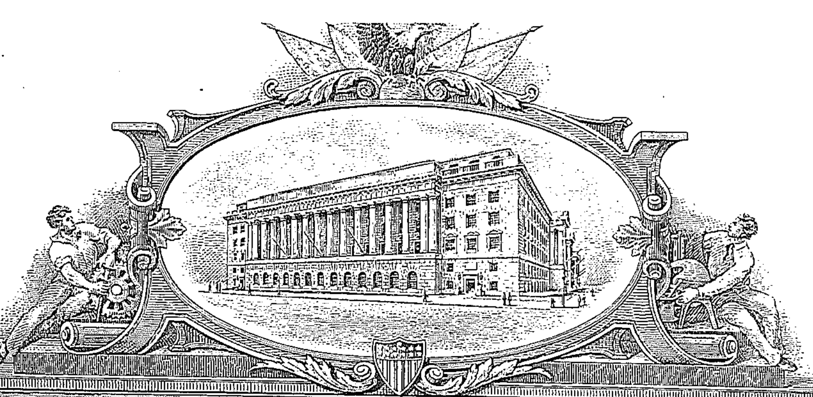


No 2220080

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas CARL J. CRANE and GEORGE R. LARKIN,

of

Dayton, Ohio,

PRESENTED TO THE Commissioner of Patents A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

SYNCHRONIZING MECHANISM,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANTS are ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID

Carl J. Crane and George R. Larkin, their heirs OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF. Provided, however, that the said invention may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this fifth day of November, in the year of our Lord one thousand nine hundred and forty, and of the Independence of the United States of America the one hundred and sixty-fifth.

Attest:

Law Examiner.

Commissioner of Patents.

Nov. 5, 1940. C. J. CRANE ET AL 2,220,080

SYNCHRONIZING MECHANISM

Filed Oct. 8, 1937 2 Sheets-Sheet 2

FIG. 2.

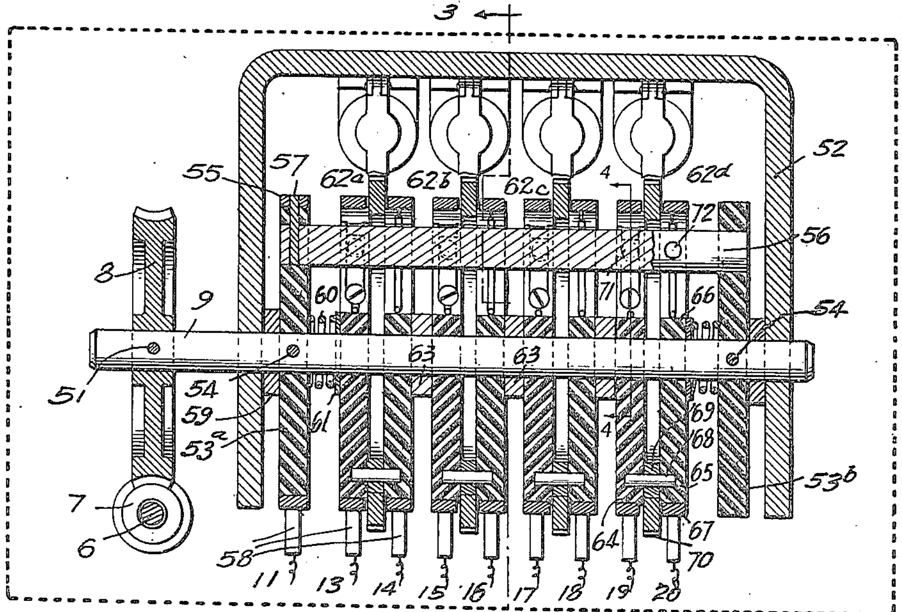


FIG. 3.

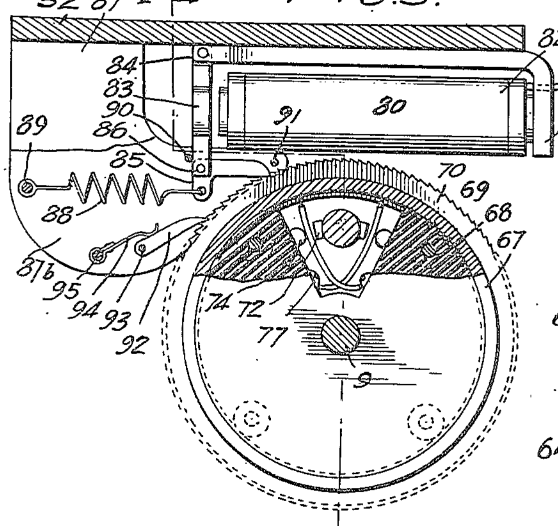
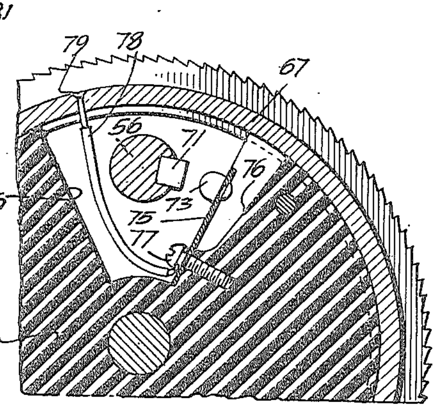


FIG. 4.



INVENTORS
CARL J. CRANE
GEORGE R. LARKIN
BY John J. Howard and
Elmde Koontz
ATTORNEYS

Nov. 5, 1940. C. J. CRANE ET AL 2,220,080

SYNCHRONIZING MECHANISM

Filed Oct. 8, 1937 2 Sheets-Sheet 1

FIG. 1.

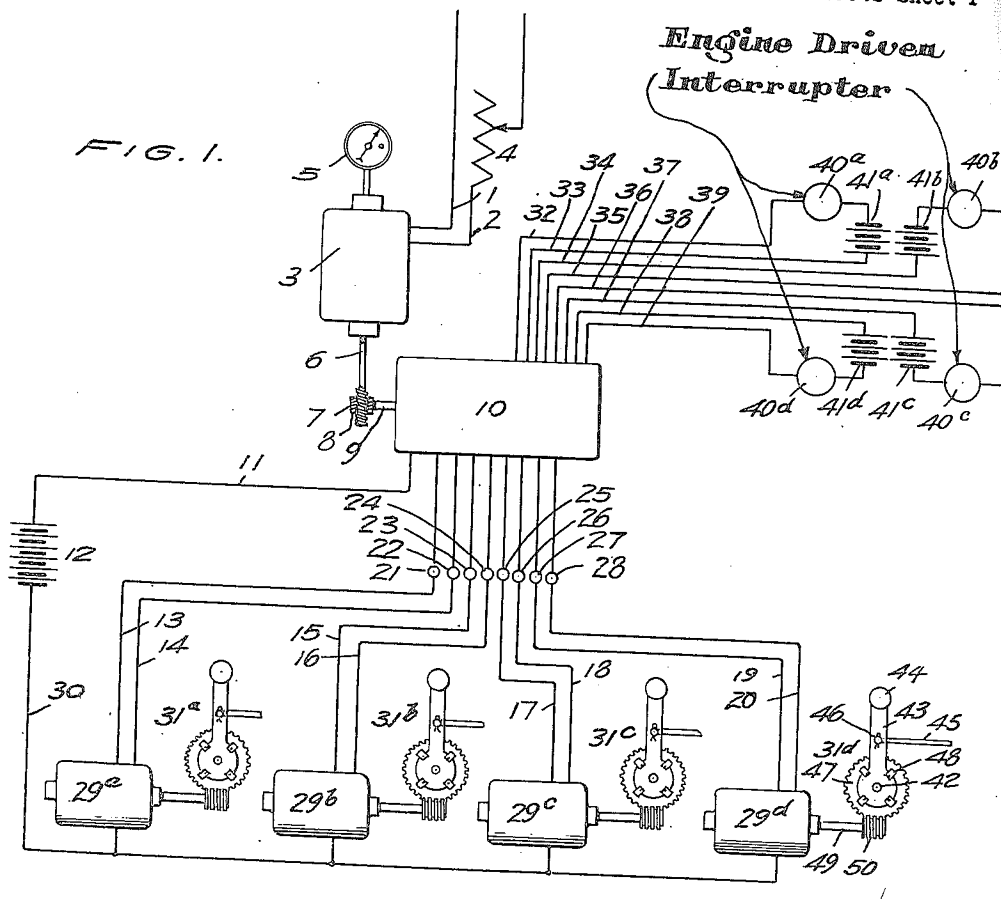


FIG. 6.

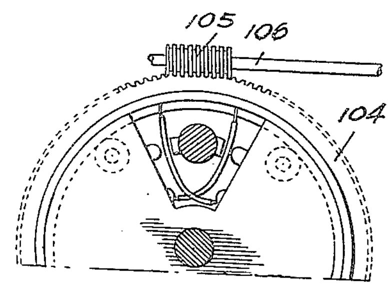
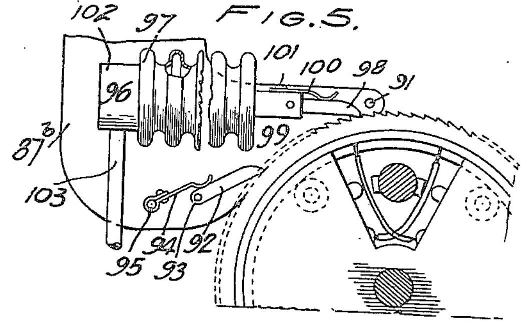


FIG. 5.



INVENTORS
CARL J. CRANE
GEORGE R. LARKIN

BY

ATTORNEYS

UNITED STATES PATENT OFFICE

2,220,080

SYNCHRONIZING MECHANISM

Carl J. Crane and George R. Larkin, Dayton, Ohio

Application October 8, 1937, Serial No. 168,026

5 Claims. (Cl. 60—97)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

It is an object of our invention to synchronize a plurality of prime movers which during normal operation may vary in revolutions per unit of time from one another or from a master speed of rotation device.

More specifically, our invention relates to apparatus for synchronizing a plurality of such prime movers as those encountered in multi-engined aircraft power plants in order to reduce to a minimum structural vibrations and auditory fatigue caused by the operation of the engines of such power plants out of synchronism.

It is well known to those skilled in the art that aircraft employing multi-engined power plants having more than one propeller, are subject to a very disagreeable "beat" or drumming noise whenever one or more engines rise above or fall below the operating revolutions of the power plant as a whole. The aforesaid phenomena subjects the personnel operating the aircraft to severe auditory fatigue and may set up destructive vibrations in the aircraft structure itself.

In aircraft employing only two propellers, it is a comparatively simple matter to eliminate beat phenomena due to engine revolution inequalities by merely varying the speed of revolution of one of the aforesaid engines until the "beat" disappears. However, when three of more propellers are employed, it will be readily seen that elimination of the beat phenomena becomes a highly complicated matter because of the fact that it is extremely difficult for operating personnel of the aircraft to tell which propellers are causing the "beat." Previously, therefore, this difficulty has proven a serious drawback to the extended use of airplanes having three or more independently driven propellers, particularly for use in carrying passengers. The safety feature introduced by the greater number of independently driven propellers, however, is extremely desirable.

It is of course possible to set engine revolutions approximately the same by using the tachometers attached to each engine, but it is impossible with tachometers alone to set engine revolutions close enough to a master revolution indicator to eliminate the objectionable "beat" referred to above.

It is therefore a second object of our invention to provide a synchronism indicator, where it is not desired to use automatic synchronism control, in order that engine revolution variations may be corrected manually.

It is a still further object of our invention to automatically synchronize the engine revolutions of multi-engined aircraft power plants.

Other objects and advantages of our invention will become apparent from the following description taken in connection with the accompanying drawings, it being clearly understood that the same are by way of illustration and example only and are not to be taken as in any way limiting the spirit or scope of our invention. The spirit and scope of our invention is to be limited only by the terms of the appended claims.

Referring to the drawings, in which numerals of like character designate similar parts throughout the several claims:

Figure 1 is a diagrammatic view of one embodiment of our invention;

Figure 2 is a partial cross-sectional view taken on the lines 2—2 of Figure 3;

Figure 3 is a partial cross-sectional view taken on the lines 3—3 of Figure 2;

Figure 4 is a cross-sectional view taken on the line 4—4 of Figure 2;

Figure 5 is a fragmental view of a second embodiment of our invention; and

Figure 6 is a fragmental view of a third embodiment of our invention.

In Figure 1 lead wires **1** and **2**, from a direct current source not shown, are operably connected with a direct current motor constituting a master speed device **3** and a rheostat **4**. One extremity of the master speed device **3** is provided with a tachometer **5**, while the other extremity thereof is provided with a drive shaft **6**, surmounted by a worm gear **7**. The worm gear **7** is operably engaged with another worm gear **8**, mounted on a driven shaft **9** of a synchronizing mechanism **10**. The internal elements comprising the synchronizing mechanism **10** will be described in detail in connection with Figure 2. For the present, external wiring and parts associated therewith need only be described. A lead wire **11** is connected to one pole of a constant current source **12**. Passing from left to right, lead wires **13** and **14** are operably associated with the first engine of a multi-engined power plant through connection with a reversible motor **29a**, while three additional pairs of lead wires **15** and **16**, then **17** and **18**, then **19** and **20**, are operably associated with a second, then a third, then a fourth aircraft engine, through connection, respectively, with reversible motors **29b**, **29c**, and **29d**. Between terminal ends, the lead wire **13** is provided with a light **21**, as are successive lead wires **14**, **15**, **16**, **17**, **18**, **19** and **20** provided, respectively, with lights 22, 23, 24, 25, 26, 27 and 28. The remaining pole of the constant current source 12 is brought into common electrical connection with the remaining third lead wires of the reversible motors 29a, 29b, 29c and 29d by means of a wire 30.

As will be more specifically apparent after description of Figure 2, it is a dual object of our invention to provide for both manual and automatic operation of the synchronizing mechanism 10. For both systems of control, we therefore further provide throttles 31a, 31b, 31c, and 31d, which are operably connected respectively with the first, second, third and fourth engine of the aforesaid multi-engined power plant. The synchronizing mechanism 10 is also provided with four additional pairs of lead wires 32 and 33, then 34 and 35, then 36 and 37, and then 38 and 39. The lead wire 32 is operably connected with one pole of an interruptor unit 40a forming a part of and driven by the aforementioned first engine. The other pole of the unit 40a is connected with one pole of a constant current source 41a. The remaining pole of the current source 41a is operably connected with lead wire 33. From the diagrammatic showing of Figure 1, it is at once apparent that the remaining three pairs of lead wires are similarly interconnected with the remaining three pairs of interruptor units and current sources.

The throttles 31a through 31d are provided with mounting shafts 42, fixed to the structure of the aircraft, upon which are mounted levers 43, surmounted by handles 44. The levers 43 are provided with push rods 45, secured by cotter pins 46. They are further provided with worm gears 47, against which frictionally engaged driving plates 48, fixed to the base portions of the lever 43 by rivets or other suitable attaching means. The reversible motors 29a through 29d are provided with drive shafts 49 and worm gears 50 adapted to operably engage the worm gears 47 discussed above. We have thus provided for both automatic and manual adjustment of the throttles 31a through 31d, the details of which will be more readily apparent after description of the internal parts of the synchronizing mechanism 10.

In Figure 2, end portions of the drive shaft 6 and the worm gear 7 of Figure 1 are shown in operable engagement with the worm gear 8. It will be noted that the latter gear is fixed to the driven shaft 9 of Figure 1 by means of a pin 51. The driven shaft 9 is supported by means of a U-shaped member 52. Within the limits of the U-shaped member 52, the outer portions of the driven shaft 9 are provided with master disks 53a and 53b, fixed against lateral or rotational movement by means of pins 54. The periphery of the master disk 53a is provided with a conductor ring 55. A conductor bar 56, parallel to the driven shaft 9, is fixed to the insulated portions of the master disks 53a and 53b by means of a conductor pin 57. Electric current from the lead wire 11, of Figure 1, is supplied to the conductor bar 56 by means of a conductor brush 58 bearing against the lowermost portion of the conductor ring 55. To prevent side play of the above described disk assembly, the driven shaft 9 is provided with washers 59, separating the outer disk faces from the inner end surfaces of the U-shaped member 52.

Four pairs of auxiliary disk units 62a, 62b, 62c and 62d are longitudinally yieldingly interposed between the inner surfaces of the master disks 53a and 53b by means of springs 60 and washers 61. The inner auxiliary disk units 62b and 62c are fixedly spaced from each other by means of a washer 63, the same fixed spacing being maintained between auxiliary disk units 62a and 62b, then 62c and 62d by means of further washers 63. Each of the aforesaid units have in common left hand disk 64, right hand disk 65, both of which are provided with like sector openings 66, conductor rings 67, four roller pins 68, four rollers 69 and a central rachet wheel 70. The rachet wheel 70, while free to turn about the rollers 69 even when the disks 64 and 65 are held stationary or vice versa, still acts as a frictional driving medium to change angular relationship between each auxiliary disk unit and the fixed master disks 53a and 53b due to the presence of the springs 60 and washers 61. The aforesaid angular change is limited, however, to but a small percentage of the sector opening 66. From left to right the four pairs of conductor rings 67 are maintained in electrical connection with lead wires 13 and 14, then 15 and 16, then 17 and 18, then 19 and 20, by means of eight conductor brushes 58.

Figures 3 and 4 bring out the manner in which the conductor bar 56 is brought into electrical connection with two or more of the conductor brushes 58.

Reference to Figures 2 and 4 indicates that the far side of the conductor bar 56, as viewed in Figure 2, is provided with four equi-spaced contact points 71, while the near side thereof is provided with four similarly equi-spaced but not oppositely disposed contact points 72. The contact points 71 are adapted to be rotated in a clockwise direction (Figure 4) into operable engagement with four oppositely disposed contact points 73, fixed to the outermost surface of four supporting springs 75. In like manner the four contact points 72 are adapted to swing in a counter-clockwise direction into operable engagement with four oppositely disposed contact points 74, fixed to the outermost surface of four additional supporting springs 75. Recesses 76 are provided in the four left hand disks 64, as indicated in Figure 4. The recess arrangement of right hand disks 65 is just opposite to that of the showing of Figure 4; i. e., each of the inner disks 64 and 65 are provided with but one supporting spring 75, the opposite face of the sector-like opening 66 being plain. Each of the springs 75 are secured to its immediate supporting disk by means of a screw 77 and is electrically connected to its encircling conductor ring 67 by means of a connector wire 78, soldered at its outer extremity 79.

Referring to Figure 3, the synchronizing mechanism 10 is provided with four impulse motors 80. Each impulse motor 80 consists of a mounting frame 81, a magnetic coil 82, and a magnet bar 83. The magnet bar 83 is secured to the mounting frame 81 by means of a hinge 84. A rachet pawl 85 is hingedly secured to the lower extremity of the magnet bar 83 by means of a hinge 86. It will be noted that lead wires 34 and 35 protrude from the rear extremity of the impulse motor 80 indicating that this motor is the second from the left, as shown in end profile in Figure 1. Two parallelly spaced mounting plates 87a and 87b are equi-spaced from and parallel to each rachet wheel 70. The major portions of the mounting plates 87a and 87b lie to the left of the magnet bar 83 as viewed in Figure 3. They provide a mounting base for a pawl spring 88 by means of which the pawl 85 and magnet bar 83 are normally maintained in the position indicated by Figure 3. The left extremity of the pawl spring 88 is secured to the mounting plates 87*a* and 87*b* by means of a pin 89. Outward movement of the magnet bar 83 is limited by a pin 90, while inward movement of the engaging tip of the rachet pawl 85 is limited by means of a second pin 91. Each inward impulse of the magnet bar 83 will rotate the rachet wheel 70 one tooth distance. In order that return of the rachet pawl 85 not return the rachet wheel 70 to its original position, a second rachet pawl 92 is provided. The rachet pawl 92 is secured to the mounting plates 87*a* and 87*b* by means of a pin 93, the rachet pawl being held in operable engagement with the teeth of the rachet wheel 70 by means of a pawl spring 94 fixed to the mounting plates 87*a* and 87*b* by means of a non-rotatable spring support 95. The foregoing concludes description of all those elements essential to the operation of the first embodiment of our invention.

As has been previously stated, operation of the first embodiment of our invention is two-fold. Referring to Figure 1, let it be momentarily assumed that the reversible motors 29*a*, 29*b*, 29*c*, and 29*d* are removed, that the wire 30 is directly connected with lead wires 13 through 20, and that the master speed device 3 has been brought up to and held constantly at "X" clockwise revolution per minute, as viewed in Figures 3 through 6. Under the aforesaid conditions, the rachet wheels 70 (or 104 of Figure 6) of the four auxiliary disk units 62*a* through 62*d* will remain stationary with respect to the impulse motors 80 (or worm gears 105 of Figure 6) while the remaining auxiliary disk unit parts, driven by continuing contact between contact points 71 and 73, will rotate at the same speed as the driven shaft 9. As long as all of the aforesaid auxiliary disk units are driven through continuing contact between contact points, the electric circuits defined by lead wires 11 and 13—30, 11 and 15—30, 11 and 17—30, as well as 11 and 19—30, being closed; visual indication of the aforesaid "continuing contact" will be apparent through continuous illumination of the lamps 21, 23, 25 and 27. Adoption of a prearranged color scheme for the aforesaid series of lamps is of course optional. Such a scheme would greatly aid the aircraft pilot in correct lamp reading.

Let it next be assumed that the first, then second, then third and then fourth engine of the heretofore mentioned multi-engined power plant, upon which are respectively mounted the interruptor units 40*a* through 40*d*, are successively started, brought up to, and held constantly at "Y" revolutions per minute; at which revolution rate the impulse motors 80 (or worm gears 105 of Figure 6) are designed to effect like revolutions of the rachet wheels 70 (or 104 of Figure 6) and the auxiliary disk units 62*a* through 62*d* supporting the same. Under the aforesaid conditions, the lamps 21, 23, 25 and 27, will still remain illuminated. However, if one or more of the aforesaid engines is momentarily "speeded up," then "dropped back" to "Y" revolutions per minute, through very slight manual advancement, then immediate retardation, of the appropriate throttles 31*a*, 31*b*, 31*c* or 31*d*; one or more of the lights 21, 23, 25 or 27, will discontinue burning. The aforesaid momentary "speeding up" results in freeing of the appropriate contact points 71 and 73, through clockwise advancement of the appropriate auxiliary disk unit 62*a*, 62*b*, 62*c* or 62*d*. It is probable that one or more of the associated lamps 22, 24, 26 or 28 will become illuminated, in which case it will be necessary for the aircraft pilot to infinitely slightly retard, then return, the appropriate throttle 31*a*, 31*b*, 31*c* or 31*d* to its initial setting to cause the conductor bar 56 and its oppositely staggered contact points 71 and 72 to seek a position substantially midway between the oppositely staggered contact points 73 and 74 installed upon oppositely staggered faces of the sector-like openings 66, the auxiliary disk units 62*a* through 62*d*. As has been stated before, the second set of lamps may also be differently colored from their predecessors to aid the pilot in more readily distinguishing between "advancement" and "retardation" of any one or more specific engine revolutions per minute with respect to the master speed device 3. We have thus set forth operation of the manual adjustment of our synchronizing mechanism 10.

Automatic operation of the first embodiment of our invention is accomplished as follows. Referring to the actual parts disposition of Figure 1, lighting of the lamps 21, 23, 25 and 27 closes the electrical circuits represented by the lead wire 11, the constant current source 12, the wire 30 and reversible motor lead wires 13, 15, 17 and 19; causing clockwise rotation of the drive shafts 49 and worm gears 50, as viewed from right to left, thereby inducing further clockwise rotation of the associated worm gears 47 and levers 43. Throttle advancement continues until the first, then second, then third, and then fourth engine of the heretofore mentioned multi-engined power plant are brought up to the aforementioned "Y" revolutions per minute; at which point further advancement is automatically stopped by the impulse motors 80 (or the worm gears 105 of Figure 6) slightly exceeding like revolutions of the rachet wheels 70 (or 104 of Figure 6), causing the auxiliary disk units 62*a* through 62*d* to free previous contact between the contact points 72 and 73. In the event that subsequent power plant operation involves "overrunning" or "lagging" of any one specific engine of the aforesaid installation, alternating contact of contact points 71 and 73, or contact points 72 and 74, will cause alternating reversals of the reversible motors 29*a* through 29*d*, with attending "advancement" or "retardation" of appropriate throttles 31*a*, 31*b*, 31*c* or 31*d*. It is thus no longer necessary that the pilot refer to illumination or non-illumination of the lamps 21 through 28. We have thus completely described operation of the automatic adjustment of the first embodiment of our invention.

As has been previously stated, many and varying forms of sub-assembly units may be employed to effect both manual and automatic adjustment of our synchronizing mechanism 10. A second embodiment of driving means for the rachet wheels 70 is shown in Figure 5. The impulse motor 80 of Figure 3 is replaced by a fluid impulse motor 96. The impulse motor 96 is composed of a Sylphon 97, provided at its inner extremity with a rachet pawl 98, secured by means of a pawl hinge 99. In order that positive engagement between the pawl 98 and tooth surface of the rachet wheel 70 may be assured, the forward extremity of the Sylphon 97 is also provided with a pawl spring 100, fixed by means of a rivet 101 or other suitable attaching means. The mounting plate arrangement of Figure 3 is retained in Figure 5, as are the limiting pin 91, rachet pawl 92, pawl hinge 93, pawl spring 94 and the spring support 95. A base 102, of the Sylphon 97, is provided with a fluid pipe. It is at once obvious that the contactor units **40**a through **40**d and current sources **41**a through **41**d, of Figure 1, will be replaced by any one of several well known embodiments of fluid impulse motors; secured directly to and driven by the first, then second, then third, then fourth engines of the heretofore mentioned multi-engined power plant.

Figure 5 primarily involves the internal mechanism of the synchronizing mechanism **10**, that is, all of the other operating parts of Figure 1, excepting contactor units and current sources, remain unaltered in their operation both in the manual and automatic adjustment of the second embodiment of our invention.

Figure 6 shows a third embodiment of our invention, in so far as the synchronizing mechanism **10** is concerned. The fluid impulse motor **96** and the rachet wheel **70** of Figure 5 are replaced by a rachet wheel **104** and a worm gear **105** driven by a conventional tachometer drive shaft **106** in direct communication with the first, then second, then third, and then fourth engine of the heretofore mentioned multi-engined power plant. If desired, one of the aforesaid engines may be substituted for the master speed device **3**, of Figure 1, by simply connecting an independent tachometer drive shaft therefrom to the worm gear **7**. As was the case in the second embodiment of our invention, the third embodiment thereof primarily involves internal modification of the synchronizing mechanism **10**, and the manual or automatic adjustment thereof is effected in the manner indicated in Figure 1, excepting omission of the contactor units and current sources shown therein, which are replaced by the tachometer shafts **106**.

Although the description is specific to the illustrations in the drawings, it is to be understood that there may be numerous departures therefrom which will still be within the field and scope of our invention, so that we do not wish to be restricted thereto, but only in so far as the appended claims are so limited.

What we claim is:

1. In an apparatus for synchronizing a plurality of prime movers, individual means for regulating said prime movers, a reference speed means, a plurality of prime mover driven means, means driven by said reference speed means about an axis coaxial with each of said prime mover driven means, all of said driven means rotating in the same direction, and means operatively responsive to a difference in the speeds of said reference speed driven means and said prime mover driven means, respectively, for actuating a corresponding regulating means to thereby obtain a predetermined speed relation between each prime mover and said reference speed means.

2. In an apparatus for synchronizing a plurality of prime movers, individual means for regulating said prime movers, a variable reference speed means, a plurality of prime mover driven means, rotatable means driven by said reference speed means about an axis coaxial with each of said prime mover driven means, and electrical means operatively responsive to a difference in the speeds of said reference speed driven means and said prime mover driven means, respectively, for actuating a corresponding regulating means to thereby obtain a predetermined speed relation between each prime mover and said reference speed means.

3. Means for obtaining a constant speed relation between a plurality of prime movers and a constant speed reference means comprising, in combination, a plurality of engine driven means, a single means driven by said constant speed means associated with said engine driven means, and a plurality of electrical servo-motor means individually operatively responsive to differences in the speeds of said reference driven means and said engine driven means, respectively, for regulating said prime movers whereby constant speed relations therebetween are obtained.

4. A device for controlling the speeds of a plurality of prime movers comprising, in combination, a support, a reference speed driven member carried by said support, a corresponding plurality of prime mover driven members freely rotatably mounted on said driven member, individual means carried by said support and adapted to actuate said freely rotatable members, and make and break means interposed between said reference speed driven member and said plurality of freely rotatable members, respectively, to make or break contact with changes in the speed relation between said reference speed means and any one of said freely rotatable members.

5. A make and break device comprising, in combination, a support, a member rotatably mounted on said support, a plurality of members freely rotatably mounted on said first mentioned member, a corresponding plurality of means carried by said support for respectively rotating said freely rotatable members in the same direction as that of said first mentioned member, a corresponding plurality of pairs of oppositely facing contact points carried by said first mentioned members, each of said freely rotatable members having a pair of spaced contact points, one positioned for engagement with one and the other positioned for engagement with the other of an associated pair of oppositely facing contact points to make or break contact with changes in the speed between said first mentioned member and said individual freely rotatable member.

CARL J. CRANE.
GEORGE R. LARKIN.