THE LATEST ROTOL AIRSCREW

"External Cylinder" Constant-speed Type : Wooden Blades : 35 Degree Pitch Range

A NEW airscrew, specially designed for the fast single-engined fighters of the Royal Air Force, but which can, of course, be applied for civil purposes, is now in production at the factory of Rotol Airscrews, Ltd., and is also in service with the squadrons. The Rotol firm, which claims the parentage of the Rolls-Royce and Bristol organisations, has for some time been making constant-speed airscrews of not only British construction, but design. This original type, with a pitch range of 20 deg. and known as the "internal cylinder" airscrew because the pitch-changing cylinder is enclosed within the hub, was fully described on page 296 of *Flight* of March 23, 1939.

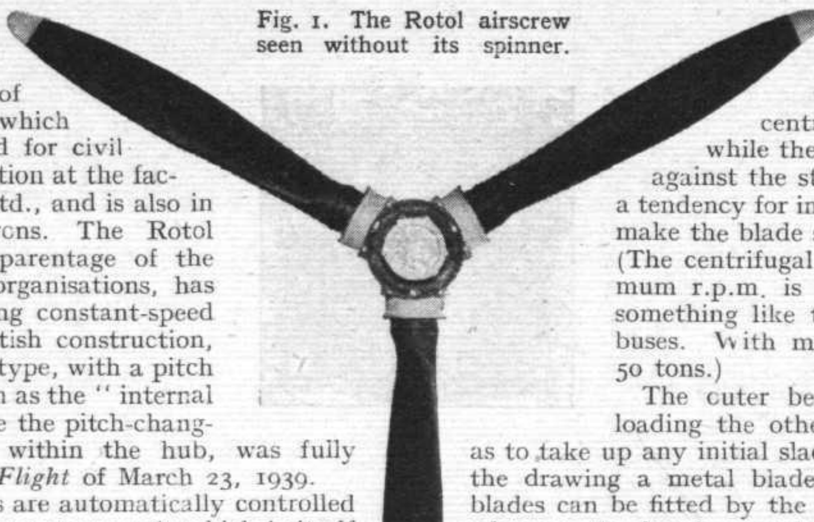

Fig. 1. The Rotol airscrew seen without its spinner.

Constant speed airscrews are automatically controlled by a constant speed governor-pump unit which is itself set by the pilot to govern the engine at any predetermined speed. Thus the pilot has a choice of engine r.p.m. irrespective of engine boost. Each setting of the airscrew governor control will maintain a definite engine r.p.m., each setting of the throttle a definite boost pressure, and adjustment of these controls provides any desired combination of boost pressure and engine r.p.m. irrespective of the attitude or altitude of the aircraft.

In addition to improved general performance, aircraft fitted with constant-speed airscrews have this advantage. When engaged in aerobatics the pilot does not continually have to manipulate the throttle to prevent the engine from "over-revving," for the governor unit will automatically vary the airscrew pitch as the forward speed changes in order to keep the engine speed unchanged at whatever figure the pilot has set the control.

The new airscrew is an advance on the previous design in that it has a pitch range of 35 deg. which is required to give sufficient variation of pitch angle for the extremes of forward speed which occur between take-off and power diving on modern high speed aircraft. Though not a feathering airscrew, it can be easily adapted for feathering by fitting a feathering pump and a cylinder with longer stroke to give the increased pitch range then required. It is known as the "external cylinder" type of Rotol airscrew as the pitch-changing mechanism is outside the hub —in front of it—though of course it is covered by the spinner.

Basically, the constructional features and method of operation are the same as for the "internal cylinder" 20 deg. type, the mechanism being worked hydraulically by engine oil, controlled by a governor-pump unit with centrifugal governor, whose design, as described in our previous article, remains unchanged. The following description which refers to Fig. 3 will enable the main constructional features and the method of operation to be readily understood.

The airscrew hub (1) is formed in one piece from a steel forging and carries a central sleeve (2) which runs axially through the hub and embodies a circular flange near its rear end which is bolted to the rear face of the hub shell. The front end of the sleeve is also bolted to a flange on the hub shell. The internal bore of the sleeve is splined at (3) to suit the particular shaft to which the airscrew is to be fitted and is also provided with the usual coned seatings. The hub shell is formed with three short barrels threaded internally and into these the blade bearing housings (4) are screwed. Each blade is supported in its housing by a stack of four ball bearings, which together serve to carry the journal loads.

The three bearings (5) nearer the airscrew axis are so arranged that the inner races tend to contract on to the blade adaptor (7) when loaded by the centrifugal pull of the blade, while the outer races tend to expand against the steel housing. There is thus a tendency for increase of rotational speed to make the blade still tighter in its mounting. (The centrifugal pull of one blade at maximum r.p.m. is about 35 tons if of wood, something like the weight of four London buses. With magnesium alloy it is about 50 tons.)

The outer bearing (6) is used for preloading the other bearings of the stack so as to take up any initial slackness in the assembly. In the drawing a metal blade (8) is shown but wooden blades can be fitted by the use of a different design of adaptor, the bearings and bearing housing remaining the same.

To seal the joint against water and stop electrolytic action, a wedge-shaped sleeve of Tufnol (20) is fitted into the housing and secured by a locking ring and setscrew. Removal of this sleeve for maintenance is effected by means of a groove around its circumference which coincides with the position of the setscrew of the locking ring. After first slacking off the locking ring, the setscrew is replaced with a grease nipple and grease pressure applied to force the ring out.

Final balancing of the airscrew is accomplished by insertion or removal of balancing strips (9) retained in position by a cover secured to the top of each housing by studs. The bearings are lubricated with grease prior to assembly, escape of lubricant from the bearings being prevented by gland seals.

Pitch-changing Loads

The base of each blade adaptor (7) carries a plate (10) to which is secured the blade operating pin (11). The plate (10) serves to lock the bearing retaining nut (12) in position and also provides a vernier adjustment (to 0.2 deg.) for the operating pin. In this way, when the blades are all set to a given pitch, the operating pins are in similar positions with respect to their blades. (The load on each pin due to torqe on the blade may reach as high as 1 ton.)

The mechanism for altering the pitch of the blades is a

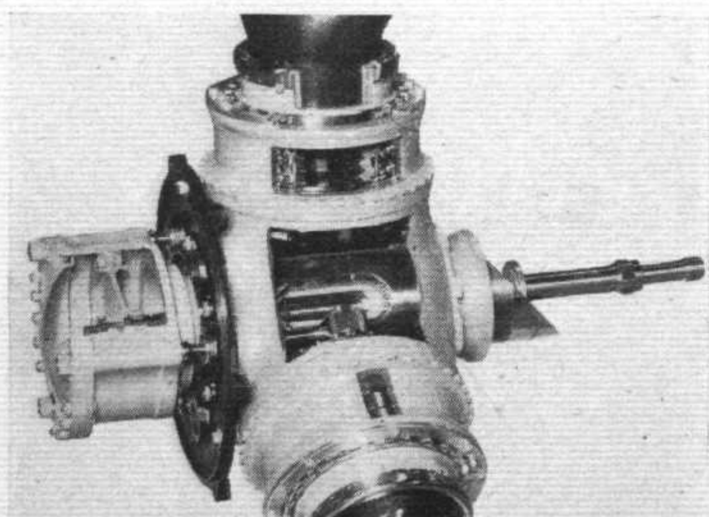

Fig. 2. Parts of the pitch-changing mechanism are visible in this sectioned hub.

double-acting hydraulic ram consisting essentially of a stationary piston (13) and a moving cylinder (14) mounted in front of the hub shell. Movement of the blades may require a total load of about 3 tons. The cylinder is connected to each of the blade-operating pins by a link (15) coupled to one end of a connecting rod (16) by a forked joint, the other end of the connecting rod being journalled on the operating pin by means of a suitable bearing. The relation of the cylinder to these links may be adjusted by the use of suitable shims (19) interposed between the shoulder on the link and the rear face of the cylinder. The forked joint forms a cross-head sliding in a tubular guide passing through and secured to the front face of the hub shell. The cylinder (14) has a long tube-like extension (17), which is arranged to slide freely within the hollow bore of the airscrew shaft. The central bore and the space between the double walls of the tube (18) serve to convey pressure oil from the governor-pump unit to the front and back of the piston respectively, and for this purpose an oil transfer (not shown on the drawing) is arranged inside the engine front cover to surround the airscrew shaft so as to feed oil to the airscrew.

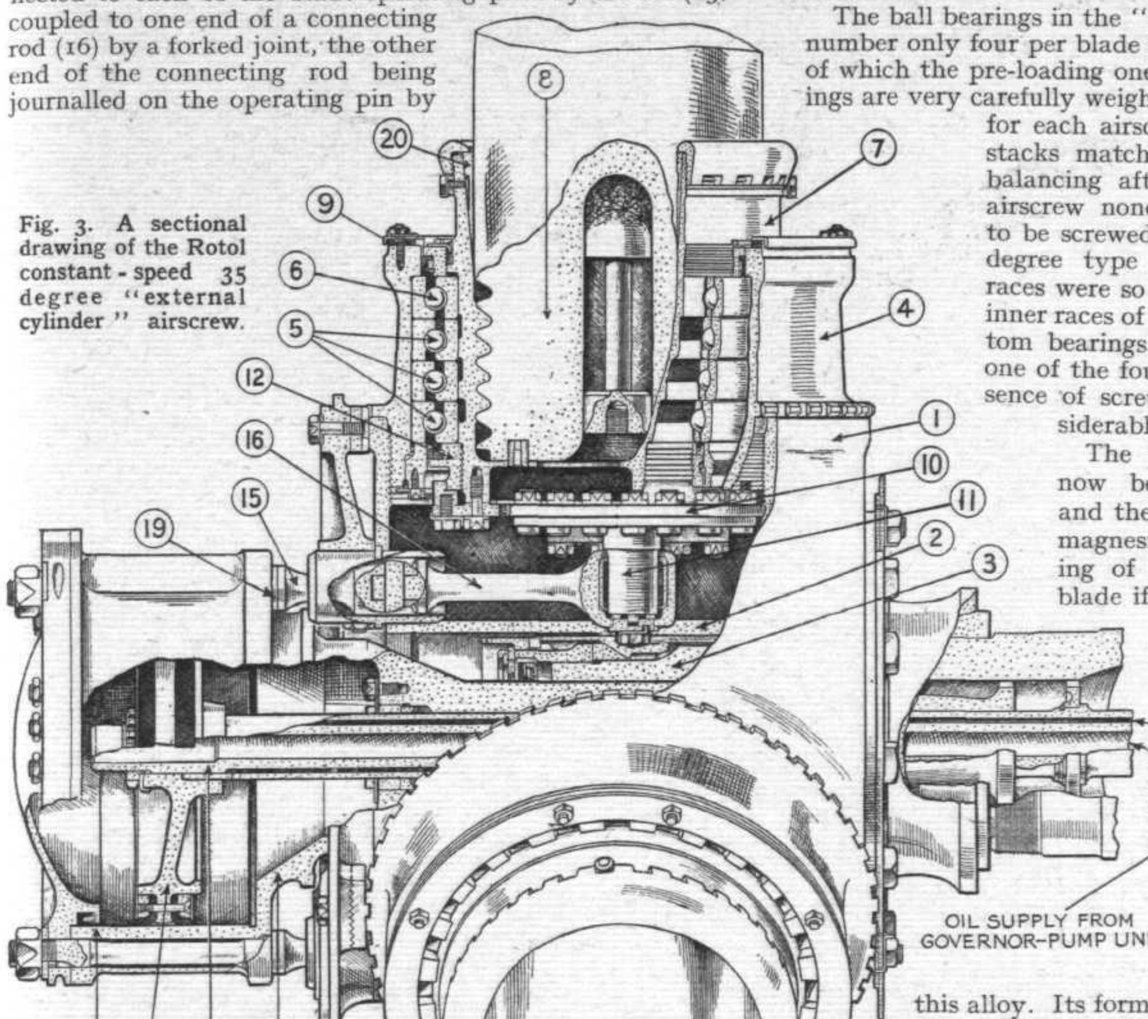

Fig. 3. A sectional drawing of the Rotol constant-speed 35 degree "external cylinder" airscrew.

A complete description of the working of the governor-pump unit was given in our previous article, and no changes have been found necessary after considerable use in service. The methods used in the production of airscrews were also described, and, as these are still in use, only new features or noteworthy points will be commented on in what follows.

The ball bearings in the "external cylinder" airscrew number only four per blade instead of the previous five, of which the pre-loading one was of smaller size. Bearings are very carefully weighed, and the twelve bearings for each airscrew are arranged in three stacks matched for weight to facilitate balancing after assembly. In the new airscrew none of the bearing races has to be screwed, as was the case in the 20 degree type airscrew, in which three races were so machined. These were the inner races of the pre-loading and the bottom bearings, and the outer of the top one of the four larger bearings. The absence of screwing is, of course, a considerable simplification.

The use of wooden blades has now been successfully mastered, and these may be fitted instead of magnesium alloy. There is a saving of something like 20 lb. per blade if wooden blades are used on a 1,000 h.p. airscrew. If wooden blades are fitted, a different type of steel adaptor with a wide-pitch thread of special form is used, and the wooden blade is screwed and cemented into this.

The thread used on the magnesium alloy blade is of interest as it has been specially evolved for use with this alloy. Its form gives the root of the thread in the magnesium a much more liberal radius of curvature than is provided in the usual V thread. Buttress threads, designed to take big loads in one direction, can be noticed in several places in the hub and housings.

Both the airscrew and the governor-pump unit are designed to work with either direction of rotation. Only a few assembly adjustments are needed to change from one to the other.

The final operation on the airscrew before delivery is balancing, which is performed on knife-edges in draught-free enclosures. Shims are added until a balance within the limit of 3 ounce-inches is obtained.

The governor-pump units are run under test and observed for oil pressure and correct functioning as their last factory process. It was demonstrated that the unit would move the oil valve and cause the airscrew pitch to change for an alteration in airscrew speed as small as 10 or 15 r.p.m.

C.S. airscrews have to-day become essential for fast aeroplanes, as an airscrew designed for maximum efficiency at top speed is hopelessly inefficient for take-off, the blades being stalled, or nearly so. Not only is the airscrew then aerodynamically inefficient, but it holds engine speed down and so reduces power.

Royal Singapore Flying Club

THE annual report of the Royal Singapore Flying Club for 1939 is a comprehensive and informative document as it analyses the club accounts into costs per flying hour as well as giving the usual total costs for various items. With a total membership of 322 (of whom 226 are non-flying or absent members), and 8 aeroplanes (6 Moths, 1 Magister and 1 Whitney Straight), the hours flown for the year amounted to 2,319, and 13,530 gallons of petrol were used, an average consumption of 5.8 g.p.h. There were no engine failures, which speaks well for the maintenance staff and the engines, all DH Gipsies. The number of "A" licences obtained was 25.

The balance sheet shows a loss of $7,000 but, in addition, $5,500 for aircraft depreciation was charged to the reserve account, so that the real loss for 1939 is $12,500, which approximates very closely to the reduction in Government subsidy. This amounted to $26,400 for 1939, while members' flying charges and subscriptions were $27,690 ($11.95 per hour). The average hourly charge for flying is very nearly $9, while petrol is about 72 cents per gallon.

Total cost per flying hour, including depreciation, is $29.68 per hour. With $1 equivalent to 2s. 3d. sterling, this is £3 7s. per hour. This cost subdivides into: petrol and oil, 15.4 per cent.; instructional staff, 14.1; ground staff, 30.2; maintenance material and spares, 13.4; depreciation of aircraft, 8.0; insurance, 2.0; hangar rent, 2.5; clubhouse and administration, 14.4.