June 3, 1947. P. F. HACKETHAL 2,421,692

PROPULSION DEVICE

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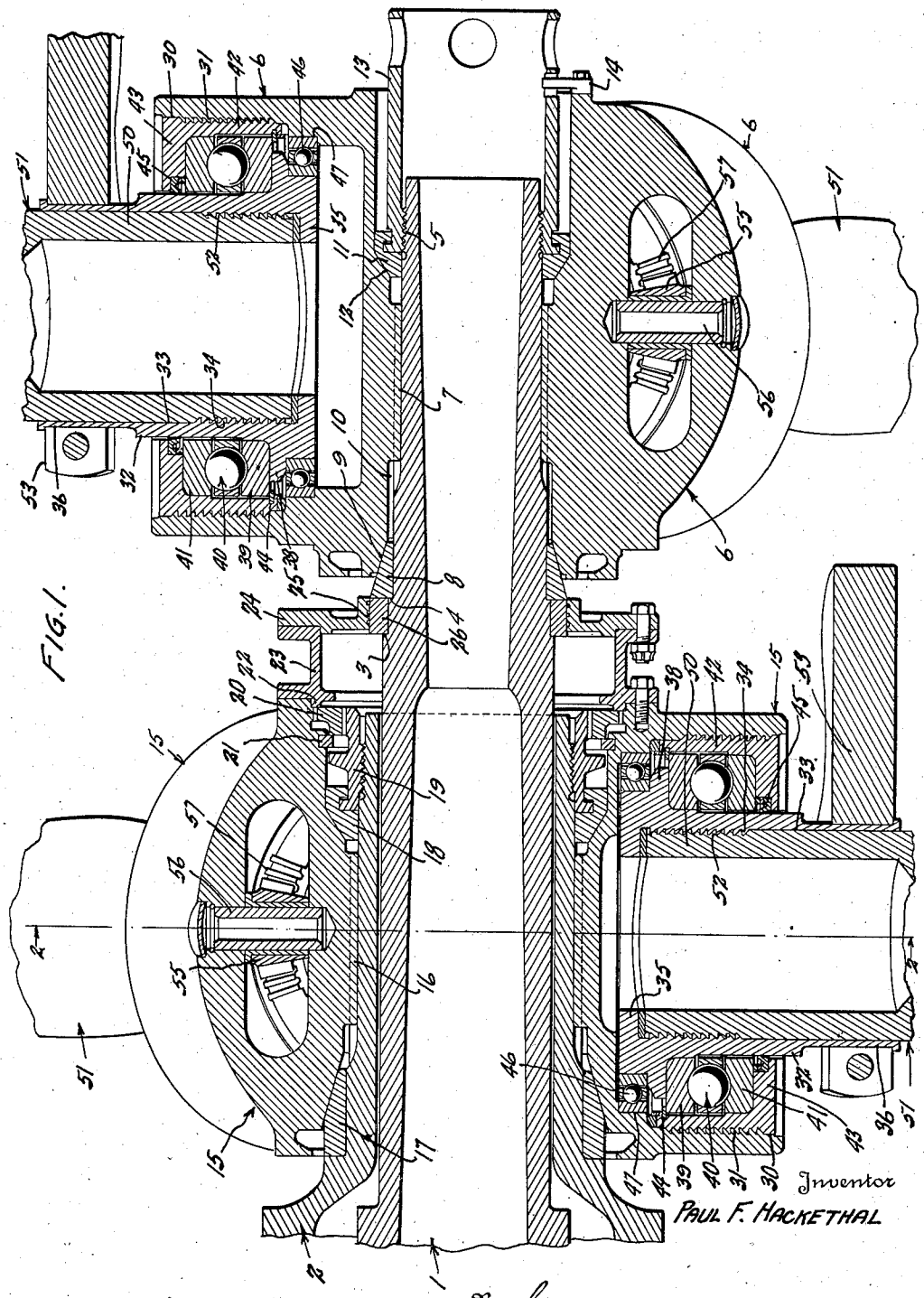


FIG. 1.

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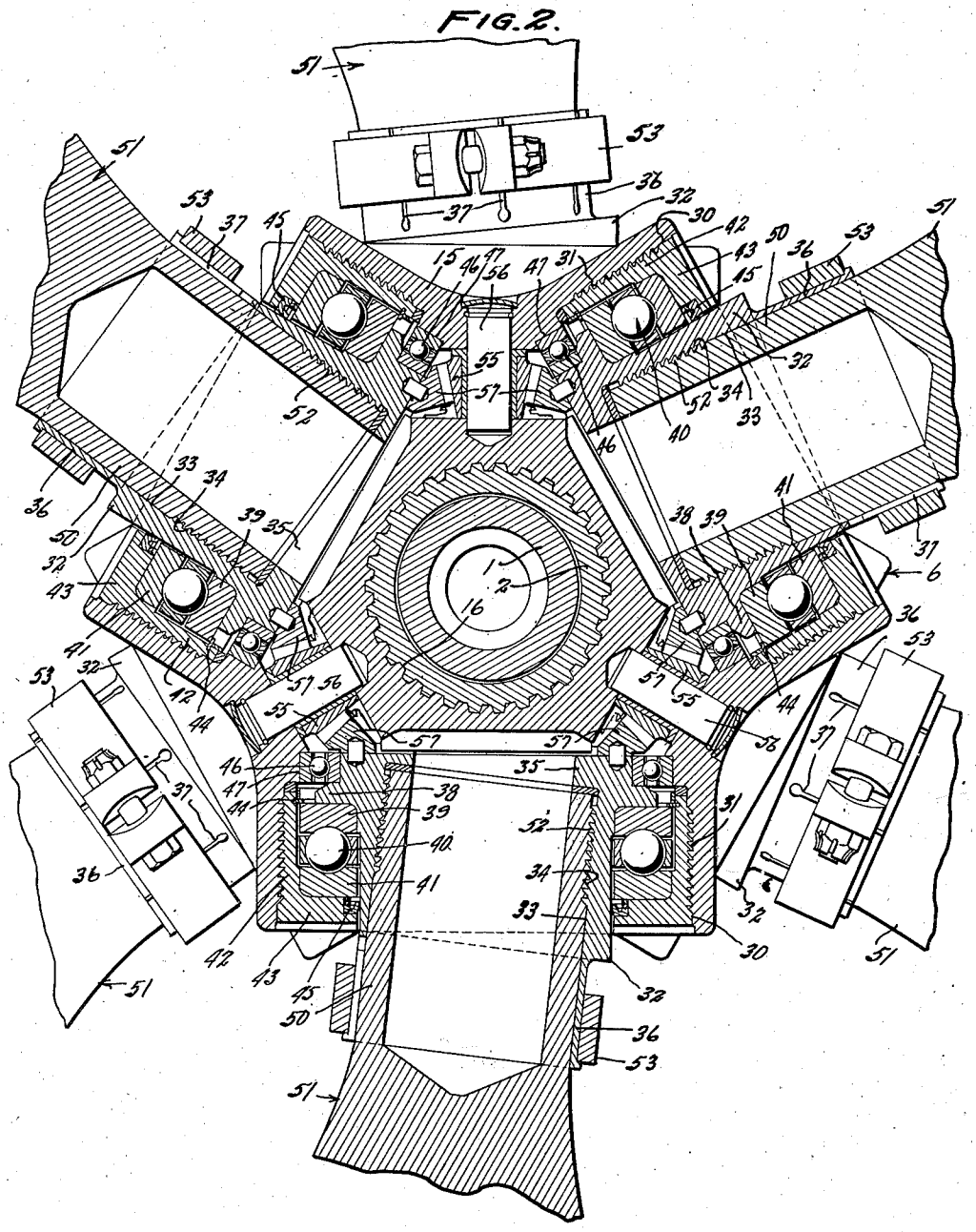
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FIG. 2.



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2,421,692

PROPULSION DEVICE

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2 Claims. (Cl. 170—135.6)

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The present invention relates to aircraft propulsion devices and more particularly to contra-rotating propellers wherein the pitch angle of their blades may be automatically varied for differing flight conditions.

With the great increases in modern engine horsepower, the use of contra-rotating propellers, that is, tandem propellers rotated in opposite directions on concentric shafts from a single source of power, has become an extremely important feature in airplane design. To fully utilize the horsepower of modern engines, a single propeller must either be of abnormal size or the number of its blades must be increased, either of which changes results in distinct disadvantages. Among these are, first, increase in landing gear size and weight to accommodate the larger diameter propellers; second, increase in tip speed and torque with its increase in added counteracting drag on the airplane, and consequent reduction in airplane speed; third, decreasing the amount of the pilot's or gunner's vision; and fourth, lowering of the propulsion efficiency of the propeller by increasing the number of its blades.

The contra-rotating propeller overcomes these disadvantages by providing a small propulsion unit of high efficiency driven from a single engine. But here too, the full efficiency of the engine is not utilized without means for varying the pitch angle of the blades.

Attempts have been made to vary the pitch of contra-propellers both by pilot control and automatic governor control, but the very nature of the propeller construction presents engineering difficulties which have precluded an efficient pitch changing device and has retarded the development and use of the otherwise efficient propeller.

It is therefore the principal object of this invention to overcome the difficulties heretofore encountered in varying the pitch of contra-rotating propellers.

Another object of this invention is to provide a contra-rotating propeller in which the blades are so mounted that they automatically assume the most effective pitch angle under different flight conditions to utilize the full horsepower of the engine.

A further object is to provide a propeller construction comprising tandem propellers rotating in opposite directions in which the blades of each propeller automatically assume the most efficient operating pitch independently of the other.

Yet another object is to provide a means for

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changing the pitch of dual propellers of a contra-rotating propulsion unit for aircraft in which there is no interconnection between the dual propellers or between the propellers and other parts of the aircraft.

A still further object is to provide means for automatically varying the pitch of contra-rotating propellers, the construction of which provides for a minimum of moving parts, a minimum of weight and a minimum of care and inspection for a maximum of operating efficiency.

Briefly stated, my invention comprises freely pivotally mounting the blades in each of the dual hubs of a contra-rotating propeller with their gravity axes inclined to their pivoting axes whereby centrifugal and aerodynamic forces acting on the blades move the blades through the arc of a cone until the forces are in equilibrium, at which time the blades automatically assume the most efficient pitch angle for the flight condition encountered. The principles underlying such a method of automatic pitch change are thoroughly disclosed in my copending application, Serial No. 392,966, filed May 10, 1941 (Patent No. 2,359,265, of September 26, 1944), and it is not thought necessary to discuss them further in this specification.

In the accompanying drawings which illustrate one form of construction of a contra-rotating propulsion unit in which the pitch of the dual propellers is automatically varied,

Figure 1 is a longitudinal sectional view taken transversely through the propeller shafts.

Figure 2 is a transverse sectional view through the rear hub taken along the line 2—2 of Figure 1 looking in the direction of the arrows.

Referring to Figure 1, the numerals 1 and 2 represent concentrically disposed propeller shafts. While the rear portions of these shafts are shown broken away, in actuality they extend into a gear box (not shown) from which they are imparted rotational motion in opposite directions.

It will be noted that the inner shaft 1 extends beyond the outer shaft 2 and is stepped to provide shoulders 3 and 4 and is also externally threaded as at 5 near its outer end.

A forward hub 6 is splined to the outward extension of the shaft 1 as indicated at 7 and is concentrically affixed thereto by means of a rear annular wedge 8 seated against the shoulder 4 and fitting within a tapered extremity 9 of the axial bore 10 of the hub and a forward annular wedge 11 fitting within a second taper 12 of the bore 10. A cylindrical nut 13 is threaded onto the screw threaded portion 5 of the shaft 1 and

engages the wedge 11 to move it toward the wedge 8 to secure the hub 6 to its shaft. A locking device 14 is provided to prevent loosening of the nut 13 after adjustment.

A rear hub indicated generally as 15 is similarly mounted on the shaft 2 by means of splines 16, annular wedges 17 and 18, and a draw-up nut 19. A locking ring 20 circumferentially serrated both externally and internally to engage serrations in the hub's bore and on the nut 19 serves to prevent rotation of the nut after adjustment. The locking ring 20 is held against longitudinal displacement by means of a snap ring 21 fitted into the bore of the hub 15 and a spigot 22 formed on one end of a flanged collar 23 which is affixed to the forward face of the hub 15 by means of cap screws 24.

The opposite end of the collar 23 has secured thereto an annular plate 24 the inner circumference 25 of which provides a bearing surface for engagement with a bearing ring 26 fitted around the shaft 1 against the shoulder 3 to maintain axial alignment of the outer ends of the two shafts.

As above set forth, the propeller blades are mounted in the hubs for free pivotal movement about the arc of a cone. To accomplish this, each of the hubs 6 and 15 are radially bored to provide stepped sockets 30 internally screw threaded as at 31. While there are shown three of such sockets for each hub, obviously more or less may be provided, depending upon the number of blades employed.

Adapted to be mounted within each of the sockets 30 is a blade mounting sleeve 32 of circular cross section which is provided with a bore 33 machined at an angle to the longitudinal axis of the sleeve. The inner end of the bore 33 is provided with internal screw threads 34 and is also internally flanged as at 35. The outer portion of the sleeve 33, adapted to extend beyond the socket 30, is turned down concentrically with the bore 33 to form a skirt 36 which is provided with a series of spaced radial slots 37, the purpose of which will be described later.

Near the inner end of the sleeve 32 is an external peripheral flange 38 against the outer face of which is fitted the inner race 39 of a combined radial and thrust anti-frictional bearing 40. The outer race 41 of the bearing 40 fits within an internally flanged cylindrical nut 42 against the flange 43. A snap ring 44 is provided to maintain the above construction in assembly while a suitable oil packing ring 45 is positioned between the nut and sleeve to maintain proper lubrication of the bearing.

Fitted around the inner end of the sleeve 32 against the inner face of the flange 38 is a second anti-friction bearing 46. In assembling the sleeves 32 within their sockets 30, the nut 42 is screwed into the threaded portion 31 until the bearing 46 is forced into the stepped portion 47 of the socket where it forms with the bearing 40 a cantilever support which permits anti-frictional pivotal movement of the sleeve within the socket.

While for the purpose of simplicity they have not been illustrated, suitable pitch change limit devices, such as have been shown and described in another copending application of mine, Serial No. 445,621, filed June 3, 1942, may be incorporated in the hubs to serve as stops for high and low pitch positions of the sleeves.

The shanks 50 of the propeller blades 51 are externally threaded as at 52 to engage the threads 34 of the sleeve bores 33 when they are fitted therein as shown in the drawings. After the blades have been screwed into their sleeves and their initial pitch has been adjusted they are fixed against further movement by clamp members 53 secured around the slotted skirt portion 36 of the sleeves. These clamp members 53 may also serve as counterweights, as illustrated in Figure 1, functioning to modify the mass distribution of the blades.

While, as heretofore stated, the centrifugal and aerodynamic forces acting on the blades automatically cause them to assume the most efficient pitch angle for given operating conditions, it is advantageous that there be a synchronized movement of the blades in each propeller. To accomplish this a series of bevel pinions 55 are mounted to rotate on radial pins 56 secured in the hub and positioned in the plane of the blade sleeves 32 and angularly equidistant therebetween. These pinions are adapted to mesh with bevel gear segments 57 which are secured to the inner faces of the blade sleeves 32.

In operation the dual, tandem propellers are rotated in opposite directions and at synchronous speed by their common source of power. While thus rotated, the several blades of each propeller are subjected to both centrifugal and aerodynamic forces acting thereon. The blades being pivotally mounted in their respective hubs as described above are affected. These forces effect a change in the pitch of the blades depending on the speed of the engine and conditions of flight. When these forces are in equilibrium the blades have automatically assumed their most efficient pitch angle. Since the centrifugal force acting on the two propellers will be the same on each, the aerodynamic forces, on the other hand, may not be equal for each propeller due to slip stream effect of the leading propeller or from other causes. It is therefore an important feature of this invention that each of the propellers be permitted to vary its pitch independently of the other depending upon the condition of the fluid through which it is rotating.

While I have shown and described only a single embodiment of my invention, I wish it understood that many changes may be made in construction without departing from the spirit of the invention and I desire to be limited therein only by the state of the prior art and the scope of the appended claims.

I claim:

1. A propulsion device for aircraft comprising a pair of tandem hubs rotatable in opposite directions about a common axis, a plurality of radial sockets in each hub, a sleeve mounted in each socket and adapted for free pivotal movement about the axis thereof, a bore in each sleeve, the axis of said bore defining an angle with and intersecting the axis of the socket, a propeller blade secured in each bore, and a plurality of synchronizing means disposed circumferentially around the propeller and interconnecting the blades of each individual propeller to maintain the pitch of the blades of that propeller uniform for all pitch variations.

2. A propulsion device for aircraft comprising a pair of tandem hubs rotatable in opposite directions about a common axis, a plurality of radial sockets in each hub, a sleeve mounted in each socket and adapted for free pivotal movement about the axis thereof, said sleeve having a slotted portion of reduced diameter extending beyond the socket, a bore in each sleeve, the axis of said bore

defining an angle with and intersecting the axis of the socket, a propeller blade secured in each bore, clamping means for securing the extended sleeve to the propeller blade, said means being weighted and serving to assist the blades in assuming various pitch positions in response to variations in flight conditions, and synchronizing means disposed circumferentially around the propeller and pivotally mounted in the plane of the blades and associated therewith for maintaining the pitch of the blades of that propeller uniform for all pitch variations.

PAUL F. HACKETHAL.

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