2.1 Engine Topics - General

Reproduced from the Motor Cycle of 23rd July, 1914.

WHY I FAVOURED THE TWO-STROKE ENGINE
by Alfred A. Scott.

(Mr. Alfred A. Scott needs no introduction to our readers. He may be described as the "godfather" of two-stroke motor bicycles, for it is undoubtedly due to his skill and untiring perseverance that the two-stroke motor-cycle has gained much popularity. In the accompanying article Mr. Scott relates his early efforts with two-stroke engines and why he favoured this type of motor. It is interesting to recall that the first description of the Scott was published in this Journal on September 2nd 1908, after its successes at the Sutton Bank and Newnham Hill Climbs.).

My inclination towards the development of a practical two-stroke engine is no doubt due to early training and association with engineers manufacturing marine and high speed steam engines so that in turning my attention to the gas engine and consequently to the petrol engine, I was naturally attracted by the possibilities of the two-stroke cycle of operations by which the regular impulse, the simplicity of design and the sound mechanical motions employed in steam engine practice could be retained; in preference to the four stroke with its irregular impulses and complications of valves, gearing and cams. I do not mean to infer that in my opinion the four-stroke system is in any way defective or unmechanical; I am simply attempting to respond to the Editor's invitation to explain my early preference for the two-stroke system, and consequent neglect of the type universally adopted in the early days of motor-cycles. My initial preference for the two stroke was further strengthened by the reliable and excellent service obtained from a two-stroke gas engine designed by my brother (Mr. A. F. Scott, M.I.M.E.) and employed for many years for driving machinery in my experimental workshop.

The two-stroke petrol engine first made a place for itself in marine work being almost universally used for small sizes in America, and was considered eminently suitable for the purpose of driving a boat, where variation in load was not recognised and where absolute simplicity was desirable, and so long as was confined to this field no serious attempt was made to design a two-stroke which would give elasticity of control required for road work. I wish to avoid giving the impression that we are particularly indebted to American genius for the invention and development of the two-stroke. Priority in its invention and development can undoubtedly be attributed to Mr. Day, and in recognition of this I have frequently referred in previous articles to the Day Cycle in contradistinction to the Otto Cycle.

MY FIRST TWO-STROKE BICYCLE MOTOR.

My first two-stroke engines were designed for marine work, and I found a decided advantage in experimenting with an engine on a boat where it was possible to make tests and obtain diagrams under working conditions.

My first bicycle motor was fitted to a Premier bicycle in 1901. The twin cylinders, 1¾" diameter, were made from steel tube with aluminium radiator flanges shrunk over the outside. Plain phosphor bronze bearings were first of all fitted and later metallic bearings with floating gland joint. The engine drove the front wheel by friction contact with the tyre, a successful drive in dry weather, but useless in wet. I was delighted with my first ride on this machine, but found that the steel cylinders were quite impractical, for, in spite of liberal lubrication they scored badly and showed no signs of taking a polish. My next engine was a development of the same idea, but with cast iron cylinders of 2¼" bore.

This engine eventually drove by belt to clutch counter-shaft and thence by chain to back wheel. One trembler coil was used, and the spark distributed to either cylinder by a simple device provided by fixing a projecting electrode on the piston head. Later on a plain coil with mechanical break was used. A rotary contact-breaker was driven by link work from a pin placed mid-way on the connecting rod, and by deriving its rotary movement from the eliptical motion of the rod, a variable motion with quick and slow periods was devised, useful for the sudden interruption required in a mechanical contact-breaker. At the same time I extended the development by experimental work on a two-cycle marine engine 4" x 4", and by keeping this engine on the test for the greater part of a year derived useful information as to what could NOT be done. The engine was fitted with a large water-cooled brake wheel, so that it could be run at full load for any length of time without heating up. On the average this engine developed 10 h.p. at 800 revs. per minute and showed 85% mechanical efficiency.

DISCOVERING THE CURVED TOP PISTON

The present Scott type of piston with the now generally adopted curved top was developed during these tests, and many developments as to port proportions made and the effect observed by the brake and indicator readings. The satisfactory behaviour proved efficiency of both the marine and the smaller motor bicycle engine convinced me of the superiority of the two-stroke for both purposes, and I decided to improve upon previous efforts and build a complete two-stroke water-cooled motor bicycle.

An accident on an early motor bicycle enforced some considerable leisure time, in which I was able to think the matter out and forecast what was wanted, and devise in its main outlines the machine associated with my name. The first complete edition of this machine (1908) had to depend on coil ignition, but the substitution of a magneto greatly improved the rapidity of ignition and overcame the most annoying of two-stroke troubles. It will be remembered that a twin cylinder two-stroke firing twice every revolution consumed four times as much current as the single cylinder engine of its time. This meant a big drain on accumulators, excessive wear on the platinum points of the mechanical break, and constant failure of the electrical equipment. The development of the magneto into the perfect machine of today has had a great influence in making the reliability of the two-stroke motor bicycle, where certainty and rapidity of ignition are particularly required. The absence of working valves on the two-stroke presented another difficulty. It was obviously necessary in producing a chain-driven two-stroke motor bicycle to provide some substitute for the usual valve lifter, since at that time all the early motor-cycles were controlled more or less by the valve lifter. This was met by providing a secondary exhaust port placed further up in the cylinder wall, which could be controlled by a lever on the handle-bar, so that compression in the cylinder could be reduced at will. The half compression lever was combined with a magneto cut-out switch, so that the engine could be controlled to the same extent as was possible with the ordinary valve lifter on the standard four-stroke motor bicycle.

PROTESTS AGAINST TWO-STROKE ENGINES

At the outset the Scott motor bicycle was regarded as an elaborate freak by the motor-cycle world of that time, which could scarcely be expected to swallow all at once this combination of open frame, water cooling, two-stroke, twin cylinder, two speed gear, kick starter, chain drive etc., and in view of this natural conservatism, I was strongly advised to limit my ambitions and develop the two-stroke on the accepted lines of the ordinary belt driven machine.

As far as the development of the two-stroke engine is concerned there was no difficulty in proving its efficiency in competition. I began the list of Scott wins at the Bradford Club's Hill Climb at Wass Bank, and then gaining three firsts on formula at the Coventry club's hill climb at Daventry, evoked a storm of protest, with the unfortunate result that the A.C.U. was induced to impose a stiff handicap on two-strokes, which, although it did not stop the record of success, checked any further inducement to compete in hill climbs and thus materially delayed the general appreciation and recognition of the peculiar pulling power of the two-stroke engine.

The question of exhaust naturally arises from comparison with the four-stroke, where a full stroke of the piston is spent in expelling the exhaust gases and in addition a full stroke of the piston is utilised to draw in a fresh charge. In the two-stroke, where exhaust takes place towards the end of the stroke, the exhaust gases move under the influence of considerable pressure; in fact, a very persuasive influence to depart is exerted compared with the mild invitation extended to the contents of the carburettor. Taking into consideration the relative conditions of pressure, area and time, I feel that in some two-stroke engines at high speed this invitation to come inside must seem so casual and off-hand that I can quite imagine the reluctance of the charge to enter the engine at all, and can sympathise with the natural attitude of the mixture in remaining sullenly in the inlet pipe with a feeling of "the welcome on the mat ain't meant for me".

THE FUTURE OF THE TWO-STROKE

In attempting to predict the tendency of future design, I would expect the ultimate successs of the SIMPLEST means of attaining increased economy, control and power, and do not think the real improvement will be secured by the complication presented by double diameter pistons, additional displacer pumps, etc., I do not, for instance, see that any real practical advantage is gained by adopting a complicated and heavier design of engine in order to avoid the use of the crankcase for compression of the charge. The crankcase compression two-stroke engine, in spite of its defects, is irresistable on account of its simplicity, and I think that in future development this characteristic simplicity will be conserved.

I anticipate the successful application of the Diesel system in combination with watercooling to increase ecnomy and efficiency of the two-stroke, and no doubt we shall depend in future upon some independent pneumatic ignition.

ALFRED SCOTT'S ENGINES

by Philip H. Smith

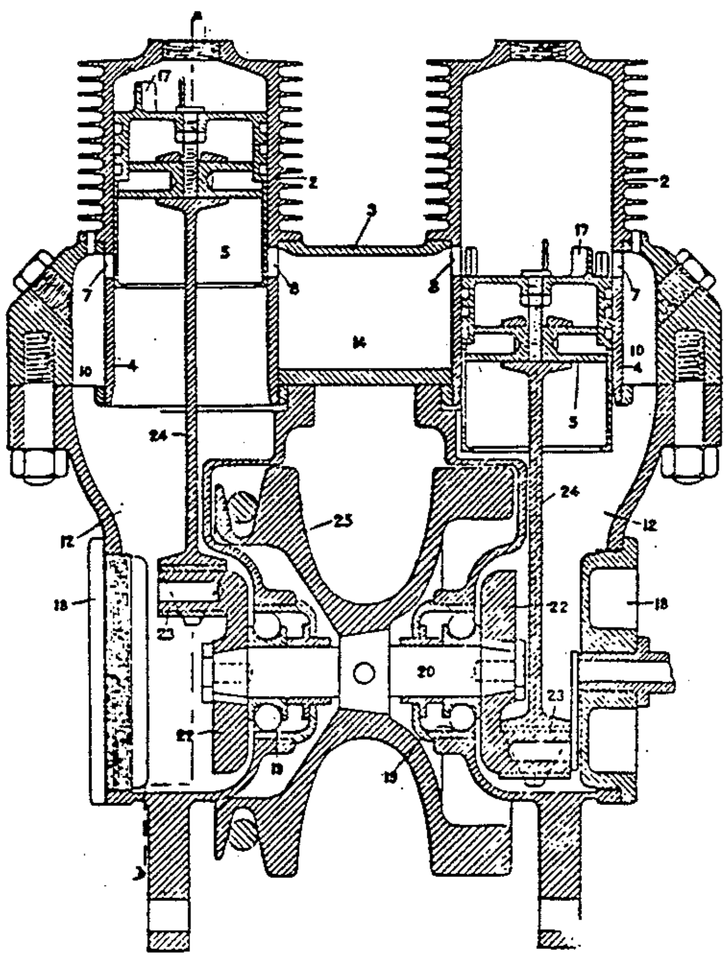
(Based on the Author's book "The High-speed Two-stroke Petrol Engine")

The history of wheeled transport in Britain has long been the subject of many biographies, covering the life and times of the great names from Stephenson and Brunel onward to the internal combustion era. Lanchester, Rolls and Royce, Renault, Bugatti and Porsche, all have had due tribute paid to them. Even in the two-wheeler sphere, we have Ronald Clarke's fine work on George Brough and his most superior motor cycle. But for some inexplicable reason, the man responsible for the Scott has yet to be given his due in biographical form.

This is quite extraordinary, since at the beginning of this Century, the two-stroke petrol engine was vastly inferior to its four-stroke rival in virtually all respects. It was due solely to the single-minded application of this outstanding engineer over a period of about fifteen years, that the two-stroke finally emerged as a formidable rival to the established type in the motor cycle field. Scott's design philosophy, and the consequences of his work, have probably no counterpart as a one-man effort, in the history of internal combustion engineering.

Alfred Scott (1874-1923) was an engineer born in Bradford, Yorkshire, an area of the country that contained a wealth of pioneering effort in the early stages of internal-combustion engine development. In common with many of his contemporaries he was "trained in steam" and started his own small engineering works when quite young. His inventions were numerous and he was much preoccupied with ensuring patent protection, taking out over fifty patents between 1897 and 1920. These covered several fields, but the bulk was concerned either with two-stroke engines or with road vehicle development, and it is evident that this was his main and abiding interest throughout his short life. These patents in particular reveal him as a natural engineer and designer, who was able to project his mind forward to the finished article and to reduce it to an acceptable

2. Cylinders
3. Casing or 'distribution box'
4. Cylinder projections
6. Opening or port, suction
7. Opening or port, cylinder inlet
8. Opening or port, exhaust
10. Compartments communicating with 7 and 12
12. Separate crankcases
14. Compartment communicating with 8
15. 'Suction chamber' communicating with 6
16. Two-way valve (if required)
17. Piston deflector ledge
18. Crankcase covers
19. Crankshaft bearings
20. Crankshaft
22. Discs or crank-arms
23. Crank pins
5. Pistons
24. Connecting-rods
25. Flywheel and pulley



minimum of components assembled in harmony. On the other hand his obvious conviction that power-weight ratio was important, and that some of the heavy sections then fashionable for highly stressed parts were not necessary, made little concession to clumsy handling or operation. Thus in practical usage his designs tended to show a degree of imbalance, and in ordinary operation failure or rapid wear would occur in some components while others were virtually everlasting.

Scott's outlook is well summarised in a letter written to the technical press in mid-1914, at a time when his motor cycle was at the pinnacle of its fame: "My inclination towards the development of a practical two-stroke engine was no doubt due to early training in steam; attracted by the regular impulse, simplicity, and sound mechanical motion of the steam engine, which can thus be retained, in preference to the four-stroke's irregular torque, and complications of valves, gearing, and cams.

"The crankcase-compression two-stroke engine, in spite of its defects, is irresistible on account of its simplicity."

Twin cylinder engine

Scott's first patent of any significance to modern high-speed two-stroke engine development was No. 3367 taken out in 1904, and this proposed a parallel twin-cylinder engine laid out as in fig. 4:1 in virtually the same form which has now survived for sixty years. The patent is worth dealing with in some detail not only because of the very large number of features which he succeeded in protecting, but also because it shows appreciation of a great many requirements of the cycle of operations (even in this earliest stage) which were being largely ignored by others. The patent is stated to cover an internal combustion engine of the two-cycle type, having two (or more) cylinders mounted on or connected to a casing provided with compartments or chambers, these being adapted to afford distribution of the mixture to either or all of the cylinders by way of the crankcases, and a common free exhaust chamber. Also covered were improvements to the engine; an enclosed and recessed crankcase in combination with a dished flywheel and pulley for allowing the flywheel rim to come close up to the connecting-rod; an exhaust silencer; and a carburetter.

The two drawings are reproduced from the specification. In describing the engine, preliminaries are taken up with a description of the working cycle and positioning of the inlet, transfer and exhaust ports. The top of the crankcase is termed a distribution box, divided into four compartments; two of these are at the outer ends of the casing and communicate with separate crankcases fixed to the casing one below each cylinder, and also in communication with the port opening (i.e. transfer ports). The other (exhaust port) openings communicate with a compartment in the casing common to both cylinders, this serving as an expansion or exhaust chamber. The fourth chamber is described as a suction chamber in connection with the gas supply.

So far, the main interest lies in the containment in the upper part of the crankcase of all the gas passages. There now follows an interesting alternative, in that the suction chamber may also be divided into two parts, connected to the suction ports and also to a two-way valve so that the delivery of the charge can be fully controlled.

The inlet (transfer) and exhaust ports are opposite each other, the piston having a deflector ledge; the suction ports however, may be placed in various positions around the cylinders as required. The crankcases have covers on their outer sides and ball bearings on the inner sides for the crankshaft, the latter having discs or arms carying crankpins at 180.

deg. The pistons are coupled to the crankpins by connecting-rods.

The flywheel and driving pulley are fixed to the shaft to lie between the crankcases, and so that the cylinders may be close together the wheel is dished over the bearings, the crankcases being shaped to allow the rim of the wheel to come as close to the connecting-rod as clearance and thickness of metal will allow. Alternatively a driving shaft can be arranged to revolve in a bearing in the crankcase cover, driven by a crank arm from the crankpin.

A light piston machined all over is specified, the gudgeon pin having flats at each end abutting against ledges inside the piston to prevent turning, and preferably attached by a single bolt or screw in the centre of the pin, threaded through a nut on top of the piston. Though the specification does not mention the point, the drawing also shows this "nut" as carrying an upward projection or spike, intended to serve as the earth electrode of a spark gap at tdc. At this position it would be situated about .015 in. from an insulated electrode screwed into the cylinder head boss. While this would certainly form a spark gap that could hardly suffer from bridging troubles, it is obvious that Scott soon realised that the spark timing would be far too late, and that in any case the spike would become incandescent. What is perhaps surprising is that he even considered the feasibility of the idea at all.

The centre of the connecting rod little-end is slotted or cut away so as to give clearance to the gudgeon pin fixing bolt.

The silencer or "condenser" comprises a chamber into which the gases pass from a connecting pipe. A number of tubes pass through the chamber from end to end. At a point near the exit end of the tubes, a number of slots are formed in the latter, which allow the gases to enter the tubes and to mix with air which has entered from outside. Coincident with the slots are small deflectors which cause the gases to exert an injector action on the air in the tubes. This draws the air through the tubes and as the mixture of air and exhaust passes to atmosphere, the cooling effect of the air being drawn through the tubes assists in cooling the gasses in the chamber, thus reducing their volume. (A similar arrangement is also visualised as being used to draw cooling air around the cylinders of air-cooled engines or for a like purpose for water circulation on marine engines.)

In regard to the operating cycle, mention is made that when the exhaust port opens, the gases escape to the exhaust chamber, and thence to the silencer. Immediately after, the inlet (transfer) ports are uncovered and the charge from the crankcase blows through. It is evident from this description that Scott realised verly early that the spent gases were evacuated by their own pressure, and not pushed out by the entering charge, as was often assumed.

Practical versions

This first engine was of course very low-powered and was in fact mounted in a heavy roadster bicycle, driving by a round belt to a countershaft and from there by chain to the rear wheel. It was at this stage that the design of an improved motor cycle began to impress itself on Scott's mind, along with improvements to his basic engine. The result was the prototype revolutionary design of machine which began its final tests in 1908.

(To be continued)

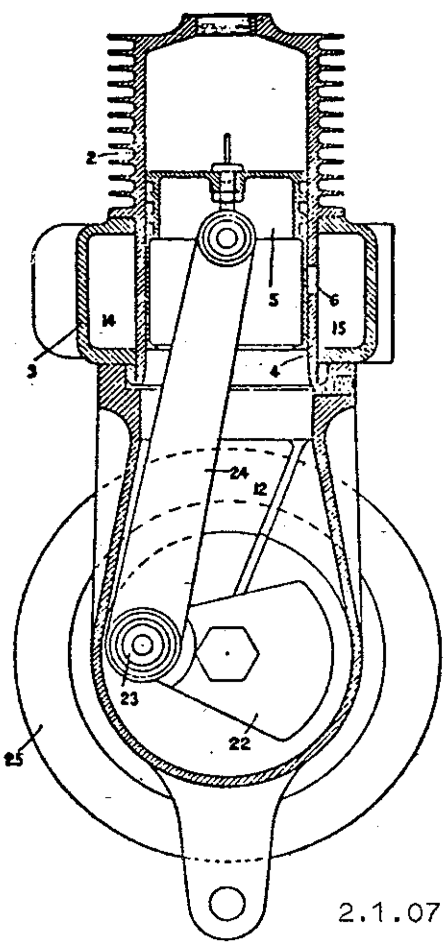
ALFRED SCOTT'S ENGINES

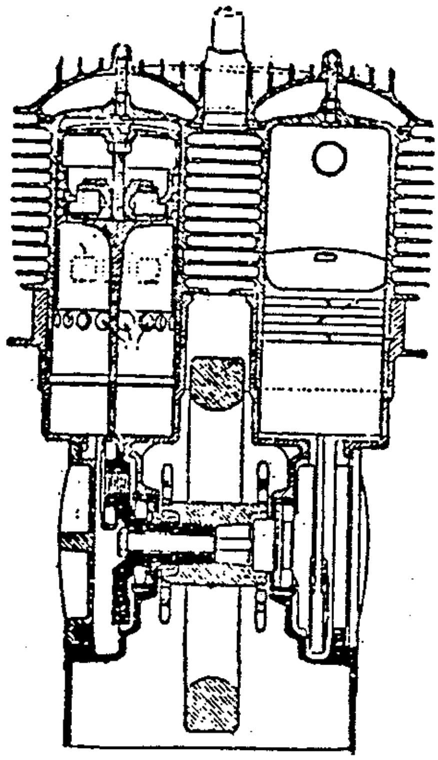
By Philip H. Smith

(Based on the Author's book "The High Speed Two Stroke Petrol Engine")
(Part 2 of series)

One of the basically disadvantageous features of the 1904 design was the arrangement of the distribution chamber. Being of thin-section aluminium, heat transfer between the various portions was rapid and complete, while the layout of the two exhaust ports discharging opposite each other would raise the temperature of the centre chamber to a high level, particularly in view of its position. This heat would of course be transferred rapidly to the induction and transfer portions. Scott however had his own convictions regarding the value of heat in improving carburation and mixture consistency, and no doubt weighed up such matters against the lower volumetric efficiency resulting from raising the temperature of the fresh mixture.

The original engine probably never exceeded 2,500 rev/min, and in fact this speed was not vastly increased except for special racing engines, during the early years of manufacture for sale to the public. However, the marketed engine design, typified by the 1909/10 type shown, can be seen to have developed many more practical features. This was of course arranged for installing in Scott's unique motor cycle frame in the conventional position. The cylinders on the first machine (1908) measured 50.8 by 53.6mm bore and stroke, giving a swept volume of 258cc. The barrels were air-cooled, but the heads were surmounted by a water-jacket cover held down by a stud and nut to the top of each head, the jacket also having external finning. Water circulation through the head-jacket was by thermo-syphon in conjunction with a small radiator. The distribution chamber combined with the crankcase had been deleted and the transfer and exhaust ports were situated fore and aft in the normal manner; the cylinders still had long spigots into the top of the case, and in each of these was a circle of round inlet ports communicating with the central "suction" chamber which constituted all that was left of what had been the distribution box, and to which the carburetter was coupled at the rear. Part of the transfer ducting was also incorporated in the rear of the crankcase, the passage to each cylinder port being formed by a detachable cover with two faced joints which had a double thickness of copper gauze in each joint to act as a flame trap. The cylinders had a forward offset, providing adequate room for the transfer passages; this feature was also one





of Scott's considerations in relation to its effect on port timing. The pistons retained the centre-bolt method of gudgeon pin fixing, but had properly shaped full deflectors, while the spark plugs were now inserted from the rear horizontally, at right angles to the bore, where their electrodes could be expected to come in contact with a substantial pocket of fresh mixture. The crankshaft construction while retaining the overhung sector-shaped cranks, had a completely different method of assembly at the centre, each shaft was tapered and inserted into the flywheel boss, which was double-tapered. The two cranks were then drawn together by a fine-thread bolt inserted through the left-hand crankshaft and screwing into the shaft on the right. The bolt was finally locked by a nut screwed on to a left-hand thread formed on a reduced portion of the bolt-end.

Both main and big-end bearings were of the roller type without cages. The crankchambers were drastically reduced in volume by the use of extremely thin connecting rods. The big-ends were assembled in precisely the same manner which has survived to the present; the retaining screws were left- and right-hand threaded for the appropriate side of the engine.

The crankcase doors were by now considered as for rapid access purposes only, and each was held by a cross-strap secured by a wing-nut, there being no implied provision for a power take-off. The two sprockets one on either side of the flywheel were arranged for a double-chain drive to a countershaft with selective clutch mechanism, providing two gear ratios by the use of different chain-drive ratios. A magneto drive was readily arranged from the countershaft.

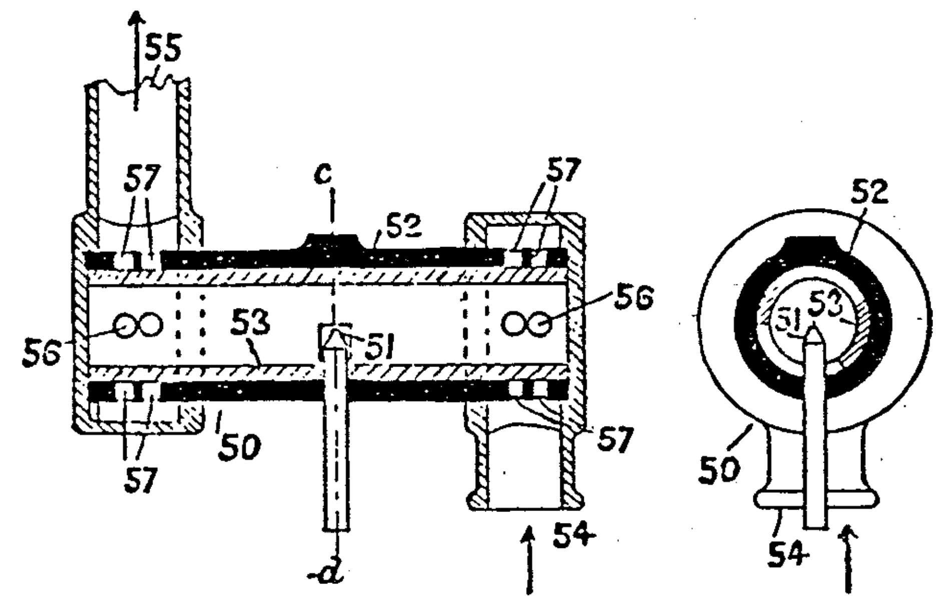
ALFRED SCOTT'S ENGINES Part 3.

(Based on the Author's book, "The High Speed Two Stroke Petrol Engine".
By Philip H. Smith.

Development.

Alfred Scott's first prototype machines powered by the engines described in the last issue, achieved some successes, but were plagued with relatively minor troubles, some due to the non-availability of small precision-made items such as bearing rollers. These snags were overcome as manufacture proceeded and requirements became more firmly based, the machine also being steadily improved as a whole. Lack of power with the original engines was remedied by increases in swept volume. In 1909, oversquare dimensions of 66.7 by 63.5 mm were used, and two years later, the bore was enlarged to 69.8 mm giving 486 c.c. A final increase in 1912, to 72 mm bore, resulted in the famous 532 c.c. engine, developing 7-8 b.h.p. at 2000 rev/min, and which remained in production until the early 1920's. Incidentally it is of interest that the stroke length of 63.5 mm, or 2.5 inches, was retained throughout the remainder of Scott's production engines.

Along with these capacity changes, the whole construction became more robust to cope with the extra power. In 1911 air-cooling was also abandoned; the cylinders were completely water-jacketed, an unfinned polished aluminium cover over the heads being retained by two bolts. The exhaust duct from the two forward-facing ports was cast in the block, with a central stub take-off to a box silencer mounted close up. The crankcase top was redesigned to form an induction belt or annulus around each ring of the inlet ports.



50. Carburetter
51. Nozzle
52. Passage
53. Tube or sleeve free to rotate in 52
54. Air inlet end of 53
55. Suction end of 53
56. Port openings in 52
57. Port openings in 53

Scott had problems with over-cooling of the head region, causing oiling of spark plugs. He tackled this defect in 1913 by abandoning the head jacket, the top of the cylinder jackets being enclosed by two circular plates held down by large diameter lock-rings which were screwed on to the tops of the plain unfinned heads. The thickness of metal in the flat combustion chamber roofs is noteworthy. The design was successful in cutting down plug troubles in normal usage, but inevitably under heavy-load conditions as in racing the plugs tended to pre-ignite. There is evidence that at the same period Scott became convinced that the average water-cooled automotive engine ran too cool for good combustion efficiency, and that air-cooled engines generally were superior in this respect. He was correct, particularly with reference to the current side-valve types where water-jackets tended towards the primitive. The decision to use plain heads having no provision for cooling whatever, was certainly influenced by this conviction.

The Scott patent carburetter which was fitted to these engines was of fixed-jet type, and had a rotating barrel which controlled apertures at both ends of the throughway, thus controlling both the induction "pull" from the engine and the intake of air from atmosphere. Further, the intake air was drawn from the warm space in the enclosed part of the crankcase casting behind the pumping chambers. However, improvements in proprietary carburetters induced him finally to adopt one of these, mounted more conventionally at the end of an induction pipe at the side of the engine.

Scott's engines were lubricated by a separate oil supply, with the exception of later designs to non-motor cycle type. Initially, a small type well was cast in the bottom of each crankchamber, and these were kept filled by a hand-pump feeding via a two-way tap. Later, the timed-port system was adopted, incorporated in the metallic spring-loaded compression glands; this form of compression seal was employed virtually from the first engine.

Finality

The 1915 type of 532 c.c. engine represented his final production example of a unit for motor cycle propulsion. In this form it had full-disc crankcheeks in place of the sector-type, an Amac carburetter, and additional spark plug bosses, normally closed by blanking plugs, in the cylinder heads. It was generally considered by users that plugs fitted in this alternative position gave slightly more power, but also earlier plug failure.

Thus, a ten-year period of rapid development of a specific type (which also included the rotary-valve racing engines) was finalised in a production design incorporating almost all of the features now accepted as essential for a successful two-stroke. The extent of Scott's influence on other designers obviously cannot be gauged; but there is no question that it was — and still is — considerable.

To summarise then his final layout; the single-entity aspect is clearly evident. Then there was the insistence on a high crankcase pressure ratio (approximately 1.4 : 1), and also fully-machined ports facilitated by the use of detachable covers which in turn could be machined internally. Water-cooling ensured relative freedom from seizures, and the damping effect gave unique quietness in operation. The central flywheel of large diameter reduced the effect of the unbalanced couple. The design of connecting-rod whose special features would seem obvious, has only quite recently been adopted in modern engines. The shape of the piston deflector though certainly evolved empirically, remained one of the best of its kind; it may even have been the absolute original of "hump" formation, i.e. as compared with a mere ridge across the piston. The crankcase pressure seals though dependent on clearances for satisfactory operation and thus not completely gas-tight, are self-adjusting for wear, and thus maintain the seal for a very long period; features which are found lacking in some present-day non-metallic seal designs.

However, there were also points on the debit side. While the ready access to gas passages and ports was advantageous from the viewpoint of machining and finish, a large number of faced and gasketted joints was called for, which were difficult to line up and prone to leak unless very expertly assembled. Although Scott insisted on an extremely high-class finish on all components both externally and internally, and this included smooth gas passages, the shape and sometimes inordinate length of the latter were prejudicial to volumetric efficiency, and there were several quite serious gas-traps in the region below the piston. The use of large-diameter uncaged rollers in the main and big-end bearings can perhaps be excused initially, in that suitable rollers to the required accuracy were difficult to obtain, but this feature persisted long afterwards. The crank dimensions, though satisfactory for low powers, were not adequately revised in line with later and quite drastic increases in swept volume affecting both piston weight and stroke strength, and which put up the inertia loads very considerably.

ALFRED SCOTT'S ENGINES (Continued) V6/7 Sept 1969

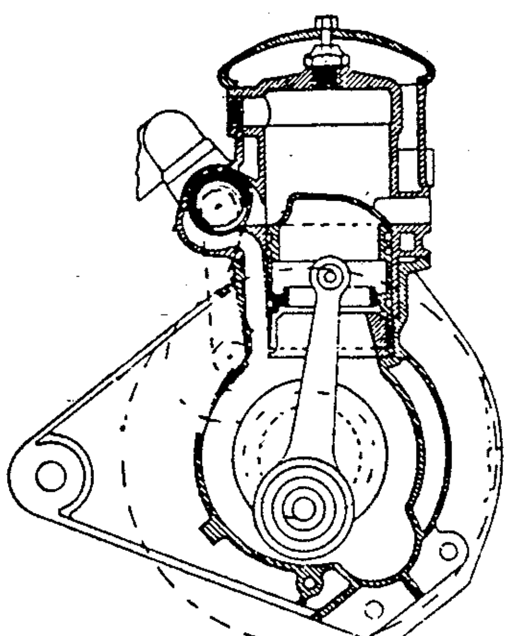
Phillip H. Smith

Part 4

Based on the Author's book
"The High Speed Two Stroke Petrol Engine"

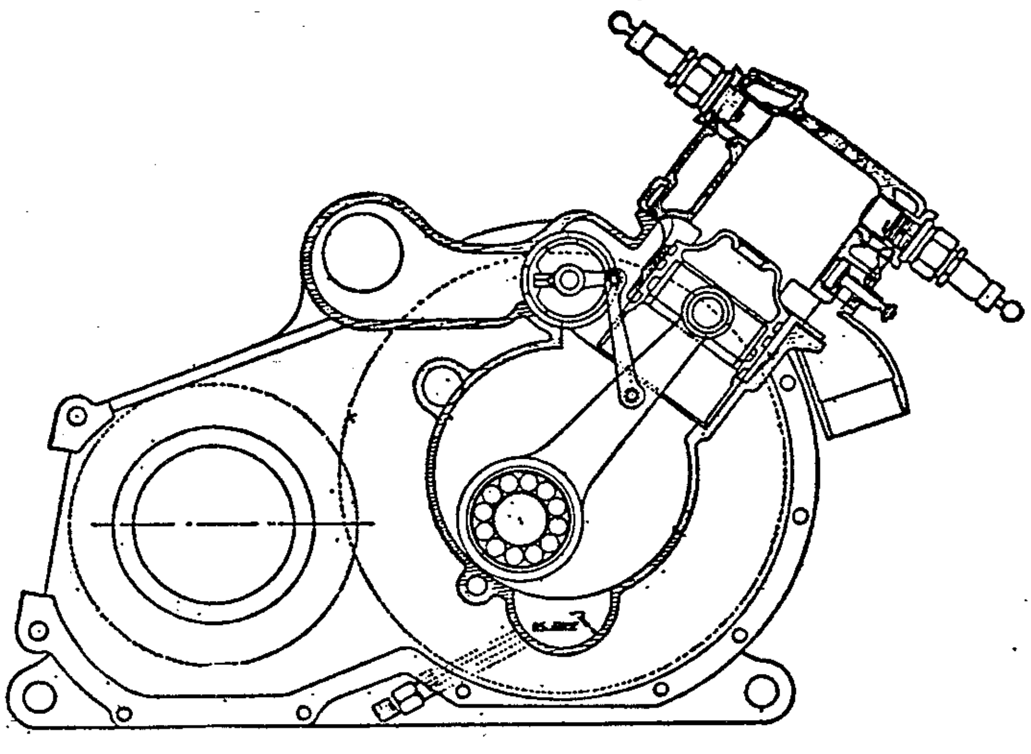
Racing engines

While Scott's motor cycle was marketed with the avowed object of providing a kind of "wheeled horse" transport in the luxury class for professional men of the late Edwardian times, he was by no means averse to competition work; not so much from the sporting aspect but largely as an opportunity for trying out new ideas and obtaining valuable publicity. His series of highly successful TT racing engines based of course on the standard design, are worth scrutiny. It should be borne in mind that the best four-stroke competitive machines of 500 c.c. had power outputs somewhat in excess of that obtainable on the standard Scott engine, and that while light weight and good roadholding of the machine itself made up for some lack in this respect, his racing engine development was very largely concerned with highly original and patented ideas for increasing the volumetric and combustion efficiency.



The rotary valve is a good example. It would take too many "Yowl" pages to describe its working and function in detail, but in brief, the valve was of barrel-type, and controlled both the transfer of charge to the cylinder and the induction to the crankcase. In his well-justified attempts to obtain the maximum possible range of useful rev/min with smooth operation throughout, Scott concentrated largely on niceties in the balance of pressure in the crankcase and transfer duct at the b d c position; hence his wish to control both the crankcase intake and egress, and provision of a hand-controlled outer sleeve to vary the cut-off. The object of this adjustment was to enable the start of the transfer to be delayed to a greater or less extent depending whether the engine was on a small or large throttle opening. That is, with a minimum quantity of charge available for transfer to the cylinder, the port opening was given the maximum delay by the valve.

Once again, however, despite the undoubted improvement in performance, a certain disregard for smooth gas-flow is apparent. The first example was fitted to the 1911 TT engine. This was driven by a short chain from a jackshaft protruding through the crankcase wall, carried in suitable bearings and driven by a meshed pair of brass gearwheels from the crankshaft, the wheels running completely open and having an extremely thin section. The chain, on small sprockets and non-adjustable, gave some trouble, and for the following year, while the initial pair of gears was retained, the chain was replaced by a gear-train, with highly satisfactory



results. A similar valve and drive was used in 1913, but this again was superseded by the unique connecting-rod-driven oscillating valve for 1914. Scott was also concerned with improving conditions in the combustion chamber. The 1911 engine had the standard water-cooled head with a single horizontal spark plug at the rear and a gradually-increasing deflector gradient from the leading edge to the exhaust port. For 1912/13 the deflector had a much more pronounced hump giving a higher compression ratio, but having the disadvantage of dividing the combustion chamber rather drastically at tdc. Although not shown in the drawing, this disadvantage was subsequently remedied by the use of a second plug to provide dual ignition, the plug being mounted horizontally at the front of the block. The cylinder heads were plain and unjacketed, a feature adopted for production engines about this time.

The 1914 TT engine undoubtedly one of his best designs, was also Scott's last attempt in the racing field. The crankcase unit housed the dual-chain two-speed gear and also the cast-in ducts for passage of the mixture from the frame tube which functioned as a manifold to the two oscillating valves. The piston deflector was very nearly symmetrical on both transfer and exhaust sides, giving a further increase in compression ratio, and the plain air-cooled cylinder heads were detachable, each being held to the block by three studs and nuts.

It will be noted that the valves no longer controlled the transfer function, but only the flow from carburettor to crankcase, though the duration of the inlet stroke was controllable by hand via an outer sleeve, as in the rotary type of valve.

In four successive appearance in the TT race, this engine series achieved four record laps and two successive wins. The 1914 engine was well up to four-stroke standards in regard to power output, but . . . total failure of the dual ignition magneto in the last few miles of the race prevented a 'hat-trick'. From this point, Scott gradually severed his business connections with the motor cycle concern, and although he had designs for an even more revolutionary machine his preoccupation was, by now, with a light three-wheeled car: this was initially intended for military purposes, but was later marketed as the 'Scott Sociable' by a new company formed after the war.

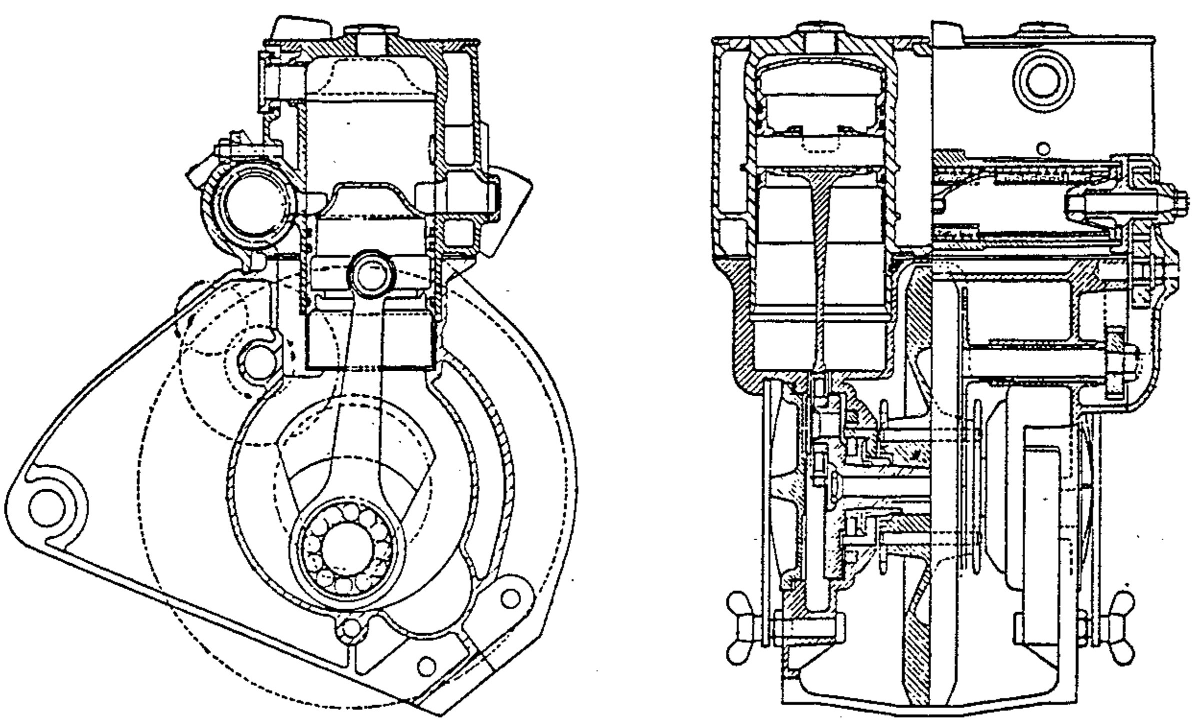


Fig. 4 : 5. Scott's TT engine 1913, showing unfinned air-cooled heads and continuous gear train to rotary valve.

ALFRED SCOTT'S ENGINES

Philip H. Smith.

(Based on the Author's book, "The High Speed Petrol Two-Stroke Engine")

Light car engine

For use in this vehicle the engine, though remaining as a parallel-twin with overhung cranks and central flywheel, showed how Scott never liked forsaking what he had originally conceived as a "good idea" He reverted to the layout of a single joint at the base of the cylinders, with the crank-case top forming a manifold chamber, again taking in both transfer and exhaust, and also the water-cooling passages to the lower part of the block. There were no induction passages involved, as two rotary inlet valves were used one on each crankcase cover.

The block construction formed the subject of patent No. 1292. The declared object is to have a form of construction which permits easy removal of the cylinders from the crankcase without the nuisance of breaking and re-making a multiplicity of joints (which certainly indicates some re-thinking compared with this task on the motor cycle engines). The design is admirably simple from this point of view, and the presence of hot exhaust gases in the crankcase casting is certainly far less disadvantageous than in the earlier engines, as this part is now remote from the transfer ports, while the inlet side is eliminated and cooling water passages added. It will also be noted that the complete outer wall of each cylinder jacket is separate, detachable, and secured to the head by a central stud, its lower edge spigoting into a register in the main cylinder casting, and seating on a joint washer.

An interesting point in the patent specification is that reference is made to the need for the transfer and exhaust passages, at the joint with the crankcase, to be sufficiently large to enable a file or other implement to be inserted for the purpose of trimming the ports to the correct proportions.

The rotary inlet valve used on the same engine was also patented, (No. 1290) a section being shown. The objects of the design in a mechanical sense are simplicity in operation, ease of removal for inspection, and advantageous location. Hence the valve is of the rotating sleeve type, integral with the crankcase cover. The rotating sleeve is mounted on the outside of a fixed sleeve or tube, and has a disc formed on the end adjacent to the crankcheek to reduce the crankchamber volume. The disc is slotted to engage a head on the crankpin end, giving rotary motion. The ports in both the rotating and fixed sleeves when coinciding face upwards towards the underside of the piston.

The outer edge of the inner sleeve or tube has a flange forming a joint with the crankcase cover while its inner periphery at this end is also made with a spherical seating against which a similar seating bears; this latter is on the end of the induction pipe, which is provided with a simple single-bolt fixing. Because of this seating, precise alignment of the long induction pipe is not critical, yet the method of assembly and attachment by one bolt ensures gas-tightness while at the same time giving easy access to the working parts. The horizontal portion of the induction pipe shown in the drawing connects both valves to a single carburetter.

Apart from these patented features the engine was not dissimilar to the motor cycle types. The same stroke of 6.3 mm was used, with the bore increased to 75 mm, giving 578 c.c. Two-spark ignition was used, the plugs being arranged vertically in the head. Each pair of plugs was connected in series, one plug of the pair being of a special type with two insulated electrodes; thus a normal twin-cylinder magneto could be used.

The crankshaft assembly was similar to that of the motor cycle engines, but an improvement is apparent in that the main bearings were proprietary double-row ball bearing assemblies instead of the loosely-assembled roller type. A similar type of bearing was also employed for the big-ends. Separate oiling was forsaken in favour of petroil, this being deemed desirable in view of the intention to market the vehicle in competition with contemporary "foolproof" light cars. A sliding pinion three-speed gearbox, incorporating a lever-type hand starter was mounted in unit with the crankcase, driven by a primary gear mounted on one side of the flywheel. This engine which was Scott's last design to reach the market, achieved some success, but the vehicle was still under development when he died.

Once again an almost inexplicable disregard of gas-flow requirements is shown. Considering all the ingenuity which he showed in the design of valve-gear over a long period it seems strange that the Scott Sociable engine used an induction pipe in which right-angle bends and maximum length appear to have been introduced almost deliberately. Many of the features however indicate outstanding mechanical thought, as well as an appreciation of production requirements and convenience in machining, particularly of inaccessible surfaces. The philosophy behind simplicity in joint-making, the minimum number of fixing points, and the ease of correct dismantling and assembly by unskilled hands is also admirable, though this was offset many times by the fragility of the parts; Scott may have given the owner only one bolt to tighten, but he made no concession to the fool who over-tightened it.

2. Crankcase cover
3. Cylindrical piece
4. Shoulder or flange
5. Port in 3
6. Engine piston
7. Valve sleeve
8. Flange
9. Embayment engaging 10
10. Crankpin extension
11. Port in 7
12. Spherical seating of 3
13. Spherically formed part 14
14. Mouth of 15
15. Removable length of inlet tube
16. Extension of 15
17. Fork
18. Winged nut or stud
19. Bevelled edge or seating of 20
20. Remainder of inlet tube (fixed)
21. Swinging yoke
22. Thumb screw
23. Resilient washer

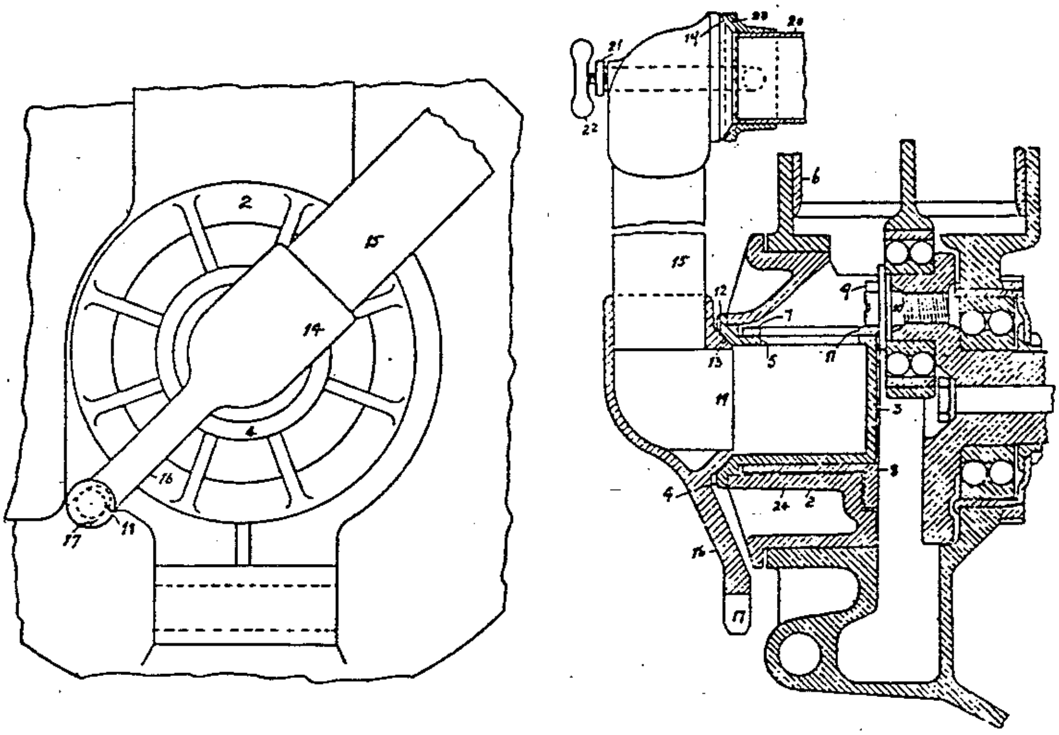
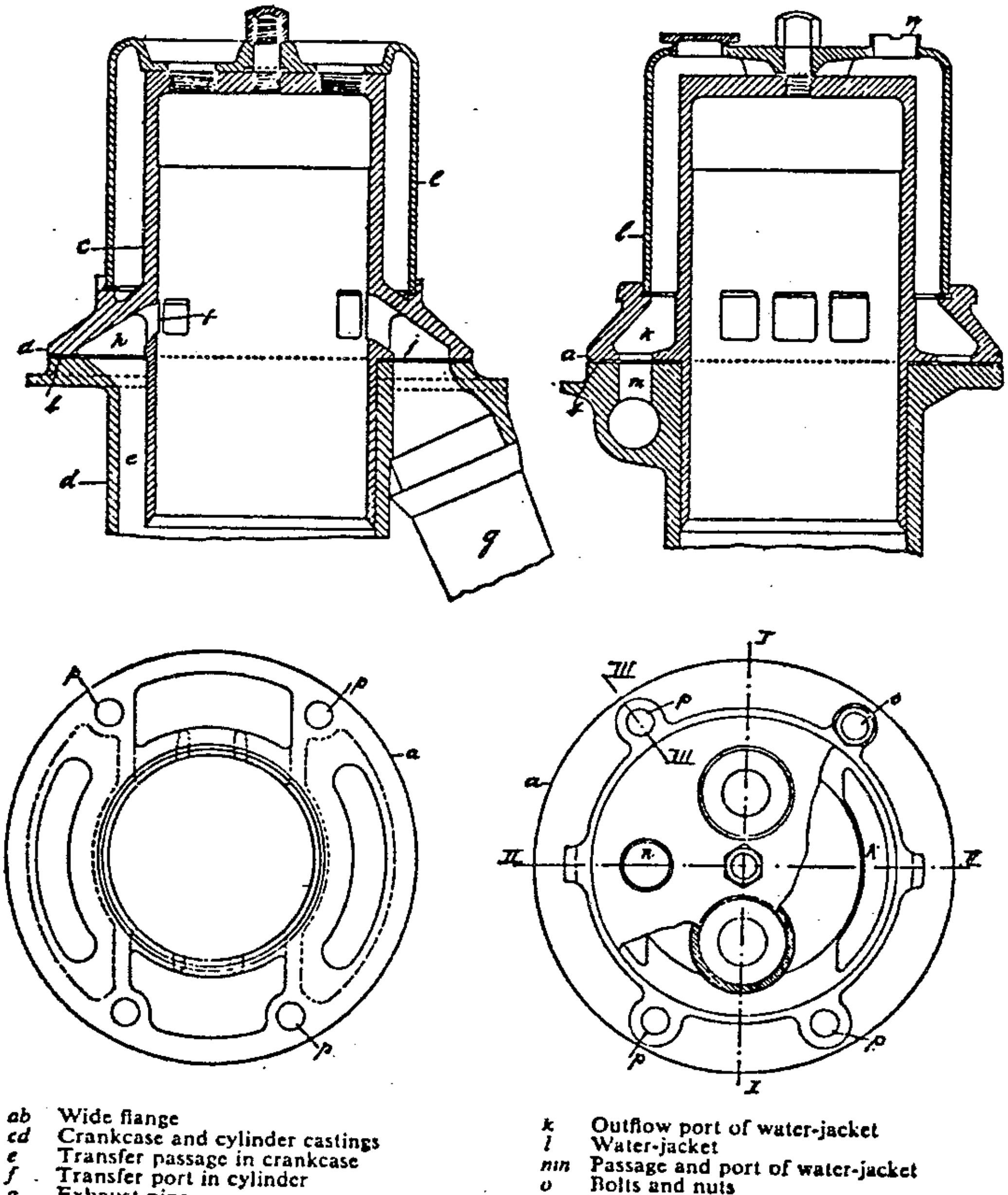


Fig. 4 : 8. Rotary inlet valve on crankcase cover, patented by Scott in 1915 and used on light car engine.

ALFRED SCOTT'S ENGINES

With this illustration, we have the last item in the series of articles by the late Philip H. Smith, which shows the porting arrangements for the Scott Sociable engine block.

In last month's Vintage M.C.C. Journal, a Sociable was offered in exchange, this making three Sociables that we know of in existence, so no doubt, we shall be hearing more of these most unusual but interesting vehicles.



ab Wide flange
cd Crankcase and cylinder castings
e Transfer passage in crankcase
f Transfer port in cylinder
g Exhaust pipe
hj Transfer and exhaust passages in cylinder

k Outflow port of water-jacket
l Water-jacket
mn Passage and port of water-jacket
o Bolts and nuts
p Holes for *o*

FLAT-TOP FALLACY

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

It is quite noticeable that when people discuss and write about improving the Scott engine (and they have been doing it since about 1908) they nearly always mention flat-top pistons. I wonder why ?

Of course, there have been and are such engines. The Cyc-Auto unit, if my memory is correct, was one ; and there is of course the Swift, and now the 350 racer, both so equipped. But there's no need to waste time on either of those—let's try to be constructive.

Any engine design is a mass of compromises. It is absolutely no use getting a "thing" about a specific item and going for it regardless. Also, the ultimate object of the design, which is the task for which the engine is intended, has to be kept very much in the foreground. Power at any price is, roughly speaking, the requirement for racing ; even a good torque spread becomes less important, with every corner that gets ironed out. But factors which give ultimate power of this kind are by no means always desirable for a good road vehicle.

At present, the flat or domed piston is a "must" for maximum two-stroke power, and the reasons are fairly obvious. But on multi-cylinders, the porting can be quite a headache. The result however is worth it, even if the engine suffers in other respects ; in other words, you obtain more power by flat-topping and Schneurle type scavenge than you lose on added snags.

In the touring engine there are many other requirements, such as engine compactness, good torque low down, and of course moderate cost, which most people would like. Does the deflector piston engine have any advantages in such matters ?

Before considering this, take a look at the deflector piston itself. The old objections used to be top-heaviness, wide temperature variations, uneven expansion with heat, and lack of mechanical strength in the crown, because of the irregular shape. None of these should apply to modern design and construction ; there are probably as many peculiar crown shapes on high-speed four strokes as on two-stroke engines nowadays, and piston makers have learned a lot. (If you doubt this, take a look at a high compression piston for any "bath tub" combustion chamber, or for a Rover 110, T.T. Norton, Le Mans Jaguar and so on).

Don't be put off by the Scott piston, 1924-64 variety. It started fairly soundly and has since developed into the worst piston ever fitted to any engine, incorporating more fundamental bloomers than one have thought conceivable by mortal man, even mortal Yorkshireman. If you don't believe this, start by weighing one, but DON'T forget the gudeon-pin—that's most important, as you gain a few pounds thereby.

Now take a look at a real deflector engine, but first taking as a yardstick the Scott power output (which is actually near the mark) stated as 30B.H.P. at 5,000 revs. per minute. This is as near as dammit 5 B.H.P. per 100 c.c. Now, the Perkins Forty outboard motor is a twin of 722 c.c., virtually the same stroke as the Scott, but bore enlarged to suit capacity. This gives 40 B.H.P. or just about 5 B.H.P. per 100 c.c. again. But it does so at 4,500 revs. per minute.

Or for a second example, there is the Mercury 35, a 500 c.c. twin with a mere 59 m.m. stroke. This is another outboard engine, and it gives 35 B.H.P. at 5,000 revs. per minute—or quite a lot more than the best T.T. Scott ever did.

As for power at low speeds, it must not be imagined that because these are marine motors, they don't bother about low-speed torque or decent two-stroking. In fact, both these are most important (we are talking about luxury outboards now, and not the rather awful pip-squeaks you still find on diminutive dinghies and the like. Quietness, smoothness and rational all round behaviour are most important, as well as lightweight and minimum size).

How do they get the power and performance ? First, water-cooling, which always has been the best bet for a good two-stroke—we should know that (the T.T. boys are coming round to this idea ; and I would suggest we shall see Yamaha following M.Z. in this direction before long). Then rigidity, large bearing areas and good balance, obtained by making the crankshaft as short as possible and supporting it properly. And finally, and VERY important—inlet valves in place of ports. If you start with a good pump you go a long way—again we should know that—rotary valves used to mean Scott T.T. wins. There's no difficulty about designing an inexpensive inlet valve—Velocette do it ; and it pays dividends not only for power flat-out but for good torque as well.

So if you are thinking about improving your standard Flyer or similar engine, don't bewail the lack of flat-tops. Knock off 500 to 750 r.p.m. from the present suicidal maximum, and the crank assembly may last a lot longer ; design a pair of decent pistons ; and graft on a couple of reed-valve assemblies to the under-piston spaces in the main casting, with a carb. on each. You'll have the power all right.

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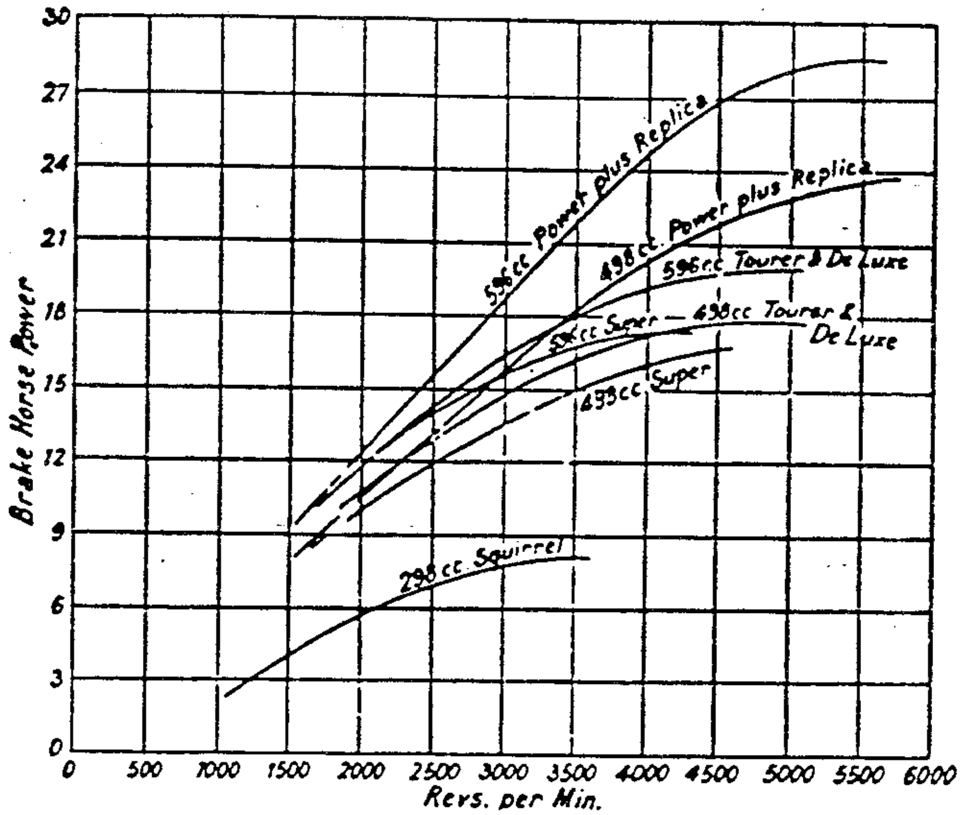


Some power curves of various Scott engines, circa 1930

COMPRESSION RATIOS

Tim Sharp

The geometric compression ratio of any piston engine is the volume at TDC compared with the volume at BDC — this latter being the swept volume plus the volume at TDC. This is not the same as the actual compression ratio because the mixture cannot start to be compressed until the exhaust port has been closed by the piston, which in the Scott is about 77° after BDC. In the four-stroke engine compression cannot begin until the inlet valve has closed and this is usually about 60° after BDC in a touring engine and as much as 85° in a high performance engine. So it is just as inaccurate to talk about geometric compression ratios in four-strokes as it is in two-strokes. However, since the compression ratio is an important factor in determining the power output and fuel efficiency, it is better to keep to geometric rather than actual ratios, because of the complications in making the correct allowances for port and valve closing times. In fact, the actual c.r. will vary according to the r.p.m. of the engine and will reach a maximum at the point of peak torque and volumetric efficiency.

But what of c.r. and Scotts? Can we achieve anything by increasing the c.r. or are we going to reduce dramatically the reliability of the fragile crankshaft and big-end?

On late DPY engines 7 to 1 was usually the quoted c.r., whereas on early Super Squirrel engines 5 or 6 to 1 was more usual. On the TT Scotts of the 20s Harry Langman talked about removing metal from the sides of the piston crown to prevent it hitting the cylinder head, and he must have been using c.r.s in excess of 10 to 1 for this to happen, but big-end trouble was not unknown.

In one of my DPY engines some years ago I fitted short-stroke pistons, which are 1⁄16" higher from gudgeon pin centres to top land, and also a short-stroke detachable head. This gave a volume at TDC of 35cc and a geometric ratio of 10 to 1. There was a marked improvement in performance at all r.p.m. and a big reduction in the life of the crankpin and con-rod bushings, but the engine pulled a 22T final drive sprocket with ease (4.0 to 1 top gear) and had bags of low-down power, although sensitivity to the magneto advance lever was increased. If we look at the effect c.r. has on the forces acting on the big-end we can see why big-end bearing life was shortened.

The standard DPY engine with a geometric c.r. of 7 to 1 has a volume at TDC of almost 50cc. Since the standard exhaust port height is 7⁄8" or 22.2mm and this represents 31% of the stroke, the actual c.r is as follows:

$$\frac{(298-92)+50}{50} = \frac{206+50}{50} = 5.1:1$$

The induced petrol/air mixture would therefore be compressed to 5.1 times the atmospheric pressure by the time the piston reached TDC. This, however, would only be true if the temperature at the end of the compression stroke was the same as at the beginning, and this is not so because as we compress a gas it gets hot just like the bicycle pump as we blow a tyre up. In fact, the period of compression is so short that very little heat can escape *via* the cylinder walls and the pressure at the end of the stroke rises according to the gas laws of Boyle and

Charles, so the pressure at TDC, before combustion starts, is in the region of 145 lbs. per sq.in. and the temperature 460°C.

At this point the sparking plug ignites the mixture and the temperature of the gas now rises dramatically to about 2,200°C. as combustion takes place. Contrary to popular belief, this does not liberate large quantities of gases which push the piston down as in an explosion. In fact, the extra volume of gases created by combustion is only of the order of 5%. The real increase in pressure comes from the rise in temperature and the attempt by the entrapped gases to expand their volume. Again, using the Gas Laws, this results in a pressure of about 488 lbs per sq.in. applied to the piston crown and consequently to the poor crankpin. The standard DPY engine, with a bore of 2⅞" has a piston area of 6.49 sq. in. and the force of the crankpin is:

$$6.49 \times 488 \text{ lbs.} = 3{,}168 \text{ lbs.}$$

If we now work these figures out for a geometric c.r. of 10 to 1 (i.e. an actual c.r. of 7.25 to 1 with a volume at TDC of 33cc) we get the following:

Geometric Compression Ratio	*7:1*	*10:1*
before ignition:		
Pressure in cylinder at TDC	145	235 (lbs./sq.in.)
Temperature in cylinder at TDC	460	573 (degrees C.)
after combustion:		
Pressure in cylinder at TDC	488	713 (lbs./sq.in.)
Temperature in cylinder at TDC	2,204	2,314 (degrees C.)
Volume of cylinder at TDC	50cc	33cc
Force on crankpin at TDC	3,168	4,660 (lbs.)

By increasing the c.r. from 7 to 1 to 10 to 1 the loading on the crankpin increases by 47% and this extra two-thirds of a ton or so of load is responsible for the shortened life of the crankpin and con-rod bushings and, also, of course, for the extra performance.

These calculations are a guide to crankpin loading on the power stroke and take no account of inertia loading as combustion takes place.

Some of the assumptions made are as follows:

1. That the pressure when the exhaust port closes is atmospheric (i.e. 14.7 lbs per sq.in.).

2. That combustion of the fuel in the cylinder produces a rise in temperature to 2,200°C. This depends on the calorific value of the fuel and on how completely the fuel is burned.

3. That combustion takes place with the piston at TDC when in fact is occurs over a short but finite time with the piston moving away from TDC.

4. That the extra volume of gases produced by combustion (about 5% with petrol) is negligible.

It is interesting to note that on the TT engines of the 1920s, which used high compression ratios, big-end life was a problem and I have had correspondence with Harry Shackleton (Scott's designer up to 1930) describing square blue big-end rollers, but crank breakages were quite rare. In fact, I believe crank breakage to be more to do with high revs than with compression ratio, and I will attempt to explain why in another article entitled *'Inertia Loading and Vibration'*.

SOME COMMENTS ON ENGINE BALANCE

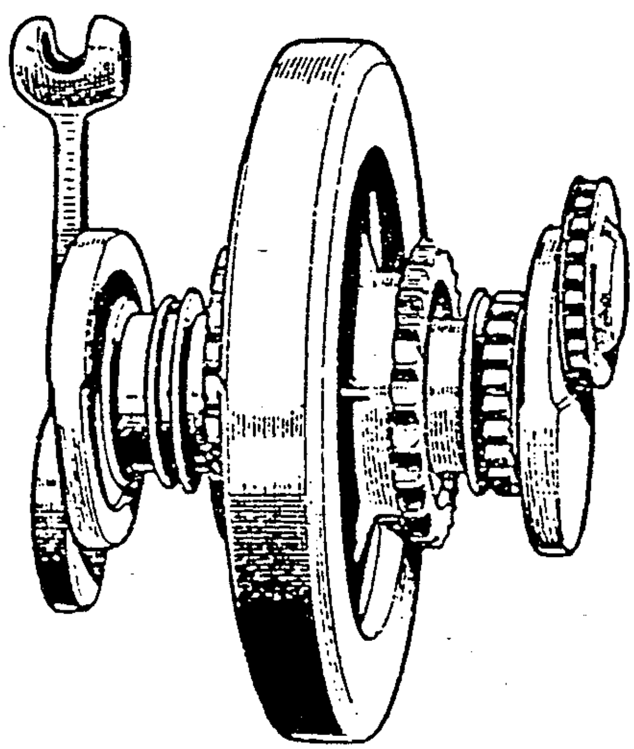
from an article by 'Pegasus' in *Motor Cycling*, February 27th, 1929.

Vertical Twins with Two Cranks

One type of vertical twin is that in which the cylinders are still set side by side, but the connecting rods are coupled to separate throws of the crankshaft set at 180 degrees. For we can, of course, neglect here the type of vertical-twin engine where the crank throws are set at 90 degrees, this being compound steam engine practice, and never—so far as I am aware—tried in motorcycle engineering.

The vertical twin with two-throw crankshaft, then, is the type of engine employed for the Villiers two-stroke unit which created such a great amount of interest when it first appeared at the 1927 Olympia Show; the two-stroke cycle, of course, having no bearing on the balance problems of this cylinder arangement. The Scott engine is also designed on the same principle, although in its special layout the normal type of crankshaft gives place to a central bearing and flywheel between the crank throws, slightly off-set from the centre line of the cylinders when seen in side view.

As to the balance of this type it is good, but not so good as the 180-degree twin engine. The main fundamental balance is perfect—that is to say, when one piston is at top dead centre the other is at bottom dead centre, so that the accelerations cancel out. Whereas, however, in the case of the horizontally opposed twin we found that the octave vibrations also cancel each other out, this is not the case with the vertical two-crank twin because of the connecting-rod angularity, which causes the maximum piston velocity to occur,



The special design of the Scott vertical twin two-stroke engine embodies a central flywheel and mainshaft bearings, with outside cranks set at 180 degrees and balanced to reduce the 'Couple'.

as we have already discovered, at 70 degrees to 80 degrees of crankshaft rotation from top dead centre instead of at 90 degrees. At the latter crank angle, therefore, the forces of both pistons are downwards so that they do not cancel out.

In addition to this we have to bear in mind that the two connecting-rod big ends are working in different planes, which introduces again the question of the rocking couple which we discussed in the case of the flat twin engine. It is, however, almost certainly bound to be worse in the case of the vertical twin, because, whereas on the flat twin the couple can be very greatly reduced, on the vertical twin the crank throws must be spaced apart by an amount governed by the bore of the cylinders and the necessity for leaving an air space or water space between the cylinder walls. It may, in fact, even be designed to have a central main bearing between the crank throws, although usually such a bearing would occupy a narrower space than the distance between the centre lines of the two cylinders.

This couple, then, has the effect of making the engine rock up and down longitudinally, the force and consequent vibration involved depending, of course, on the mass of the reciprocating parts and the speed of engine rotation. Another factor which must be taken into consideration, although it has nothing to do with balance, is the point that although on a two-stroke engine of this type the firing impulses are evenly spaced, on a four-stroke unit the explosions from the two cylinders follow each other after an interval of 180 degrees, and there is then a wait for 540 degrees until the next explosion occurs.

In theory, therefore, such an engine would appear to leave quite alot to be desired on the score of smooth running. At the same time, as "Carbon" pointed out in a recent issue of *Motor Cycling*" theoretical objections are not always found to be so very important from a practical point of view, and a great deal must depend on the whole set of conditions governing the installation of a particular engine in a frame. A special point in this connection is that the "rocking couple" described above can be considerably reduced in amount by fitting bob-weights to the crankshaft. These bob-weights should amount to, roughly, half the total reciprocating masses in weight, and the engine vibration, although still present, will be considerably lessened. The vertical twin-cylinder engines of two-crank type so far employed for motorcycle use at any rate do not seem to have suffered from vibrations to any very noticeable degree.

INERTIA LOADING AND VIBRATION

Tim Sharp

Inertia can be described as the reluctance of a moving mass to change speed or direction. The larger the mass and the higher its speed the more reluctant it is to change speed or direction and the forces needed to bring about these changes in acceleration will consequently be greater.

In a single-cylinder engine the piston has to be accelerated from standstill to maximum speed at approximately mid-stroke position twice per crankshaft revolution and it is the forces necessary to achieve these large changes in speed that give rise to vibration.

Unfortunately it is not possible to balance completely the reciprocating mass of the piston and that part of the con-rod deemed to have reciprocating motion by counter-weighting the flywheels opposite the crankpin, because the circular motion of the counterweight creates a continuous out of balance force, whereas the reciprocating masses generate an intermittent one at T.D.C. and B.D.C.

So if the whole of the reciprocating masses were counterweighted opposite the crankpin, the engine would be balanced at T.D.C. and B.D.C., but would be just as bad as before at the mid-stroke positions where piston acceleration is zero. The net result would be to exchange an engine which vibrated in the direction of piston movement for one which vibrated just as badly in a plane at right angles to this.

In practice the inevitable compromise is carried out where a proportion of the reciprocation weight is added to the flywheels opposite the crankpin. This can be anything between 40% and 80% of the reciprocating masses and depends on the design of the frame and engine mountings, and the r.p.m. range in which the engine is likely to spend most of its life, the idea being to move the inevitable vibration into an r.p.m. area which is used least.

The most satisfactory way to balance reciprocating masses is by adding another cylinder, so that the out of balance forces of one cylinder are opposed by those of its partner, as in the 180° vertical twin and even better in the flat twin.

In the Scott, which of course is a 180° twin (assuming that the flywheel key has not sheared!) the balance is good, but not perfect, because the forces are acting in planes several inches apart and this sets up a rocking horse couple which would be considerably reduced if the flywheels were counterweighted with 50% of the reciprocating masses. Fortunately, a rocking couple has less external effect than a straightforward vibration and 180° twins usually run very smoothly.

However, the Scott has no room in its compact crankcase to employ 50% balance factor and furthermore I doubt whether the small amount of counterweighting on the cranks is sufficient to balance the rotating masses of the big-end and that part of the con-rod deemed to have circular motion. Some Scott engines have been made to run more smoothly by creating a small rocking couple on the flywheel by drilling the rim at opposite sides 180° apart so that the rocking couple opposes that generated by the centrifugal out of balance forces of the crankpin and lower half of the con-rod.

This still leaves the large rocking couple generated by the piston and upper part of the con-rod, which are completely unbalanced and consequently the vibrating force acts in the direction of piston movement and attempts to rock the engine sideways across the frame. This effect is reduced by the heavy central flywheel, and by the engine mountings which are spaced wide apart in the very rigid frame of the later Flyers.

Only two factors can be changed to give a smoother Scott engine:

1. Increase flywheel weight;
2. Reduce reciprocating weight.

The first has the disadvantage of slightly reducing acceleration, the second has the advantage of reducing internal loading on the crankshaft assembly.

Also, the crankshaft assembly must be true, and it is wise to assemble the cranks and flywheel outside the crankcase and mount between centres in a lathe. A dial gauge reading on the main bearing bushes should ideally be dead true but ½ thou out is still quite good. In my experience it is unusual for this reading to be exceeded unless the cranks have run without being driven up solid into the flywheel. At least then we are only contending with the rocking couple and not with vibration from an out of truth crankshaft.

The standard 11 lb. flywheel of the long-stroke engine should not be lightened and Super Squirrel engines used a 13 or 14 lb. flywheel which gave additional smoothness and probably made up for the less rigid engine mountings and flimsier frames of the earlier Scotts.

Inertia forces are proportional to reciprocating weight and if this were to be reduced by 20% we would have a 20% smoother engine. Some interesting figures are listed below:

Item	**Weight in ounces**
Con-rod:	
Top half of standard rod with bronze bush	4.50
Top half of standard rod with aluminium bush	3.75
Top half of lightened rod with aluminium bush	3.50
Gudgeon Pin:	
Standard Scott (596) with bronze end pads	3.00
Standard Silk, no end pads	2.50
Lightweight pin, no end pads, for Silk piston	2.20
Piston:	
Early cast-iron with rings	25.00
Sand-cast Hepolites with rings (596)	14.66
Die-cast Hepolites with rings (498)	11.50
Die-cast Hepolites with rings (596)	12.00
Die-cast Silk with rings unported	10.50
Die-cast Silk with rings ported	10.00

If we take the average case of a standard con-rod with bronze bush, standard gudgeon pin with bronze end pads and Hepolite die-cast piston (596) we have a total reciprocating weight of:

4.50 + 3.00 + 12.00 = 19.5 ounces.

If now we take an engine with lightened con-rod and aluminium small-end bush, lightweight gudgeon pin with circlip retention and ported Silk pistons we have:

3.50 + 2.20 + 10.00 = 15.7 ounces

— a reduction of 19.5% in reciprocating weight.

(To be continued.)

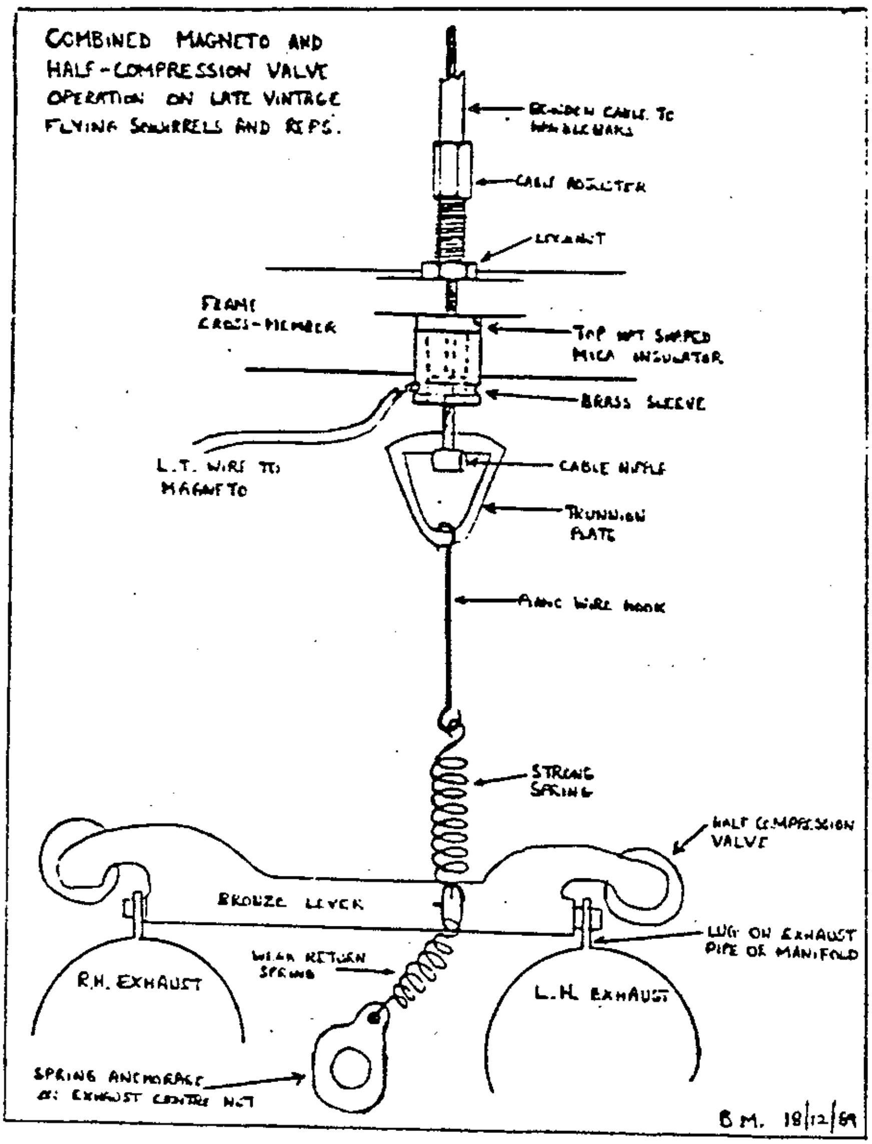
INTERCONNECTED HALF-COMPRESSION AND MAGNETO CUT-OUT ASSEMBLY, USED ON LATE VINTAGE FLYING SQUIRRELS (AND ALSO ON T.T. REPS)

Very, very few machines seen today seem to be original in this respect. The device was of doubtful utility in the first place, and half-compression valves had a nasty habit of sticking open and/or leaking black messy goo all over the engine.If you do decide to fit one and be totally original, they are easy enough to make (apart from the actual bronze lever, — I got mine from the Spares Scheme).

I hope my sketch and photo are self-explanatory. After the initial lever movement has operated the half-compression valves further movement stretches the strong spring which brings the cable trunnion up into contact with the insulated boss to which the magneto earth wire is connected.Thus the magneto low tension current earths via the cable and spring, and stops the engine. (Force needed to stretch spring must be greater than force needed to operate half-compression valves).

Personally, I have blanked off the half-compression valves, and just use it as a magneto cut-out, but, if you are a real masochist, give it a whirl!

B.M.



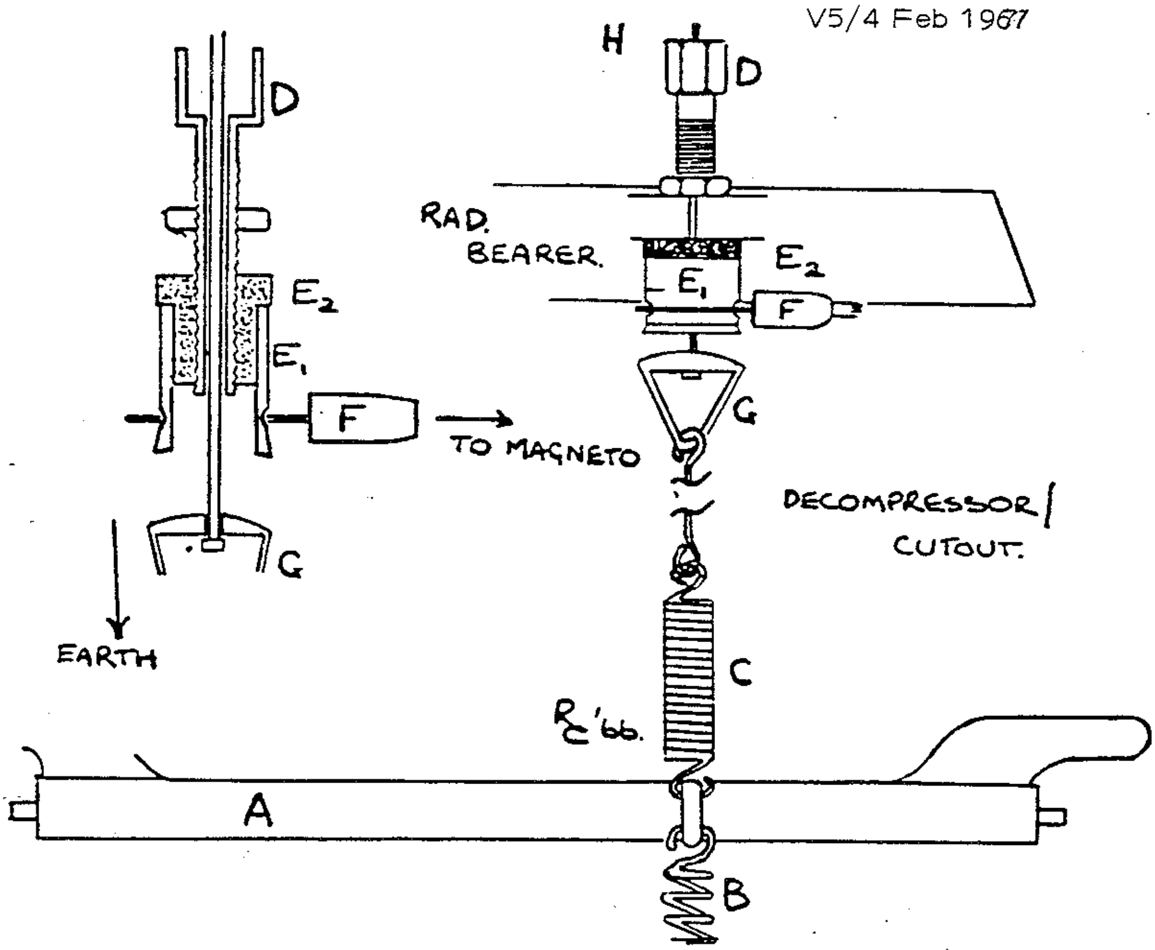
HALF-COMPRESSION VALVE LEVER AND MAG. CUT-OUT OPERATION

Jim Best has phoned to tell me that the sketch I did in the February issue of this idiosyncratic gadget showed an incorrect bottom spring anchorage. Although I have seen one or two bikes with the spring anchored to the exhaust centre nut, as in my sketch, Jim says that it should be hooked into a $^{3}/_{32}$" hole in the front of the crankcase. Sure enough, when I looked at my crankcase there is such a hole, and I remembered wondering what it was for when I rebuilt the engine on my Rep!

Jim also replied to my query on the wheelrims on John Thompson's 1926 596cc two-speeder, depicted on page 240 of the Feb. issue. This seems to be yet another "grey area" as the 1927 model, which would have been at the 1926 Show, did have wired-on type rims and tyres. Whether or not these became available on late '26 bikes, after the Show, is another question altogether! Of course these things did happen, which explains the "1928 T.T. Reps," a few of which escaped in 1928 even though it wasn't "listed" until 1929.

B.M.

V5/4 Feb 1967



VINTAGE "FLYER" DECOMPRESSOR/CUTOUT ASSEMBLY

by *Bob Cordon-Champ*

Cable H from the handlebar lever, when pulled, actuates the decompressors through the bar A, stretching the weak tension spring B, which is attached to a thin triangular-shaped plate held by the centre "sleeve" nut of the exhaust system. When these reach the limit of their travel, (position shown in the drawing) if the pull on the lever is continued, the strong spring C stretches, allowing the metal cable achorage G to contact the metal base E_1 of the adjuster D, this being insulated from the cable H by the plastic block E_2 into which it screws but connected to the magneto by the lead F.

Earthing of the magneto thus takes place through the spring C.

A LONGSTROKE SHORTSTROKE

by Ian Robertson

The awful clatter from the loose gudgeon pin of my Replica motor had become noticeably worse throughout the winter months. When at last the temperature rose to a degree warm enough to turn one's thoughts to summer Scotting, I lost little time in lifting the block to rectify matters.

Loose gudgeon pin was the understatement of the year! I had two badly worn pins, two pistons with oval gugdeon pin holes, and for good measure a couple of well-seized rings on the L.H. piston. Sheer neglect of course, but the operating conditions had been pretty impossible for good maintenance.

I scanned the Exchange and Mart; my luck was in—or so it seemed: a 489 block and pistons were advertised for 30/-, I made a beeline for the G.P.O.

Three days later a massive-looking parcel arrived by rail. Delving into the large cardboard box I found beneath a copious swathing of rag a rather elderly looking blind-bore block and two ringless pistons. A closer examination of these parts helped to restore my sunken spirits: both pistons and cylinder bores were in excellent condition; new rings and a coat of paint to the cylinder water jacket and it was simply a matter of fitting to the crankcase. So thought I in all innocence! It wasn't until I tried to turn the engine over that I realised something was wrong. And how! The pistons was hitting the head.

Careful measurements confirmed my worse fears: in my haste to secure a bargain I had bought a shortstroke Flyer block.

Reference to measurements published in recent copies of Yowl told me that there was some 3mm difference in the stroke of the two engines; common sense insisted that I should abandon the idea, or change the cranks and rods: sheer pig-headedness made me look for a way to assemble things as they were.

Then came inspiration. The thickness of a cork base washer was about the clearance I needed, so why not fit two? I did. This left a like gap where the paper rings go, and it was then that I recalled another Technitip: the use of cornflake packet to replace the paper rings. I miked a typical packet, and found the thickness was .020" so a little arithmetic was needed to arrive at the conclusion that I should have about seven or eight of these rings on each cylinder, as something had to be allowed for when the material became compressed. In actual fact I needed ten or eleven of these packings, firmly cemented together with Osotite joining compound before I was satisfied that the pistons would safely clear the fixed head.

For some strange reason the port timing was something like right, and although it seemed a lot to expect, I began to hope that at least the motor would run in some sort of fashion.

A little modification of the half compression valves (now fixed in the closed position) was needed before I could fit my exhaust system, but eventually all was ready for the test.

The engine started at the third swing of the kickstart, and to my great delight sounded smooth and very Scott like. A run up the road confirmed this impression; the amount of power was surprisingly good considering the small ports, and the smoothness a revelation. I at once became a short stroke convert.

Since then some 2,400 miles with the 'hybrid' have passed beneath my Avons; with each mile I have become more attached to the old Flyer block. No snags have been encountered yet, but I have kept a constant check on cylinder base bolts — just in case they decide to come loose. Maximum speed is around the seventy mark, and fuel consumption 50 M.P.G.

UNDER THE MAPLE TREE

The mind wanderings of an expatriated Scott Enthusiast

D. W. Avis

I went to see Bill Beeman in Ottawa the other night; hadn't seen him in four years, which is positively indecent. The last time I saw him, the Medics had been at him and replaced a few lengths of clogged fuel lines. He now seems to be fully recovered and to prove it, he has just acquired a BMW Model K. The horrendous cost of this was easily covered by selling his BMW R7 and a Vincent Rapide. He has one of his two-speeders at the final assembly stage and we plan to join forces shortly to fire it up one evening.

After an excellent meal, we got to our usual technical philosophising. Bill is a Civil Servant with a solid position, but in spite of this he has a really enquiring mind. He has lots of mechanical acumen and a basement full of nice equipment to back it up. He loves to discuss theoretical and practical matters, but expects a proper justification for your beliefs if you expect him to be convinced.

We fell to discussing air leaks in Scotts, and how to trace them. Having had old Scotts with distorted or butchered castings I know about leaks. I explained that leaks in a Scott can be classified in three ways:—

a) Leaks between the induction system and the outside atmosphere.
b) Leaks between the crankcase and the outside air.
c) Leaks between the crankcase and the induction system.

Class "a" leaks can occur at the carburettor flange or at the outside joint between the block and the crankcase casting. Unless very bad, they do not spoil the starting or running characteristics very badly. The mixture will be weakened at low throttle setting, but this can be beneficial to smoother idling in some cases. I noticed this on my 1928 Flyer de Luxe, which used to lose segments of the paper washer under the block. Eventually the cause of the failed washers was traced to the cylinder bolts, which bottomed before providing the full clamping pressure. This cured, the idling became lumpy, even with the idle screw hanging out. The carburettor, a relatively modern Amal, with internal primary air intake, was removed and a 1/32 hole drilled up into the threaded part where the idle screw is retained. After about two turns, the idle screw is providing all the air it can through the air jet it controls. Screwing out another turn or so would uncover the hole and bleed in more air. The big advantage was a smoother "cut in" when the throttle was opened. Years later my 1949 model was modified by inserting a small union on the front of the crankcase casting which fed air into the induction gallery. A pipe connected the union to an adjustable jet down by the oil pump. (A chain oiler dripper was used as the control jet). This enabled idle mixture to be regulated for atmospheric variations. All very clever stuff. (Strangely, however, when the "Lofty Lube" scavenging lube system was installed, the absence of excess oil in the mixture required that the extra air be discontinued). The engine is set to idle at minimum throttle, the cut-in is clean and there is no popping on the overrun.

Class "b" leaks are a different proposition. They grotesquely affect the running of the cylinder afflicted, because air is drawn in all the time the piston is rising and mixture is lost all the time the piston is decending. The leak therefore, has a big advantage over the normal gas flow which is only transferred at the ends of the piston stroke. Leaks result in one-sided running at low throttle settings and spitting at the carburettor. If both cylinders are bad, the engine often has to be push-started.

The leaks can occur at several places:—

1 At the transfer port cover
2 At the crankcase doors
3 At the main bearings.

One way to find the leaking joints is to paint on small amounts of fuel whilst the engine is running. The engine note will change when you hit the leak-spot. (Use a squirt to test the bearings).

Once the spots are located, it's up to you to fix them. Old castings distort and some careful work is often required to get the castings to joint properly. Some blocks do not quite match the crankcase and the transfer covers are slightly tilted. I once made packings from two layers of cocoa tin metal stuck on the crankcase aperture with epoxy, the cover (greased) being put on whilst it set. This corrected the problem permanently although the covers were removed numerous times after.

Leaks at the crankcase doors seldom seem to cause "spitting" for some reason. They do upset the running however, and also put the engine oil on your boot, instead of on the big-end. (This will turn blue with envy if you're belting down the motorway).

The most diabolical leak, without doubt, is at the main bearing. It can make a machine give you nightmares. Bad starting, scratchy running, spitting and snatching, occasional seizures if the oil is being lost, and reversing at traffic lights. (This can occur when the engine is over-advanced to compensate for the weak mixture and you grab a handful of throttle to prevent a stall).

Usually the leaky mains are caused by the packing glands not sealing due to having "picked up" from lack of oil. Sometimes however, the bearings are out of line because the crankcase is distorted. This can be because of weld repairs or distortion when clamped in the frame. Old crankcases sometimes crystallise and a crack can start radially from the cup along a casting line. I had this trouble with my '28 Flyer, so I drilled a $\frac{1}{32}$ inch hole at the end of the crack, flushed the crack with acetone and filled it with plastic metal. Don't *think* of welding it.

Whatever the cause of the leak, the test is that the crankcase must hold paraffin oil without leaking, even at the main bearings. Some people paint soapy water around the outside of the motor to check for leaks. This is fine but you can't check the mains this way. One can, of course, squirt petrol down the crankcase between it and the sprocket, when the motor is running. A change in engine note or speed indicates a leak. The only final bench test, however, is to fill with paraffin.

Intermittent bad running can be due to air leaks at the mains due to the packing gland being lifted. This happens in engines with considerable end float on the crankshaft. The packing gland driving tongue "saws" its way into the keyway in the flywheel. It eventually can catch on the step and be lifted out of contact with the bearing face on which it seals. The problem is common on rebuilds where the wear is not corrected and the engine reassembled with more end float than before. Many a Scott has been lovingly restored by a would-be enthusiast, only to be exchanged for a Beesa because the poor fellow just couldn't cope with its temperamental traits, caused by this very problem.

I used to have the flywheel keyway welded and then paintstakingly file the keyway to shape. One blob of weld on the taper, however, can cause anguish indeed. In this event, you can clean off the worst with a round file, then grease the crank taper and use it as a tool to cut the flywheel taper to shape. (The crank is hard and the edge of the keyway in it's taper is very sharp. I eventually solved the problem on my '49 machine, whose gland tongues themselves were showing wear at around seventy thousand miles. I ground the tongues square, but now they were too narrow. I repaired the flywheel keyway and lapped in the cranks and was all ready for assembly.

Now an idea struck me: why not put in a wearing strip that could be replaced? To this end, I filed the side of the crankshaft key until I could insert a piece of that blue, rather brittle steel strip used around shipping cartons. When trimmed, this was inconspicuous, but meant that about 12 to 15 thou had been removed from the width of the keyway into which the packing gland tongues were to enter. This compensated for the grinding back they had received. The wear would not be prevented, but the flywheel would be protected by a piece of metal that could be changed each time the engine was dismantled. An interesting result was that, even after another forty thousand, the metal had not worn enough to warrant changing it. This could be, of course, because I shimmed for only about seven thou end float. A note here: when working on the mains like this, always put the spacer in the top rear mounting holes and using a distance piece to compensate for the frame lugs, insert the through bolt and tighten it up. Ten thou at this joint is three thou at the bearing. If the distance piece is not the right width to just fit in, look for wear or crankcase distortion. Both occur on old machines, particularly where the engine has not been bolted up tight and vibration has caused wear . . .

Up to this point there has been no mention of Class "c" leaks. The most likely place for these to occur is at the cylinder base washers, causing leakage between the crankcase and the induction tract, although badly worn, or oval piston skirts can also be a cause. Class "c" leaks don't give rise to weak mixture since both spaces contain petrol-air mixture. Clearly however, mixture trapped in the crankcase is squirted back into the induction system all the time the piston is descending and therefore not available for transfer when the port opens. That cylinder will fire less energetically than the other, giving the exhaust a hollow, one-sided sound. The affected cylinder will "chime in" as the throttle is opened. Failure of C.B. washers is rare these days. The cork variety used to split, and the rubber ones used to turn to goo so failure was not uncommon in the heyday of the Scott, but the butyl type available today will not let you down, providing the seating surfaces are o.k.

I had a classic case of bad failure on my '28 Flyer. I had acquired a 600cc block and pistons, having discovered that the existing block was only a 500, and damaged beyond repair. The bores and pistons were in a shocking state after repeated seizures, but after much handwork, it was decided to assemble the engine and try it. Now let me introduce a character, one "Smokey" Spooner. He was a 'bus mechanic who had been bitten by the Scott bug and owned a '37 machine. Since he had access to unlimited supplies of SAE 50, and never slowed for anything when he was driving, his machine used frequently to bring traffic to a halt in the town by reducing visibility to zero — hence the nickname. I rode on his pillion from Southend to Laindon to collect said block. On the return trip the bike skidded from under us as we slowed to turn through the centre reservation of the A127 to go to his house at Leigh. Since it was dark, we were never sure whether it was ice or oil that caused the spill. I think it was ice, because I skidded thirty yards on my knees without wearing through my leggings.

Assembly was being done at Smokey's shed and I went home for Sunday lunch, leaving the block still to be assembled to the crankcase. Upon returning, about two hours later, I found Smokey just about to hook up the primary chain. He could never stop once he had his teeth into a job. The machine had to be pushed to get it started, which was a bad sign. Although both cylinders were firing, only one was doing any work until the throttle was half open. I took it home and rode it for a couple of weeks, putting "Piston Seal", and other proprietory products designed to rejuvenate ailing four-strokes, down the plug holes. These did nothing for the Scott. In the end I concluded that only a rebore would fix it, so ceased to ride it since the bad running got on my nerves.

One frosty Sunday morning, the gang came round to coax me out for a pint down at Leigh Old Town. I wheeled out the Scott and took off the cover. A tongue of ice curved out from a horizontal three-inch split across the back of the block, reaching as far as the carburettor cables. As the heat of the sun warmed the motor, the ice drew back into the split without melting, and the crack closed up before our eyes, the whole performance taking about ten minutes. I stripped the motor a week later and I found the real cause of the atrocious running. A piece of the cylinder base seating surface was missing where it crossed the transfer aperture. Smokey had a habit of spinning flywheels after assembly, and evidently had done so with the conrods attached. Pull that stunt and the rods will take those vital pieces of metal right out and you won't even see them go.

This was a terrible situation. Not only was my beloved Scott irreparably damaged, but evidently by a good friend in a mad moment of exuberance. I counselled patience to myself; the problem might yet be solved. In the meantime, the block was welded. This proved to be a mistake, since it caused some distortion; grooving and soldering would have been quite sufficient and would simply open in the same place if the same neglect occurred again. Local firms declared the block unmachinable, but a certain Harry Sharp reckoned otherwise. He was a man dedicated to perfection in things motoring. Laystall of London was his favourite engineering shop, so he took me and my block to see the man. The block was gauged, the wall thickness measured and the situation thoroughly assessed. The verdict was a tough one. I should order plus 50 pistons and they would bore to these, one bore to be de-centred by .050. Harry collected it three weeks later and it looked a beautiful job.

This gave me new hope, and sure enough, a day or two later, an idea popped into my head. This would be a first class botch-up, but it might buy me time to find a new crankcase. Now I had lost three-eighths of an inch of the cylinder-base sealing surface so must first bridge the gap with something strong enough to support the pressure of the joint. I did this by making hacksaw cuts sideways at the transfer apertures, about a sixteenth below the plane of the C.B. seating surface. A piece of sheet steel, one and a quarter wide, was slid into the slots. Its nose had to be trimmed to follow the curve of the cylinder base and its trailing end cut to protrude one eighth into the gas path. It could now be folded upward against the casting, out of the way of the gas flow and at the tame time gaining the required stiffness.

I now had a supporting bridge, but sitting a sixteenth too low. Fortunately I had a brother in the printing trade and had accumulated a good stock of type-casting metal. This can be melted by a very hot soldering iron, and as it solidifies, it expands to assure a sharp edge to the letters. It also has a plastic state like plumbers' metal so it can be worked hot without melting away. When cold, it is quite hard so that the type will do a lot of work. The insert was tinned and wiped and installed using plastic steel. When set, the type metal was worked into the depression with the soldering iron. The careful filing and scraping that followed yielded a seating surface in which the joins were almost undetectable.

That repair never gave any problem during my use of the machine, during which I wore out three rear tyres and one and a half front ones. The bore, however, was a trifle close I think, because it took a lot of running-in. All in all, however, it was a marvellous motor, and a joy to drive. I gave the bike to Mr. Beal when I left England; the motor had been reconditioned and should have been ready to roll.

THE POTTY CRANK PROBLEM

Glyn Chambers

Some years ago, after breaking several long-stroke cranks (I've never broken a short-stroke one yet!) I had all the long- and short-stroke Flyer cranks in my possession (about ten pairs) crack tested using the Magnaflux plus dye technique (by this country's most famous aero engine co.). About half the long-stroke and *all* the Flyer ones proved to be cracked! Over the next few years I bought several new long-stroke cranks from Roger Moss etc., to cover all my immediate needs. I also bought a few second-hand long- and short-stroke Flyer cranks.

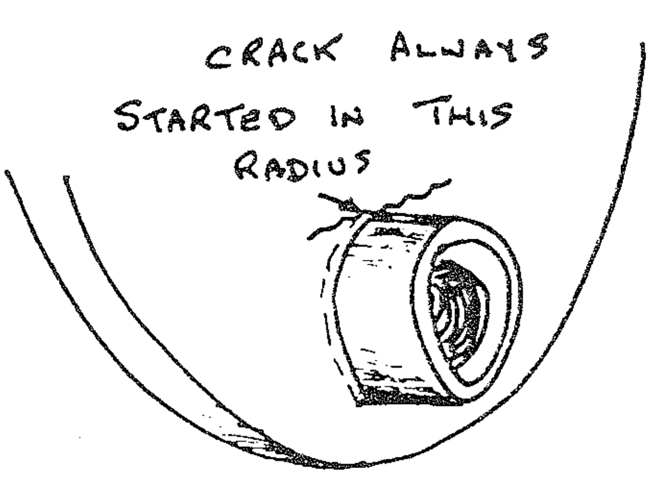
A few months ago I was fortunate to visit the laboratories of a large and famous vehicle producer who tested 20 cranks, including two previously declared cracked, but to my magnifying glass looking OK. Out of the 20 only one (an almost new long-stroke one) was found to be sound. This means I have no uncracked Flyer cranks and I dare not take down my 'old nail's' engine in fear of what I might find and I cannot build up any of my Flyer engines.

Some of the cranks had very small cracks, some were quite extensive, but in each case the crack started from the radius of the crankpin at some machining mark, or burr caused by the back of a rotating bush, and also I suspect from a knife-edge tool used for removing the pin bush (I might be guilty of this myself).

The main reason for crank breakages

(accepting the basic limitation of the design)

1. Incipient flaw in the radius of the pin.
   — a polished and perhaps slightly larger radius would give the crack a much harder starting point.
2. Web thickness of the crank face too thin, causing excessive bending moments around the crankpin radius'
   — cranks vary in thickness enormously and the thickest possible crank that will allow clearance to the main bearing cup should be used. *Note:* most long-stroke cranks were thinned down and a knife edge formed to act as a centrifuge oil supply to the big-end — totally unnecessary!
3. Incorrect material and/or heat treatment.
   — material must be used that can stand the fatigue flexing that takes place, something like the modern equivalent of EN36B suitably treated — no doubt one of our experts will know.



THE CRANK CRACK PROBLEM

ON THE SUBJECT OF CRANKSHAFTS

Tim Sharp

In 1982 I had correspondence with Harry Shackleton, who was draughtsman and chief designer at Scotts in the twenties until their 1930 crash of the Scott Motorcycle Co. Ltd. when many people lost their jobs as the company was deduced in size to fit the much smaller order book of the depression years. Harry was one who lost his job and 'emigrated' to the Midlands to work for many years at Villiers of Wolverhampton. I believe that, prior to joining Scotts, he had worked at Parkinsons of Shipley, makers of the once famous Parkson range of milling machines. His reply to my letter asking about the type of steel used in the Scott crankshaft follows:

Carlisle
January 5th 1982

Dear Mr. Sharp,

I was interested to receive your letter and hear the names of my contemporaries of 50 and more years ago. Bill Moseley's name I recall, but cannot bring him to mind. Your queries as to materials of crankshafts — they were drop forged mild steel case hardened. The crankpin and main bearings bushed with hardened chrome steel bushes. I cannot recall in my time a broken crankshaft, but I have seen bearing rollers anything but round (poor lubrication).

Please excuse my brief reply but at my age (88) my memory is not good.

My best wishes to you for 1982.

Harry Singleton.

It is a fact that broken cranks in Squirrel and Super Squirrel engines of the twenties are extremely rare, even after all these years for metal fatigue to take its toll. I know of only one instance, the late Brian Stephenson of the Northern Section experienced a broken crank whilst riding his two-speeder in the Bradford area during the 1939-45 war. The interesting thing was that the crank fractured where the shaft joined the web — under the main-bearing bush, and not in a crescent shape across the web just below the crankpin as is usual with later crankshafts.

It is a fact that peak r.p.m. and power output were increased in the Power-Plus engines, whilst crankshaft webs became thinner to accommodate the undercut designed to collect oil and pass it through the crankpin drilling to the big-end, in theory.

In the late fifties and early sixties there used to be a Saturday morning gathering of Scott enthusiasts at Geoff Milnes' shop in Leeds and I well remember being present when lubrication generally was being discussed. Both Geoff Milnes and Harry Langman were of the opinion that the undercut behind the crank and the drillings in the crankpin itself were of no benefit whatsoever and that oil existed in the crankcase not as discrete drops, but as atomised tiny droplets which filled the crank chamber like a vapour. If this is true it would make more sense to use race plates with large holes as in the early Scott engines and to abandon the weakening of the cranks by undercutting and drilling oilways. Is this another example of Alfred Scott being right all the time.

In 1962 I built myself an LFY engine with long-stroke cranks which had no undercut or oil drilling in the crankpin or crank cheek. Harry

Langman called these Tourer cranks of about 1933 as distinct from Replica cranks of 1929 which also had no oil drillings, but had a thicker rim measured radially. These were probably the strongest cranks to be made at Shipley and are now exceedingly rare.

This engine has done about 60,000 miles in my faithful Flyer and I can honestly say that big-end life is no different to the DPY type of crank, which has the undercut and oil drillings and I believe that Harry and Geoff had it right. In my experience big-end life has more to do with the accuracy of fit than anything else.

In the late twenties or early thirties (the date is not certain) cranks were made from drop forgings of nickel case hardening steel, which gave a higher core strength.

Finally, why do some cranks emit a ringing noise when struck with a spanner and some give a dull thud? In neither case do these cranks appear to be cracked. Both the Tourer cranks in my LFY engine gave a dull thud and they still show no signs of a crack after 60,000 miles. (Goodness knows how many miles they have done from 1933 to 1962). How much do cranks deflect and how does this increase with r.p.m? Are there certain critical speeds where crank deflection becomes much greater and what are these speeds?

V19/8 Feb 1996

SCOTT POWER OUTPUT

Tim Sharp

In response to Patrick Garland's letter in December *Yowl,* I have dug out the following figures which may be of interest:

Specific Power Outputs of Some Interesting Motor Cycle Engines.

1) Four stroke racing engines

Make	*Capacity cc*	*Cylinders*	*Valve operation*	*bhp*	*rpm*	*bhp per litre per 1,000 rpm*
Manx Norton (Bill Lacey)	499	1	d.o.h.c.	57	7,200	15.8
7R AJS	350	1	s.o.h.c.	42	7,800	15.4
BSA Gold Star	499	1	pushrod	42	6,800	12.3
Morini (1963)	250	1	d.o.h.c.	38	11,000	13.8
Rudge (1930)	499	1	pushrod 4 valve	38	6,000	12.6
MV Agusta (1972)	350	4	d.o.h.c. 4 valves per cyl.	66	14,000	13.5
V8 Guzzi (1957)	500	8	d.o.h.c.	80	12,000	13.3

The specific power output measured in b.h.p. per 1,000 r.p.m. per litre is a measure of how effectively the cylinders are filled and is related to the pressure in the cylinder during the power stroke, i.e. the Brake Mean Effective Pressure or B.M.E.P. Since a two-stroke engine fires every revolution of the crankshaft it will produce the same power as a four-stroke engine of similar swept volume with only half the B.M.E.P. at the same r.p.m., of course.

The figures show how good the Manx Norton engine was, the motor produced for Mike Hailwood for the 1961 Senior TT by Bill Lacey, using a one-piece crankshaft and aluminium con-rod with plain big-end bearing, produced well over 60 b.h.p. at a higher r.p.m. This was, I believe, the last single cylinder machine to win the Senior TT, at an average speed of over 100 m.p.h.

The fabulous 250cc Morini single of 1963 ridden by Tarquinio Provini was perhaps the last time a four-stroke was a challenge to two-strokes in the lightweight class of GP racing. The world championship was decided in the final round when Provini was beaten by the two-stroke Yamaha. From this point on the two-stroke engine was able to out-perform the four-stroke with the help of the resonant exhaust system or pulse generator to give it a more meaningful name.

2) Two-stroke racing engines

Make	*Capacity c.c*	*Inlet valve operation*	*Cylinders*	*bhp*	*rpm*	*php per litre per 1,000 rpm*
Suzuki (1966)	50	disc	2	17.5	17,300	20.2
Yamaha (19168)	125	disc	4	44	17,500	20.1
Suzuki RG500	500	disc	4	108	11,600	18.6
Villiers Starmaker (road racing)	247	piston	1	31.2	7,500	16.8
Villiers Starmaker (scrambler)	247	piston	1	22	5,500	16.2
QUB (Professor Blair)	500	piston	1	60	7,800	15.6
Ossa	250	disc	1	42	11,000	15.2

The chart shows that cylinders of below 125cc are more effectively filled than those above 125cc, even though r.p.m. is much higher with the smaller cylinders. This is because port areas are greater with smaller bore cylinders relative to the swept volumes and also the resonant exhaust system is more effective at higher r.p.m. where sound waves of greater amplitude or energy can be harnessed.

The QUB engine (Queen's University Belfast) developed by Professor Gordon Blair is unusual for a two-stroke in being air-cooled and a very large 500cc single cylinder. Gordon Blair used a computer to design the ports and exhaust system and Yamaha made use of his knowledge and frequently flew him out to Japan. The size of the cylinder and the need to maintain close piston clearance at all times irrespective of temperature variations across the piston and cylinder made the engine unreliable and frequent seizures were experienced.

The 247cc Villiers Starmaker engine was without doubt the best engine produced by Villiers and it is a pity that it was just too late. However, it does show that a specific power output of 16.2 b.h.p. is possible at the low speed of 5,500 r.p.m.

3) Two-stroke touring engines

Make	*Capacity*	*Cylinders*	*Inlet valve operation*	*bhp*	*rpm*	*bhp per litre per 1,000 rpm*
Suzuki YDS (5 port)	247	2	piston	29	7,500	15.7
MZ Trophy Sport	250	1	piston	21	5,400	15.5
Ossa Yankee Twin	500	2	piston	58	7,500	15.5
Villiers 37A (trials)	246	1	piston	12.4	5,000	10.1
Suzuki 500T	500	2	piston	46	7,000	13.3
Scott Replica	596	2	piston	29	5,500	8.9
Scott Replica	498	2	piston	24	5,800	8.3
Scott Super Squirrel	498	2	piston	16	4,500	7.9
Scott Super Squirrel	596	2	piston	17	4,000	7.1
Scott (1914 racer)	486	2	piston	10	3,000	6.9
Scott Aero Four	650	4	rotary	15	2,000	11.5

I do not have any performance figures for the short-stroke Flyer engines of 2 11/16" stroke (68.25mm), but they had shorter inlet timings which improved the low speed performance. The long-stroke 498cc machines for the 1929 TT developed almost 26 b.h.p. and revved up to 6,000, but at this speed they were unreliable.

Many years ago I asked Geoff Milnes and Harry Langman at one of the Saturday morning gatherings at Dewsbury Road what was the most powerful Scott engine produced at Shipley. Geoff Milnes replied that he had seen 35 b.h.p. on the brake from an engine built from a combination of short-stroke and long-stroke parts giving 650cc of swept volume, He did not say at what r.p.m. this figure was produced or how far back he was standing at the time.

I have included the specific power output of the Scott Aero Four engine taken from George Stevens' original research (published in *Motor Cycling,* December 5th 1962) where Alfred Scott had predicted 15 b.h.p. at 2,000 r.p.m. This gives a specific output of 11.5 b.h.p. and no doubt Alfred Scott had based his calculations on the high volumentric efficiency created by the small crankcase volume.

Scott port timings

Machine	*Inlet*	*Transfer*	*Exhaust*	*Exhaust lead*
Short-stroke Flyer	94°	129°	149°	10°
Long-stroke Replica	117°	130°	154°	12°
Super Squirrel	97°	120°	139°	10°
Silk Scott Vintage Racer	140°	130°	164°	17°
Herman Meier Tuned Villiers 34A (peak rpm 6,000)	162°	125°	155°	15°
Yamaha TD2 Racer piston inlet. r.p.m. 11,000	195°	140°	195°	27.5°
MZ 125cc Racer disc valve inlet. r.p.m. 11,000	205°	125°	175°	25°

The connecting rod of the Scott short-stroke engine is $^1/_8$" shorter in length than the long-stroke and this gives a shorter inlet timing and also a smaller crankcase volume at b.d.c. compared with the long-stroke.

Compression ratios of Scott engines

Generally I have found blind head Replica engines to have a geometric ratio of between $9^1/_2$ and 10, Short-stroke Flyer engines from 6 to seven, and Super Squirrel engines $5^1/_2$ to $6^1/_2$.

Compression ratios on the racing Scotts of the 1920s must have been higher than ten. I remember Harry Langman describing how he used to use engineer's blue when hand shaping the piston to obtain 20 thou clearance at t.d.c. This would, of course, give a useful squish from the curved section of the piston crown and enable higher compression ratios to be used without detonation. Harry lapped the TT course at almost 65 mph in 1925 on a two-speeder and he must have had 25 b.h.p. to achieve this on the poor quality roads of the day.

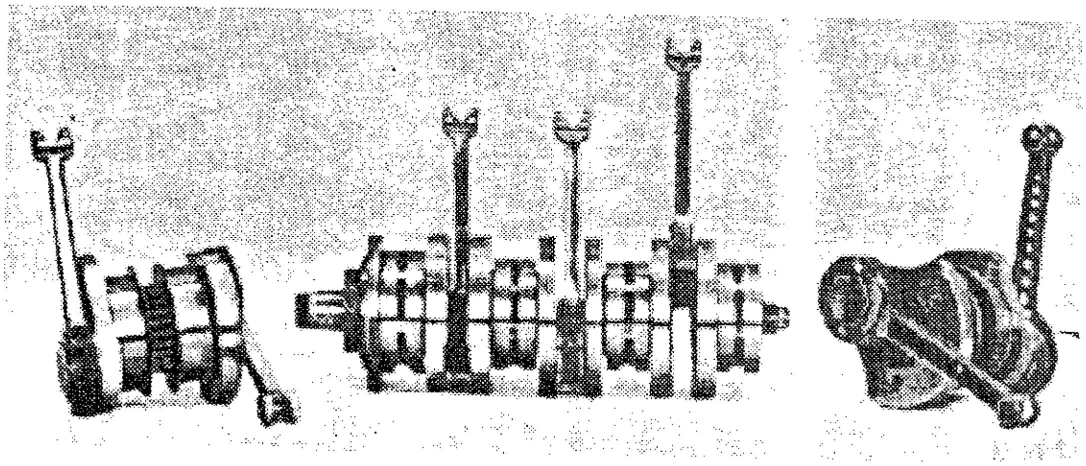
Standard port depths of Scott engines

Type	*Depth of inlet port*	*Depth of transfer*	*Depth of exhaust*	*Exhaust lead*
Super Squirrel*	$^3/_8$"	$^9/_{16}$"	$^{21}/_{32}$"	$^5/_{32}$"
Short-stroke Flyer* (FY or FZ)	$^1/_2$"	$^{11}/_{16}$"	$^{13}/_{16}$"	$^3/_{16}$"
Replica Long-stroke RY,RZ,PY,PZ,DPY,DPZ	$^9/_{16}$"	$^5/_8$"	$^7/_8$"	$^1/_4$"

* On Super Squirrel and Short-stroke Flyer engines the transfer port is set $^1/_{16}$" lower in the cylinder block than the exhaust port. The transfer port is consequently down-swept into the cylinder.

SOME FURTHER COMMENTS ON SCOTT ENGINES

Tim Sharp



The illustration shows crankshaft assemblies of the A2S (Flying Flea) engine on the extreme left and right hand sides, and the 3S three-cylinder engine in the centre. They all appear to use the same connecting rods, but the A2S is an overhung crank design, whereas the 3S is a fully built-up construction.

The table below includes the performance figures for the Scott engines from the February issue of *Yowl* with four additional ones:

1. The A2S inverted twin-cylinder engine for the Flying Flea light aircraft.
2. The 3S three-cylinder engine primarily intended for cars, but similar to the unit installed in the three-cylinder motor cycle of the mid-1930's period.
3. The Silk 700S, well known to everybody and basically a Scott engine capable of higher r.p.m. without blowing apart.
4. The long-stroke/short-stroke hybrid which, in the writer's opinion, is the nicest Scott engine of all, with power concentrated at lower r.p.m.

Type	*Capacity*	*Cylinders*	*b.h.p.*	*r.p.m*	*Specific Power b.h.p. per 1000cc per 1000 r.p.m.*
1914 Racer	486	2	10	3,000	6.9
Super Squirrel	596	2	17	4,000	7.1
Super Squirrel	498	2	16	4,500	7.9
Replica	498	2	24	5,800	8.3
Replica	596	2	29	5,500	8.9
3S	980	3	48	5,500	8.9
A2S	650	2	34	5,200	10.1
Aero 4	650	4	15	2,000	11.5
Silk 700S	660	2	48	6,000	12.1
Scott long-stroke/ short stroke hybrid	650	2	30	4,000	11.5

The output of the Aero 4 engine was Alfred Scott's prediction, as a prototype engine was never completed.

Quite a few A2S engines were made and tested, the engine being intended for the 'Flying Flea' light aircraft of the mid-1930s period. This engine was similar in layout to the twin-cylinder motor-cycle engines with overhung cranks and central drive via two-to-one reduction gears to the propeller shaft. The propeller itself acted as the flywheel, but the illustration shows substantial counterweights on the cranks, which are of much thicker section than those in the motor-cycle engines. They are also pear shaped to increase the counter-weighting. The con-rods are much wider at the big-end than normal Scott, with three rows of what appear to be $^3/_8$" x $^1/_4$" rollers. The rods of 'I' section with plenty of holes drilled in the centre section to reduce reciprocating weight. The engine had to be less likely to suffer mechanical failure than the motor-cycle engines — a crank failure at 2,000 feet altitude would certainly have sharpened the mind, if only briefly.

Vibration

Another important point regarding the A2S engine is that the engine was not rigidly attached to the aircraft and consequently had to run with a minimum of vibration.

It is generally accepted that for minimum vibration from the rocking couple inherent in 180° twins there should be a 50% balance factor, i.e. all the rotating masses and 50% of the reciprocating masses should be balanced by counter-weighting the cranks. Looking at the illustration this appears to be the case. This is in contrast to the Scott motor-cycle engines which balance about 25% of the rotating masses and none of the reciprocating ones. In the motor cycle, vibration is minimised by rigidly mounting the engine in the frame and by the heavy central flywheel. It is interesting to note that the Swift engine, when used by John Hartshorne in his sprint special experienced very severe vibration problems. These were probably due to the heavier crankpin and big-end causing larger rotating out-of-balance forces made worse still by a lighter flywheel.

Scott motor-cycle engines can be made to run more smoothly by keeping rotating and reciprocating masses to a minimum. Alfred Scott used race plates with large holes not just for big-end lubrication but for lighter weight. Crankpin screws on early engines were lighter and very early engines had pear-shaped cranks to achieve more counter-weighting of the big-end assembly, although these would not be strong enough for the later engines.

Greater smoothness can be achieved as follows:

1. Absolute truth of crankshaft flywheel assembly.
2. Heavier flywheel.
3. Connecting rods, pistons and gudgeon pins made as light as possible. (Reciprocating masses.)
4. Race plates and crankpin screws made from highest grade steel and made lighter. (Rotating masses.)
5. Extra counter-weighting could be introduced during the manufacture of crankshafts by drilling five $^3/_8$" holes in the crank outer rim opposite the crankpin and letting in inserts of a heavy metal such as tungsten, which is $2^1/_2$ times heavier than steel.
6. An opposing rocking couple can be generated *à la* George Silk by drilling the flywheel rim on opposite sides at 180° so that the small rotating rocking couple thus created opposes that of the big-end assemblies. This does not have any effect on the reciprocating out-of-balance forces which create a rocking couple in the plane of the cylinder axis, and it has the advantage of reducing flywheel weight.

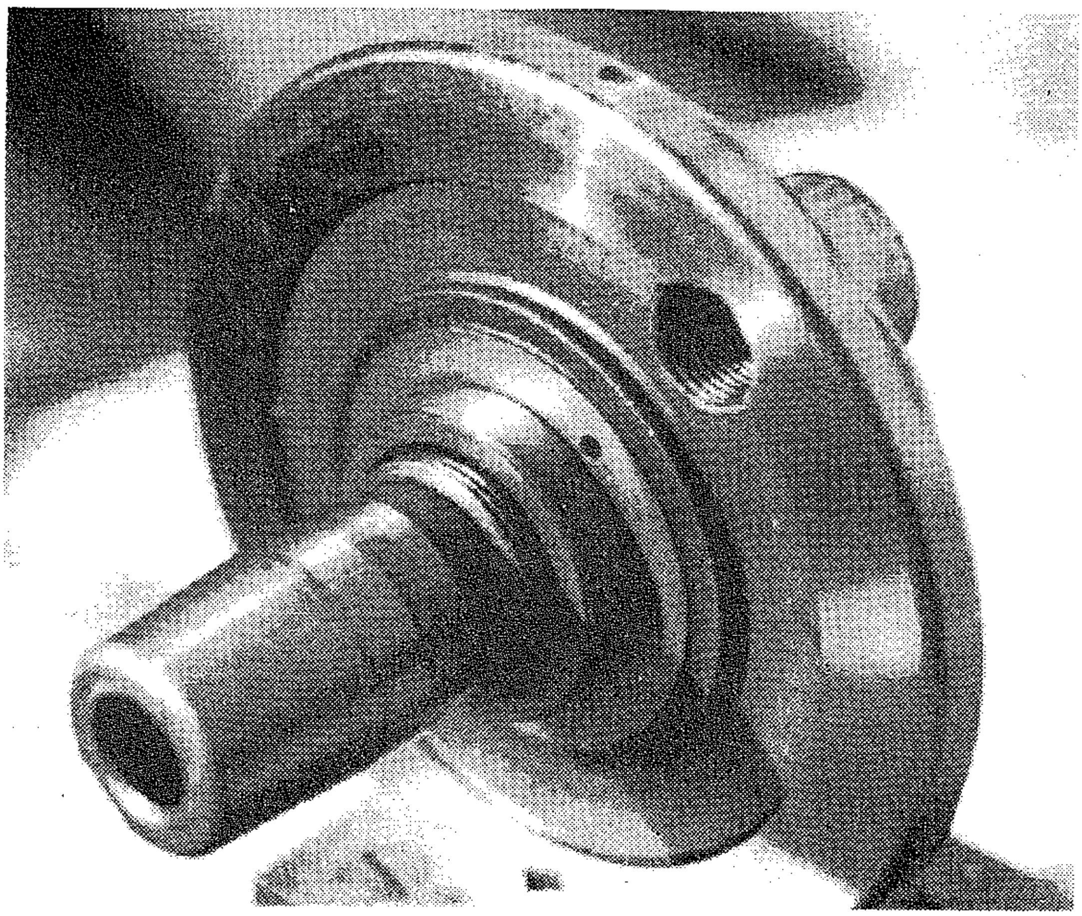
There is nothing which can be done to balance the rocking couple from the reciprocating masses, but compared with the balance problems of a single-cylinder engine, this is small.

ANOTHER LOOK AT SCOTT CRANKS

Ken Lack

In 1927 Scotts produced a crank (four sets known of so far) which would appear to be far superior to the DPY design of later years, which we all know now was a disaster. This early design retained ample 'meat' where required, and the lubrication design was, I think, short of a force feed, almost ideal. Consisting as it did of an axial hole in the cheek of the mains roller track and another similarly in the big-end roller track, the two being connected by the radial hole in the crank web blanked off at the rim of the crank. Surplus oil in the cup would be 'squeezed' by the rollers to enter the inner hole and once in there centrifugal action would fling it outward and this action would automatically suck in oil from the main bearing — admittedly only a small amount of the total, but quite enough for the needs of the big-end.

One wonders why such a design was not followed through. 1. Quite possibly production time was a factor. 2. Problems with scrap due to broken drills and/or the drilling not meeting up with the inner hole? Who knows? A great pity in that it was followed by such an inferior DPY design.



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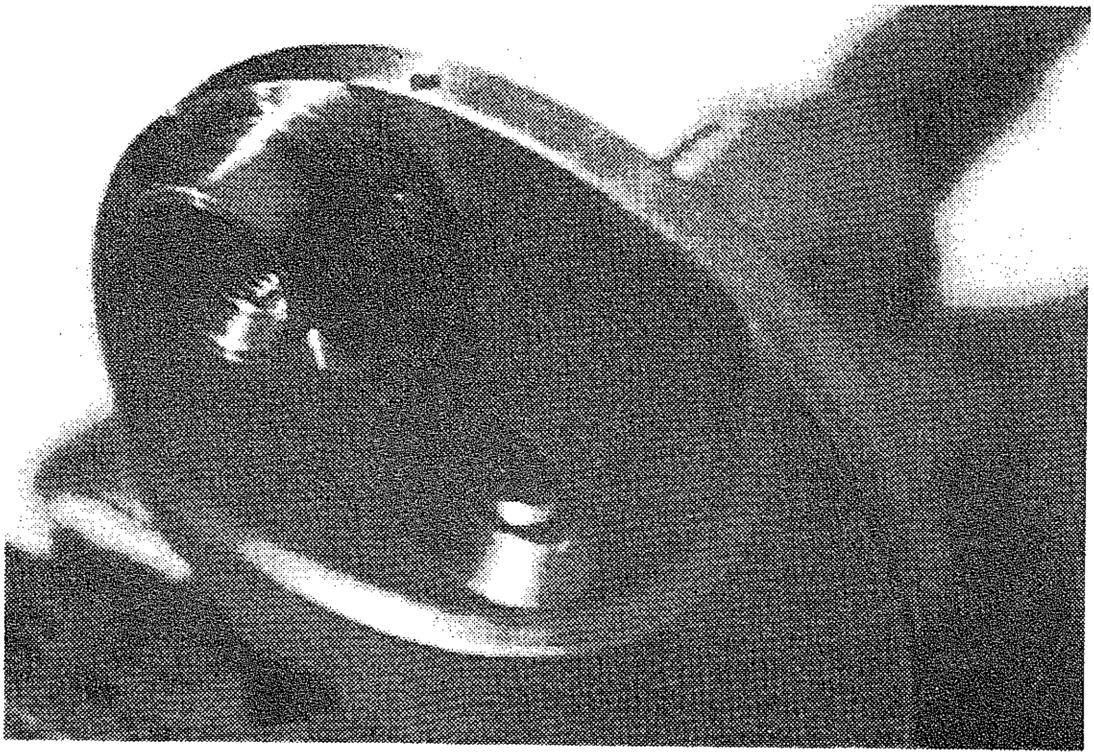


Oil-holes in Scott cranks (See previous page)

V19/12 Oct 1996

SCOTT CRANK TAPER ANGLES

Roger Moss

I was recently asked, what was the angle of the Scott crank taper?

My reply was, that in the absence of evidence from the original factory drawings, that I had arranged to have the taper of sample undamaged cranks measured.

The measurements indicated an indicated angle of 8 degrees, 20 minutes.

It was pointed out that several others, including some who had manufactured cranks, claimed that the correct angle was 8 degrees.

This initially caused me some concern, but having reflected that I had used this value, with total success, for many years, I was reassured and gave thought to the origins of the measured value.

When any production item is measured, its size should fall within a tolerance band specified to the original design drawings. If no drawing is available it is then necessary to interpret what were the original prime dimensions and make an assessment as to the most appropriate tolerances that might have been originally applied to them.

In other words, the sample may be measured and a value defined that is within a 'tolerance' (range of permitted error). This measurement will rarely be the correct nominal measurement, and should be treated accordingly.

The prepared examples were inspected on jig boring machines, using high accuracy 'Society Genevoise' rotary tables. Knowing the machines and the operators, I would confidently assess the measurements to be within 0.0005" accuracy.

Whereas we are nowadays familiar with the measurement of angles being quoted in degrees, we must remind ourselves that in earlier times, conical angles were usually defined in terms of prime Imperial fractions of an inch per fit.

For example: Imperial taper pins are $^1/_4$" per foot, 'Brown and Sharpe' tapers are $^1/_2$" per foot, 'Morse' tapers are $^5/_8$" per foot. These are all known as 'Stick' tapers, for obvious reasons. A common 'Non Stick' taper is the 'International' series made for mounting cutting tools onto milling machines. This taper is $3^1/_2$" per foot.

In the case of the Scott crank taper, the correct figure is, I am sure, $1^3/_4$" per foot. This equates to 8 degrees 20 minutes 27 seconds included. Producing companies, such as Scott, would manufacture conical bars, ground as accurately as possible to the designed taper. These were known as 'Masters' and one would be used to 'set up' the grinding machines, another would be used in the inspection dept., to check samples of production parts.

As it is always necessary to apply a tolerance, then the protocol for tapers is to allow nominal to tight at the neck end.

For example, if you had a perfect female taper gauge and applied blue to it, then blued the crank taper to it, it should, at one extreme of tolerance, blue all along its length.

The other extreme of tolerance would be that it should blue a little heavy at the larger outer end. The amount, I would guess, would be up to plus 0.0015".

If the taper is bigger at the outer end (i.e. the angle is slightly greater than nominal) then the most secure support is at the end nearest the load, also that end is of smaller radial thickness in the supporting flywheel, and thus more likely to 'give' a little than the inner section of the taper seating. If the taper was to sit heavy at the inner end, then any rock would translate into a greater movement at the outer load point.

Consider a see saw rather than a plank of equivalent length but pivoted at one end.

I well realise that the only positive way to resolve this question will be to have sight of the original works drawings, which are not yet available. However, having regard to the matter of the almost universal contemporary convention of expressing the size of tapers in terms of prime fractions of an inch per foot, and the almost exact correlation of the figure of $1^3/_4$" to the foot to our original measurements, then I would be most surprised if the works drawings did not confirm this in due course.

V19/12 Oct 1996

JIM'S JOTTINGS: SCOTT CRANKS

Jim Best

As I mentioned some time ago when I wrote the article on timing I intended to write about Scott crankshafts. After reading the piece by Brian Lilley that the Club was looking into the possibility of getting some long-stroke cranks made it got me around to putting pen to paper.

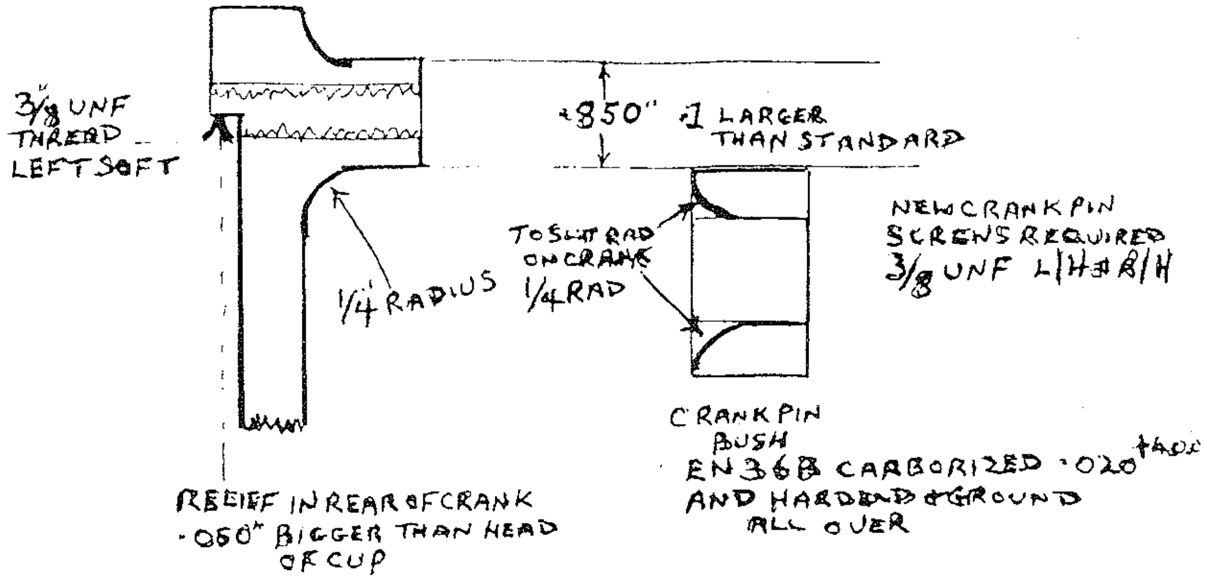
I must say first that in 35 years Scotting and many thousands of miles on the road and in competition I have never broken a crank, which is not to say it hasn't always been a worry in the back of my mind. I've been told I've been lucky. Now I have said that I am bound to break one! It is an opinion that short-stroke cranks don't break, but I don't go along with this as I have seen holes and repairs to crankcase crank chambers in both long- and short-stroke crankcases and seen broken cranks of both types. The reason for this opinion may be that you are less likely to see a broken short-stroke crank as they were only made for some seven years, while the long-stroke motor was made for some 35 years. Scotts must have found soon after 1927, when they introduced the short-stroke motor, that the cranks gave trouble. They found out in the Isle of Man for a start, with broken cranks and blue big-ends through whipping, but did nothing about beefing up the cranks. Then in 1928, when the long-stroke motor appeared, nothing was still done to strengthen the cranks, though the engine was produced to give more power. To get over the blue big-end problem a sharp cornered undercut was put in the back face to collect oil and a hole was drilled through the crank to give some oil to the roller track. It may have been an attempt to get over one problem, but obviously caused another, making the crank still weaker. Any engineer will tell you that a sharp corner in a component, especially one that has to be hardened, is asking for trouble. They carried on with the same design of crank and in 1948 decided to drive a dynamo from the left-hand crank and a coil ignition set and oil pump from the right-hand crank, loading the poor old cranks even further still.

When Matt Holder started production of the Brum Scott in 1957 he went one step further and drove an alternator from the left-hand crank. Anyone who has turned an alternator over by hand will know the amount of effort required plus the start/stop action. It loads the crank still further. I find it incredible that, from 1928 to the Brum Scott, no attempt was made to improve the design: the only improvement that could have been made was the material it was made from.

Scotts produced a long-stroke crank without the undercut in the back face and the oil hole to feed the big-end track. I have a pair of these, I also have a pair with a hole in the face for big-end oiling the same as the short-stroke. In fact I took them as being short-stroke until I measured them over the outside dia. S/S 3.720 L/S 3.840. Cranks of this type were, I know, fitted to the 1934 LFY and LFZ motors. I read in *Yowl* that they were fitted to the first '28 Reps, Sprint Specials and Dirt motors.

It is accepted by most people that if a crank breaks, and the crankpin is pulled out of the face of the crank leaving the outside dia. intact, this is caused by over-advanced ignition. But if the crankpin comes away with part of the outside diameter moon-shaped, this is caused by fatigue. I once asked Ted Murphy why Scott cranks broke. He told me people fit the crankpin bush too tight. I thought this was a curious answer at the time, but when you think about it it's not so daft because when the bush needs replacing most people put the crank in the vice, unsupported, and attack the small lip that sits above the outside diameter with a punch and hammer. This can break the crank or put fatigue cracks in it. I have never had cranks crack-tested as I have never been happy with the equipment used in engineering. All I do is remove the crankpin bush. It is better to remove the main bearing bush as well. Hold the crank on the taper with one hand and strike the crankpin with a chrome vanadium spanner. If I hear a ring like a bell I will use it, but if I hear a dull thud as far as I am concerned it's scrap.

When I built my Sprint Special I intended to use it for what it was made for and sprint it. When I started to build the motor I decided to produce a pair of stronger cranks. Firstly, what material to make them from? To cut a long story short I sent a good crank and a broken crank to the metallurgy department of a large steel firm with a letter explaining what the cranks did, the problems that had been found with them, and a drawing of the modifications I intended to make. I received a report back saying that the cranks were almost certainly forgings, but were made of a very poor quality steel. They felt the design was also poor as the cross section that takes the most load around the crankpin boss was too tight and must be subject to some flexing that would lead to failure. This was not helped by the undercut in the back face. He had looked at my drawing and agreed that it would be a vast improvement over the original component. He suggested making them out of EN36B or EN36C and to carborize and harden them and leave the thread soft in the centre of the crankpin. He suggested it might be worth a try to produce a pair out of tool steel and leave them soft. The decision was made for me when they supplied me with two billets of EN36B. I produced a pair of cranks with my modifications. I used them in my Sprint Special from 1990 to



Jim Best's crank modifications.

1993. I produced another two pairs of cranks and used one pair in another motor for my Sprint Special and fitted it in 1993 and it is still in it. I've competed in over 40 sprints and done around 1,000 miles on the road on the two engines with no problems. The other pair I fitted in the Vane Scott and have entered two sprints on it and done around 400 miles on the road with no problems. I feel this has given them a fair test. I won't go into how I made them as it won't mean a lot to a lot of members, but if anyone is thinking of producing a pair and wants any information, give me a ring or drop me a line. I believe the modification I have made could have been done in 1927 at very little extra cost to production and they would have saved Scott owners past and present a lot of trouble. And I probably wouldn't have had to write this article!

SOME MORE COMMENTS ON THE 1930 FULL CRANK ENGINE

Tim Sharp

In 1930 a completely new racing Scott with a four bearing crankshaft was designed by the drawing office headed by Harry Shackleton. The engine would be able to achieve higher r.p.m. with reliability — essential to compete with the increasing power output of the four-stroke competition of the day. Unfortunately the machines suffered from severe and incurable vibration and were unridable in the 1930 TT. Two of the new TT models were taken to the Island and in the event modified 1929 TT Scotts were used instead, but none finished the race.

What were the reasons for the vibration and could it have been cured?

The cause of the vibration was undoubtedly the rocking couple inherent in the 180° twin-cylinder engine made worse by the wide spacing of the cylinders and the almost complete lack of any counterweighting on the crankshaft. It would appear that in the interests of crankcase pumping efficiency first consideration had been given to minimising crankcase volume and there was not room for bob weights. In addition, the lower half of the connecting rod was much heavier than in the normal Scott, the result being that none of the reciprocating masses were balanced and very little of the rotating masses (i.e. big-end and lower half of connecting rod). Furthermore, the frame lacked rigidity and there does not appear to be any frame members under the crankcase. This was probably in response to the competition department' request for a lighter machine compared with the relatively heavy, but very rigid, frame introduced in 1926 and continued right up to the end at Shipley in 1950. The flimsy frame was incapable of restraining the vibration from the engine and the machines had to be withdrawn from the 1930 TT.

Scotts had produced an engine which was capable of sustained higher r.p.m., but one which was not balanced and a frame which was unable to restrain the transverse vibration caused by the large rocking couple.

What changes could have been made to correct this problem? Firstly it is generally accepted that 180° twins are smoothest with a 50% balance factor. That is, all the rotating out of balance masses (big-end and lower half of con-rod) and 50% of the reciprocating masses (piston and upper half of con-rod) should be balanced by counterweighting the crankshaft opposite the crankpin. A larger crankcase volume would be inevitable, but this could be kept to a minimum by using Scott-type elliptical con-rods and a built-up crankshaft. The A2S engine designed for the Flying Flea aircraft had a counterweighted crankshaft and must have been free of vibration to have such flimsy mountings in the airframe, and it produced 34 b.h.p. at 5,200 r.p.m.

Secondly, the cylinders should be as close together as possible to reduce the size of the rocking couple. the deflector piston design enables the cylinders to be separated by only the thickness of the cylinder wall (as in multi-cylinder outboard motors) because there are no transfer ports at the side as in the flat-top piston engine.

The central flywheel should then be moved outboard of the engine sprocket and this probably would have been a difficult break with tradition for Scotts. These two changes, I believe, would have given a smooth engine without the need for a heavy frame, but unfortunately everything was back to the drawing board and Scotts were already experiencing the recession of the early 30s and did not have the resources to try again.

I cannot believe that Harry Shackleton had a free hand in this design, which must have been an expensive mistake in terms of money and prestige. My guess is that he had to conform to pressure from traditionalists at Scott and the design was an unsuccessful compromise between the Scott engine as we know it and conventional motorcycle design of the late 20s. Scotts, after all, were supposed to be the *different* motor cycle.

But just imagine if a third cylinder had been added with the cylinders as close together as possible and crankpins at 120°. The outside flywheel would be unnecessary, because only one piston reaches T.D.C. at a time and the other two provide the flywheel effect. The engine would have been only slightly wider than the twin and only slightly heavier. Things would then have been *very* different.

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