Aug. 20, 1946. J. A. CHILMAN 2,406,196

LIMIT SWITCH SYSTEM

Filed Feb. 2, 1943 2 Sheets-Sheet 1

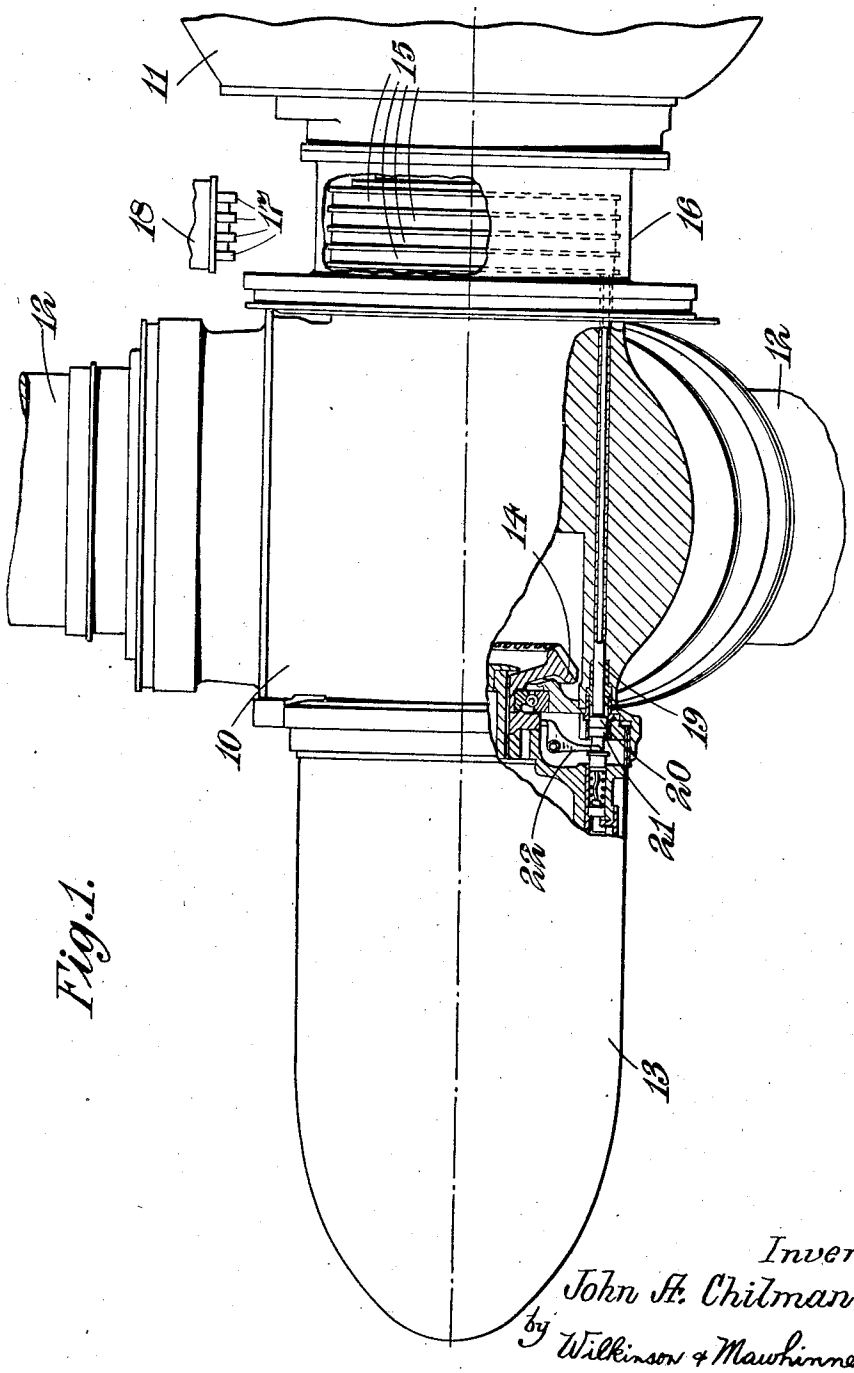



Fig. 1.

Inventor
John A. Chilman
by Wilkinson & Mawhinney
Attorneys

Aug. 20, 1946. J. A. CHILMAN 2,406,196

LIMIT SWITCH SYSTEM

Filed Feb. 2, 1943 2 Sheets-Sheet 2

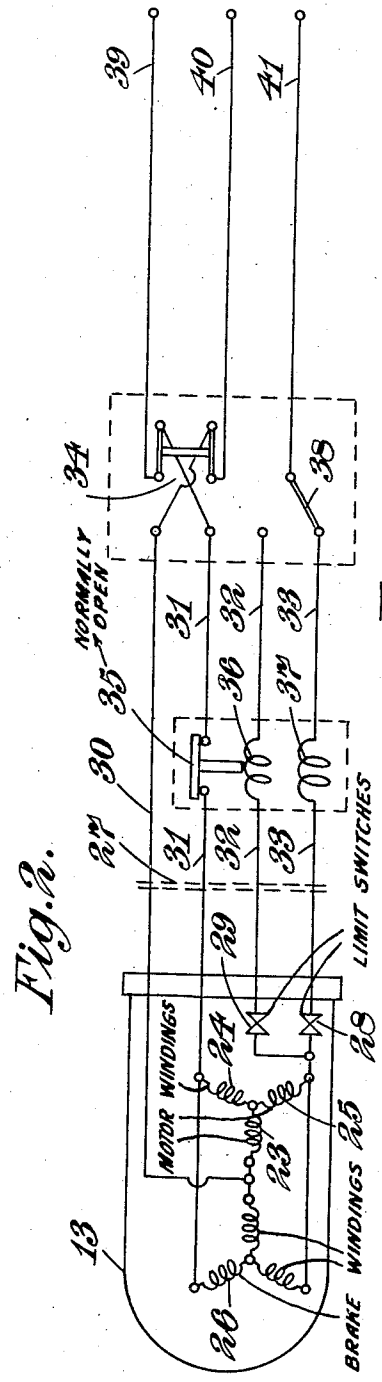



Fig. 2.

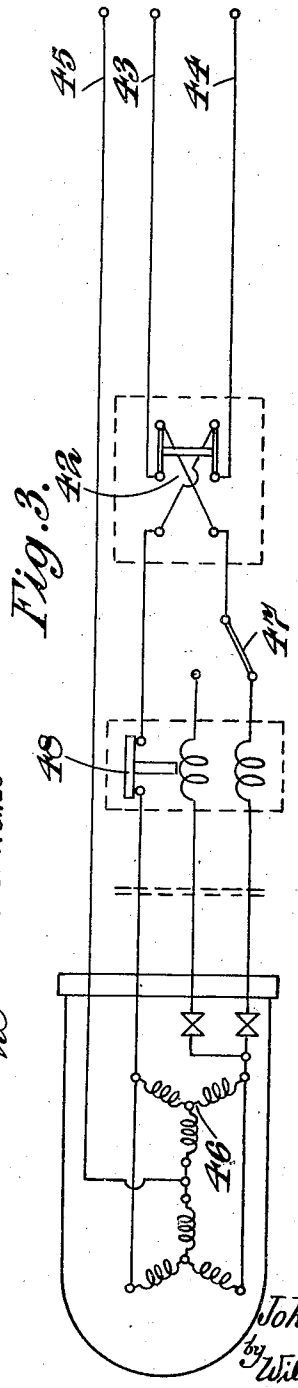



Fig. 3.

Inventor
John A. Chilman
by Wilkinson & Mawhinney
Attorneys

Patented Aug. 20, 1946

2,406,196

# UNITED STATES PATENT OFFICE

2,406,196

## LIMIT SWITCH SYSTEM

John Alfred Chilman, Gloucester, England, assignor to Rotol Limited, a British company

Application February 2, 1943, Serial No. 474,449
In Great Britain December 22, 1941

3 Claims. (Cl. 172—239)

1

This invention concerns improvements in or relating to variable-pitch propellers of the kind in which the pitch-changing movement of the blades is effected by an electric motor carried on the hub of the propeller. In the simplest kind of variable-pitch propeller, the pitch is adjustable between a fine-pitch setting and a coarse-pitch setting, but it is also desirable that a further range of adjustment should be provided to enable the blades to be feathered, and in recent developments, the range has been still further extended to enable the pitch to be reversed. Furthermore, it is desirable, and is already known, to provide for automatic or manual control of the adjustment of the pitch, the automatic control being used for making such adjustments as will maintain the engine-speed constant, whilst the manual control is used for feathering, reversing, or for adjustment of the pitch when the automatic control is cut out. It is also desirable to provide limit-switches or cut-outs automatically operated by the blade when it reaches a limiting position in any of its adjusting movements in order to simplify the operational control.

It is an object of the present invention to provide an improved arrangement of controlling circuits when a three-phase alternating current-supply is used, and to enable any or all of the above control arrangements to be obtained with the minimum number of connections to the motor. The importance of reducing the number of connections lies in the fact that the motor is mounted on the propeller-hub and rotates therewith so that separate slip-rings are necessary for each separate connection to it.

According to this invention, an alternating current electrically-operated variable-pitch propeller comprises a three-phase pitch-changing motor, and not more than four slip-rings providing connections therefrom to control-switches whereby any of the operational controls above set forth may be effected.

The invention also comprises in an alternating current electrically-operated variable-pitch propeller as above set forth, the arrangement wherein one phase winding of the motor is connected to two automatic cutouts which are in parallel with one another and are connected through a two-way selector-switch to one phase of the supply, a solenoid-operated switch having two alternative operating windings connected respectively in the lines between said selector switch and said cutouts, and a reversing-switch for two phases of the supply, one of the output lines of said

2

reversing-switch having the solenoid-operated switch in it.

Preferably the automatic cut-outs aforesaid are connected to one phase of the supply and the reversing-switch in the other two phases of the supply, and with this arrangement only four slip-rings are necessary for the motor connections.

According to another feature of this invention, one of the automatic cut-outs aforesaid is arranged to be operated in the two limiting positions of the range of movement of the blade, such, for example, as the reverse position and the feather position, and the other cut-out is arranged to be operated at some intermediate position such, for example, as the limiting fine-pitch position for normal operation of the propeller. The advantage of this arrangement is that when the propeller is being returned from its reverse position, it is automatically stopped on reaching the said fine-pitch cut-out and the automatic control can then take charge if so desired. It will be appreciated, however, that for this purpose any other suitable position for the intermediate cut-out could be used, such, for example, as the maximum coarse-pitch position for automatic working, but it is preferred to use the fine-pitch position for this cut-out.

In the accompanying drawings,

Figure 1 is a simplified drawing of so much of an electrically-operated variable pitch propeller as is necessary for the understanding of this invention,

Figure 2 is a diagram of the control circuits, and

Figure 3 is a diagram of an alternative arrangement of control circuits.

Referring to these drawings, the propeller comprises a hub 10 which is mounted on the shaft of an engine indicated at 11 to be driven thereby, and has the blades 12 mounted in it so as to be variable as to their pitch. The pitch-changing movements are effected by an electric motor and suitable reduction gear contained in a housing 13, the reduction gear driving a bevel-wheel 14 which meshes in the usual manner with similar gears mounted one on the root end of each of the blades.

The electric supply to the motor, which it will be appreciated is rotating with the propeller, is effected by means of slip-rings 15 mounted on the driving shaft within a housing 16 secured to the crankcase of the engine. Contact with these slip-rings is made by means of brushes 17 mounted on a carrier 18, which, in Figure 1, is

shown as displaced, but is inserted through a suitable opening in the casing 16.

From each of these slip-rings 15 an insulated conductor 19 extends through the hub 10 to a contact member 20, and similar contact members are mounted on the casing 13 to mate with them, so that the complete motor with its reduction gear, and other associated parts, can be detached as a unit. In the case of two of these conductors, the mating contact 21 is spring-pressed forward and associated with a cam-operated bellcrank lever 22 to constitute a limit switch or automatic cut-out; the lever 22 is operated by a suitable cam or cams rotatable with the gear 14, and the object of this construction is to provide an automatic cut-out at certain pitch positions of the blades as hereinafter described. Automatic cut-outs of this kind are used on variable-pitch propellers which have a direct current pitch-adjusting electric motor.

In the present invention, a three-phase alternating current motor is used as the pitch-changing motor and this is shown in the circuit diagram Figure 2 with the three-phases 23, 24, 25 star connected. It is desirable to use a spring-loaded brake in association with the motor to hold it stationary, and a three-phase electromagnet 26 is connected in parallel with the motor for the purpose of releasing the brake, whenever current is supplied to the motor to operate it.

Two of the phases 23, 24 are connected directly to the slip-rings 15 of Figure 1, the position of which is indicated at 27 in the circuit diagram Figure 2, and the third phase 25 is connected to two automatic cut-outs 28, 29, which correspond to the contacts 20, 21 of Figure 1. These two cut-outs 28, 29 are connected in parallel with one another and to their respective slip-rings, and the cut-out 28 is arranged to be automatically opened when the blades reach either their feathered position or their reverse position. The cut-out 29 is arranged to be opened at any suitable intermediate position in the range of travel of the blades, and in general it is convenient that this position should be a limiting fine-pitch position for normal working conditions.

From the four slip-rings, one line 30 is taken to one pole of a reversing switch indicated generally by the reference 34; the second line 31 is taken through an electromagnetically-controlled switch 35 to the other pole of the reversing switch 34; the two remaining lines 32, 33 are taken through solenoids 36, 37 either of which when energised closes the normally open switch 35. These two lines 32, 33 are continued to two contacts of a two-way selector switch 38.

The three-phase supply has two of its lines 39, 40 connected to the reversing switch 34, and the third line 41 connected to the two-way selector switch 38.

It will be seen that the function of the reversing switch 34 is to interchange the power supply lines 39, 40 with the two lines 30, 31 which are connected to the two phases 23, 24 of the motor, and that the selector switch 38 in either of its closed positions connects the supply line 41 to the phase 25 of the motor. The throwing over of the reversing switch 34 from one position to another, by reversing the two phases 23, 24, reverses the direction of rotation of the motor.

The operation of the controls will now be described. Assuming that the reversing switch 34 and the selector switch 38 are both open, if it is desired to adjust the blades towards a coarser-pitch position, the reversing switch 34 is closed, say to the position shown in Figure 2, to select the desired direction of rotation of the motor and the switch 38 is closed on to the line 33 so that a circuit is provided through the cut-out 28 to the motor, it being appreciated that the cut-out 28 is closed in all positions except when the blades reach their reverse or feathered positions. The closing of the switch 38 energises the coil 37 and therefore closes the switch 35 so as to complete the circuit of the line 31 so that all three phases of the supply are connected to the motor and it is set in rotation in the appropriate direction to coarsen the pitch of the blades. If it is merely desired to make a small adjustment, the operation can be stopped by opening the switch 38. This disconnects the supply line 41 from the motor, and the coil 37 is therefore no longer energised, so that the switch 35 opens, which disconnects the supply line 39 from the motor; two of the phases being thus opened, the motor stops and the brake is automatically applied.

If it be desired to feather the blades, the setting of the switches 34 and 38 above described, that is to say the setting illustrated in Figure 2, is allowed to stand until the blades reach their feathered position. At this point the cut-out 28 is automatically opened, thereby disconnecting the supply line 41, de-energising the coil 37, opening the switch 35 and disconnecting the supply line 39 so that two phases being opened, the motor stops.

Starting again from the original setting with the two switches 34, 38 both open, if it is desired to adjust the blades to a finer-pitch setting, the reversing switch 34 is thrown over so as to reverse the direction of rotation of the motor, and the switch 38 is closed on to the line 32. This energises the coil 36 and closes the switch 35 so that all three phases are now connected to the motor and it rotates in the appropriate direction, the circuit through the cut-out 29 being normally closed. If this movement be allowed to continue, the cut-out 29 is opened when the blades reach their limiting fine-pitch position for normal working, so that the supply to phase 25 of the motor is interrupted, the coil 36 is de-energised and the switch 35 is automatically opened so that the second phase of the supply to the motor is opened, and the motor thereupon stops.

The setting of the switches for adjusting the blades to a finer pitch is also used for returning them from their feathered position which was attained as above described. In attaining the feathered position, the switches 34, 38 were arranged as shown in Figure 2, and at the feathered position the cut-out 28 was automatically opened. To return the blades from this position, the switches 34, 38 are set as above described for adjustment to a finer-pitch setting. The switch 38 is now connected through the line 32 to the cut-out 29 which is closed since the blades have been moved past the normal fine-pitch position. The motor is therefore set in rotation bringing the blades towards their normal fine-pitch setting and on reaching that point the cut-out 29 is opened so that further control ceases. Any further adjustment may be effected manually, or automatically as hereinafter described.

If it be desired to adjust the blades to their reverse-pitch position, this is effected by setting the reversing switch 34 to give the appropriate direction of rotation to the motor (which is the same as for obtaining a finer-pitch as above de-

scribed), but the switch **38** is connected to the line **33** so that the circuit is taken through the cut-out **28** instead of through the cut-out **29** which opens automatically at the normal fine-pitch setting. The adjusting movement of the blades therefore continues beyond the normal fine-pitch setting until the cut-out **28** is opened automatically on reaching the reverse position.

For the purpose of returning from the reverse-pitch position of the blades, the switch **34** is set for the appropriate direction of rotation, which is that of coarsening the pitch, and the switch **38** is connected to the line **32** so that the circuit is completed through the cut-out **29** which is closed when the blades are in their reverse position. The motor is thereby set in rotation and continues until the cut-out **29** is opened automatically, if the adjustment is not interrupted before that point is reached by manually opening the switch **38**.

It is customary to provide on variable-pitch propellers an automatic governor-operated control for maintaining the engine-speed constant by making suitable adjustments in the pitch of the blades, increasing it as the engine-speed tends to rise and decreasing it as the speed tends to fall. Mechanism for this purpose is well-known, and may be arranged to operate through relay switches connected to the supply side of the solenoid-controlled switch **35**, such switches performing equivalent operations to those above described for adjustment towards fine-pitch or towards coarse-pitch respectively.

It will be seen that the above described arrangement of control circuits enables all the required controlling operations to be effected on the pitch-changing motor whilst using only four slip-rings for connection with the motor and this is of importance as any increase in the number of slip-rings usually involves an undue increase in the overall dimensions of the installation.

In Figure 3 there is illustrated a modified arrangement comprising a reversing switch **42** for interchanging two phases **43**, **44** of the supply. The third phase **45** is shown as directly connected to one phase of the motor **46**. The selector-switch **47** corresponding to the switch **38** of Figure 2 is connected in series with the reversing switch **42**, being connected to the output line thereof which is not connected to the solenoid-operated switch **48** corresponding to the switch **35** of Figure 2. The general mode of operation of this system is similar to that described with reference to Figure 2, but it offers the advantage that since the supply line **45** is directly connected to the motor, one of the slip-rings could, if desired, be omitted, thereby reducing the number to three, the connection being made by earthing the phase **45** of the supply and the corresponding phase of the motor. In some installations it is considered undesirable to earth one phase of the supply so that this arrangement is of a more limited application than the arrangement shown in Figure 2.

In the arrangement according to this invention, the full range of control of the pitch from reverse to feathering positions is provided, but in some instances lesser ranges of adjustment may be sufficient and these are provided principally by a suitable design or selection of the cut-outs



**28, 29.** Thus, for example, if the reverse setting of the blades of a propeller is not required, the cut-out **28** which as described above is opened at both the feathered and reverse positions, may be arranged to operate only in the feathering position; also it may be desired to provide an automatic stop at the coarse-pitch limit of the normal working range, and this would be provided on the cut-out **29**. In this case the switch **38** would normally be connected to the line **32** of Figure 2 and would be connected to the line **33** only for the purpose of feathering. Similarly any other desired arrangement of cut-out can be used to suit any particular requirements, with appropriate modifications in the operation of the switches.

I claim:

1. In combination with a three-phase motor, and a three-phase supply line for the motor, of a control comprising a normally open electro-magnetic switch connected to one phase of the motor, a reversing switch connected to another phase of the motor and to said electromagnetic switch and also to two of the lines of the supply for reversing the motor, a two way selector switch connected to the third line of the supply, two circuits connecting said selector switch with the third phase of said motor, a limit switch and a coil of said electromagnetic switch being in each of said circuits whereby closing of either circuit by said selector switch will cause closing of the electromagnetic switch.

2. Controlling means for a three-phase electric reversible motor comprising in combination three feed lines of a three-phase electric power supply, a reversing switch connected to two of said feed lines, a supply line from one output terminal of said reversing switch, a second supply line from the second output terminal of said reversing switch, a solenoid-operated switch in said second supply line, a two-way selector switch connected to the third feed line, two solenoids connected respectively to the output terminals of said selector switch, said solenoids being alternatively operable to close said solenoid-operated switch, connections from each of said solenoids to a third supply line, and means for connecting said three supply lines respectively to the three-phase-terminals of a motor.

3. Controlling means for a three-phase electric reversible motor comprising in combination three feed lines of a three-phase electric supply, means for connecting one of said feed lines with one phase-terminal of a three-phase motor, a reversing switch connected to the second and third feed lines, a supply line from one output terminal of said reversing switch and means for connecting it to the second phase-terminal of a three-phase motor, a solenoid-operated switch in said line, a line from the second output terminal of said reversing switch to a two-way selector switch, lines from the two output terminals of said selector switch, a solenoid in each of said lines, said solenoids being alternatively operative on said solenoid-operated switch, a line from each of said solenoids connected to a third supply line, and means for connecting said third supply line to the third phase-terminal of a three-phase electric motor.

JOHN ALFRED CHILMAN.