This form of engine is ideal for short flights up to say one or two hours; it is also particularly suitable for trick flying and exhibition work.

The second school builds an engine with a particular view to all-round efficiency, especially with regard to petrol and oil economy, and an absence of the need for a specially trained mechanic in constant attention. It is generally of the vertical or "V"-type, with parts as light as is consistent with reliability, and it generally develops about 80 per cent. of the maximum power obtainable from an engine of its size. It is not so light as the first type of engine mentioned, but the whole outfit is lighter when both are carrying enough oil and petrol for a flight of four hours or more. It is sometimes air-cooled, and sometimes water-cooled, and runs at 1,300 or 1,700 revolutions per minute; in the latter case gearing is interposed between the engine and propeller.

The third school, which is not very much in evidence, builds an engine of more or less automobile practice, with heavy cast-iron cylinders and solid parts throughout. The weight efficiency of the engine is obtained by running the engine at a high speed, by large and quick lifting valves, by high compression, and by perfect tune. It runs at about 2,400 r.p.m. or possibly more, is water-cooled, and is more or less an orthodox car engine, lightened in external fittings. Its chief disadvantages are that in getting the last 10 per cent. of power it is probably stressed 25 per cent. more.

Experience has shown many times that an engine will run up to a certain horse-power regularly and reliably, whilst an attempt to get the last ounce of power often ends in the engine breaking up altogether.

The greatest disadvantage of this type of engine, however, is probably its propensity for getting out of tune. Such an engine seems to think nothing of dropping 100 revolutions from one day to the next with no apparent reason, and this probably the worst danger to flying. The pilot possibly knows it, but risks it occasionally, but such risks ought not to be offered to him.

Occasionally racing cars do 12 hours all out on Brooklands track, and this is claimed as an exceptional performance, which of course it is, and which few manufacturers succeed in doing at the first attempt, even if they succeed at all.

On the other hand, any and every aero engineman, any and every day, has to be capable of doing this if called upon, and whilst the car engine in its 12-hour run is allowed several short rests by being throttled down every two or three hours to fill up and change tyres, and has the best experts from its factory looking after it, the aero engine, on the other hand, has to do the 12 hours or more in the hands of inferior mechanics and without a moment's rest of any sort, With all this, the aero engine must be some 40 or more per cent. lighter than the car engine.

Racing cars nowadays invariably run in classes, and they are designed solely with the object of obtaining the maximum brake horse-power out of a certain and limited cylinder capacity. To carry this practice into aero engine design is to quite unnecessarily handicap oneself, because aero engines are not tied down to capacity, the only features being desired are low weight per brake horse-power, low oil and petrol consumption, and absolute reliability.

To ever hope to obtain the same reliability from a hard worked engine as from a lightly loaded one, is of course unreasonable, and for this reason the first type of engine we referred to has had the greatest measure of success so far.

Whilst the highly stressed engine has to be carefully kept in perfect tune by constant attention in order not to show a falling off in power, the engine of very low horse-power per cylinder capacity will run for months without any appreciable drop in revolutions. In fact the average rotary motor has something seriously wrong with it when it has dropped as much as 20 revolutions per minute.

Some Government departments are demanding (and quite rightly) that all engines shall pass a ten-hours full throttle test and that the brake horse-power shall not vary more than 3 per cent. above or below throughout the whole ten hours, the control levers not being touched during the run. This will probably do more good in evolving a successful engine than anything else, as it not only compels the designer to make an engine that will run for twelve hours, but covers points with regard to sharp cams and weakening springs, occasional misfiring, badly designed or gummed up piston rings, burnt exhaust valves, loss of compression, &c.

It is generally accepted that we should have been flying twenty or thirty years ago had there been any engines in existence, and just as the birth of the aero engine has made practical aviation possible, so will the advancement of the aero engine on proper lines help to bring about perfection in aeroplanes.

The engine is, of course, a much more difficult proposition than the aeroplane, and whilst aeroplanes can be designed and built in a few weeks with a certainty of flying, and flying well, at the first or second attempt, the engine is only evolved at the expense of many months, and more often years, of experiment.

The use of proper materials is perhaps the first and foremost thing to consider, and it is rapidly being brought home to engine manufacturers that steel is the only reliable and light material for its strength that can be found. Cast iron and aluminium alloy are the two last materials one should think of using when reliability is such an essential feature. Aluminium may be light in itself, but taking weight for strength it is some six or eight times as heavy as good quality steel. Cast iron, on the other hand, is neither light nor strong, and is at the best of times very treacherous and uncertain.

Probably another two or three years will see cast iron, phosphor bronze, cast aluminium, and all such metals entirely discarded by aero engine manufacturers, and it is not surprising to note that the most reliable and consistent, as well as the lightest, engines in use to-day are constructed almost entirely of steel.

Having realised that extreme lightness combined with strength to resist fracture, is the chief factor in aero engine design, one would think it very natural for the designer to ask himself, at the very beginning, "What material is the lightest for its strength and at the same time the most consistent?" The reply would be without hesitation—Steel; and more especially when one realises the enormous tensile strength of some of the steels obtainable to-day. Here is the danger of following automobile practice and in not appreciating the totally different conditions of the two subjects. One can quite easily be led into using cast iron cylinders on cast aluminium crank-cases, when a few moments' thought would convince one that an engine so designed, although it may be excellent in its way, has not the faintest chance in competing in lightness and reliability with the engine using materials some ten times stronger. The sooner we in this country realise this, the sooner shall we be in a position to prevent our orders for engines going abroad. It is interesting here to note that the one part of a racing car engine that is required to be as light and as strong as possible (I refer to the piston), formerly cast iron, is now almost universally replaced by steel.

With regard to the various types of engines already in existence, we all gave our own ideas as to what we think will be the ultimate type, but it is of course impossible for anyone to predict what the future will bring. As to whether or not the air-cooled engine will outlive the water-cooled one, appears to depend entirely upon the question of whether the principle of air-cooling will be so perfected that it can compete with water-cooling in all the latter's best points.

I have no hesitation whatever in saying that if air-cooled engines can be made that will be as economical on oil and petrol for flights of 15 hours or more, that will have valve gear as reliable and free from loss of strength in valve springs and lengthening of valve stems, that will not require any greater amount of attention and tuning up, that will not require dismantling and cleaning out more often, and that will have as long life as the water-cooled engine, then the air-cooled engine will survive. If water-cooling can be done away with without any sacrifice, it will most assuredly not be retained. Water-cooling may be necessary for seaplane work, but even then if the cylinders of an air-cooled engine can be made to withstand, after running for several hours, a cold plunge under salt water without distortion or other damage, water-cooling will die a natural death. Whether the air-cooling advocates will succeed as far as this remains to be seen. At the same time it looks rather unlikely that the believer in water-cooling will stay where he is and let air-cooling catch him up.

At the present time water-cooled engines are at a disadvantage owing to the difficulty of obtaining very light radiators that will stand a little rough usage without leaking, and these same engines have been greatly handicapped in the past through machines not being designed with proper provision for a suitable radiator. The machine has been designed by one, the engine by another, and the radiator by a third, with the result that in assembling the machine the radiator has been hung in some position suitable for the machine, and often quite unsuitable for the engine. This has involved the use of unnecessary and long water-pipes, and of numerous rubber joints, with the result that water leaks and air-locks in the water pipes have occurred, and the engine through no fault of its own has been given a bad name.

The near future promises to remove all this, and automobile practice in this one instance is aiding the water-cooled engine. Radiators of the honeycomb type are now being fitted either immediately in front or immediately behind the engine, with a better head of water above the cylinders, and a great reduction in length and number of water-pipes and joints.

The question of the shape of engine most suitable for an aeroplane does not arise so much from the aeroplane constructor's point of view to-day as it did formerly. The average aeroplane *fuselage* is now so large that any engine within reason can be tucked away without projections to offer head resistance, and the matter of shape lies chiefly with the engine designers, except in the case of some stationary radial engines, which require the air from the propeller to cool them. In this case the cylinders, in order to function properly, must offer head resistance, with a consequent reduction in flying speed. (*To be concluded.*)