PROPOSED DESIGN FOR A

by L. K. B. (Aus

A PARAGRAPH in "Smoke Rings" of THE MODEL ENGINEER, May 22nd, on the subject of gas turbines and jet engines, inviting views on the subject, has prompted me to put forward some ideas which I have arrived at after a considerable amount of thought. I would like to say that these ideas are as yet theoretical, but have arrived at a stage where I feel that a start on construction can be made, and this I intend to do.

Before describing the proposed design, it would be as well to go briefly into reasons for the adoption of this particular design. Throughout, simplicity has been one of the main points to be considered wherever possible. It follows, in the main, the type which has been most successful in full-size practice. The centrifugal compressor has been adopted for its simplicity, and ease of construction. This type also allows of the use of individual combustion cans employing a central fuel nozzle. While having certain disadvantages, this type appeared

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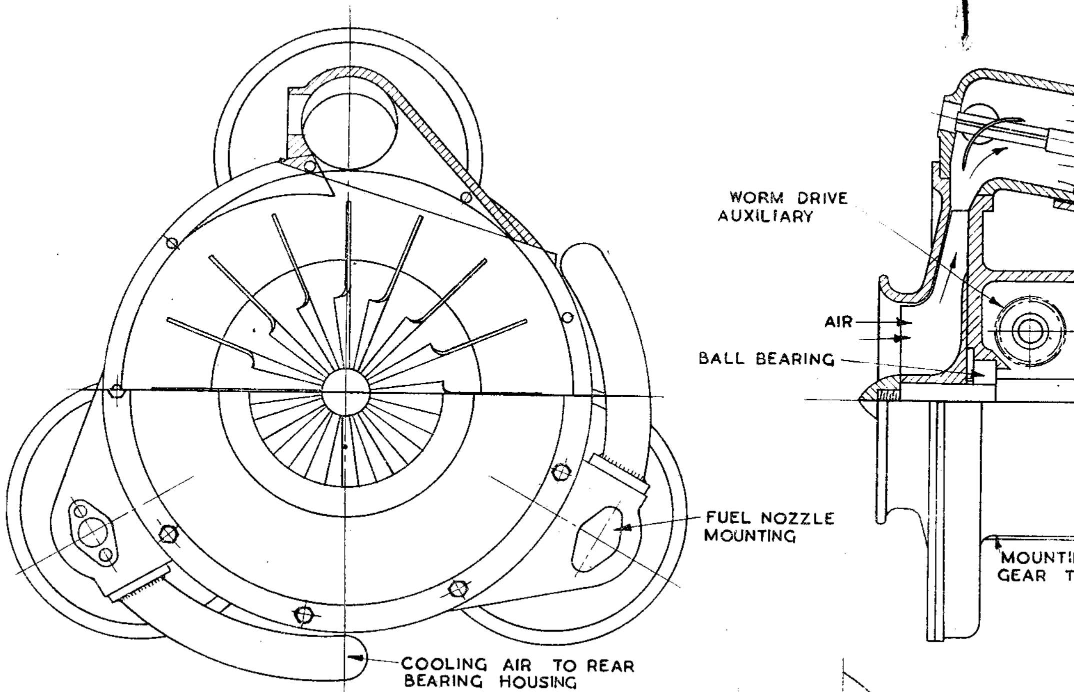
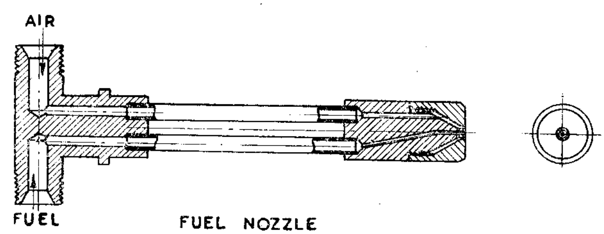
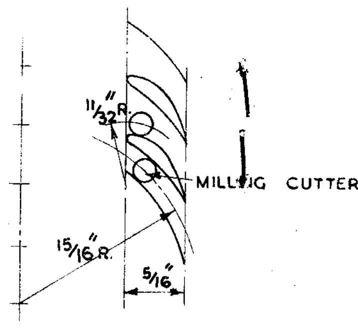




FUEL NOZZLE
TWICE SCALE SIZE



METHOD OF CUTTING BLADES
ON TURBINE WHEEL
TWICE SCALE SIZE

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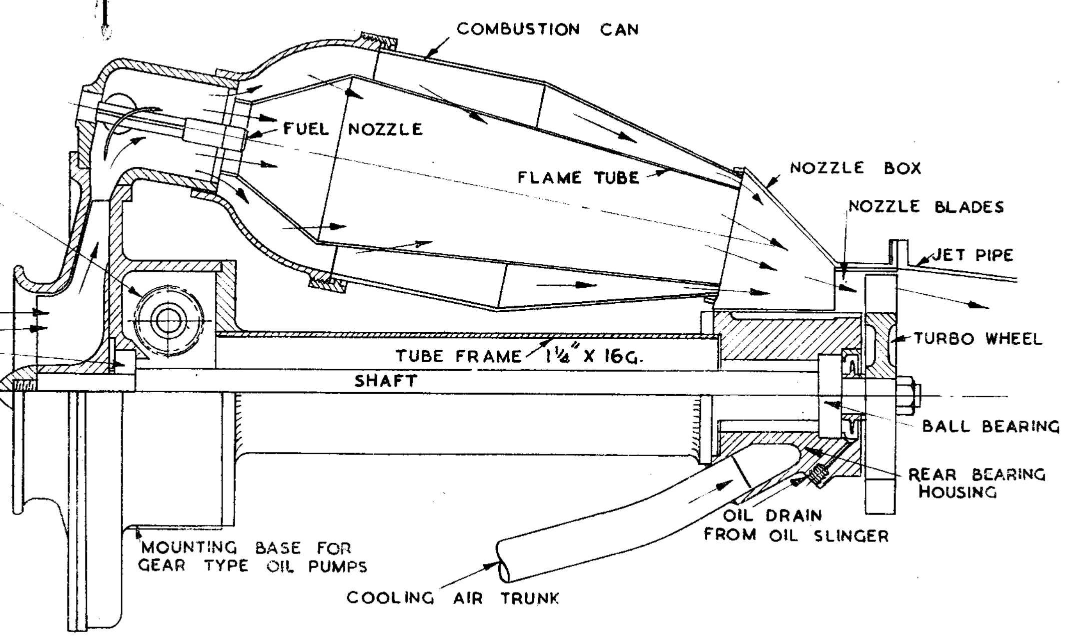
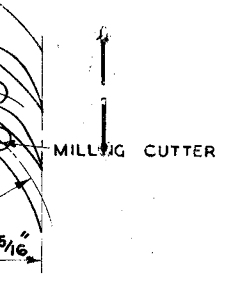
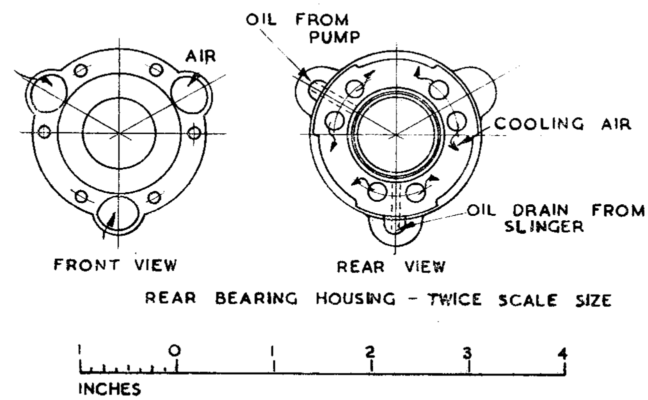
in the size under consideration, to have certain advantages over the single annular combustion chambers used on some full-size engines employing axial flow compressors. This type in this size would require more numerous fuel nozzles and it was feared that localised excessive heating might take place. The three individual combustion cans are of a size which should give more chances of success, as a fuel nozzle of workable size may be used. One of the chief problems would appear to be the adequate cooling of the turbine wheel, nozzle box and rear bearing, and considerable attention has been paid to this feature, both air and oil spray cooling systems being provided for. No details of the drillings in the flame tubes has been shown, as it is expected a number of different arrangements will have to be tried. In this connection it will be noted that both the combustion cans and the flame tubes have been kept as simple as possible and are easily removable. Injection of solid fuel alone in small quantities offered difficulties, and it





CUTTING BLADES
WHEEL
ALE SIZE



REAR BEARING HOUSING - TWICE SCALE SIZE

was felt that at least in the early stages injection with and by air would be more satisfactory, offering more efficient atomisation and mixing of the fuel and air. The type of nozzle adopted is similar to one described in THE MODEL ENGINEER some time ago, in the construction of a paint spray gun, although, of course, a good deal smaller.

Full Size Practice

The general construction of the engine will be seen to follow full size practice to some degree. The compressor has a single entry impeller which has sixteen blades. These are formed of sheet brass, which are sweated into radial slots milled in the hub which is turned from brass bar, and secured to the front end of the shaft. Both the impeller and turbine wheels are "overhung." The impeller is 4 in. in diameter, the blades $\frac{3}{16}$ in. in width at the tip, $\frac{3}{8}$ in. at the entry and extended forward and given a twist in the "eye" of the compressor intake. The compressor casing consists of a front circular cover spigoted to the rear half and delivery elbows. The rear half may be described as the main casting, as it carries the three delivery elbows bolted on to flat seatings at 120 degrees, also the gear case is incorporated on its rear face to furnish drives for auxiliary services. The front main bearing is also situated in it immediately behind the impeller. Spigoted to the rear of this gear case is the front flange of the main "frame" of the engine, which consists of a $1\frac{1}{4}$ in. diameter $\times$ 16 g. steel tube, to which the front and rear flanges are brazed or welded. To the rear end of this is attached the rear bearing housing, which is drilled to convey cooling air from the cooling trunks to the rear face of the turbine wheel. This air then passes outwards and backwards past the inner surface of the nozzle box and to the atmosphere. Its exit to the atmosphere is restricted somewhat in order to ensure that a slight pressure is built up, so forming a pressure seal on the rear bearing to prevent the escape of oil. The rear bearing housing is also drilled to provide a flow of oil from the oil pump over the rear face of the rear bearing. Drainage passages are also drilled to take excess oil away from the oil slinger channel back of the rear bearing and the rear housing.

The centre-lines of the combustion cans are at 11 degrees to the axis, and it will be seen that the discharge elbows on the compressor convey the air directly into these allowing them to be of symmetrical and simple construction. The fuel nozzles are introduced through the front of the discharge elbows and these elbows are cast with a long spigot which can eventually be cut off to provide a seating for the nozzle bases, they can be chucked by these while the rear portion is machined. The flat base by which these are attached to the main casting can then be machined at 11 degrees to the centre-line of these elbows. The elbows are then bolted to the rear casting, this assembly being then set up for machining the front face to which the front cover is spigoted and bolted. All castings so far mentioned are of light alloy.

The front portion of the combustion cans are of mild-steel. It is hoped that it will be possible to machine these from reducing pipe couplings. The rear portion of the combustion cans is of heat resisting sheet, cut out and welded up, the rear end being afterwards skimmed up in the lathe for a sliding fit in the nozzle box openings. The flame tubes are also welded up from heat resisting steel sheet. At the entry end of the latter the fuel nozzle is situated and held central by a radial guide vane which gives the air a swirl as it enters. The discharge ends of the flame tubes are squashed somewhat to a square form so that they are supported in the inside of the combustion cans. Holes will be drilled in the flame tubes to allow primary air to enter as combustion proceeds.

The nozzle box offered some problems, but, finally, with a "mock up" of the discharge end of the combustion can and nozzle blade outer shroud, and numerous trials with pieces of sheet iron, a shape was evolved which should meet the case. Broadly described, it resembles three fishtails such as are used on motor car exhausts with their discharge bent into a third of a circle. The whole assembly consists of a cylindrical winch wall with three scallops cut out to clear the cooling air trunks and oil pipes, a short tube to receive each combustion can and a short tube of a diameter to go over the nozzle blade shroud ring. These are all connected by a curious shaped piece of sheet which was evolved as above. The whole is of heat resisting steel sheet welded together. The nozzle blade assembly consists of an inner and outer ring having holes to receive the ends of the blades which are of sheet and placed at an angle of 45 degrees to the axis; tabs on each end of these pass through the holes and are turned over. There are sixteen blades.

The turbine wheel is $2\frac{1}{2}$ in. diameter, has 18 blades $\frac{3}{8}$ in. long cut from the solid by a similar manner to one described in "Model Steam Turbines," but modified to suit the different shape required and the chord line which requires to be at an angle of 45 degrees to the axis. The wheel is cut from a disc of heat resisting steel $\frac{5}{16}$ in. thick, and is secured to the rear end of the main shaft.

The jet pipe is tapered from where it joins the nozzle box rear face by a flange to a diameter of 2 in. at its orifice. A "bullet" cone may be fitted to protect the rear face of the turbine wheel from the hot gases.

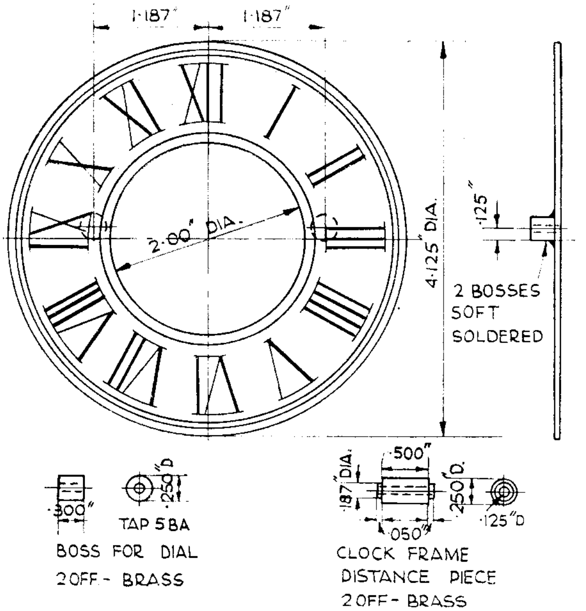
Experimental Work

The auxiliary drives referred to earlier will not at first be used until some experimental work on the bare engine has shown what is required. The supply of air for fuel atomisation, fuel and lubricating and cooling oil will be from an external source. However, provision has been made for driving a transverse horizontal shaft by worm and worm wheel to carry fuel and air pumps and a tachometer drive. Driven by bevel gear from this shaft is a vertical shaft, the lower end of which drives the gear type oil pressure and scavenge pumps.

Cooling air is taken from the compressor

(*Continued on page* 405)

I have not given any drawing of the hands, as they can be cut out of thin sheet steel to suit your own tastes. A couple of bosses will have to be turned up to suit the minute spindle and the hour wheel. The glass dome is a stock article. I checked one up on a friend's clock, one of those with a revolving balance - weight, and found it was $5\frac{3}{8}$ - in. internal diameter by $10\frac{1}{2}$ in. high. A friend helped me out with mine after we had nearly walked our shoes away looking in second-hand shops. The base will have to be turned up to suit whatever dome is obtained, and a deep recess turned out of the underside to accommodate a $1\frac{1}{2}$-volt dry cell, one pole of which is connected to the pendulum pillar and the other pole to the two clock pillars. I think I have made everything reasonably clear, but I will be pleased to answer any queries through the Editor.



Proposed Design for a Small Gas Turbine

(*Continued from page* 402)

discharge elbows by $\frac{3}{8}$ in. diameter pipe or cooling air trunk to the rear bearing housing.

No provision is shown for ignition, but this will take the form of a spark plug in each combustion can operated by a trembler coil for starting. No combustion can interconnectors are shown as used in full size practice, but in the interests of simplicity, it is hoped in the size of engine under consideration they will not be found necessary.

No details are shown of the method of fixing the impeller and turbine wheel to the shaft, but a taper form of mounting will probably be adopted.

The following table sets out the proposed dimensions of the main features of design which I may add are not "scientifically" designed in that no design formulae for either compressor or turbine was available covering the size under consideration. However, as much data as possible was obtained of full size engines and areas and sizes of parts have been kept to the ratios it appeared had been used in these.

Compressor	
Impeller diameter	4 in.
Intake "eye" diameter	2 in.
Blade tip	$\frac{3}{16}$ in.
Blade root (at 1 in. rad.)	$\frac{3}{8}$ in.
Cooling air trunks	3 in. × $\frac{3}{8}$ dia.
Combustion Cans (3)	
Entry diameter	1 in.
Maximum diameter	$2\frac{3}{8}$ in.
Discharge diameter	$1\frac{1}{4}$ in.
Length (total)	$5\frac{1}{2}$ in.
,, (to joint)	$1\frac{9}{16}$ in.
Flame Tubes (3)	
Maximum diameter	$1\frac{3}{4}$ in.
Discharge diameter	$1\frac{3}{16}$ in.
Entry diameter	$\frac{7}{8}$ in.
Turbo	
Diameter	$2\frac{1}{2}$ in.
Thickness	$\frac{5}{16}$ in.
Blades (18)	$\frac{3}{8}$ in. long
Nozzle Box	
Three branches.	

I trust the foregoing may be of interest and also the drawings, which are to scale; time does not permit me to do a complete set, however, they should serve to illustrate the description.