Oct. 25, 1949. C. F. SCHORN ET AL 2,486,212

THROTTLE CONTROL

Filed March 22, 1944 6 Sheets-Sheet 1

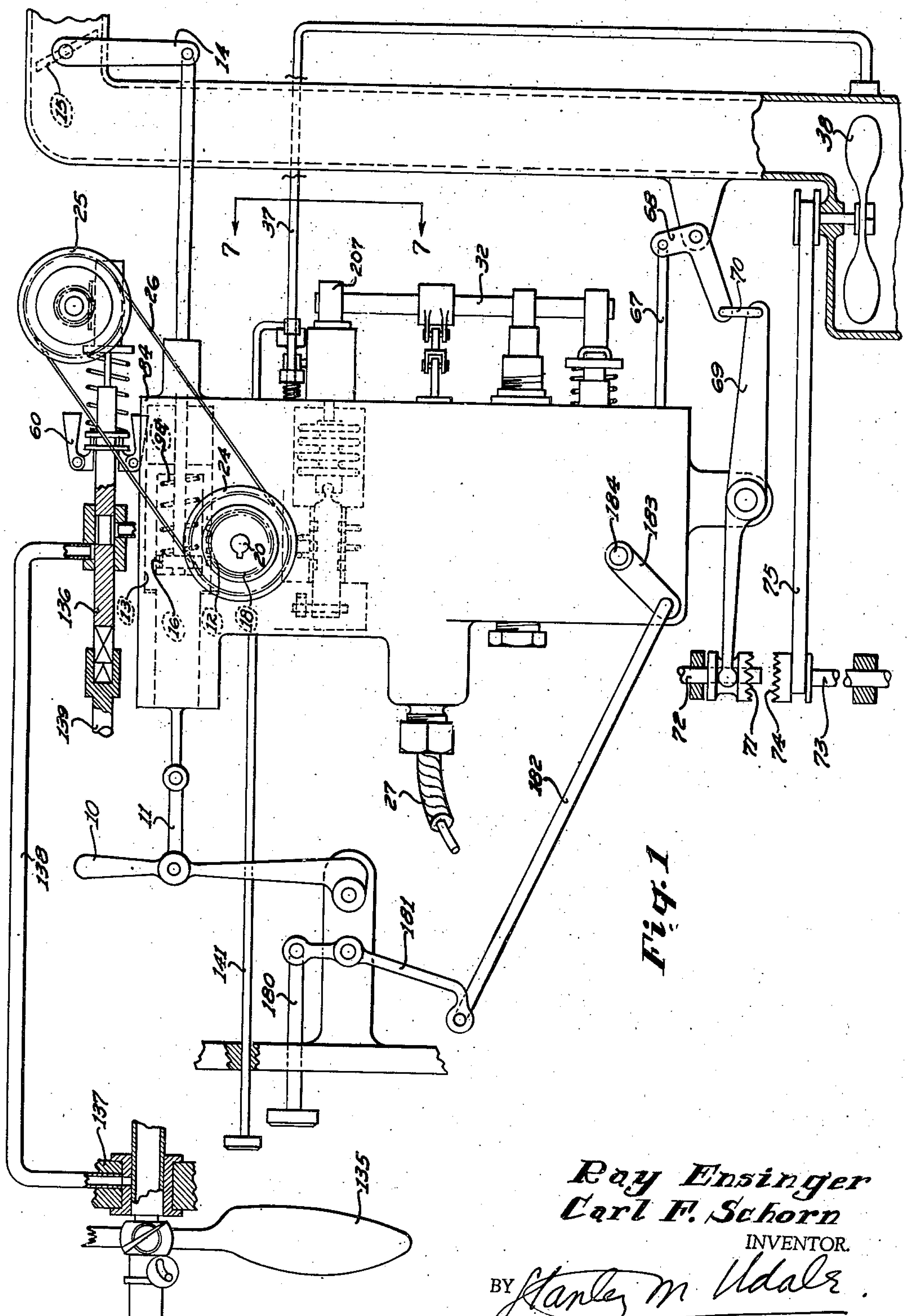

Fig. 1

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THROTTLE CONTROL

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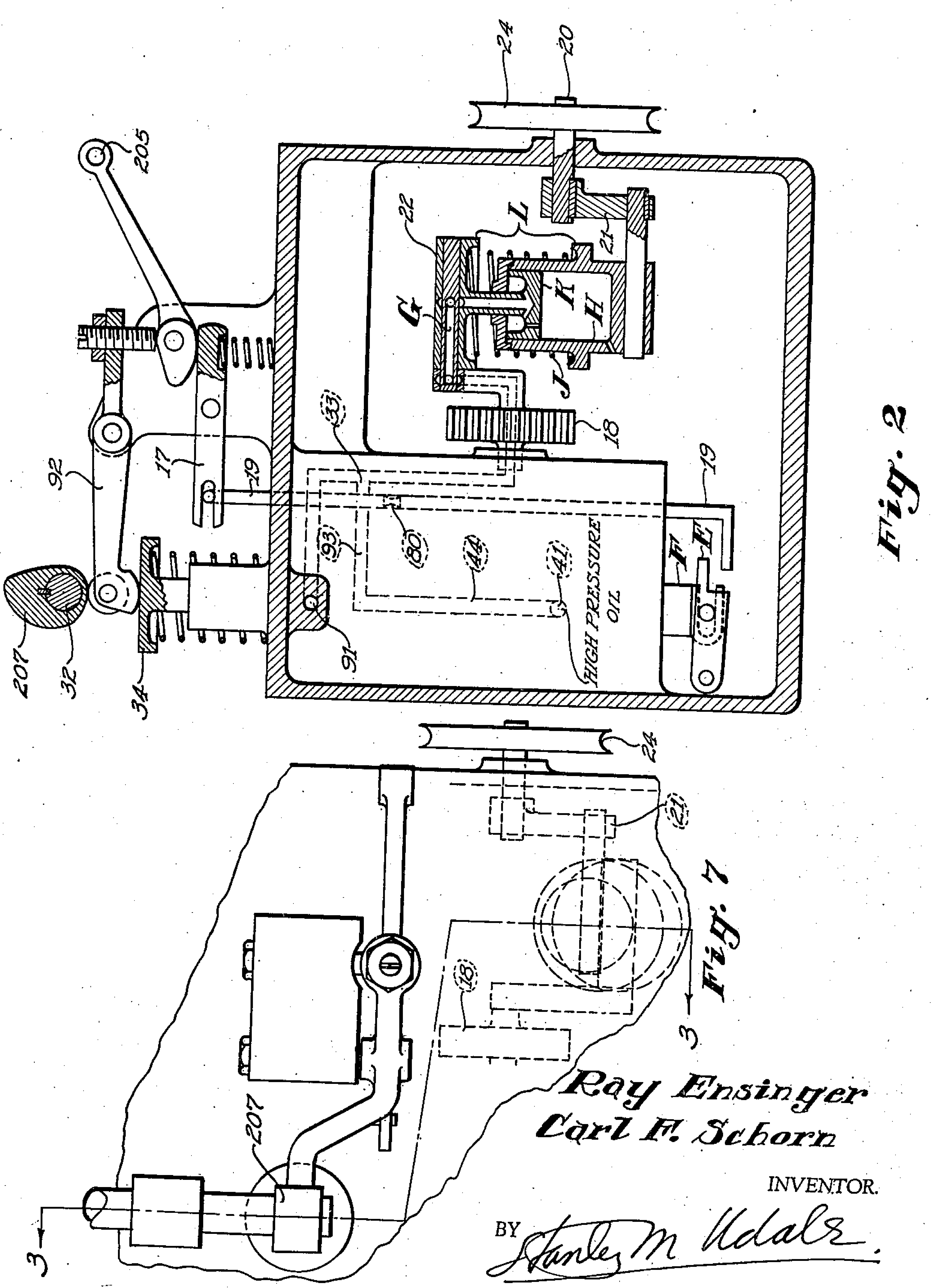

Fig. 2

Fig. 7

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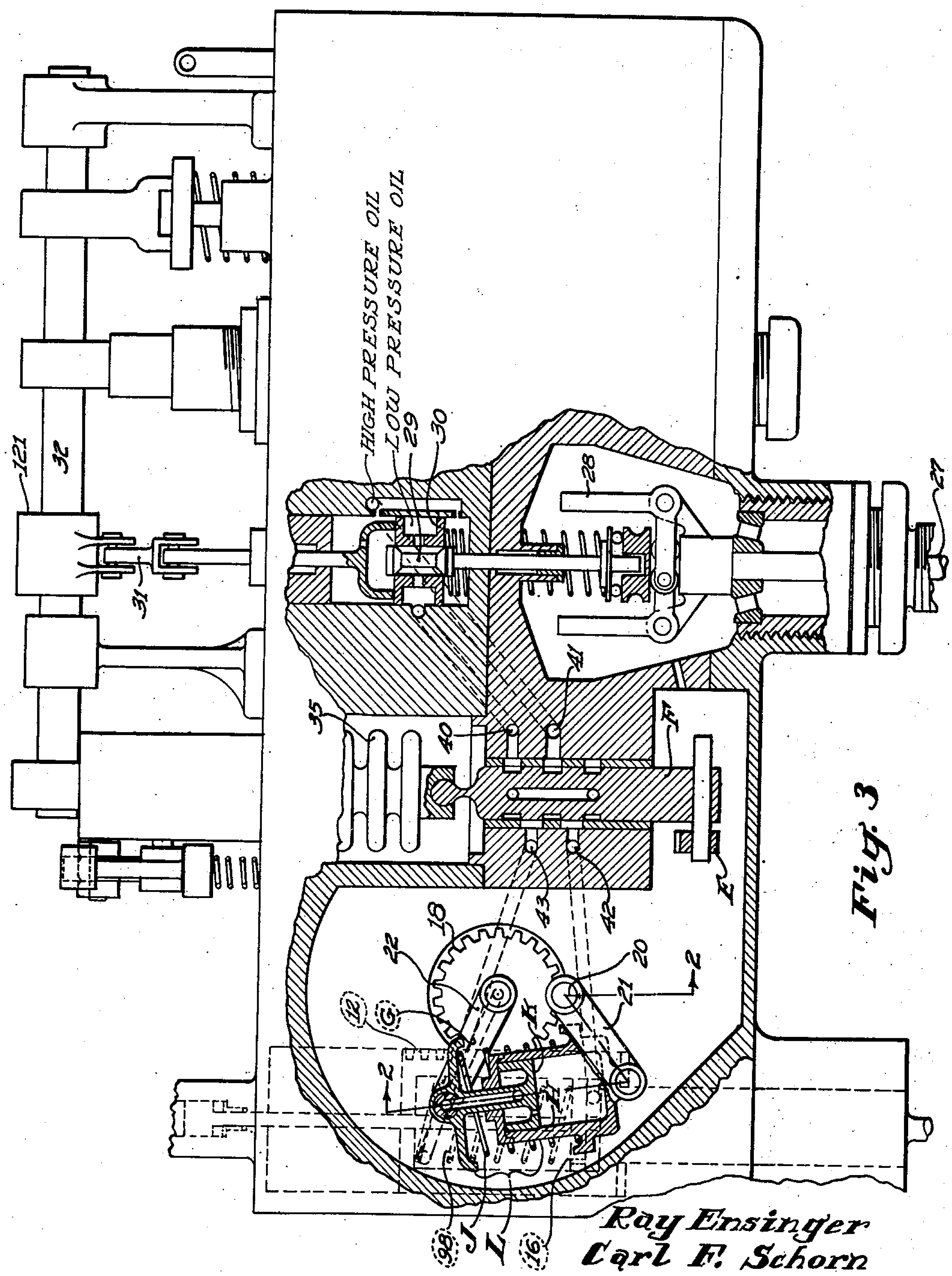

Fig. 3

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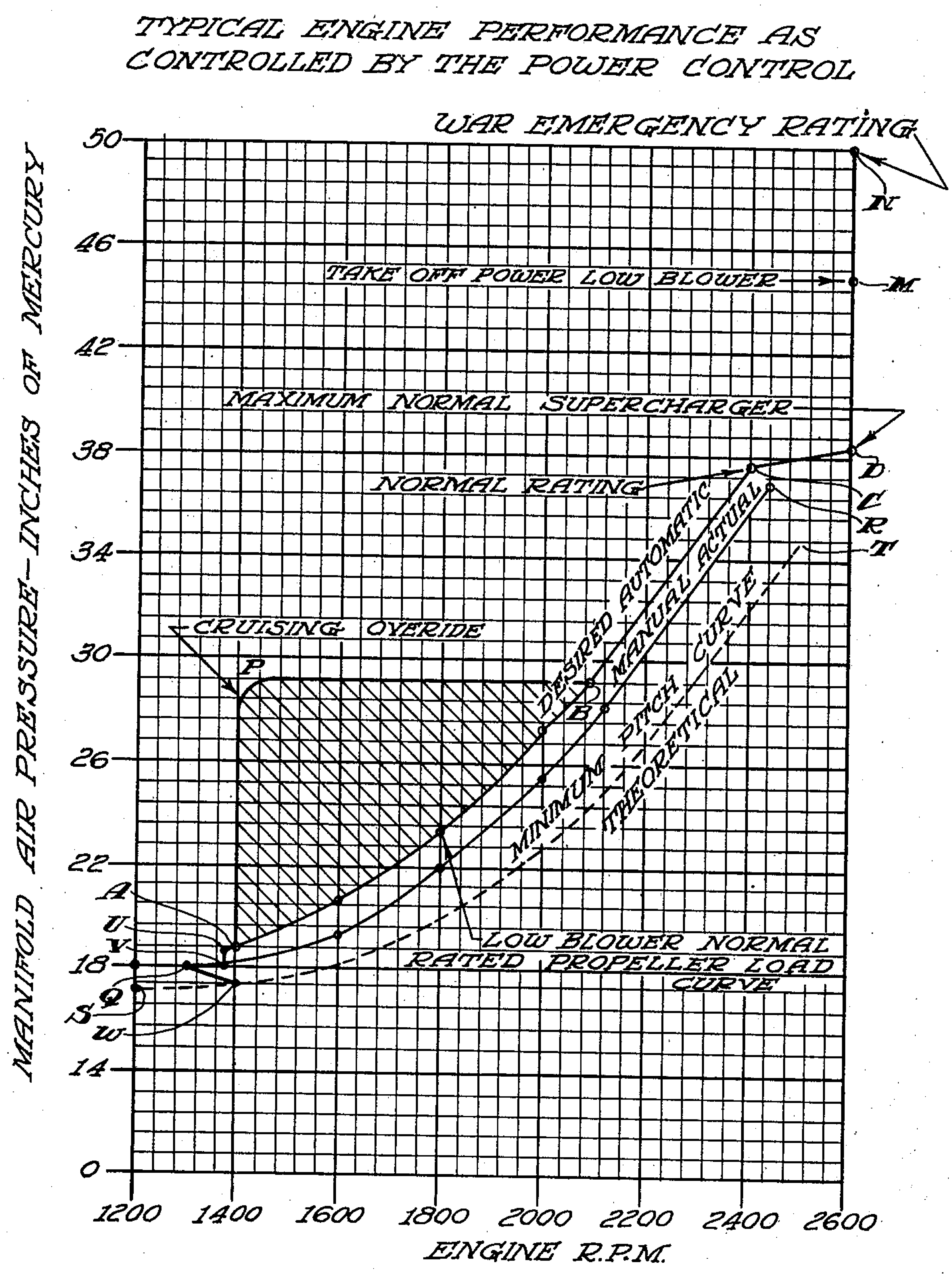

Fig. 4

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THROTTLE CONTROL

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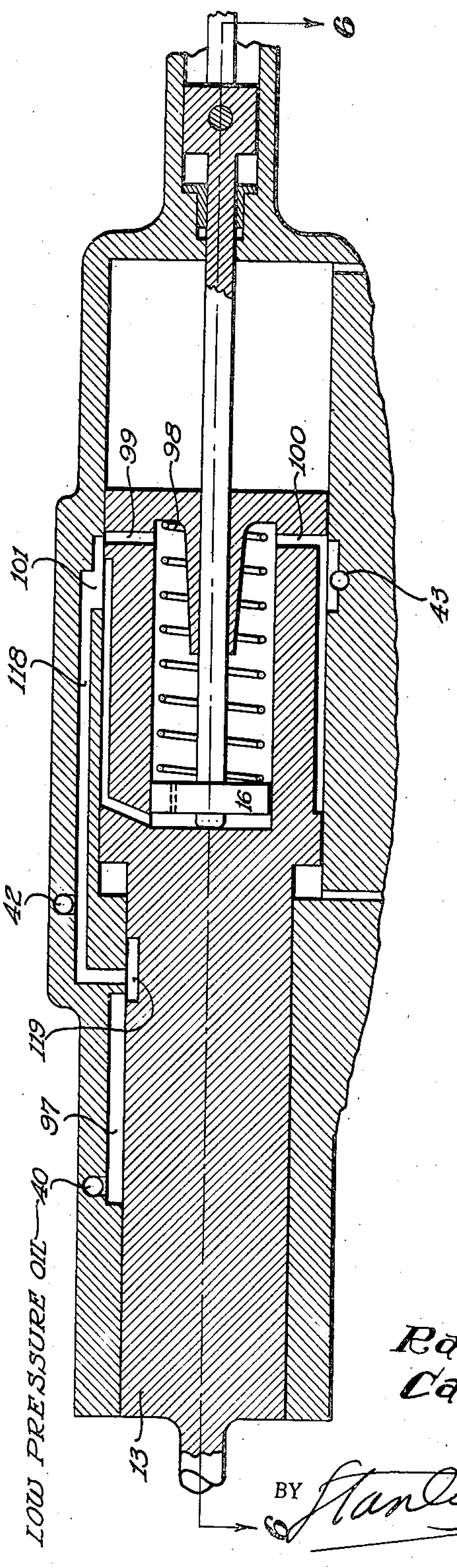

Fig. 5

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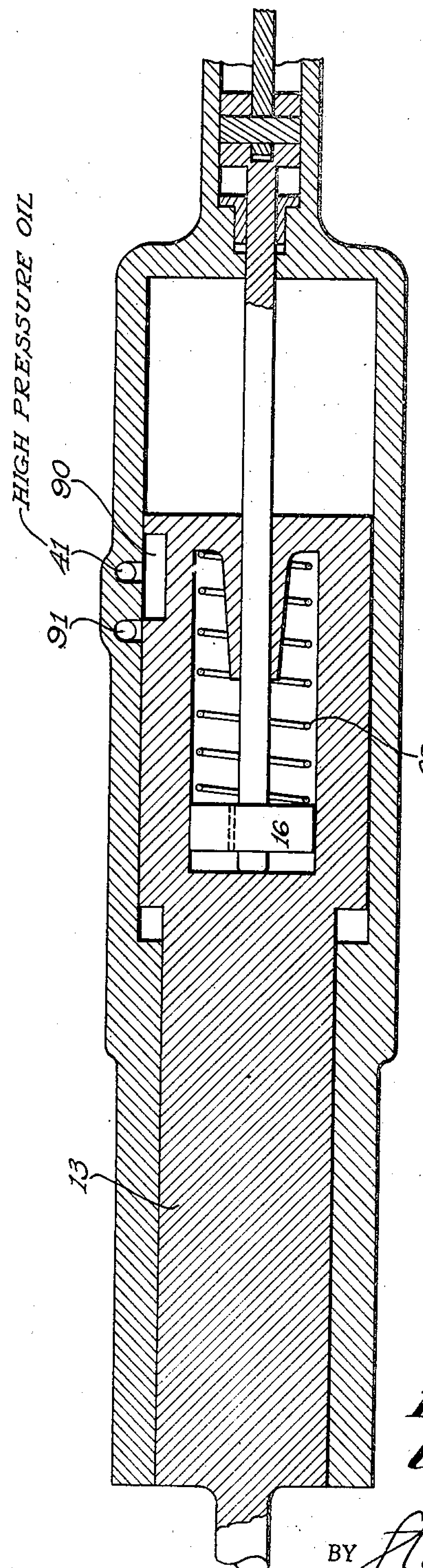

Fig. 6

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Patented Oct. 25, 1949

2,486,212

UNITED STATES PATENT OFFICE

2,486,212

THROTTLE CONTROL

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Application March 22, 1944, Serial No. 527,623

7 Claims. (Cl. 170—135.74)

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The object of this invention is to simultaneously control the throttle opening of the induction system of an aircraft engine and the propeller governor on an automatic constant speed propeller on a power plant installation equipped with a power control similar to that described in United States Patent application, Serial No. 487,229 (Patent No. 2,428,531 of October 7, 1947) filed by Carl F. Schorn, filed May 17, 1943, so that it is possible to test and check the ignition system of the engine by the usual means. When testing the ignition system of an aircraft engine equipped with an automatic constant speed propeller, the reading of the engine speed indicator in revolutions per minute is no longer an indication of the condition of the ignition system when performing a conventional magneto check-up. The reason for this is that the constant speed mechanism of the propeller operates to hold the speed of the engine constant regardless of engine conditions. Hence, the variation in the engine speed is no longer a criterion of the condition of the spark plugs, magneto, etc.

It has, for the last 35 years, been standard practice to determine the efficiency, or rather, the effectiveness of the ignition system by observing the change in revolutions per minute of the engine at any given throttle position when a spark plug is shorted or one of two magnetos rendered inoperative. In making the test, the revolutions per minute of the engine is observed first with both magnetos in use, then with one, and then with the other. Excessive falling off of engine speed when one of two magnetos is rendered inoperative indicates partial failure of the other magneto. This test compares the two magnetos with each other.

We have discovered that if, at the time the throttle is placed under manual control, the setting of the speed control is such as to call for a higher speed for the given throttle position than the engine can supply with that particular throttle opening, then it follows that the pitch of the propeller will automatically be placed in its minimum pitch position; that is, in its position for maximum revolutions per minute. Hence, the revolutions per minute of the engine under such conditions will indicate the satisfactory or unsatisfactory performance of each magneto and of each ignition system generally.

A second object of this invention is to improve the engine control during the landing operation by simultaneously controlling the throttle opening of the induction system and the propeller governor so that when the engine speed is decreased

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to less than that corresponding to minimum cruising speed, an increase in engine speed will be called for by an automatic change in the propeller governor setting, thus causing the propeller to move toward its minimum pitch position. This is the same position called for when testing the ignition. In this position, the propeller acts as a brake when the aircraft is moving forward at a speed faster than that of the propeller slipstream which speed is a product of R. P. M. and pitch. Unless this is done, it has been found that when coming for a landing (when operating at below the minimum cruising power), excessively high landing speeds may result.

In the drawings:

Fig. 1 shows the preferred form of our invention.

Fig. 2 shows a cross-sectional elevation taken on plane 2—2 of Fig. 3.

Fig. 3 shows a cross-sectional elevation taken on plane 3—3 of Fig. 7.

Fig. 4 shows diagrammatically the operation of the control.

Fig. 5 shows a cross-sectional elevation through the main body of the throttle control.

Fig. 6 shows a section taken on plane 6—6 of Fig. 5.

Fig. 7 shows a plane view looking down on plane 7—7 of Fig. 1.

Describing first the general arrangement of the device to which our invention is applied, in Fig. 1 a manually operated throttle lever 10 operates the link 11 which is indirectly connected to a throttle lever 14 which controls the movement of the throttle 15 which controls the air entrance leading to a supercharger 38, the pressure of which is transmitted through a pipe 37 of the device about to be described.

The link 11 is directly connected to a two-diameter piston 13 inside of which there reciprocates a smaller piston 16, which smaller piston is pushed to the left by a compression spring 98 (Fig. 6) carried inside the larger diameter of piston 13. This smaller piston is directly connected to the lever 14 so that if the spring 98 is expanded so as to place the piston 16 in its extreme left hand position, the movement of the throttle control lever 10 is positively related to the lever 14 and the throttle 15 follows the movement of the control lever 10. This is the situation during manual control and also when oil pressure is not available.

The movement of the piston 13, the side of which contains a rack 12, rotates a pulley 24, Fig. 1, by means of a pinion gear 18 which engages with rack 12, levers 21 and 22, collapsible link L, and shaft 20, shown in Fig. 3. Pulley 24 is connected by a belt 26 (Fig. 1) to a pulley 25 which controls the compression of the spring of the governor 60 which determines the speed of the engine by controlling the pitch of the variable pitch propeller 135 in a well known manner. The operation of the constant speed variable pitch propeller mechanism does not form a part of this invention.

A rotating shaft 136 acts as a valve for admitting high pressure oil to the pipe 138 which admits high pressure oil to the element 137 which controls the pitch of the propeller 135. The drive shaft 139 is connected to the engine; hence, the movement of the throttle control lever 10 also controls the speed of the engine.

The speed of the supercharger is controlled as described in the corresponding application Serial No. 487,229 of Carl F. Schorn referred to above. In that application, a rod 180 (Fig. 1) is shown connected to a lever 183 through a lever 181 and a link 182. Lever 183 controls the shaft 184 which through the operation of mechanism not shown controls the movement of a rod 67 connected to a lever 68, a link 70 and a lever 69. A clutch 71—74 is thus controlled so as to vary the speed of the supercharger 38. The shaft 73 rotates at a lower speed than the shaft 72 so that when the clutch 71—74 is engaged, an over-ride clutch (not shown) on the shaft 73 permits the supercharger 38 to be driven faster by means of the belt 75. By this means, the speed of the supercharger is increased. This, also, forms no part of this invention.

A camshaft 32 and cam 207 in the same application is shown adapted to select the "boost" pressure at which the engine is to run for any given speed of the engine. The means for accomplishing this is shown in Figs. 2 and 3, in which a servomotor valve F, controlled by a pressure responsive element 35, which element is subjected to the supercharger pressure through the pipe 37, (Fig. 1). The servovalve F controls the movement of the piston 16 inside the double piston 13 (see Fig. 5). The high pressure oil is admitted from the passage 41 to either the passage 43 or to the passage 42, depending on the position of valve F. When the supercharger pressure admitted through pipe 37 falls so as to cause the element 35 to expand, the valve F is moved below the neutral position in which it is shown and high pressure oil from a passage 41 is admitted past the annular servomotor passage in valve F through a passage 42 beneath the piston 16, and the piston thus opens the throttle 15 and continues to open the throttle until the supercharger pressure restores the valve F to the neutral position when the throttle ceases to move.

The shaft 27 in Fig. 3 drives the governor 28 and this centrifugal governor 28 controls a servomotor valve 29 which reciprocates inside a piston 30. The effect of an increase in speed is to move the servomotor valve 29 up which causes high pressure oil admitted from passage 41 beneath the piston 30 to push the piston 30 up, the oil above the piston being allowed to escape past the valve and through the piston out passage 40. This upward movement of piston 30 rotates the shaft 32 by means of the link 31 and the lever 121, which is keyed to the shaft 32. The shaft 32 is therefore rotated into a different position for each speed of the engine. The cam 207 keyed to shaft 32 positions the top of the barometric element 35 for each speed; therefore, at each engine

speed a desired boost pressure is selected. A manually operated lever 205 is normally locked in the neutral position in which it is shown in Fig. 2. Anti-clockwise movement of lever 205 will put the mechanism in position for ignition testing. Clockwise movement of lever 205 will put the mechanism in position when landing to cause the engine and propeller to act as a brake, due to the tendency of the propeller to act as a wind motor when the speed of the craft is faster than that of the propeller slipstream.

When lever 205, Fig. 2, is rotated clockwise, the lever 92 is rotated anti-clockwise depressing element 34 and therefore the barometric element 35. By this means the selection of the boost pressure comes under manual control and remains under manual control until with increasing engine speeds the lift of the automatically controlled cam 207 equals the lift of the override lever 92 when the rotation of the cam 207 resumes its control of the M. A. P.–R. P. M. relationship.

The pinion 18 and the lever 22 (Fig. 3) is rotated by a rack 12 on the side of the piston 13. The lever 21, which is connected to the speed control pulley 24 through the shaft 20, is connected through the piston K and the cylinder H of the collapsible link L with the lever 22. The piston K is held in the position shown by the compression spring J (Figs. 2 and 3).

When it is desired to check the relative effectiveness of the ignition system, the lever 205 (Fig. 2) is moved manually anti-clockwise without disturbing lever 92. A lever 17 is then rotated clockwise which lifts the rod 19 in which there is a port 80. This port 80 is thus brought into alignment with an oil passage 33. The rod 19 also engages with the lever E and raises the servomotor valve F so as to place high pressure oil in communication with the passage 43 of Fig. 3. The admission of high pressure oil from passage 41 to the passage 43 pushes the piston 16 to the left (Fig. 5) and places the throttle under manual control. Low pressure oil escapes through passages 42 and 40. The throttle 15 is now controlled manually by the movement of the lever 10 (Fig. 1).

Meanwhile, high pressure oil is admitted through passages 41, 44, and 93 and 80 to the center of the lever 22 (Figs. 2 and 3) through the passage G which conveys oil under pressure above the piston K in the cylinder H in which the piston K is connected to the lever 22 (Fig. 3). This cylinder H rises under the influence of the pressure of the oil compressing a spring J and shortening the link L. The rise of the cylinder H rotates the lever 21, the shaft 20 and the pulley 24 clockwise in Figure 3. This rotation of the pulley 24 (Figure 1) rotates the pulley 25, which controls the propeller governor 60 so as to set the pitch of the propeller 135 for a higher rate of speed. But the throttle is not sufficiently open to permit the engine to reach this higher rate of speed called for by this emergency setting (for ignition purposes) of the governor; hence, the propeller blades assume a position which will give the highest possible speed under these circumstances. The propeller is thus put into its minimum pitch position. Under such circumstances, the revolutions per minute vary with the state of the ignition and the effect of a missing cylinder is to reduce the revolutions per minute. In normal operation, if a cylinder misses, then the drop in revolutions per minute is immediately corrected by a reduction in pitch, so that the revolutions per minute indicator no longer gives any indication of a defective spark plug. The testing of the ignition and magneto systems can then proceed in the normal way, which has been standard practice with fixed propeller airplane engines for the last 35 years.

In Fig. 5, when the two diameter piston **13** is in the position shown, the spaces to the left and right of piston **16** are in communication with each other and with the low pressure side of the oil system through passages **99**, **100**, **101**, **118**, **119**, **97** and **40**. Therefore, the servomotor valve is ineffective in positioning piston **16** and the piston is held out of action to the left by spring **98** and the throttle opening is controlled solely by the positioning of the two diameter piston **13**. With the two diameter piston in the position shown, the opening of the throttle **15** (Fig. 1) is slightly less than that corresponding to minimum cruising power at sea level and at the engine speed called for. When the two diameter piston is moved to the left to further close the throttle, the passage **90**, Fig. 6, in the side wall of piston **13** (Fig. 2) places the high pressure oil passage **41** in communication with the passage **91** which passage communicates with passages **33** and G in lever **22** (Fig. 2). Oil under pressure is thus admitted above piston K and causes cylinder H to compress spring J and rotate lever **21** (Fig. 3) clockwise which rotates the speed control pulley **24** to a higher engine speed position, thus causing the propeller to move to a low pitch position. The actual increase in engine speed is small since the power output of the engine corresponding to the manually controlled throttle opening is comparatively small. The propeller operating at the lower pitch acts to decrease the speed of the forward motion of the plane thus enabling the pilot to land the aircraft in a shorter distance.

Operation

In Fig. 4, the relation between the revolutions per minute (R. P. M.) of the engine is shown with the manifold air pressure (M. A. P.). In this figure, the curve marked "desired automatic" represents the normal relationship between these two variables as determined by the cam **207**. This curve marked "desired automatic" is marked ABC. At the point C, the revolutions per minute of the engine increase from 2400 to 2600 to the point D and at 2600 without any increase in speed, the manifold air pressure increases to points M and N. The means for accomplishing this are discussed in the previously mentioned application of Carl F. Schorn.

Between the cruising speeds 1400 R. P. M. and 2100 R. P. M., it is possible to normally override the automatic R. P. M.-manifold air pressure schedule to obtain more efficient engine operation. This overriding operation is shown by curve A. P. B.

The means for accomplishing this are shown in Fig. 2. The lever **205** is moved clockwise to rotate the lever **92** anti-clockwise and the cam **207** ceases during this speed range to control. This feature is no part of this invention and is merely shown to make a complete disclosure. The curve ST represents an artificial curve which would be followed when the lever **205** is moved anti-clockwise if the engine could respond to the R. P. M. called for when actually, this minimum pitch curve is not reached because the pitch of the propeller will not assume a sufficiently low value to permit the engine to reach the required revolutions per minute indicated by the line ST. In endeavoring to reach this curve, the propeller automatically goes into

its minimum pitch position and, therefore, when the engine attempts to follow the line ST it actually follows a line intermediate between the line ST and the line QVR and under these circumstances any change in the efficiency of the ignition system is reflected in a change in the revolutions per minute of the engine so that R. P. M. can then be used as a criterion of the ignition performance. The mechanism shown in Figs. 1, 2, 3 and 7, specifically, the hydraulic mechanism H, J, L, K, places the governor mechanism shown in the upper right of Fig. 1 in the position to call for a higher speed, that is, the propeller **135** is placed in fine pitch position when the lever **205** is manually moved in the anti-clockwise position (Fig. 2) and the lever **17** is rotated clockwise, and high pressure oil is admitted from **41** to passage **33** to passage G (Fig. 2).

When closing the throttle, that is to say, closing along the line CBA, at the point U the mechanism shown in Figs. 5 and 6 causes the manifold air pressure to drop from the point U to the point V which is on the line QVR. In other words, as the throttle moves to the idling position, the control moves to the manual control position. If the throttle is manually closed an additional small amount, the revolutions per minute of the engine falls and the manifold air pressure remains substantially constant at 18" Hg. A further movement of the two diameter piston toward the closed position causes the collapsible link L to collapse (Fig. 2) just as it did when the rod **19** was moved downward and the valve also moved down so as to put the high pressure oil into communication with the passage G. The passage **91** obtains its supply of high pressure oil direct from passage **41** when the piston **13** is moved to its idle position to the left as shown in Fig. 6. When the collapsible link L collapses, the action of the pitch governor **60** is to put the propeller **135** into its minimum pitch position so that the revolutions per minute is increased from about 1,300 to the greatest speed possible at that particular throttle position with the pitch of the propeller in its minimum pitch position.

This is indicated by the point W. The decrease in the propeller pitch that takes place between the point Q and the point W acts to check the flight of the plane because the plane is moving forward faster than the air displaced by the propeller is pushed backwards, because the pitch is so small. This is similar to throwing the clutch out and applying the brake on an automobile.

To sum up, the low speed operation includes the following steps: Step 1, A—U—V—When the barometric element **35** is put out of action and the throttle **15** becomes manually controlled. Step 2, V—Q—Throttle is manually controlled but speed remains automatically controlled and the pitch variable. Step 3, Q—W—Pitch becomes reduced to the point when the minimum pitch stop limits the pitch and allows the engine speed to increase.

What we claim is:

1. In a device for automatically controlling a supercharged airplane engine having a governor controlled variable pitch propeller, manually operated means for selecting the speed of the engine by controlling the governor which controls the pitch of the propeller, an air entrance to said engine, a throttle valve therein, said manually operated means being also adapted to partially open said throttle, automatic means including a second governor driven by said engine so con-

structured and arranged as to give an additional opening to said throttle, said means being responsive to the action of said second governor and to the air pressure on the engine side of the supercharger and so constructed and arranged as to control said automatic means whereby at any given engine speed the supercharger air pressure cannot exceed a specific value for that particular speed, means for placing the propeller in its minimum pitch position, said means comprising a stop on said variable pitch limiting the minimum pitch and a manually operated means for rendering inoperative said automatic supercharger air pressure controlling means and for giving an additional movement to the means for selecting the speed of the engine, said additional movement of the speed control means calling for an engine speed above that at which the engine normally operates for that particular throttle opening whereby the pitch of the propeller is automatically placed in its minimum pitch position by the action of the propeller governor, and the speed of the engine responds directly to the manual operation of said throttle valve.

2. In a device for automatically controlling a supercharged airplane engine having a governor controlled variable pitch propeller, manually operated means for selecting the speed of the engine by controlling the governor which controls the pitch of the propeller, an air entrance to said engine, a throttle valve therein, said manually operated means being also adapted to partially open said throttle, automatic means including a second governor driven by said governor so constructed and arranged as to give an additional opening to said throttle, said means being responsive to the action of said second governor and to the air pressure on the engine side of the supercharger so constructed and arranged as to control said automatic means whereby at any given engine speed the supercharger air pressure cannot exceed a specific value for that particular speed, means for rendering inoperative said automatic means responsive to said supercharger air pressure comprising a stop on said variable pitch limiting the minimum pitch and means integral with the first mentioned manually operated means for partially opening and closing said throttle and for selecting the engine speed, said means being operated so that when the said manual means for partially opening the throttle and for selecting the engine speed is moved from its minimum cruising position towards its idling position the automatic means are no longer operative and the propeller remains in its minimum pitch position.

3. In a device for automatically controlling a supercharged airplane engine having a governor controlled variable pitch propeller, manually operated means for selecting the speed of the engine by controlling the governor which controls the pitch of the propeller, an air entrance to said engine, a throttle valve therein, said manually operated means being also adapted to partially open said throttle, automatic means including a second governor driven by said engine so constructed and arranged as to give an additional opening to said throttle, said means being responsive to the action of said second governor and to the air pressure on the engine side of the supercharger so constructed and arranged as to control said automatic means whereby at any given engine speed the supercharger air pressure cannot exceed a specific value for that particular speed, means for rendering inoperative said automatic means responsive to said supercharger air pressure comprising a stop on said variable pitch limiting the minimum pitch and means integral with the first mentioned manually operated means for partially opening and closing said throttles and selecting the engine speed, said means being operative so that when the manually operated means for partially opening the throttle and selecting the engine speed is moved towards its idling position, the automatic means are no longer operative and means for giving additional independent movement to the means for selecting the speed of the engine whereby an additional engine speed is called for and the propeller therefor is moved towards its minimum pitch position when the said manually operated means for partially opening the throttle and selecting the engine speed is moved towards its idling position.

4. In combination with an internal combustion engine having an engine driven supercharger adapted to deliver air to said engine, an air entrance to said supercharger and a throttle valve, control linkage therefor adapted to control the air flow through the air inlet, a variable pitch propeller driven by said engine having a spring loaded centrifugal governor adapted to control the engine speed by varying the pitch of said propeller, a control linkage for said governor adapted to select the speed of the engine by varying the load on the governor spring, a manually operated control lever, a motion transmission system connecting said control lever to said throttle valve control linkage, and also connecting said lever to said control device for said propeller governor control, a barometric responsive device, a variable pressure chamber enclosing said barometric device, a passage connecting said chamber to the air inlet on the engine side of said supercharger, a second governor driven by said engine, a shaft adapted to control the manifold air pressure and to be rotated by said second governor in response to variations in engine speed, a cam mounted on said shaft adapted to engage with said barometric device, a servomotor valve controlled by said cam and by said barometric means, a servomotor controlled by said valve, said motor being interposed in said motion transmission system, an override device comprising a stop on said variable pitch limiting the minimum pitch and manually operated means for moving said servomotor valve independently of the barometric means so as to cause the throttle valve to be moved toward its closing position by the motion transmission system said manually operated means being also adapted to move that portion of the motion transmission system which connects said control lever to said propeller governor control to a position calling for a higher engine speed whereby the propeller is automatically forced into its minimum pitch position.

5. In combination with an internal combustion engine having an engine driven supercharger adapted to deliver air to said engine, an air entrance to said supercharger and a throttle valve, control linkage therefor adapted to control the air flow through the air inlet, a variable pitch propeller driven by said engine having a spring loaded centrifugal governor adapted to control the engine speed by varying the pitch of said propeller a stop on said variable pitch limiting the minimum pitch and, a control linkage for said governor adapted to select the speed of the engine by varying the load on the governor spring, a manually operated control lever, a motion transmission system connecting said control lever to

said throttle valve control linkage, and also connecting said lever to said control device for said propeller governor control, a barometric responsive device, a variable pressure chamber enclosing said barometric device, a passage connecting said chamber to the air inlet on the engine side of said supercharger, a second governor driven by said engine, a shaft adapted to control the manifold air pressure and to be rotated by said second governor in response to variations in engine speed, a cam mounted on said shaft adapted to engage with said barometric device, a servo motor valve controlled by said cam and by said barometric means, a servomotor controlled by said valve said motor being interposed in said motion transmission system, means integral with the motion transmission system connecting said control lever to said throttle valve in which the automatic means for opening the throttle are rendered inoperative when the said manually operated control lever is moved below the cruising speed condition and the propeller remains in its minimum pitch position.

6. In combination with an internal combustion engine having an engine driven supercharger adapted to deliver air to said engine, an air entrance to said supercharger and a throttle valve, control linkage therefor adapted to control the air flow through the air inlet, a variable pitch propeller driven by said engine having a spring loaded centrifugal governor adapted to control the engine speed by varying the pitch of said propeller, a stop on said variable pitch limiting the minimum pitch, and a control linkage for said governor adapted to select the speed of the engine by varying the load on the governor spring, a manually operated control lever, a motion transmission system connecting said control lever to said throttle valve control linkage, and also connecting said lever to said control device for said propeller governor control, a barometric responsive device, a variable pressure chamber enclosing said barometric device, a passage connecting said chamber to the air inlet on the engine side of said supercharger, a shaft adapted to control the manifold air pressure and to be rotated in response to variations in engine speed, a cam mounted thereon adapted to engage with said barometric device, a servomotor valve controlled by said cam and by said barometric means, a servomotor controlled by said valve, said motor being interposed in said motion transmission system, an override device comprising means integral with the motion transmission system connecting said manually operated control lever to said throttle valve and to said propeller governor whereby as the said control lever is moved towards the idling position the automatic means for opening the throttle are rendered inoperative and then that portion of the motion transmission system which connects the said manually operated control lever to the control device for said propeller governor is moved so as to call for an increase in engine speed as the said manually operated control lever is moved toward

its idling position and the propeller remains in its minimum pitch position.

7. In combination with an internal combustion engine having an engine driven supercharger adapted to deliver air to said engine, an air entrance to said supercharger and a throttle valve, control linkage therefor adapted to control the air flow through the air inlet, a variable pitch propeller driven by said engine having a spring loaded centrifugal governor adapted to control the engine speed by varying the pitch of said propeller, a control linkage for said governor adapted to select the speed of the engine by varying the load on the governor spring, a manually operated control lever, a motion transmission system connecting said control lever to said throttle valve control linkage, and also connecting said lever to said control linkage for said propeller governor control, a barometric responsive device, a variable pressure chamber enclosing said barometric device, a passage connecting said chamber to the air inlet on the engine side of said supercharger, a shaft adapted to control the manifold air pressure and to be rotated in response to variations in engine speed, a cam mounted thereon adapted to engage with said barometric device, a servomotor valve controlled by said cam and by said barometric means, a servomotor controlled by said valve, said motor being interposed in said motion transmission system, an override device comprising a stop on said variable pitch limiting the minimum pitch and manually operated means for moving said servomotor valve to the position to move the throttle valve towards its closing position, said means being also adapted to move that portion of the motor transmission system which connects said manually operated control lever to said control linkage for said propeller governor in the direction to cause an increase in engine speed whereby the override device simultaneously calls for a higher engine speed and for a lower throttle opening so that the propeller is moved toward its minimum pitch position.

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