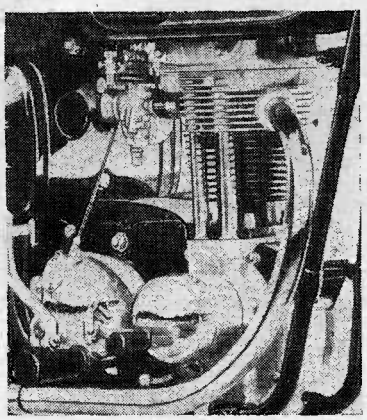
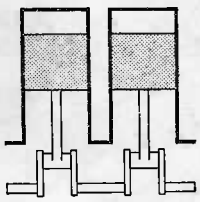
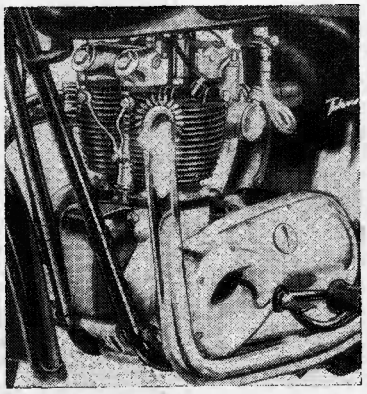
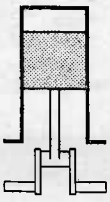








The types which dominate the field today—the single and the parallel-twin four-stroke. Examples shown are the 350 c.c. A.J.S. Model 16 and 650 c.c. Triumph "Thunderbird."

MOTORCYCLE ENGINEERING—15

Which Engine Layout?

Pros and Cons of Basic Power Unit Types

by PHIL IRVING

WHEN one considers the combinations and permutations possible with the factors involved in the basic design of the power unit—including the firing cycle, the number of cylinders, the manner in which they may be arranged, the type of cooling and whether or not the engine and gearbox shall be in unit—the choice available to the designer seems almost infinite. In practice, it is severely limited by commercial considerations.

From the sales point of view, the success of a new model—not necessarily in its first year, but within the next two or three seasons—may depend, and in fact almost certainly does depend, upon an intelligent appraisal of the trend in public taste. Strictly speaking this has nothing to do with engineering except in so far as, on more than one occasion in the past, engines or complete power units which failed commercially on their first appearances have been resurrected years later with resounding success. This could have been because the original edition, though sound in conception, possessed some defects in design or materials which outweighed its good features, or it may have been merely that at the time of introduction buyers were not prepared to accept something which differed radically from the ruling practice. But, whatever the cause, no one who is concerned with the commercial success of a new model can afford to ignore public opinion, however much praise is lavished on the product by those who are not likely to buy one anyway.

When constructing a model for some specific purpose such as racing, scrambling, or record-breaking, or a "one-off" special to suit one's personal tastes, the position is quite different. One is then at liberty to select the design which will provide the right tool for the job, irrespective of any other considerations—except that it may not be considered good policy for a factory which makes its living from, say, single-cylinder two-strokes to use a four-cylinder four-stroke or something equally exotic for its "works" competition models.

Coming down to cases, there are only three cylinder groupings worth consideration for general work, namely, the single, the twin and the four.

The single-cylinder has the great merit of simplicity, and even in the smallest capacities none of its components is ridiculously tiny. Size for size, in four-stroke form it gives more power than any multi-cylinder (unless the latter is built as a collection of singles, each with its own induction and exhaust system). On the reverse side, it lacks smoothness, partly because it fires only once in every two revolutions and partly because of its inherent lack of mechanical balance. It is true that both these defects can be made less obtrusive by good design and installation, but nevertheless they remain and must be accepted as part of the price paid for simplicity.

The two-cylinder engine can be made in three ways—with the bores parallel to each other, arranged in V formation or horizontally opposed to each other, on each side of the crankcase.

The most common arrangement today is the parallel twin—an outstanding case of a layout which made two or three premature appearances before it "caught on." This form of engine, in four-stroke guise, with both pistons going up and down together, is no better than a single as regards mechanical balance, but has a smoother performance because its power impulses occur once per revolution and are only half as great as those of a single of equal capacity.

Except for doubling the number of pistons, rods and valves, this layout entails no great increase in complication, and orthodox constructional and overhauling methods can be used. There are no difficulties in installation—in fact this may be somewhat eased by the reduced height, and the extra width is not much of a problem. Cylinder cooling can be as good as that of the single, and in some circumstances even better, because of the greater width of the fins, provided adequate precautions are taken to ensure a good flow of cooling air through the narrow space between the cylinder barrels.

In the two-stroke form of parallel twin, the pistons move up and down alternately in order to give a power impulse on every stroke, thus affording very smooth power-production and rather better balance than with the four-stroke arrangement. Balance, however, is still not perfect. Owing to the wide spacing of the bores a "rocking couple"—i.e., a tendency to oscillate the engine in relation to the centre-line—is present, and though its effect can be made quite unobtrusive by correct balancing and mounting, it cannot be completely eliminated.

The V-twin, once a very popular arrangement, is now out of favour with manufacturers, the only current production models being those of Harley-Davidson in the U.S.A. For all that, the layout has several points which render it attractive, especially for engines of large swept volume.

It is very little larger overall and not quite so tall as a single of half the capacity, and though it is much larger at cylinder-

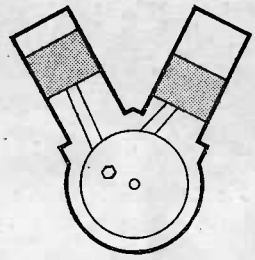
head height the extra inches can be accommodated in corners which are not normally fully occupied in a conventional frame. Owing to the circumstance that the pistons do not come to rest simultaneously at the end of each stroke, as they do in a twin or four, the flywheel weight for equivalent smoothness need not exceed that necessary for a single of half the size, and, one way and another, the V-twin will provide a greater number of working cubic centimetres in less block bulk and with less weight than any other arrangement.

The firing impulses, though not spaced at regular intervals, are at least as frequent as those of a parallel twin, and the mechanical balance is a peculiar compromise between good and bad which can be made to furnish an almost vibrationless performance, though the inherent balance is not as good as that of the horizontally opposed arrangement.

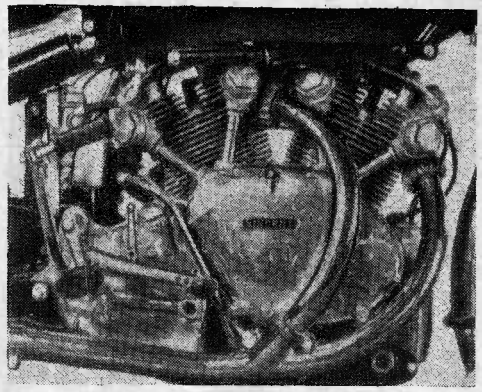
The h.o. twin is another time-honoured design which has fewer adherents today than it has had in the past. Mechanically there is a lot to recommend it, the outstanding feature being almost perfect mechanical balance due to the fact that the inertia forces generated by one piston are exactly cancelled out by equal and opposite forces from the other. If it were possible, without resort to complicated divided connecting-rods and twin geared crankshafts, to make the two bores actually in line, the word "almost" could be deleted; but with the conventional two-throw crankshaft there is necessarily a small offset, about an inch or so, between the cylinder centre-lines, and this gives rise to a rocking couple, fortunately of such small magnitude that it can be disregarded.

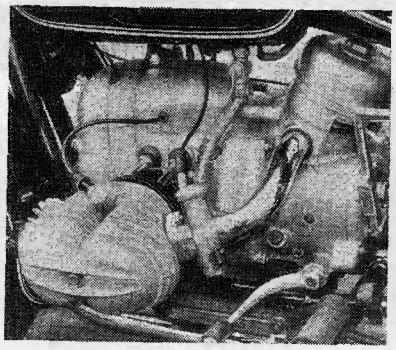
When the h.o. unit is installed in the plane of the frame, however, the cooling of the rear cylinder is bad because it is almost impossible to avoid severe masking by other components. If it is placed with the cylinders transversely the great overall width is a handicap on large-capacity units, particularly for fast solo work when the possibility of grounding the rocker-box covers becomes serious unless the whole engine is raised a long way above ground level.

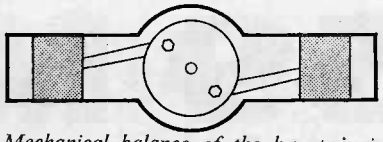
Carburation is also a difficulty. Two instruments are preferable, but expensive and difficult to mount without getting in the way of the rider's feet; and the long induction pipes required with one carburetter have been known to give trouble with icing-up in cold climates. On the other hand, the cooling is about as good as it is possible to be, even in still-air conditions, and for medium and small capacities the type has some decided advantages, though the torque reaction brought about when the speed of a transverse engine is rapidly altered is not in its favour.



Maximum c.c. in minimum space with minimum weight—the geometry of the V-twin fits snugly into a motorcycle's engine-space. Illustrated, a 1953 Vincent "Rapide."







Mechanical balance of the h.o. twin is almost perfect; installation geometry not so good. The B.M.W. R69.

When four cylinders are employed, the power impulses occur in an almost continuous stream and this affords very smooth running without the need for transmission shock absorbers. There are several possible cylinder arrangements—the "in-line" type (which may be mounted either longitudinally or transversely), the "square-four" type with two crankshafts geared to rotate in opposite directions, the horizontally opposed, with a pair of cylinders on each side of either a single shaft or two geared shafts, and the V-type with two pairs of cylinders set at any included angle that the designer wishes.

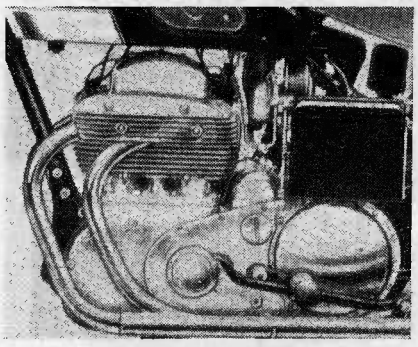
Of these, the "in-line" or straight four with fore-and-aft crankshaft is the least suitable. It is difficult to house due to its length (although it is possible to crib a little space by mounting the gearbox alongside the crankcase of a small engine) and cooling of the middle two cylinders is very bad when normal air-cooling is employed.

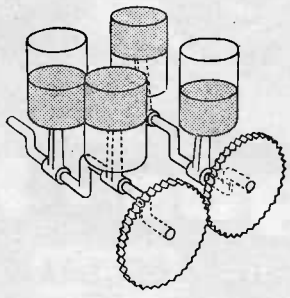
If the "in-line" four is mounted across the frame, as in the Gilera and M.V. racers, the cooling is extremely good, which may be a contributory reason for the success of these makes in long-distance events. Constructional complications, however, are introduced by the fact that the only satisfactory form of primary transmission is the expensive central gear train which is a feature of these models.

The "square four" arrangement gives a compact engine sufficiently narrow to permit the use of a normal offset primary drive to a conventional gearbox. As two pistons (on one diagonal) are at t.d.c. when the other two (on the other diagonal) are at b.d.c., the balance is exactly the same as that of a straight four. Since the induction strokes are equally spaced, a single carburetter feeding to a distributor-type manifold can be used if moderate power is the aim; but if it were desired to obtain racing power it would be difficult to instal four carburetters, which can be mounted quite easily on a transverse "in-line" four. Cooling of the bores on the sides near the centre of the square also poses a difficult problem, and obtaining absolutely silent running of the crankshaft gears is by no means easy, especially in view of the change in centre-distance between hot and cold conditions which is unavoidable with an aluminium crankcase.

The horizontally opposed four is almost exactly the same as a twin of the same family except that with a single horizontal crankshaft the cooling of the rear cylinders is not very good. Obviously, this form

(Continued on page 186)





The unique Ariel "Square Four": 1,000 c.c. in a very small space, the mechanical balance of a straight four, simple carburation.