MAKING PETROL ENGINE PISTONS

by "Chuck"

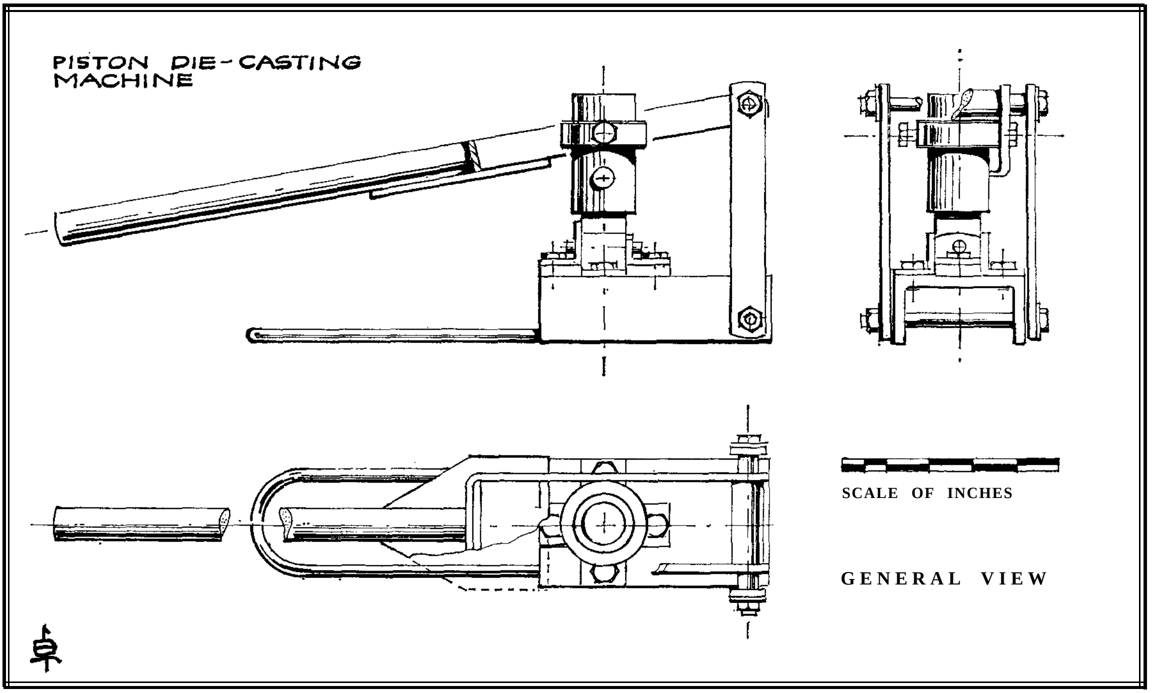
CHUCK BELIEVES it is true to say that the model engineer generally has little use for a reproduction process. He acknowledges that the meticulous builder may well undertake the production of his own bolts and nuts to scale proportions and, for this purpose, sets up his lathe temporarily for repetition work. And, although Chuck really knows very little of the requirements of the "steam man", he can well imagine that a rapidly produced quantity of handrail knobs, all to the identical profile, and a succession of quickly threaded stay rods may well be worth an hour or two's prior tooling up. Jigs to assist in repetitive boring are also common enough in the amateur workshop. But how many components are there that your model man can reproduce for "stock", as it were, and which may be acceptable for use in models to different designs?

Since Chuck's interest lies largely in the direction of internal combustion engines it is understandable, perhaps, that it is with the requirements of these machines that he allows his imagination to dwell. Few model engineers, unless they entertain aspirations towards a small factory, and the possibility of selling their end product, will be interested in developing one engine and producing a run of identical models. As a rule, if a modeller is interested in producing his own castings, for example, he will be satisfied with pouring one or two good copies only, and shelving the pattern for possible future use. He may also, possibly, make an odd set or two for his friends. Outside of that, however, he is unlikely to find that a component designed for one engine is going to fit, sweetly, his next brain-child.

But is not a piston "blank" a valid exception to the foregoing?

By a piston "blank", Chuck refers to a casting in light alloy; cast hollow, with suitable internal profile, and carrying gudgeon pin bosses in the traditional manner. And a properly formed piston is extremely difficult, if not impossible, to produce by any other means than casting. It is certainly no end of a juggle to ***machine*** out the interior to any resemblance of the desired shape ***!***

No ! no! no ! Not even Chuck in the moment of his wildest fancy would consider the possibility



of reproducing a piston blank which could be utilised at one end of the scale for an .049 in., and at the other for a 30 C.C. racing engine!

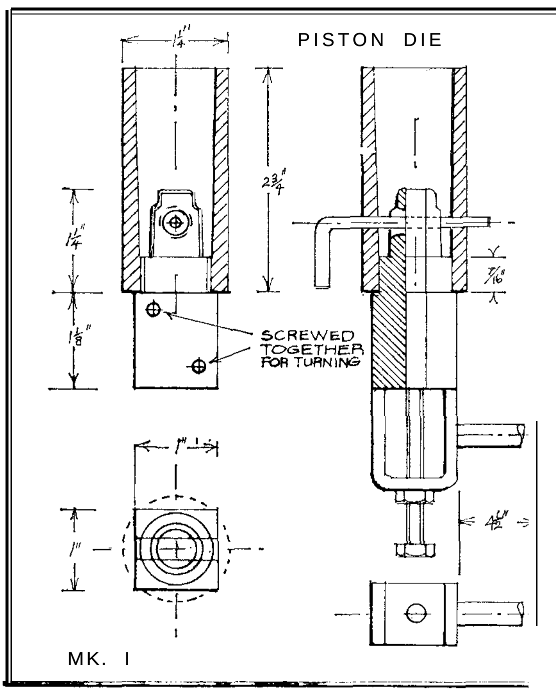
Within what he believes to be acceptable limits, however, it will be seen that it is, in fact, practicable to design a piston blank which is quite capable of being machined to suit engines of widely varying bore and stroke. The one you are about to read of has, indeed, been fitted to engines of from 3 to 6 C.C. per cylinder. If you are fortunate enough to possess a copy of the late Mr. E. T. Westbury's little book on "Model Petrol Engines", turn to page 219, where he has provided us with a useful chart indicating the relationship between bore and stroke and cubic capacity. A straight-edge across from 20 mm. bore to 20 mm. stroke gives you a little over 6 cc. A square configuration reduced in the piston radius by only one millimeter to 18 mm. bore and stroke indicates a capacity of less than 5 C.C. Take off another millimeter in the radius and your engine is now little over 3-1/2 c.c.!

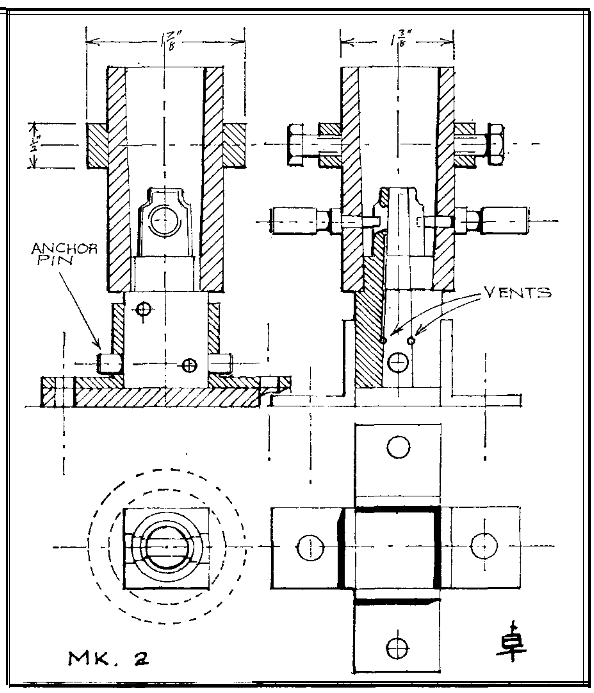
True, if you are to machine the same piston blank in this way to reduce the diameter, the piston wall thickness is also going to be reduced. In this respect it is the skirt thickness left by the core which is going to dictate the smallest diameter of piston for which a blank can be utilised. In the same way the upper limit will be governed by the outer diameter of the casting. In the case of the larger piston the extra wall thickness below the gudgeon pin bosses can be regulated by skimming away the interior until the desired skirt thickness has been achieved. The crown of the piston will have more meat the larger the bore, but this should not be disproportionate as, in all probability, it will be expected to accommodate thicker rings. A happy medium has also to be struck in the outside diameter of the gudgeon pin bosses. Practically, however, there need not be so marked a difference in gudgeon pin diameters between an engine of, say, 3-1/2C.C. and an engine of 6 C.C.

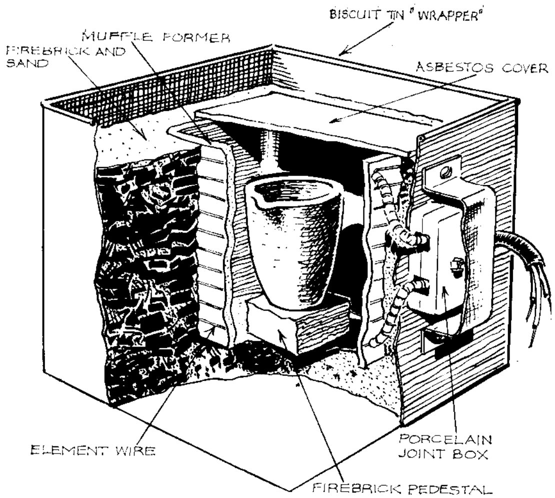
Chuck illustrates an actual piston casting which has been finished off in various sizes and with success. These pistons are die cast and have been used in a vertical twin with a total capacity of 6-1/2C.C. and in his V twin, which is 12-1/2 C.C. ; as well as in various motors in between and a four-cylinder engine of 21 C.C.

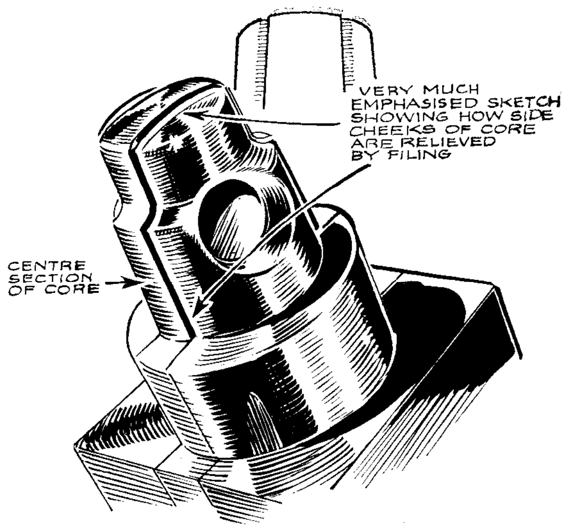
In the hand

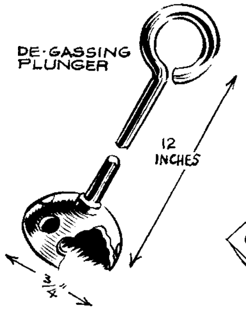
His first attempt at a die cast piston was the use of a "hand-held" die! Such a mould becomes tricky to handle when hot, and the interior of his workshop, during the process, was apt to become somewhat cloudy from sizzling spit on his finger ends! The die itself tends to get damaged, too, from the action of clamping it in the vice, after the pour, for the purpose of extracting the core and so on. Pistons ***could*** be made in this

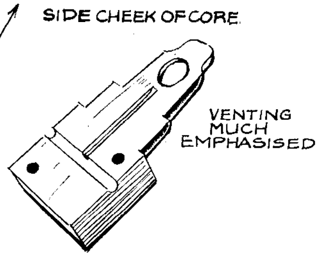












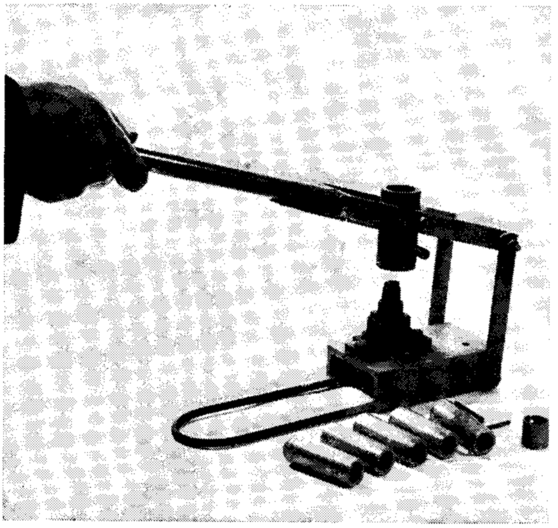
way-and good pistons, too-but the work was uncomfortable to say the least.

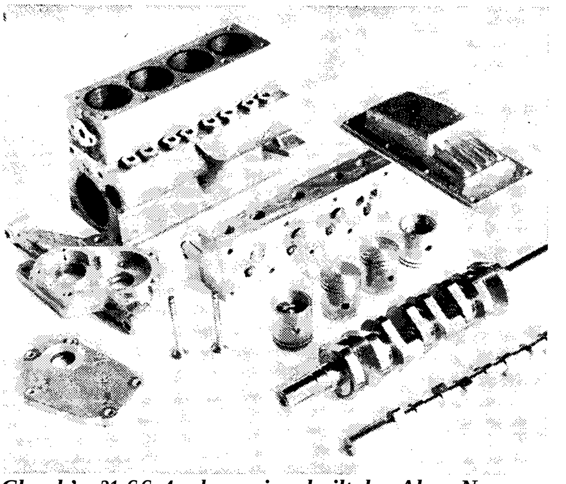
It may have become clear to most readers by this time, that Chuck prefers, as far as possible, to prepare his own material for his models. He has been heard to boast that he purchases only the plugs and the ball races but, in actual fact, he is known to utilise ready-made screws and nuts as well. In truth, however, he does provide all his own castings, where such can be employed. But he machines blocks of dural or similar material to produce connecting rods and, perhaps, cylinder heads, rocker pedestals and so on. But small cylinders, if not actually cast to shape, are machined from sticks of his own crucible-cast iron and, at one time, he made his pistons and their rings from the same material.

Chuck's first vertical twin of 10 cc. capacity had cast iron pistons. This engine, which I will show later, has performed many years' marine duty powering ***Ducky*** a Fairey "Swordsman". (Give credit where it's due! -An Aerokit.) ***Ducky's*** engine can idle or yet push the boat along at a fair rate of knots. But at certain r.p.m. along the speed range the vibration is simply terrific. So much so that for successful operation the engine has to be supported in very resilient mountings indeed! Clearly some improvement had to be made to the balance of future engines and Chuck could see little else to blame than the heavy pistons. Thus, even before his four cylinder engine had arrived at the drawing board stage he had already decided to try his luck with light alloy pistons. Thus the first tentative venture into the "hand-held" diecasting technique! For the record the "four" doesn't waltz a millimetre when running stood free on its base-board on the bench at any speed. A duplicate of the vertical twin, made at a later date, merely screams at speeds in excess of 12,000 r.p.m.

Toolmaking

Drawings of the two dies, the hand-held one and the machine die, are illustrated for comparison. In the case of the former, the outer part was a mild steel cylinder, bored on the inside to provide draft for withdrawal. The core, which, of course, constitutes the main part of a die of this sort, was machined from three mild steel flats each 1 in. wide, the outer "cheeks" being 3/8 in. thick



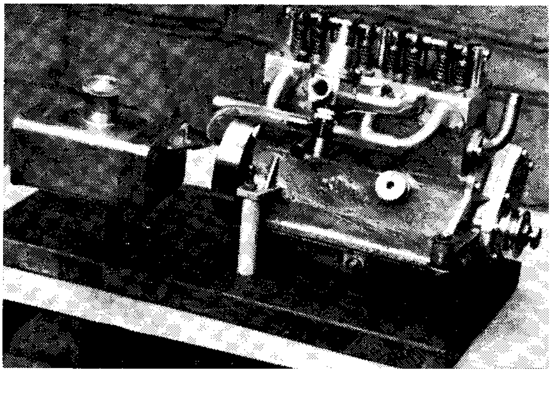


Chuck's 21 C.C. 4-cyl. engine built by Alan Norman of Ellesmere Port, showing die-cast pistons.

and the inner "sandwich" a 1/4 in. thick. The gudgeon pin bosses, of course, are moulded in negative in either cheek and the centre section is the "key" to withdrawal. It is the first part of the core to be removed from the casting, after the pour, so that the cheeks will collapse inwards to clear the bosses on the way out.

But aluminium alloys contract rapidly as they solidify and, while the metal clears the inside of the cylindrical part of the mould happily enough, it tightens like a hot vice on the core, making the withdrawal of the centre very difficult indeed. Chuck's original idea was to draw this out by means of a bridge and a screw tapped into the underside of it. But the "sandwich" as aforesaid, was only 1/4 in. thick and the largest thread it was possible to tap into this just would not stand the strain. He had to resort to striking out the cores with a hammer. This, sometimes, required many heavy blows and the die number one suffered damage. Nevertheless, and in spite of this handicap, it produced many pistons; all of which can now reciprocate!

Below: Zgnition by glow-plug. Runs on pure methanol with Castrol "M". 10,000 r.p.m. plus!



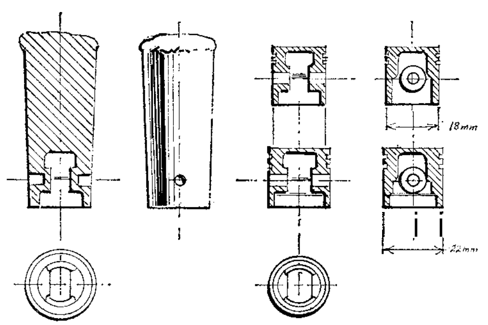
Another fault with Mark 1 was that Chuck had provided for the core for the gudgeon pin location to be a taper pin passing right through the die trom one side to the other. But here again the contracting metal made the pin very tight and it had to be driven out by force. It was found, too. that the alloy tended to seize onto the pin and a smear of metal came away with it each time. This in spite of a liberal coating with soot from a gas flame inside the mould before each cast.

Ordinary blacklead, by the way, has now been found a more convenient substitute for soot.

Melting the Alloy

Several years, ago Chuck read an advertisement in ***Model Engineer*** for an "Electric Muffle Furnace". He cannot remember the price but he thinks it must have been pretty low or he would never have sent for one. When his purchase arrived he found he was the better off for a, rather rough, rectangular, fire-clay former; internally 6 in, x 3 in. x 4-1/2 in., and wound on the outside with fairly heavy gauge element wire. The two loose ends of the wire were formed into loops and that was all.

No one will ever know what Chuck imagined he was going to do with this thing when he ordered it. He certainly didn't know what he was going to do with it when he received it! It had also been slightly damaged in transit and this fact did nothing to increase his confidence in its practical possibilities. Hence the "Electric Muffle Furnace" found its way back into its packing and smartly under the bench where it remained, forgotten and forlorn, for quite a number of years.



And then, one filthy, cold winter's night, Chuck found himself contemplating the production of one or two quite small castings in aluminium. His outdoor furnace was lashed with rain and half buried under a small mountain of rotting, dead leaves and, in the words of the great W. C. Fields, " 'tweren't a fit night out fer man ner beast!"

A sudden recollection of an erstwhile purchase, a scuffle among the debris of years under the bench, and there, unveiled for the second time and looking, frankly, as forlorn and useless as ever, stood the electric muffle furnace!

Chuck halfheartedly tried it for size. Had it been made cylindrical it might have accommodated a No. 2 crucible, a four pound pot, quite comfortably. It cleared the height by more than an inch and a half but lacked half an inch in the width, a No. 2 being 3-1/2 in. diameter. But its unfortunate rectangular section would admit nothing bigger than a No. 1, which is 2-3/4 in. diameter. And at this stage it was by no means positive that the muffle would, in any case, even reach the temperature required to melt light alloy.

In fact, to attain this heat the muffle would require to be well insulated on the outside as well as being provided with safe electrical connections and an earth. If progress was to be made that night a satisfactory answer to these problems would have to come to light as the result of an indoor foraging session.

To cut a long story short the muffle finished up in the form shown in the drawing, embedded in a mixture of sand and broken firebrick, the only refractory materials readily to hand, within the enclosure of an old-fashioned biscuit tin. Lead-out wires were passed through the side of the tin encassed in secondhand ceramic beads and connected in an ex-junkbox, porcelain jointbox on the outside. The sheet metal cover for this was added at a later date because it was found that, within the limits of its capacity, the electric muffle furnace was a success!

Clean Metal

For melting, the crucible is placed in the furnace while cold and a good hour is usually required to heat the whole thing to red, which is the kind of temperature required to melt light alloy rapidly. The pot is charged with bits of broken pistons and, once a pool is formed in the bottom of the crucible, added metal fuses into this quite quickly.

For making miniature pistons great care is taken to retain, as much as possible, the original qualities of the alloy. Chuck does not in any way lay claim to any metallurgical knowledge, but he has a kind of pious hope that, if he is a good boy and doesn't use dirty scrap and keeps unprotected iron plungers and stirrers out of the molten metal (iron will contaminate aluminium alloys) the ensuing castings will be reasonably sound. The proof of this particular pudding is not in the eating, but in the subsequent machining and the ultimate usefulness of the little pistons when they are in the engine. His castings can hardly be said to be subject to quality control and none has been analysed, but Chuck has been able to recognise the difference in the machining qualities of these small diecastings with-for example-his own more usual run of sand castings melted in a coke-fired furnace. And the pistons certainly perform well!

Having no combustible material inside the furnace the metal cannot, to any large extent, be subject to deleterious furnace atmosphere. But the textbooks tell us that molten aluminium absorbs hydrogen from the air, and this, automatically, gives rise to a decidedly porous structure in the finished casting. (At one time it was believed that this porosity was inseparable from light alloy castings.)

To be continued