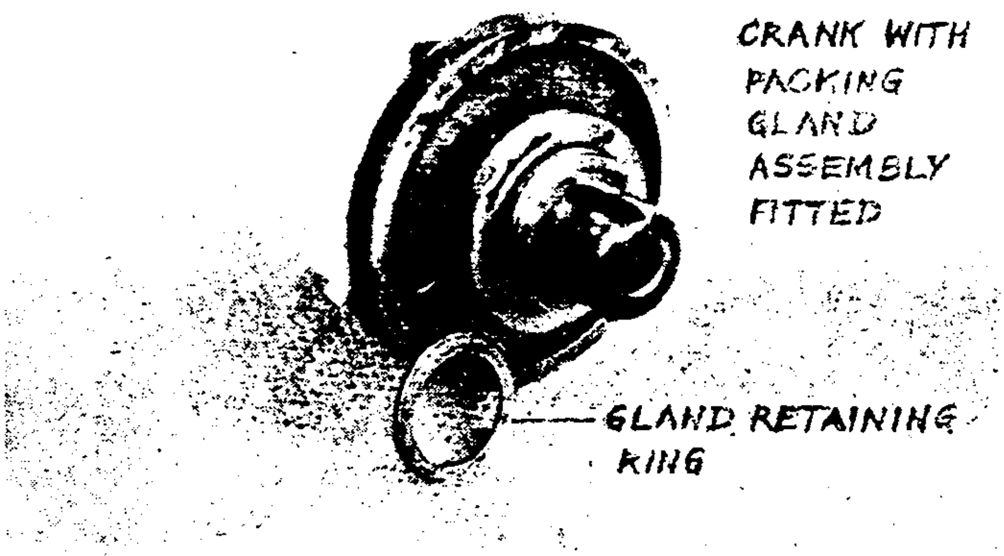




any one, or all three places. The outer roller plates were located on a short spigot on the hexagon retaining nut screwed on to the male threaded RH or LH crankpin, which also differed from the usual construction. The cranks were secured together to the central flywheel by means of a larger than standard (½" x 24 TPI) bolt and L.H. threaded locknut.

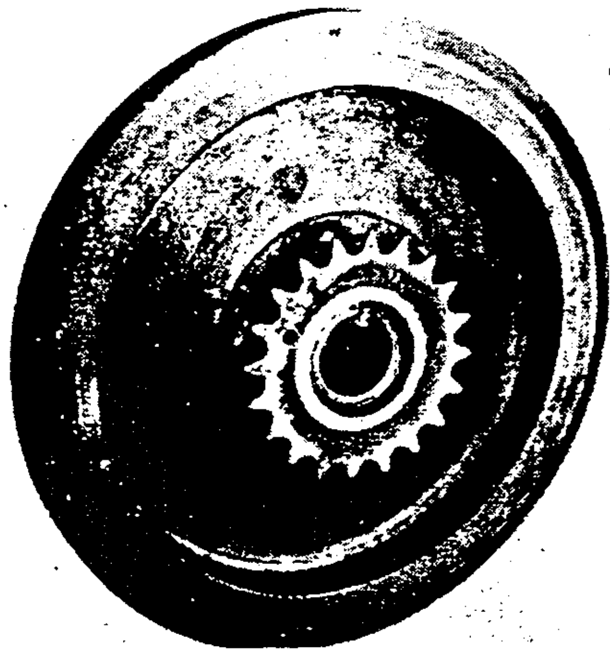
The gland arrangements were also special. Immediately behind the main bearing bush (which was *not* retained in the usual way with a threaded plate) was a pressing with three tongues projecting inwards on the outside diameter and keyed to the crank. The face type gland had three radial recesses which registered with the three tongues previously mentioned and encompassed three short compression springs approx. ¼" DIA x /4" LONG to provide the spring loading of the gland against the crankcase cup. The gland floated endways on a

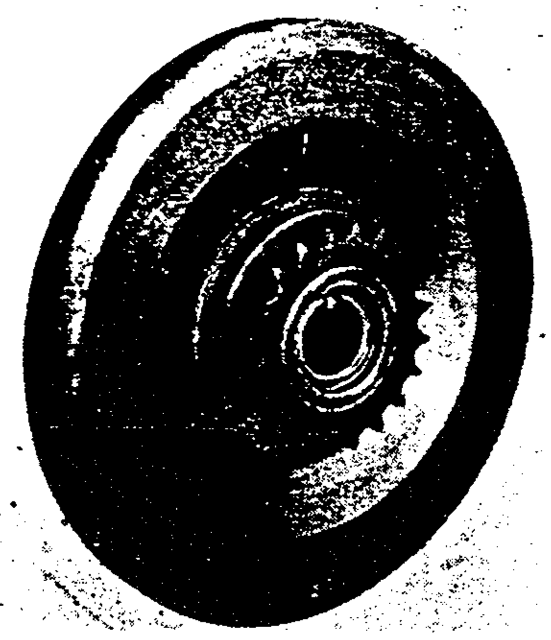




hardened sleeve bush which was fractionally longer than the gland and also keyed to the crank. Both gland and sleeve had three mating radial holes to receive and distribute oil from the supply to the crankcase cup. On the gland face was a radial slot and three axial holes which connected with the radial holes. The gland and sleeve assembly was retained on the crank by a thrust washer which was a close fit on the crank and the two crank assemblies were bolted up to the flywheel boss faces in position in the crankcase with shimmirg applied between the thrust washer and flywheel boss to ensure the required end float.

The crankcase was I believe machined up from a standard casting, but differed in two major respects. The crankcase cups were more substantial, being arranged with a large outer flange secured to the crankcase by six small screws; there were no shroud rings. The oil drillings in the crankcase cup were also arranged differently with

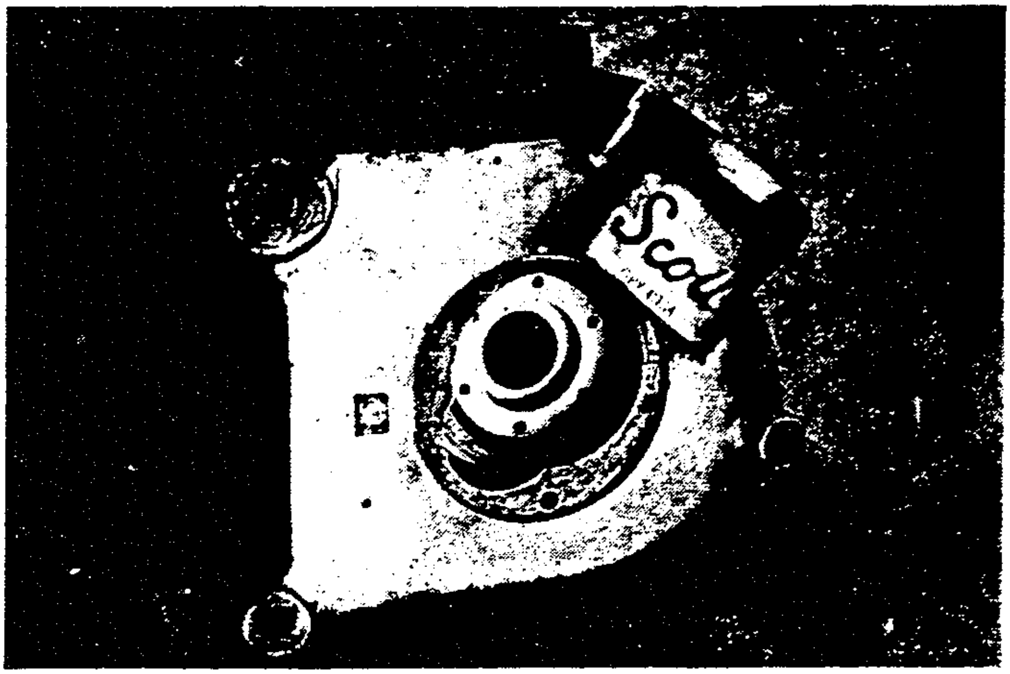


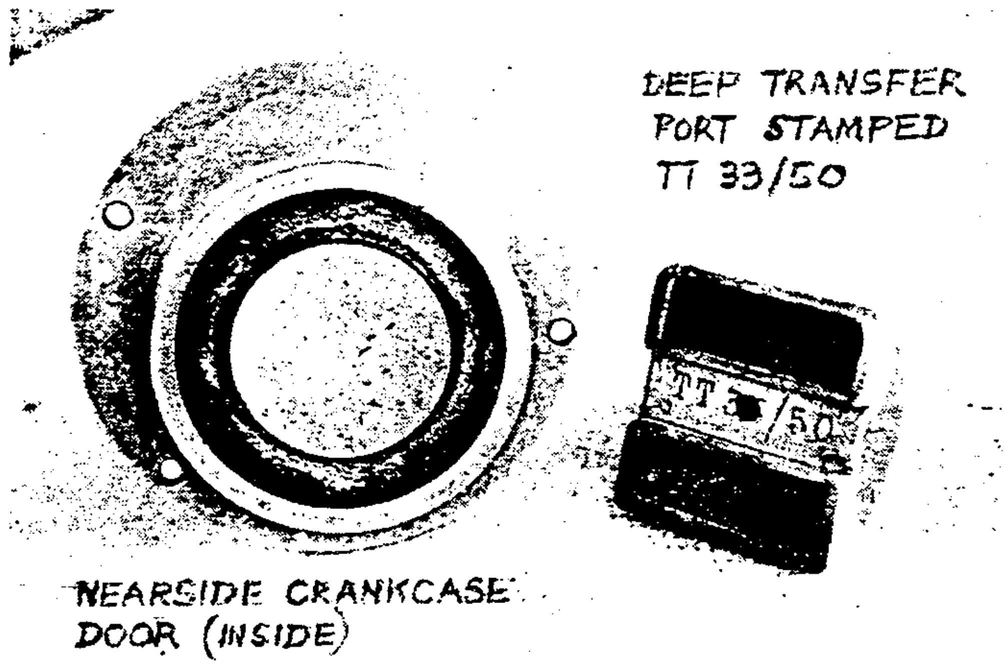


'plugged' axial drilling connected to a radial drilling with the objective of getting the oil into the corner of the gland face.

The crankcase door openings were also very large with offset recess and special nearside crankcase door, which was face fitting and secured by three unequally spaced fixing screws (no door straps or clamps) so that when fitted together it was perfectly flush. A special Scott swash-plate pump was fitted on the offside crankcase, feeding the main bearings in the usual place and the cylinder wall oiling arrangement identical to the subsequent 'Clubman Special' models, (which of course had two duplex Pilgrim pumps).

I believe that of the ten or so engines which were made several had problems with crank fracturing, as the borrowed crankcase had been welded up in the usual places, and if one examines the construction more closely the following observations could be made:-





1) The diameter-to-length proportions were poor — This was not as rigid as the standard taper arrangement.

2) There had to be clearance, however small, for the crank to be fitted to the flywheel as the cranks had to be assembled with the flywheel in position. This clearance probably gave rise to 'fretting' of the key.

3) The 'overhang' of the *much heavier* crank mass from the point at which the crank emerged from the flywheel should be noted and was obviously a disadvantage.

Summing up — This was a brave attempt to improve the Scott engine and produce more power, but it was not successful and so the original basic design continued for another 18 years until the end of production in 1951.

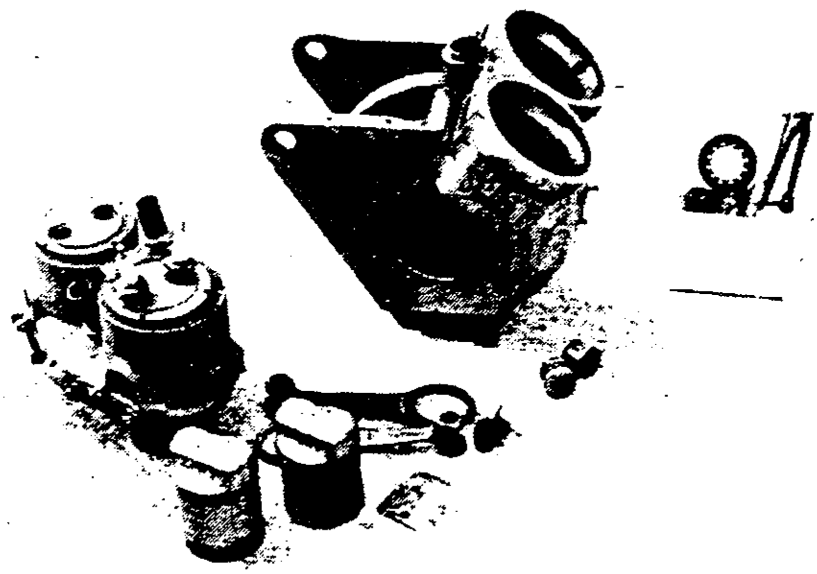
John Underhill.

Four-spark Squirrel

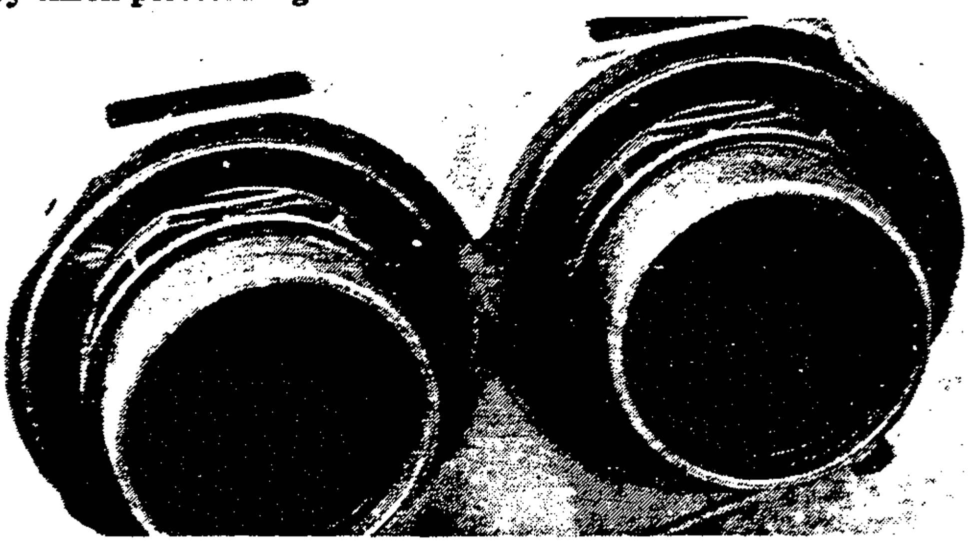
Dear Tom,

Enclosed are some close-up photographs of a dismantled 1923 four-spark Squirrel (486cc) engine that members may find of interest. The 'flats' at the cylinder spigots, and odd-shaped ports are intriguing. I still have the bottom end of the engine, but the block has been sold to one of the Light brothers and MIGHT appear in this year's Banbury Run.

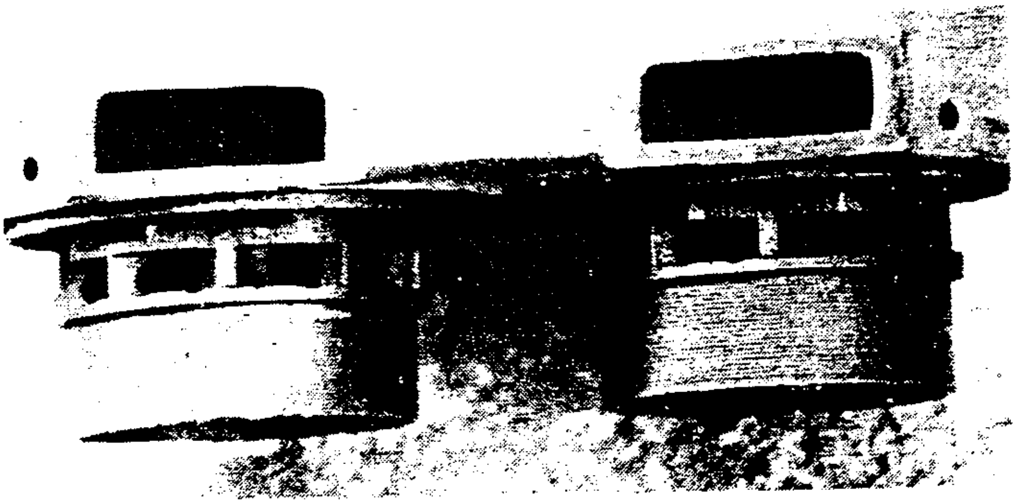
Brian Marshall.
Aslockton, Nottingham.



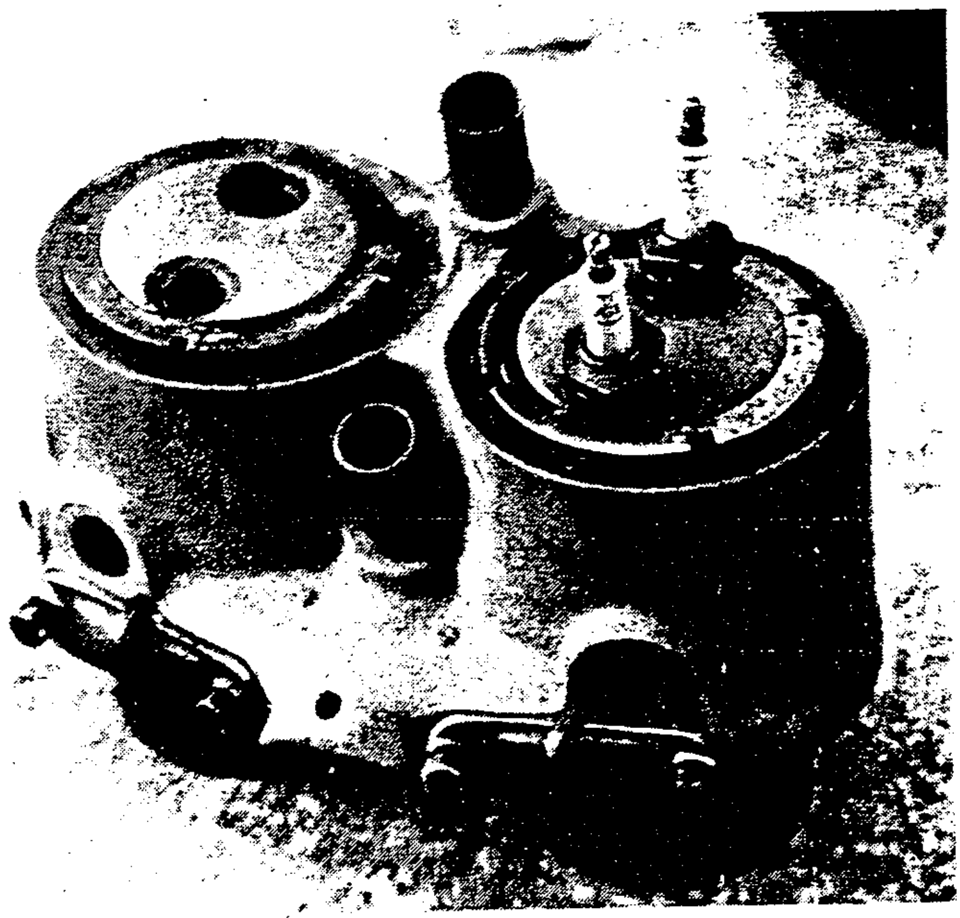
Dismantled 486cc four-spark Squirrel engine. Number 6327 dates it to 1923. Pistons are alloy, but shaped with steep sides to the deflectors, just like the old cast-iron pistons, and with very thick piston rings.



The 'flats' at the cylinder spigots can be clearly seen in this shot, together with oil-retaining grooves (?) in the bottom of the cylinders.



Ports appear to be just drilled through, and not 'squared-off'; remarkably crude.



Close-up of the cylinder barrel shows the twin plug positions; not quite vertical. If the VERY special four-spark magneto was not available, two holes could be blanked off, and a 'normal' magneto employed. See photo on page 101 of *The Scott Motorcycle* by Jeff Clew for the origins of this particular design, the 1922 TT machines.

THE BRADLEY INLET VALVE

by *Philip H. Smith,* M.I.Mech.E.

Some time ago, "Yowl" published a few particulars of "Felix," the all-conquering Scott Special combination, built by Bill Bradley in 1925, and which is still going strong. "Felix" however was much more than a highly unusual sidecar outfit. For over ten consecutive years the machine served as a mobile test-bed, on which many inventions aimed at better Scotting, were tried out. The same thing has been going on, at longer intervals, ever since. And apart from motorcycles, Bill has been inventing and patenting mechanical things all his life; his last patent was taken out last year, around his 80th birthday!

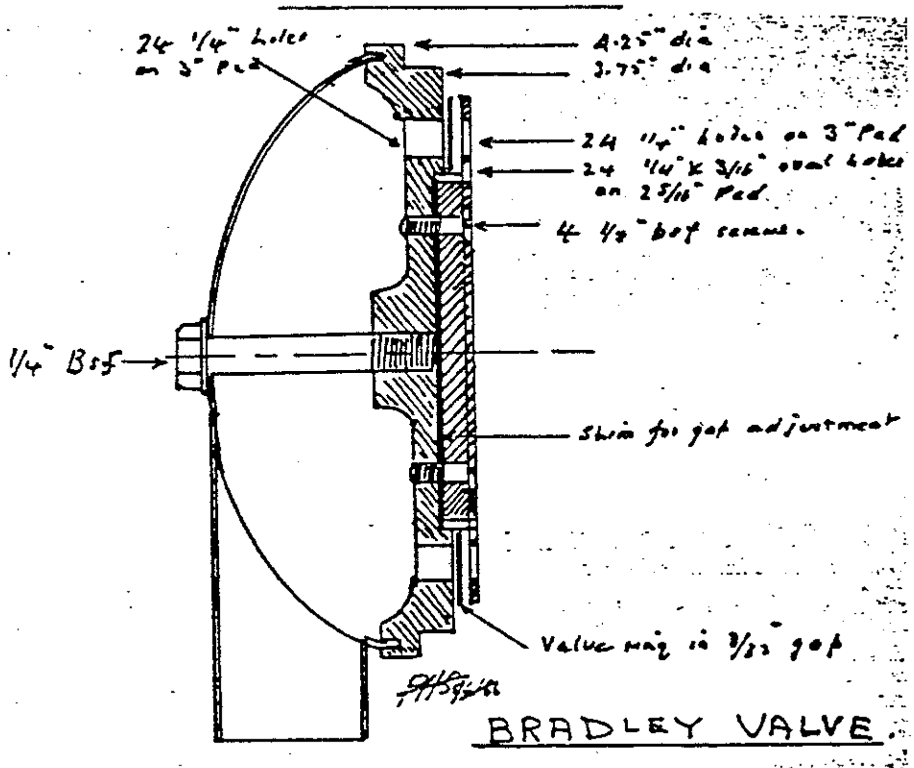
Amongst the most successful modifications ever fitted to "Felix" was the Bradley plate-ring type inlet valve, duplicated on each crankcase door opening. This is the kind of development on which Scott enthusiasts might really want to "go to town," though rather surprisingly, little interest has been shown by the few who have actually viewed the valve assemblies in the flesh. However, a description may arouse interest, as it should be pointed out that employment of such an inlet valve, instead of the standard port system, enables internal alterations to be made to the engine which materially improve the scavenge efficiency.

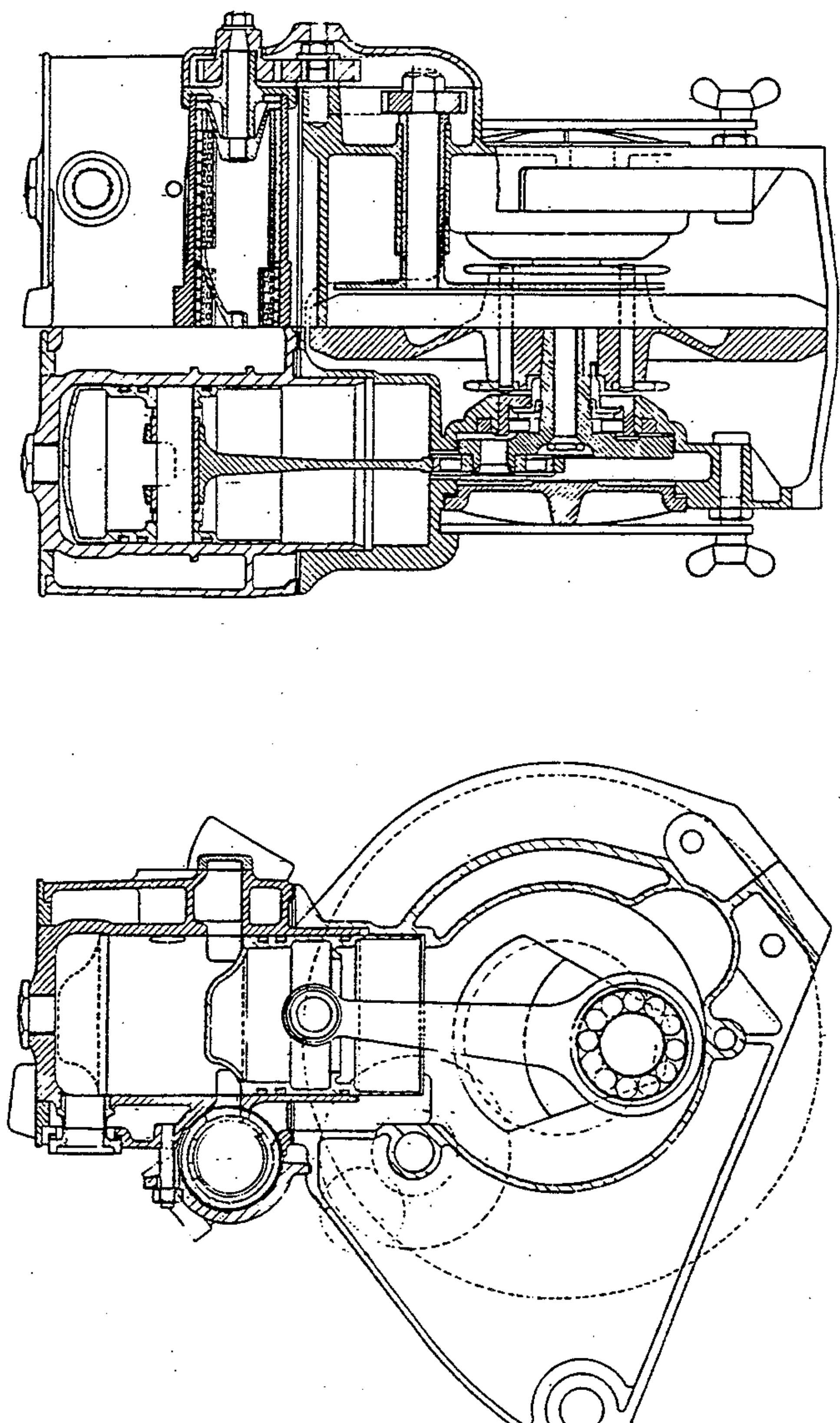
Each valve assembly comprises a plated outer chamber shaped like a bell-gong (that being in fact what it is). Into this, an induction stub is brazed. The open side of the bellhousing is closed by a circular aluminium plate, suitably turned with a spigot for the door opening. A second plate is firmly secured thereto by four screws and a central spigot, so as to leave a gap which is adjustable by shimming at the spigot. Between the plates, in the gap, a ring-shaped valve is located, and can float axially on the spigot. Both outer and inner aluminium plates are drilled around their outer diameters for passage of the gas, as shown in the sketch.

On the induction stroke, the depression at the holes in the inner plate pulls the valve-ring firmly in contact therewith, and allows the suction to be communicated over the inner and outer edges of the ring, and through the holes in the main valve-plate, to the bellhousing and induction pipe. On the crankcase compression stroke, pressure through the holes in the inner plate presses the valve-ring firmly in contact with the holes in the main plate, completely sealing off the crankcase from the induction system. In the manner of all plate and reed-valves of this type, an inherently variable timing is obtained, as dictated by engine load (see "The High-speed Two-stroke Petrol Engine," page 143).

One carburettor may be used, in conjunction with a long U-shaped induction pipe; alternatively two carburettore can be mounted, one on each bell-housing stub. Basic internal modifications to the engine involve blanking off the existing inlet ports and carburettor flange. However, since the piston skirt design is no longer determined by the necessity for inlet port control, a vast improvement can be made to the transfer duct entry, this being the most serious bottle-neck in the whole Scott scavenge system. Providing a properly designed exhaust system is also used to prevent loss of live charge, the increased volume of burnable mixture present on the firing stroke gives an appreciable increase in working pressure, and thus greater power, with no increase in rev/min. On the other hand, since the valves will operate at revs. up to 5,000 there is good maintenance of torque right up to peak.

Various materials have been used for the valve-ring, which obviously must be as light in weight as possible, but at the same time satisfactory from a sealing viewpoint, for which a degree of flexibility is desirable.





1913 T.T.
4 H.P. SCOTT ENGINE.

V3/5 May 1963

A reproduction of Alfred Scott's drawing number 384 of 1913, from a faded blueprint kindly lent by John Bever. Some slight imperfections could not be avoided in copying, and for clarity all dimensions, threads and fine cross-shading have been removed. Valve drive was from a thin brass gearwheel by the engine sprocket: this was of 3¼" pitch dia., with 55 teeth, and meshed with a similar one on a short shaft through the crankcase well. A series of 1-3/8" pitch dia. 23-teeth gears, with one idler, coupled the honeycombed valve rotor. Bore was 2-3/4", and the stroke 2½". Note the quickly detachable stator—unlike the 1912 engine. Forward sparking plug does not appear on the side-section, as it was at about 10° to the rear one.

THE 6-CYLINDER SCOTT TWO-STROKE

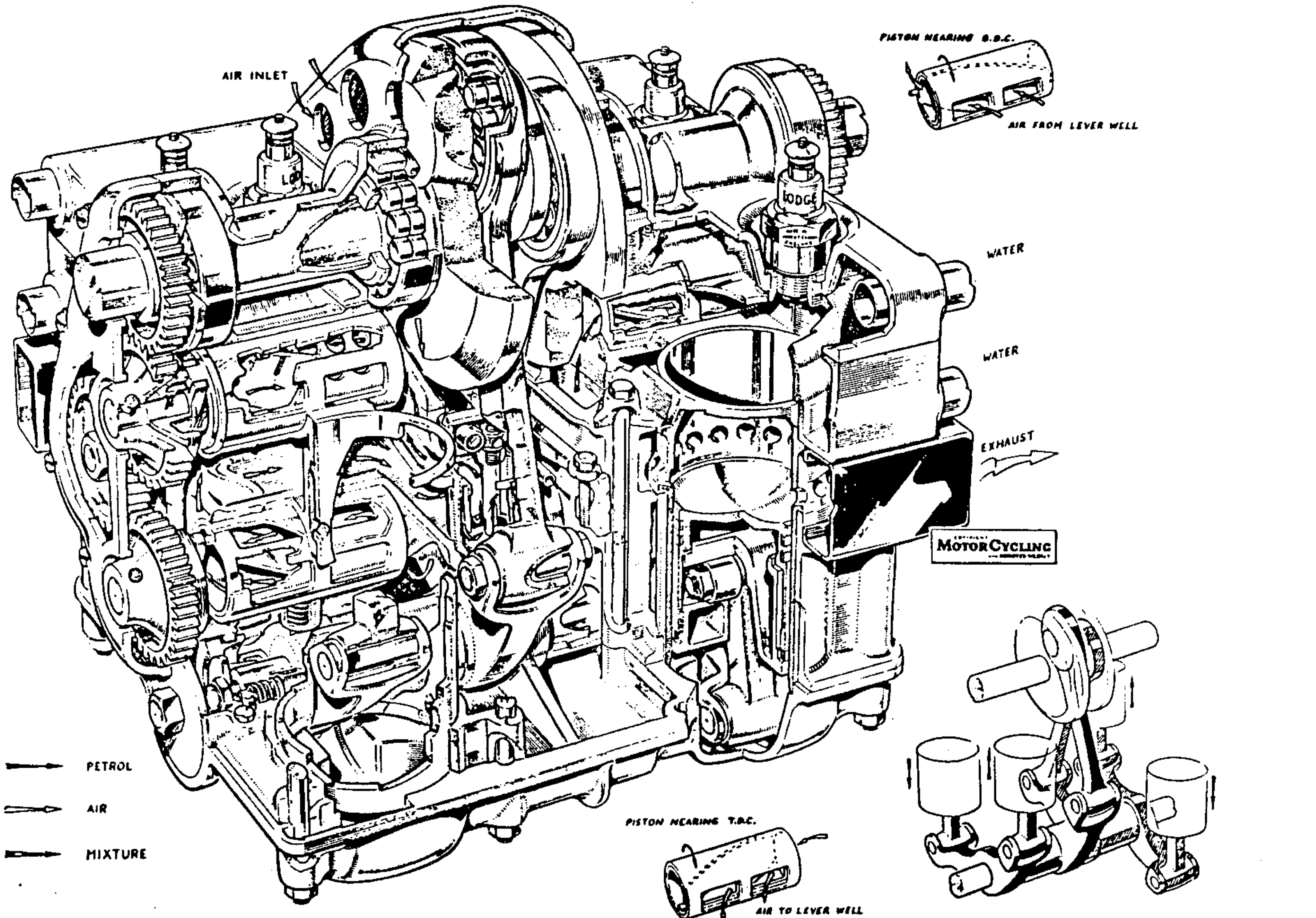
from Motor Sport, *February 1944*

Very considerable interest is aroused by the picture of a 6-cylinder Scott 2-stroke engine installed in a 1928 Aston-Martin, published in the December, 1943, issue of MOTOR SPORT, so we have pleasure in adding further details of the engine, kindly supplied by the owner, Dr. R. Wood. The Scott Company is normally associated with the famous 2-stroke motorcycle which it introduced before the last war, and with the curious 2-track, 3-wheeled Scott "Sociable" of the early nineteen- twenties. Some time before the outbreak of the present war a 1-litre 3-cylinder-in-line 2-stroke engine was announced, and experimentally installed in a popular make of small car. The 6-cylinder 2-litre 73 x 78 mm. version which Dr. Wood had installed in an Aston-Martin in 1937 was a development of the 3-cylinder engine. Deigned by Mr. Cull, it has called forth praise from Cecil Clutton and, indeed, showed a remarkably high output, giving 86 b.h.p. as supplied, while the designer claimed that it could easily be developed to give 126 b.h.p., or 170 b.h.p. unblown, if somewhat modified. The engine was of normal 3-port type, with cast-iron block and aluminium head, crankcase, sump, inlet pipe and transfer port covers. The crankshaft was of built-up 6-throw type with disc webs, running in eight double-row roller bearings. The front three throws were as in a normal 6-cylinder engine, and the rear three were at 120° to each other, No. 4 being at 180° to No. 1, thus giving a power stroke every 60° of rotation. The throws carried double-row roller races, round which were clamped the normal big-ends of the 2-stroke-type con.-rods, which had partially cut-away little-ends. the flywheel was normal Scott and carried a Borg and Beck clutch. The crankshaft carried a thick aluminium disc outside each main bearing and these exactly fitted tunnels, one in each of five crankcase webs.

Thus the crankcase (a single alloy casting) was divided to secure crankcase compression for each cylinder, sealing being by the oil film in the roller races. The transfer passages were formed internally, with a detachable plate for the outer wall, shaped to form a venturi. Separate sleeves in which the ports were accurately machined spigoted at their lower end into the crankcase and at their upper end into the cylinder block. The cylinder head had centrally disposed sparking plugs.

Cooling was by a pump, chain-driven from the front of the crankshaft. It had vanes set at 90° to the rotor and very effectively delivered water via an internal pipe to the area around each exhaust port. The pistons were normal Scott, with small saw cuts on the skirts to distribute oil round the cylinder bores. Lubrication was by a scavenge and a pressure pump in the sump, the former drawing oil from each crankcase chamber and returning it to the 2½-gallon sump. The pressure pump forced oil to two metering pumps, one at each end of the near side of the crankcase. These pumps were driven by swash-plates from an auxiliary shaft and had six plungers. The swash-plates were controlled in conjunction with the carburettor throttle opening so that the pump stroke increased as the opening increased, metering more oil to the bearings, etc.; the pressure pump actually supplied oil pressure, the auxiliary pumps merely controlling the supply. The auxiliary shaft was driven by roller chain from the front of the crankshaft, lubrication being by pressure-release from the main pump. Oil was fed to the junctions of the port sleeves and cylinders and to the cylinder bores as well as to the bearings. the engine had a safe speed of 6,600 r.p.m., limited only by the flywheel safety factor; it weighed about 350 lbs. and carburation was by two T.T. Amals.

(I am indebted to Charles Windsor for sending the above article and am grateful to Motor Sport *for permission to reprint it. I wonder if the possible development to give 170 b.h.p. should have read 'blown' rather than 'unblown'? Ed.)*



Alfred Scott's extraordinary rocking-beam 'square four' engine. I suppose this reconstruction by a *Motor Cycling* artist (from original drawings) must have appeared in *Yowl* at some time in the past. The rocking-beam principle is not too difficult to understand, but has anyone ever explained how the induction and exhaust systems worked? Ed.

(A *Motor Cycling* drawing)

ALFRED SCOTT'S 1917 'AEROFOUR' LEVER ENGINE

George Stevens

"Scott's Last Engine" I called it, 33 years ago, when bursting into print with the first published account of this fascinating proposal. That wasn't strictly true, of course; Scott's last engine was his ultimate production version of the Sociable motor, with double-row roller bearings, 'top hat' rotary inlet valves and petroil lubrication. But try making a snappy three-word title for an article about a 40-year-old, square four, rocking beam, overhead crankshaft engine!

Scott himself called it his 'Aero' engine (actually he spelled it 'Aereo'), but I will return to his reasons for that later. First, a little background history. Back in the middle years of the 20th century, I spent a lot of time and money chasing shadows. That is to say I sought out old men who had known Alfred Scott in their youth; searched through the National Archives and so on. I was very lucky. One of the greats was still alive and fairly well and living in Chislehurst. For help in finding him I shall always be grateful to Leslie Green, one of the old Scott Autocar Co. employees, and the A.C.U. Benevolent Fund. Herbert Oliver Wood ('Tim') had won the 1913 TT and come close to doing it again in 1914. He'd worked for and with Alfred Scott for many years, and they often went buzzing about Yorkshire together on test machines.

To cut a long story short: I wrote to 'Tim' Wood and he invited me to visit him. In December 1960 I made the trip to Lubbock Lane, Chislehurst, Kent. The old boy was slightly unsteady on his feet, due to Parkinson's disease, but mentally as bright as a trivet. His memory was excellent, his total recall of long-ago events surprisingly good. I took copious notes, mainly about the early days of Scott motor cycles and their riders. All Tim's memories matched the historical records. His yarns about TT racing on dusty stony Manx roads were fascinating, his knowledge of Scott rotary and semi-rotary valves, was, as one would expect, authoritative. I took some photographs, had some tea and was preparing to leave when Tim threw his little bombshell. Alfred Scott had designed a 'square-four' engine, he said, but he could not remember ever seeing one in the metal. I was intrigued and pressed for further information, but Tim couldn't recall any details, except that it was a bit like the Ariel square four.

I returned to the North West and scratched about looking for more of the old Scott men. Albert Reynolds and Tommy Hatch I found in Liverpool, and collected more notes and pictures. Then I started a real blitz in and around Bradford. None of the famous Scott riders (Langman, Clarry Wood, Milnes, Alan Jefferies, to name a few) had heard of the square four Scott design; they all admitted to knowing very little about Alfred Scott, the man, as distinct from the motor cycle bearing his name. It looked as though I'd come to a dead end; that the flicker of memory kept for over 40 years by 'Tim' Wood was the nearest I would ever get to the Scott square four. (Some of the old men remembered the 'blown' vee-four experimental engine built at Shipley, and the Morgan three-wheeler fitted with two Scott motorcycle engines. All sorts of suggestions came forth, mainly along the lines of two Scott cylinder blocks, back-to-back, running on a rather special crankcase, with the crankshafts rotating in opposite directions — ideas which, at the time, I shared).

Harold Wood had been a small boy living in Bradford, just around the corner from Scott, at the height of the great man's fame. He knew nothing about a square four — but what a wonderful collection of photographs he had built up! In the same road as Harold lived Ben Jowett, and by the greatest good fortune he answered the door personally when I called, without prior warning or appointment. He was very old, and normally shielded from callers by a dragon masquerading as carer. I was just lucky to arrive when she was out. Ben spared me several hours and dug out many old pictures, but knew nothing of a Scott four.

Tom Ward, the wizard of Ward St., Derby, knew nothing about Alfred Scott's four — and what Tom didn't know about Scotts and their history wasn't worth knowing. At that point, I decided that the whole thing was a phantom, not worth chasing any more. Yet Tom lent me some old photographs, one taken at the old Mornington works near central Bradford, in 1911 or '12. Some of the men, Tom thought, might still be around. On my next trip to Bradford, Harry Langman recognised a lot of the old faces and directed me to Charlie Jennings, living in retirement at Saltaire. He knew nothing of a Scott four. Obviously there was no such thing; 'Tim' must have crossed wires on the old memory cells. But somehow I still believed his recollection to be a true one, so sure had he been.

As we parted, Charlie Jennings threw out the suggestion that I might try a call on Charles Hustwit, also living in retirement in nearby Victoria Road, Saltaire. Hustwit, apparently, had been one of Scott's favourite workmen, and when Scott left the Shipley works he set up an experimental workshop back in Bradford, Hustwit had been one of the few who went with him. Once again, I was lucky. Hustwit was at home when I called, and delighted to recall the old days. Not nearly so delighted as I was! He had, he told me, machined some of the parts for "Mr. Scott's square four". Confirmation at last! Hustwit drew some very rough sketches for me, all levers and valves which looked much too complicated to have been design work by Alfred Scott, champion of the simplest heat engine.

Hustwit also remembered that the engine had been an exercise in compactness — a box with a shaft and a few pipes emerging — and that Scott was interested in a power unit for a light aircraft. Scott had also envisaged making it possible for each four-cylinder box to be attached to another, transversely or coaxially, to build up more powerful engines. Tim Wood's recollections were confirmed completely. But no published work had ever appeared about this engine design; I can vouch for that, having scoured the National Archives very thoroughly. I concluded that the fragmentary memories of a few elderly men were the only details available.

If Hustwit's recollections had excited me, it was nothing compared with what followed a few weeks later. I started off on another track, looking at Alfred Scott's career as a potholer. He had, I soon found, been a prominent member and even President of the Gritstone Club. In the years immediately following World War I, groups of young men from Bradford went across Europe, climbing mountains and exploring the world away from their black old city. Mostly they were sons of professional men, and their activities a break from weekly pressures. Soon a nucleus devoted its time and energy to the potholes in the Pennine Hills, making weekend trips to Ingleborough and the like.

Some of the old climbers and cavers were still alive in 1960. Among these was Ralph Bracewell, Managing Director of Chekko Brake

Linings Ltd., Bradford. By arrangement I stayed with him one weekend at his home near Ilkley. He had an amazing garage, full of electronic test gear used to check the friction qualities of his products, new materials, and so forth. Mainly our talk was about the old potholing days, Alfred Scott and his Sociable, and it was really only an afterthought which prompted me to ask Bracewell if he'd ever heard of Scott's square four. Yes! He had seen the original drawings, just after the Kaiser War. Come to think of it, he knew a man who might still have the original drawings!

Bracewell gave me some copies of the Gritstone Club journal, with articles and illustrations by Alfred Scott, and he arranged an introduction to John Bever, Managing Director of Drum Engineering Ltd., Bradford. Bever and Bracewell had been young and enthusiastic potholers together in the early twenties; had in fact been close friends of Alfred Scott, and were his companions on that final, fatal outing to Alum Pot in 1923. They had both bought early Scott Sociables, joining the 'Pillar Pot Express' at weekends.

To cut another long tale short, I went to see John Bever, who spared me several hours. Yes — after Scott's funeral, he had collected as many of the great man's notes and beautiful drawings as he could and cherished them for 40 years. He promised to look them out for me. I was over the moon — always a mistake. On my next visit, a few weeks later, Bever sadly informed me that the drawings could not be found — probably lost in one of several house moves. Regrettable. But he promised to get in touch again if they should come to light — and they did! With his son, John Bever junior, who had admired their quality as works of art.

On my last trip to Drum Engineering, I felt a bit like Chapman first gazing on Homer — you know, "wild-eyed, silent on the peak", all that stuff. There were side sections and elevations of primitive, turn-of-the-century engines, standard Scott engines, TT racing engines, guncar and Sociable engines and — at last — the fabulous four.

In King Edward's reign and the years running up to the first World War, Scott progressively reduced the crankcase volume in his engines. First, he narrowed the big-end and connecting rod. Then he introduced the full crank disc instead of a quadrant. Finally, in his racing engines, he used stuffing blocks to fill the underside of the pistons at bottom dead centre. No further reductions were possible with the existing layout, in which room had to be left for the swinging connecting rod. Only by a complete change in the lower half could a smaller volume be attained.

He had gained useful experience with rotary and semi-rotary valves, those which did so well in his TT engines. The problems encountered were not, apparently, in the valve rotors but in the chain or fine brass gearwheel drives. The next stage was to have been a train of steel gearwheels running to the rotor, but instead he changed horses completely and brought out the oscillating valve driven by a short link to the connecting rod. Next came his guncar/Sociable engine, with rotary 'top hat' inlet valves on the crankcase doors.

All these engines shared the inevitable failing of three-port two-strokes: some unburnt fuel mixture was always lost through the exhaust port. They all used deflector-top pistons and crossflow scavenge. In his next design, the 'Aero', Scott endeavoured to incorporate features which would overcome all the two-stroke's inherent faults — at the expense of the utter simplicity which had so attracted him.

Let us now look at the working cycle and construction of Scott's proposed engine, for simplicity starting off with one cylinder in which the piston is descending towards B.D.C. It uncovers a ring of symmetrically disposed exhaust ports, and burnt gas rushes out — evenly around the bore. At or near B.D.C. a two-stage rotary valve in the cylinder head opens and compressed air enters and purges the cylinder bore. As the piston rises and approaches T.D.C., a second port in the rotary valve opens and air/fuel mixture under pressure is admitted. At or near T.D.C. the rotary valve closes, ignition takes place and bang! — the cycle is repeated.

The arrangements for supplying compressed air and fuel/air mixture lie in the unconventional lower half of the engine, where Scott replaced the crankshaft by a lever and the crankcase by a gas-tight leverwell. A very short connecting rod links the piston to one lever extremity, and the underside of the piston is blanked off to bring the leverwell volume down to an irreducible minimum — much smaller than in any 'normal' crankcase assembly. (The short connecting rod moves through a very narrow angle, and clearances in the leverwell are very small. Much higher gas pressures are reached than in Scott motor-cycle engines.)

A second, lower, rotary valve opens to the atmosphere as the piston approaches T.D.C., and pure air is drawn into the leverwell. The piston begins to descend, the lower rotary valve closes, air is compressed until the piston approaches B.D.C., when another port in the rotary valve opens and the compressed air is transferred in two directions. Some goes to a pressure reservoir which is connected to the upper rotary valves, and some goes to a fuel vaporiser and then on to the upper rotary valve for admission to the cylinder head, via a second port. (We came in here!)

The piston crown is slightly concave and the cylinder head is as near hemispherical as possible — features which give a near-perfect combustion chamber. Those are the good features. All the bearings inside the leverwells are in constant thrust — one of Scott's ideals — but not those in the levers to the outside world and the 'overhead crankshaft'. Scott was a splendid professional mechanical engineer, well aware of the advantages and disadvantages in his designs, and the inevitability of gains in one direction being offset by losses in another.

The engine is in the shape of a box, with one dimension longer than the other two. Along the top is the 'overhead crankshaft', supported by four double row roller bearings. (Scott used them, later, on Sociable motors.) On the Aero, I must concede, the shaft could have been intended for a propellor support and drive. Between the two centre bearings is a pair of flywheels carrying two crankpins and double row roller bearings — the big-ends of two long connecting rods which articulate, down in the heart of the engine, on two lever extremities.

At the bottom of the engine, the levershaft runs parallel with the overhead shaft, passing through the leverwells and the central partition. Between the parallel with the two shafts are the cylindrical valve housings and rotors, driven by meshed gears from the crankshaft. (Magneto and water pump would have been installed hereabouts.) The four cylinders are mounted vertically, one at each corner of the box, over the gas-tight leverwells.

Scott's beautiful 1917 general arrangement drawings are full of sealing gland detail, dimensions and other information, and the levers hidden. He stressed that lever bearings inside the leverwells are in constant thrust but not those transmitting the thrust to the crankshaft. Whereas plain keys were proposed for the 'internal' levers, the external levers were to have their keys brazed into position. Use my rough sketch in conjunction with the exploded view used as a centre-spread in *Yowl* two editions ago. (In my original article, I made the mistake of suggesting that pistons rose and fell in symmetrical opposition, an absurdity. There are four firing strokes for a single revolution of the overhead crankshaft, evenly spaced, and thus when one piston is at top dead centre, and its partner at bottom dead centre, the two remaining pistons must be half way on their strokes. Would this raise problems with rocking couples, out of phase and not absorbed by any equivalent of the heavy central flywheel in Scott's motor-cycle engines? Some engines, especially steam engines, run quite happily at low revs, but elbow themselves to pieces when the speed is increased and vibration sets in.)

Many aspects of Scott's policy with his Aero engine are completely out of character. He kept the design secret and did not apply for any patents. No prototype was completed, although Hustwit made many of the parts. It could be that Scott did not wish to prejudice his high standing in the mechanical world of 1917, that he foresaw all kinds of problems — the amount of heat discharged from the exhaust manifolds into the engine interior, for example; the mechanical losses and those due to pumping gas at higher than normal pressures beneath the pistons. A fine mechanical engineer like Alfred Scott would, quite rightly, regard his design as a compromise, trading off some power for the sake of other advantages.

There are actually 19 moving parts in the design: four pistons, four short connecting rods, two rocking beams (each built up from three lever arms), two long connecting rods, a crankshaft, four valve rotors (complete with gearwheels) and two idling gearwheels. The layout gives an unusually shallow engine, about as compact as can be attained with four cylinders and a crankshaft. If he had intended it for light aircraft, to run mostly at constant speed, that idea of doubling up and linking together two or more units would have been useful. (Say two per wing on a biplane!)

We should allow for the circumstances in 1917, one of the bitterest years of the Great War. Britain was almost entirely on a war economy and most little firms were contracted to produce goods for the war effort, even Scott's experimental workshop in an old schoolhouse. Hustwit and his colleagues made parts for Crossley engine, and after the Armistice all their efforts were turned to the three-wheeler.

Scott's drawings were rolled up and stored away. The Great War ended, the Scott Sociable venture was not a great success like the motor cycle, and all Scott's gains from the 'bike disappeared. Just six years after preparing the drawings, Scott met his untimely death and the 'confidential' plans stayed secret until 1962.

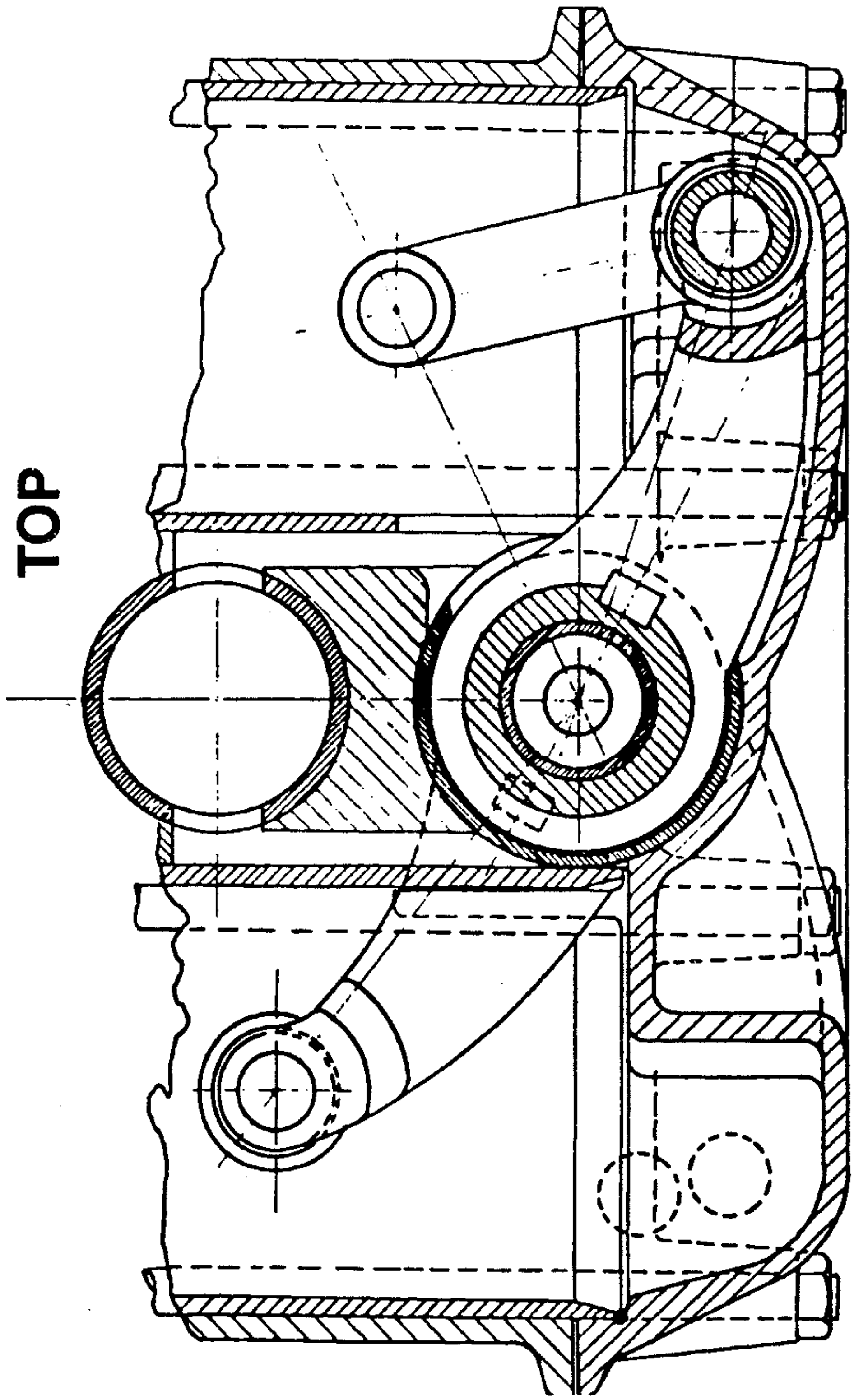


Fig. 1. End section of a pair of lever wells. Two levers are locked to a common fulcrum, forming a 'rocking beam'. Each leverwell is a separate gas-tight chamber; the lower rotary valve is fully open to each leverwell, and the pistons are at T.D.C. (left) and B.D.C. (right). (From Alfred Scott's drawing number 7199, dated 5th November, 1917 — a Guy Fawkes Special?)

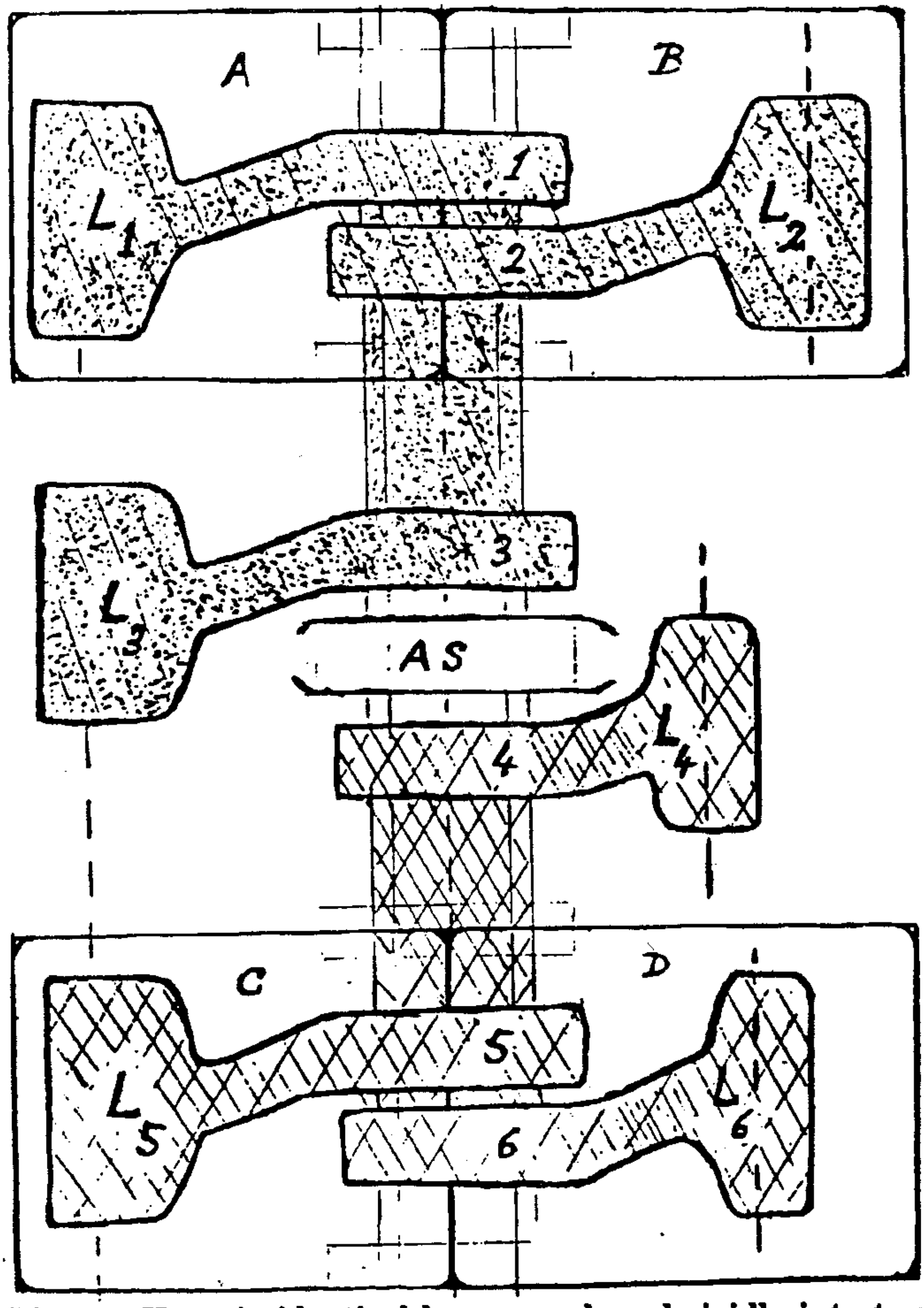


Fig. 3. How six identical levers are keyed rigidly into two separate 'rocking beams'; a schematic sketch only. The rectangles A, B, C and D represent separate gas-tight leverwells. Running the entire length of the engine is a case-hardened steel shaft, locked at each end and supported at the middle. ('AS' is short for axle support, not Alfred Scott.) Partially rotating on the shaft are two long bushed sleeves which are partly outside the pumping chambers, and into each sleeve three levers are keyed at different angles. (The apparent foreshortening of levers 4 and 6 is due to their upward angles). Phosphor-bronze bushes are specified for the gudgeon pins L1 to L6. L3 and L4 are little-ends for the long connecting rods to the overhead crankshaft.

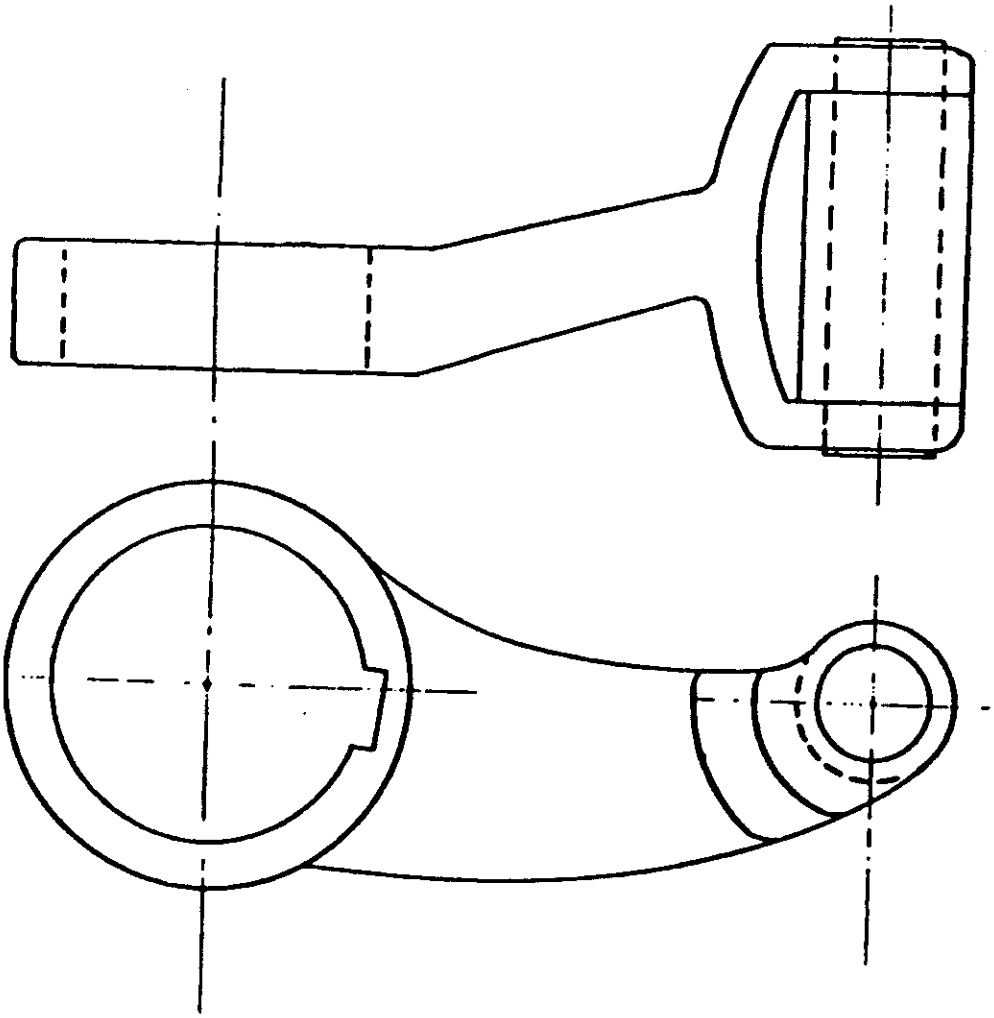


Fig. 2. One of the lever forgings.

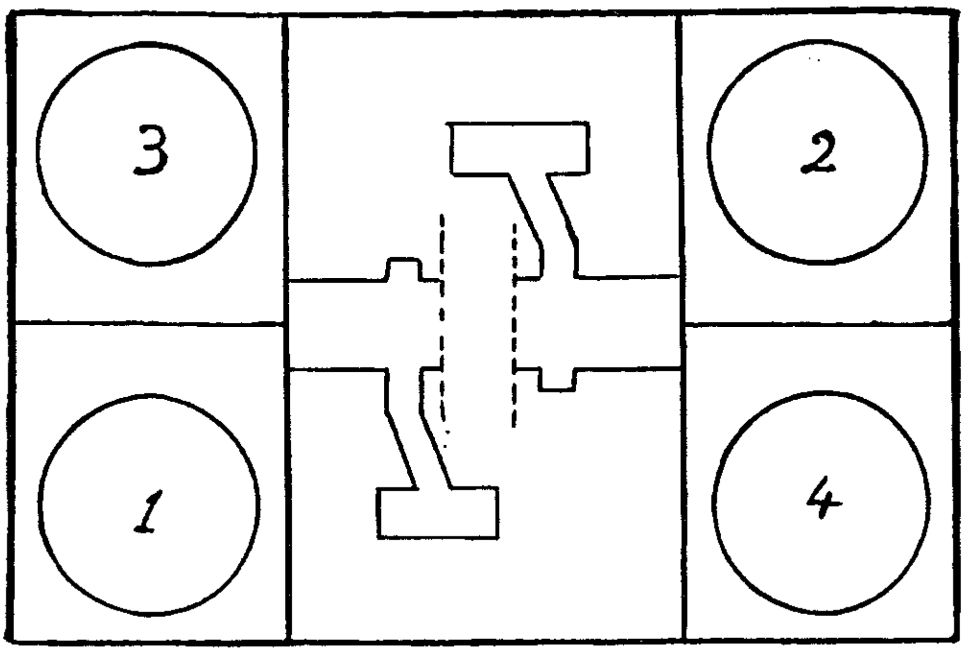


Fig 4. The cylinder firing order. Diagrammatic only and not to scale.