

S. JACHIMOVICZ.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED AUG. 12, 1907.

1,001,595.

Patented Aug. 22, 1911.

4 SHEETS-SHEET 1.

FIG. 1

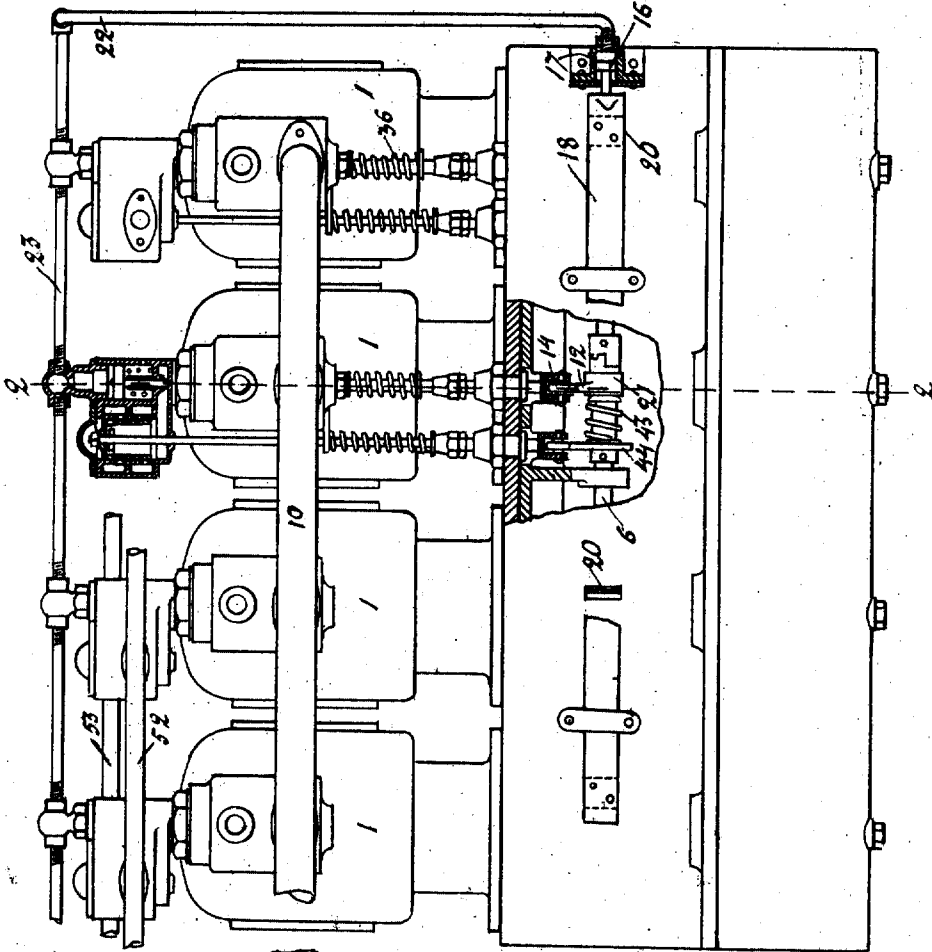
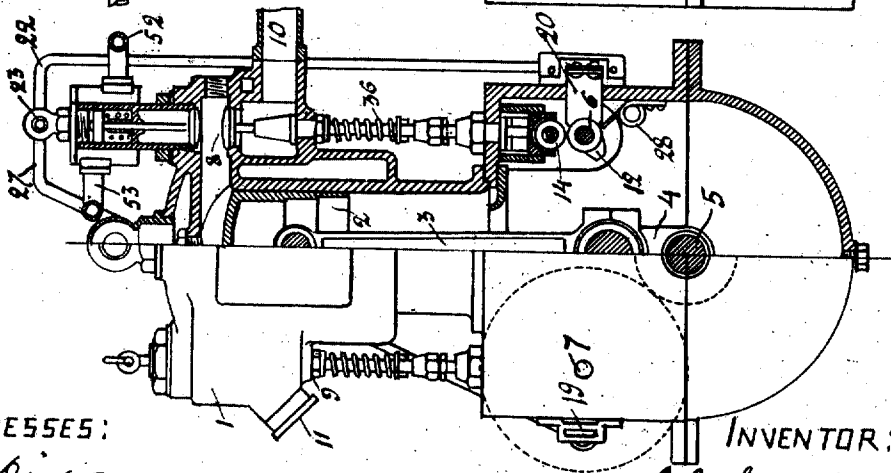


FIG. 2



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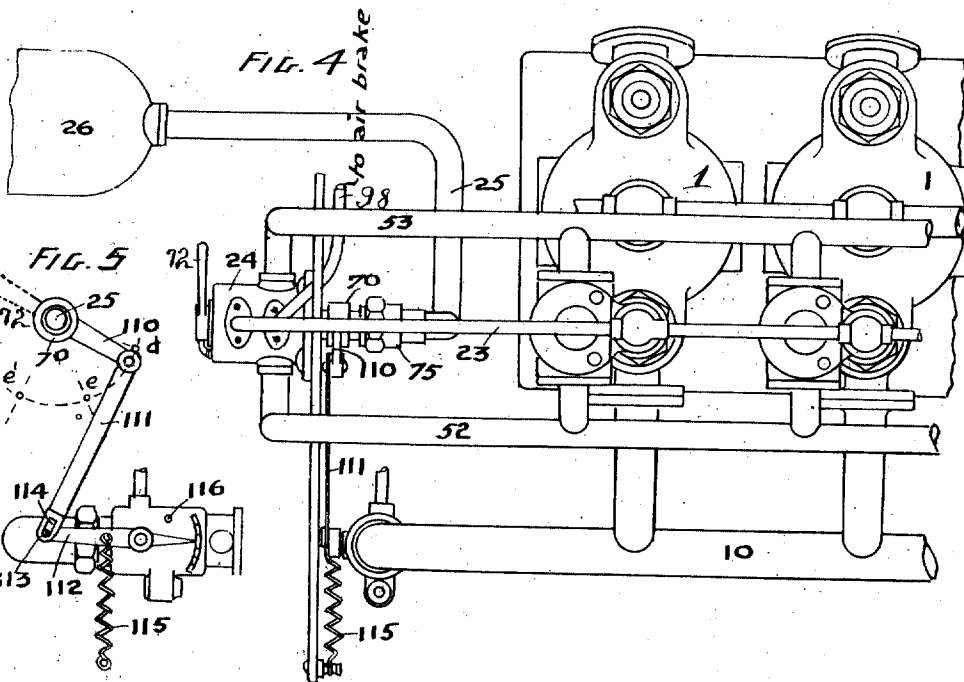
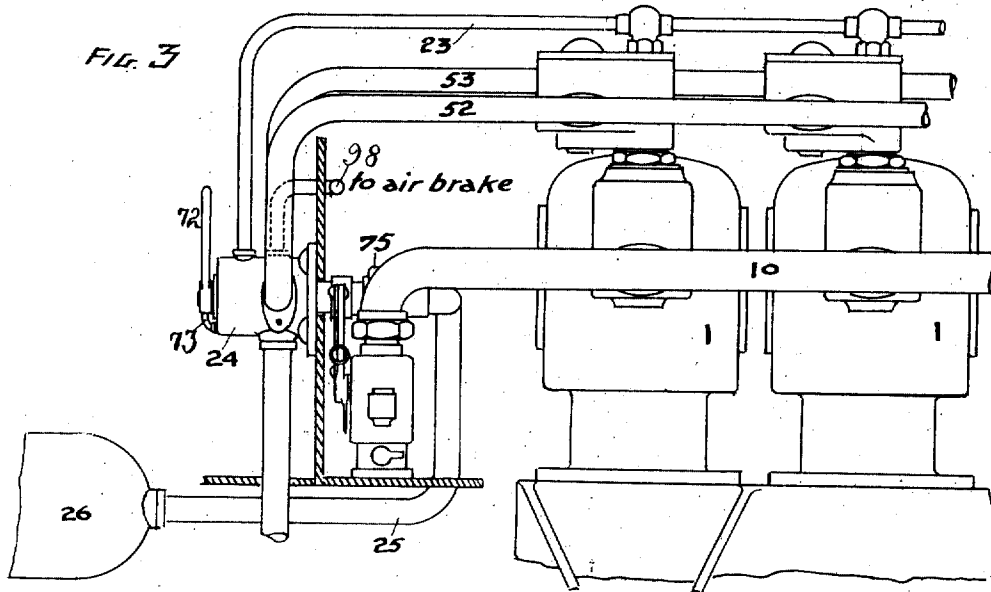
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4 SHEETS—SHEET 2.



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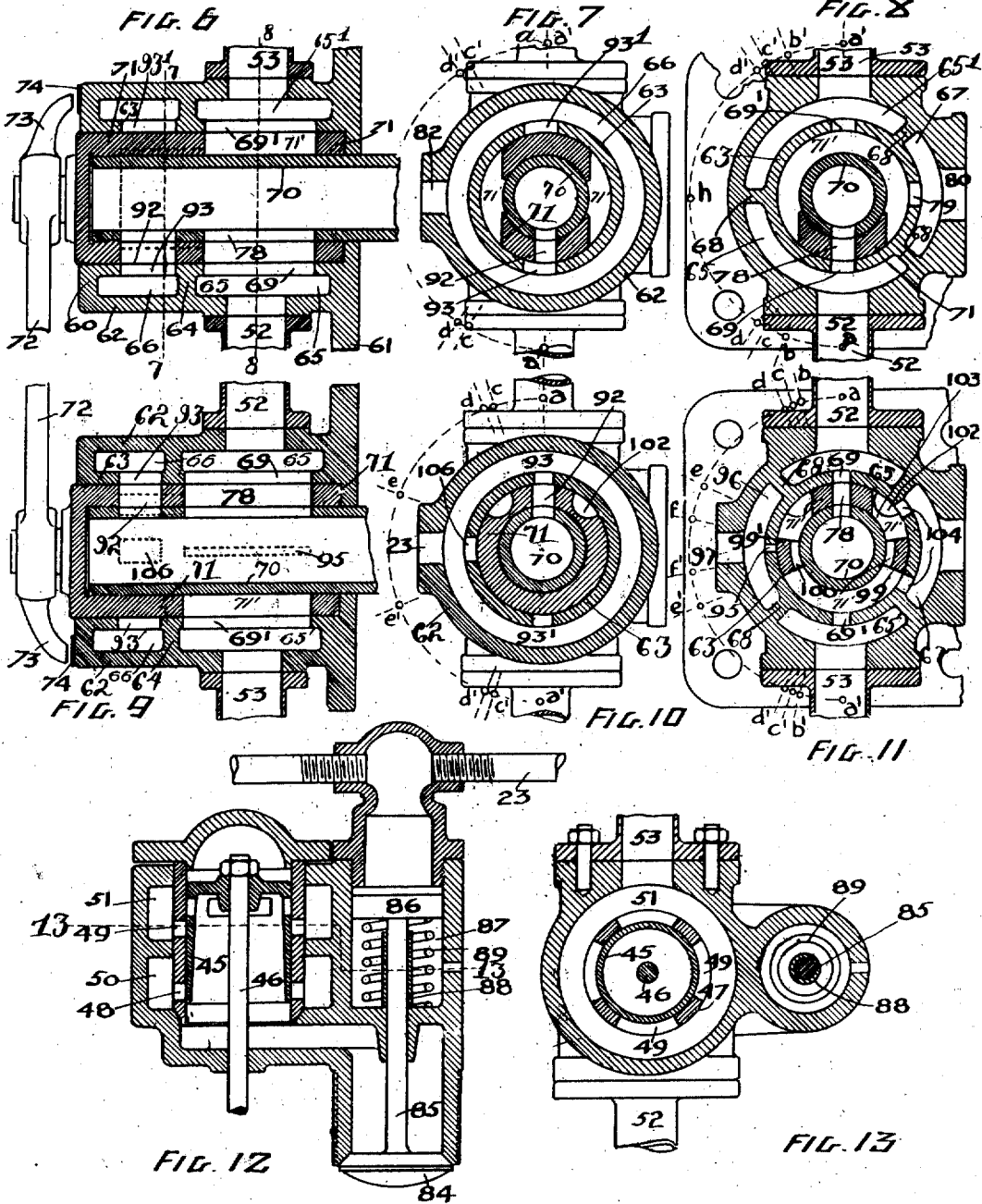
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4 SHEETS—SHEET 3.



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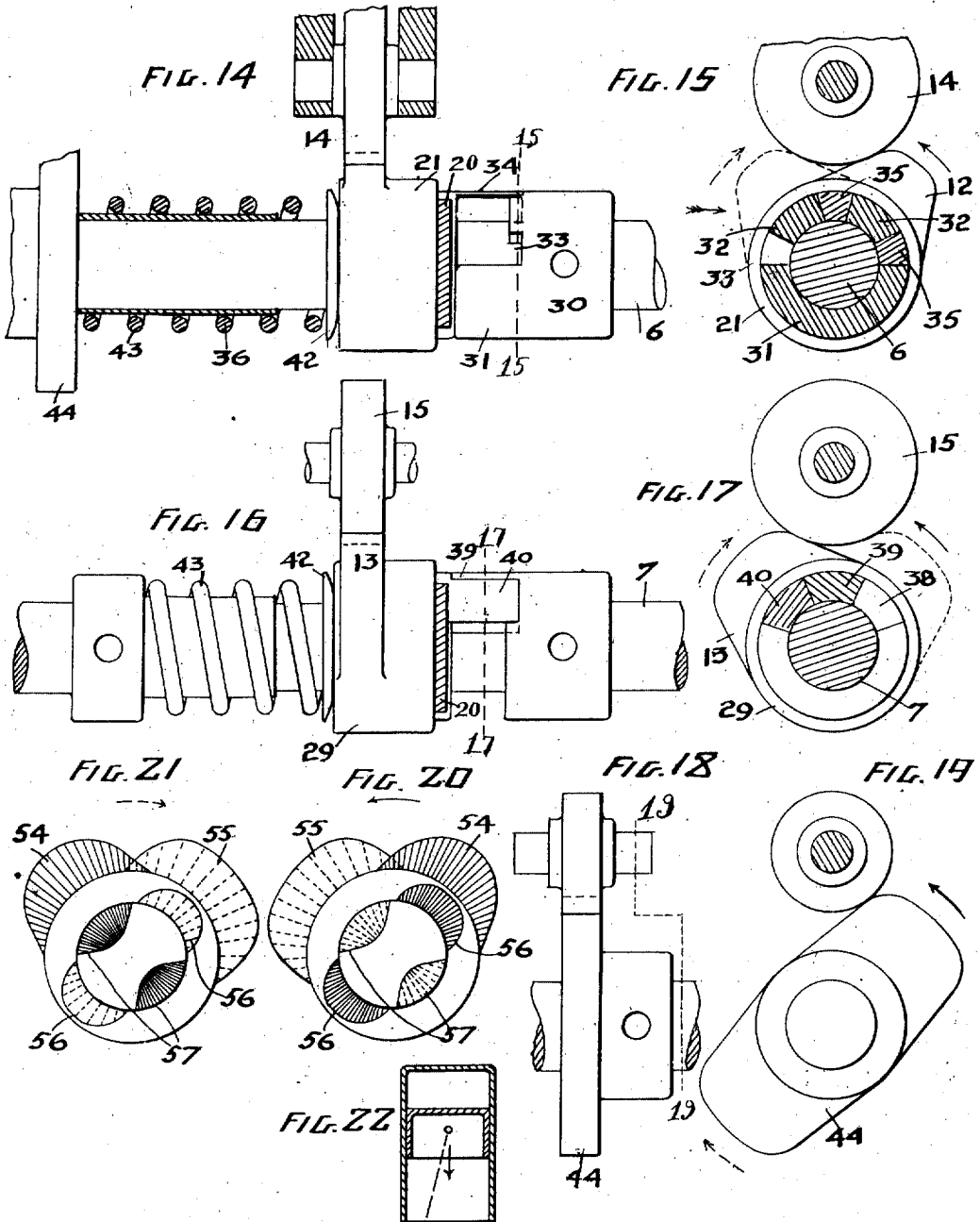
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INTERNAL-COMBUSTION ENGINE.

1,001,595.

Specification of Letters Patent.

Patented Aug. 22, 1911.

Application filed August 12, 1907. Serial No. 388,077.

To all whom it may concern:

Be it known that I, SZYMON JACHIMOVICZ, a subject of the Emperor of Russia, residing at Berkeley, in the county of Alameda and State of California, have invented new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

This invention relates to 4-cycle internal combustion engines, the object of the invention being to provide mechanism whereby a shaft, driven by a plurality of such engines, can be started under a load in either direction; by which its direction of motion, when running in either direction, can be reversed; and by means of which the above mentioned starting or reversal can be effected by merely turning the handle of the regulating valve which regulates the admission of gas to the engine; also in which by the movement of the same handle; the momentum of the moving parts can be used to do work, for the purpose of checking the motion of said parts.

In the accompanying drawings, Figure 1 is a broken front elevation, showing four internal combustion engines to which my invention is applied; Fig. 2 is a vertical section of the same, partly in side elevation; Fig. 3 is a detail side view of the valve mechanism for said engines, showing also a portion of the compressed air reservoir; Fig. 4 is a broken top plan view of the same; Fig. 5 is an end view of the valve-operating handle, showing also the connection therefrom to the carbureter; Fig. 6 is a longitudinal section, on an enlarged scale, of one form of the regulating valve for said engines, especially for boats; Fig. 7 is a cross section of the same on the line 7-7 of Fig. 6; Fig. 8 is a cross section on the line 8-8 of Fig. 6; Figs. 9, 10, 11, are views, similar to Figs. 6, 7, 8, of the form of the regulating valve particularly adapted for use with automobiles; Fig. 12 is an enlarged section of the starting and slide valves; Fig. 13 is a horizontal section of the same, on the line 13-13 of Fig. 12, being shown in plan view; Fig. 14 is an enlarged side elevation, partly in section, of a portion of the shaft for actuating the inlet valve and compressed air valve; Fig. 15 is a cross section on the line 15-15 of Fig. 14, looking in the direction of the arrow; Fig. 16 is a broken side

elevation of the shaft for actuating the outlet valve; Fig. 17 is a cross section on the line 17-17 of Fig. 16; Fig. 18 is a broken detail section of the same shaft as is shown in Fig. 14, showing the cam thereon for actuating the compressed air valve and the roller actuated thereby; Fig. 19 is a section on the line 19-19 of Fig. 18; Fig. 20 is a diagrammatic view showing the periods of opening and closing of the inlet and exhaust valves and of opening and closing of the passages for conducting air to the starting valve; Fig. 21 is a similar view showing said periods when reversing; Fig. 22 is a diagrammatic view of one of the engines.

Referring to the drawings, 1 indicates the casings of gas engines, of which there are here shown four in number, 2 indicating the pistons of said engines, connected by pitmen 3 to cranks 4 on the shaft 5 of the engine. From said shaft 5 are driven, in the usual manner, the shafts 6 and 7, actuating the inlet valves 8 and the exhaust valves 9, the gas being admitted by the inlets 10 and exhausted by the outlets 11, all of the above construction being usual and forming no part of my invention.

In my invention, the cams 12, 13, which actuate the rollers 14, 15, and thereby control respectively the inlet and exhaust valves, are not fixed to the shafts 6, 7, as has been customary heretofore, but form parts of sleeves 21, 29, movable on said shafts both longitudinally and circumferentially. The longitudinal movement of said cam sleeves on either shaft is effected by means of a plunger 16 in a cylinder 17, said plunger being connected with a rod 18 slidable in bearings 19, and having at suitable intervals clutch fingers or bars 20, curved at their inner edges to fit closely against said sleeves. All of the cams controlling the inlet valves of the several gas engines are thus simultaneously movable longitudinally by means of said cylinder 17, the power being derived through a pipe 22 leading thereto from a pipe 23 leading from a controlling valve 24, hereinafter more fully described, to which valve 24 a pipe 25 leads from a reservoir 26 of compressed air. In like manner all of the cams controlling the outlet valves of the several gas engines are movable longitudinally on the shaft 7, by means of a similar cylin-

der and piston, said cylinder being supplied by a pipe 27 connected with the same pipe 23. Springs 43 resist the said longitudinal movement of the said cam sleeves and move them in the opposite direction when the compressed air is withdrawn from the cylinders. The movement of the cam sleeves on either shaft due to the admission of the compressed air into the cylinder is limited by the extent of movement of the piston of the cylinder 17.

Upon the shaft 6 is secured a fixed sleeve 30, which has a large tooth 31 and two small teeth 32, forming with the large tooth and with each other three recesses 33 of equal size, the outer recesses being spaced an equal distance from the middle one. In like manner, the sleeve 21 of the cam is formed first with a large tooth 34 which extends over an angle slightly greater than a right angle, which is again formed with two small teeth 35, which are spaced from each other a suitable distance, and are of suitable size to fit into either adjacent pair of the three recesses 33. With this arrangement, the cam can assume one of two positions relative to the fixed sleeve upon the shaft, such positions being shown in full and dotted lines respectively in Fig. 15. One of these positions is given to the cam when it is desired to run the engine in one direction, and the other when it is required to run it in the other direction, and said positions are spaced from each other by an angle slightly less than a right angle. When the cam sleeve has been moved to its limiting position, the large tooth of the cam sleeve has nevertheless not been moved past the end of the large tooth on the collar, the length of either of these teeth being greater than the distance through which the cam sleeve is so moved. However, the distance through which the cam sleeve moves is sufficient to cause the cam itself to pass the edge of the roller 14, so that said roller immediately thereupon, under the action of the spring 36, drops upon the cylindrical portion of the cam sleeve, and thereby closes the inlet valve. It is necessary to make the width of the cam and the width of the roller less than the distance through which the cam is moved longitudinally, in order that when said cams are all shifted on the valve inlet actuating shaft, all of the rollers 14 drop, and all of the inlet valves are immediately closed to prevent the escape of compressed air through the gas engine when starting the same by means of compressed air. A very similar arrangement is provided for the exhaust, except that in this case the collar has two notches 38 with a long tooth 39 between them, and the cam sleeve has a single long tooth 40 adapted to engage either of said notches 38.

The arrangement of teeth, cam sleeves and

collars upon the two valve actuating shafts to control the reversal of the engine is important. If it is desired to reverse the direction of the engine, compressed air is by means which will be presently described admitted to the cylinder proper and to the two cylinders 17 which shift all cams, and thus close all inlet and exhaust valves, so that the engine is stopped, but is started immediately in the opposite direction by such compressed air. The direction in which said engine will move when so started is determined by the controlling valve in the manner presently described. Assuming however that the engine is running in the opposite direction by means of compressed air it will result that the two cam shafts will now also rotate in the reverse direction. In the meantime all the cam sleeves, under action of compressed air admitted in cylinder 17, are shifted longitudinally to the left by clutch fingers 20. The shifting of the cam sleeves compresses springs 43 which force said sleeves back against clutch fingers 20. The friction so created slows the motion of the cam sleeves relatively to the shaft or even stops it for a moment, which will cause the teeth upon the collars to advance past the teeth upon the cam sleeves until the large teeth of the cam sleeves are struck by the teeth of the collars which causes the cams to assume a different position relative to the shaft, the two positions being shown by the full and dotted lines in Figs. 15 and 17.

In order to prevent the cam sleeve moving with the shaft and until positively compelled to, it is desirable to make the above change with as little friction as possible on the cam sleeve, and so there is provided a convex washer 42 of hardened steel interposed between the spring 43 and the side of the cam sleeve adjacent thereto. There is also provided a spring 28. When the cam sleeve is shifted to the left this spring engages the top of the cam and retains it while the cam shaft advances, and insures the rotary shifting of the cam.

From the above description it will be seen that while the engine is running in either direction, spring 43 presses the cam sleeve against the collar 30 making a positive clutch of them. But when the engine is started on the motion reversed, the spring 43 forces the cam sleeve against the clutch fingers 20 producing angular displacement of said cam sleeve upon the shaft.

As soon as the compressed air is withdrawn, the spring 43 returns the cam sleeve to the right, but it is possible that the ends of the small teeth upon the cam sleeve do not return at once to their proper position in the notches, but as soon as the cam strikes the edge of the roller, then said short teeth upon the cam would be moved

sufficiently to enable them to spring forward into the other pair of the notches. The short teeth are provided to prevent the pressure of the rollers upon the rear side of the cam forcing the cam forward on the shaft out of its proper position.

The angle through which the shaft of the inlet valve cams must turn in the reverse direction before the front edge of the long tooth on the collar strikes the rear edge of the long tooth on the cam sleeve is a little less than a right angle. It is to be observed that in Fig. 15 the parts are shown with the shaft in both cases in the position corresponding with the dead point of the piston. That is, if we first consider the parts in the position in which the cam is shown in full lines, before the reversing of the shaft takes place, and then suppose the shaft to be reversed from a left handed direction of rotation to a right handed direction of rotation, the cam remaining stationary, then the shaft will be moved through an angle a little less than 90° before the connection of the cam and shaft is completed. Then the shaft is supposed to have been brought back through the same angle, in order to show the same position as before for the engine, and this will bring the cam from the position shown in full lines to the position shown in dotted lines, the shaft being now again in the same position as before. A precisely similar mode of operation takes place in regard to the cam controlling the outlet valve, the main difference being that the angle through which the shaft turns, before its engagement with the cam takes place, is much greater than for the cam controlling the inlet valve, being a little less than three right angles. In each case the cam assumes symmetrical positions on its shaft on opposite sides of the dead point of the crank shaft of the engine. It is for constructive reasons that it is found desirable to use two small teeth for the inlet valve controlling cam sleeve and only one tooth for the outlet valve controlling cam sleeve. Upon the shaft of the cam which controls the inlet valves is also provided a fixed cam 44 which controls the compressed air slide valve. Said slide valve is shown more particularly in Figs. 12 and 13 and comprises a cylindrical slide 45 attached to a rod 46 and sliding in a cylindrical wall 47 connected by ports 48, 49 with two chambers 50, 51, said chambers surrounding said cylindrical wall 47 and being connected respectively at opposite sides with the pipes 52, 53. These pipes are used alternatively, the one for compressed air, and the other for exhaust, the selection of said pipes for compressed air or exhaust depending upon the operation of the regulating valve herein-after described. It is by the selective use of these pipes, the one for compressed air

and the other for exhaust, that the engine can be started in either direction. Since the cam shaft carrying the cam 44 makes one complete revolution, for two complete revolutions of said engine shaft, there are four points in the complete revolution of said cam shaft corresponding to the two dead points of the engine shaft. In Fig. 19 is shown one of these four positions of the cam shaft, that is, in which the general direction of the cam is midway between the vertical and horizontal. In this position corresponding to the dead points of the engine shaft, the roller controlling the movement of the compressed air slide valve 45, and therefore also said valve, are in their middle positions, in which positions both the ports 48, 49, are closed. If the cam shaft is moved in the direction of the arrow shown in Fig. 19, which corresponds with the direction of movement of the engine as shown by the arrow in diagram Fig. 20, then the roller and the compressed air slide valve begin to rise from their middle position and the lower ports 48 are opened, and remain open until the cam shaft has moved through substantially 90° degrees, and the slide valve has returned to its middle position again closing both upper and lower ports.

Referring to Fig. 22, it will be seen that the piston of the engine is moving downward. In a 4-cycle engine this corresponds to one of those periods of the cycle in which either explosion or admission takes place. Now, when it is desired to start the engine in either desired direction by the admission of compressed air, it is obviously necessary that the compressed air should be admitted to the cylinder of the engine while the piston is moving downward, that is, in either one of the two above-mentioned periods of its cycle. Since then the arrangement of the parts is such, that while the engine is moving in the direction shown in Fig. 22, and the cam is moving in the direction shown in Fig. 19, the lower ports 48 are open, it follows that compressed air should be admitted to the lower chamber 50, connected with said lower ports 48, so that during movement of the slide valve, compressed air may be admitted into the engine during one of the periods corresponding with either explosion or admission in its regular cycle of operation.

The movement of the cam which controls the compressed air slide valve is arranged relatively to the cam which controls the inlet valve of the engine as indicated by full lines in Figs. 15 and 19. In Fig. 15 it will be seen that the cam moves in the same direction as in Fig. 19, and that it has just begun to open the inlet valve, that is, admission is beginning to take place. Compressed air for starting the engine must be limited during either the admission period or the

explosion period of the cycle of the engine, and since the position of the slide valve corresponding to the position of the cam in Fig. 19 is one in which the lower ports 48 are just opened or beginning to be opened, it follows that it is to this lower port that compressed air must be admitted for starting the engine in the direction as shown in Fig. 22. In this way it is determined to which one of the pipes 52 and 53 the compressed air should be admitted. The means for selectively admitting compressed air to one or the other of these pipes is more particularly shown in Figs. 3 to 11, which show the construction of the regulating valve.

Figs. 20 and 21 are diagrammatic views illustrating the openings and closures of the inlet and exhaust valves and also of the ports controlled by the movement of the slide valve to admit or exhaust the compressed air, and also indicating the direction in which the compressed air is admitted and exhausted through said ports. In these figures the larger circular diagram shows the openings and closures of the inlet and exhaust valves of the engine; the smaller circular diagram shows the opening and closing of the upper and lower ports controlled by the slide valve. In the larger diagram, the part 54 intersected by full radial lines indicates the time and extent of opening of the inlet valve of the engine and the part 55 intersected by broken radial lines indicates the time and extent of opening of the exhaust valve of the engine. Supposing that the crank shaft is rotating in the direction indicated by the arrow in Figs. 15 and 19, it will readily be seen that the control of the valves will be indicated diagrammatically by traveling around said diagram in the opposite direction to the movement of said shaft. Thus, on referring to said diagram it will be seen that the inlet valve is opened slightly before the crank of the engine arrives at its uppermost position, shown in Fig. 22; as the engine shaft rotates, the inlet valve is opened wider until the engine shaft has made one-fourth of a revolution, and then the inlet valve begins to be contracted and is completely closed when the crank shaft has arrived at its lowermost position. The above is the period of admission into the gas engine. In the next half of the revolution of the engine shaft is a period of compression, and on referring to the diagram it will be seen that the inlet and exhaust valves are closed. At the end of this period the crank and piston have returned to their uppermost position. At this point explosion takes place, which forces the piston downward again, and during the downward movement of the piston, for nearly one-half of the revolution of the engine shaft, both the inlet and the outlet valves remain closed, as shown by the dia-

gram, but when the engine shaft has rotated through about four-fifths of this half of its revolution, the outlet valve is opened, as indicated by the part of the diagram intersected by radial lines in Fig. 20. The opening of the outlet valve increases in extent until it reaches its maximum, and then remains wide open for a considerable period, then contracting, and finally closing soon after the crank of the engine shaft has again passed its uppermost vertical position.

Turning to the smaller diagram in Fig. 20, which illustrates in the above described period of the engine cycle, the opening and closing of the upper and lower ports controlled by the compressed air slide valve, the inclosed spaces 56 without the circle indicate the time and extent of opening of the lower ports, while the inclosed spaces 57 within said circle indicate the time and extent of openings of the upper ports. These spaces, when intersected by full radial lines, indicate that the corresponding ports are opened for the passage of compressed air into the engine, and when intersected by broken lines they indicate that the air is exhausted from the engine through the corresponding ports. Thus, while the diagram of the outer circle indicates the movement of the cams controlling the inlet and outlet valves, the diagram of the inner circle indicates the movements of the cam controlling the ports for the compressed air slide valve. On examination of the diagram shown in Fig. 20 it will readily be seen that for forward movement of the cam shaft there are two periods during which compressed air may be admitted through the lower ports for starting the engine, these periods corresponding to the periods of the engine cycle during which admission and explosion respectively take place. And since these periods are in Fig. 20 shown as taking place while the lower ports are opened, it is necessary that the compressed air should be admitted to the lower port when it is desired to run the engine in the direction indicated by the arrows in Fig. 20, and exhausted through the upper ports 49 during the compression and exhaust strokes of the working cycle. Turning to Fig. 21, which indicates the times of openings of the inlet and exhaust valves of the engine when running in the reverse direction, it will be seen that the compressed air must be admitted in this case through the upper ports and exhausted by the lower. Therefore, in order to start the engine in any desired direction all that is necessary is to select one of the two pipes 52, 53, leading to the upper and lower ports respectively through which the compressed air must be admitted, the other pipe then being connected with exhaust.

The regulating valve 24 is shown in side 13'

elevation in Fig. 3, in plan view in Fig. 4, and illustrated in detail in Figs. 6 to 11 and provides the means whereby the compressed air may be admitted, as desired, into either the upper ports 49 or the lower ports 48, the other ports being then connected with exhaust. It is also used, as will be hereinafter described, to control the cam shafts, and starting valves, and it is further used for converting the engines into pumps in order to convert the energy of the moving parts of the vehicle or boat into work in compressing air, for the purpose of arresting the speed of said vehicle or boat. It can also be used, when the engines are employed for propelling a vehicle, to set air brakes for the purpose of positively arresting the vehicle. This valve comprises a cylindrical casing 60 having a base 61 and outer wall 62, an inner wall 63 and a vertical partition 64 connecting said walls 62 and 63, thus forming an outer annular chamber 66 and inner chambers 65, 65' and 67 separated by partitions 68. These partitions are only in the inner annular part of the valve dividing it into three mentioned chambers, 65, 65' and 67. It will be seen that in Fig. 8 there are three of such compartments, while in Fig. 11 are shown four such. The reason of this will appear later, but at present it may be observed that, in either case, two of these compartments, being opposite, are connected with the two pipes 53, 52, connected respectively with upper and lower ports of the compressed air slide valve. These two compartments are also connected by ports 69 and 69', with the interior of the inner wall 63, and within this inner wall can rotate a rotary valve comprising a pipe 70 which is screwed into a sleeve 71 carrying a handle 72, having a pointer 73 which moves over a suitable indicating dial 74. The pipe 70 always moves rigidly with sleeve 71. The other end of said pipe 70 extends into a stuffing box 75 connected with a pipe 25 leading to a compressed air reservoir 26 and the inner end of said pipe 70 can rotate in said stuffing box. The sleeve 71 carried by the pipe, and also the pipe itself, are formed with a passage 78 which is adapted to register with either one of the two ports 69, or 69', leading to the interior of the inner wall from the two chambers 65, 65'. Thus when the parts are in the position shown in Figs. 6 and 8, the compressed air can pass from within the pipe 70 through the passages to the lower pipe 52 and at that time the other pipe 53 is connected through the other port 69' and a port 79 with the passage 80 leading to exhaust. If the valve were rotated through two right angles, then the direction of compressed air and exhaust would be reversed.

The outer chamber 66 is not divided into

compartments and is connected by an opening 82 with the pipe 23 leading to the starting valves of the several gas engines and also to the cylinders for the shifting cams on the cam shafts. Each starting valve is adjacent to the corresponding compressed air slide 45, and comprises a valve proper 84 having a stem 85 attached to a piston 86, moving in a cylindrical chamber 87, its movement being limited by means of a tube 88 around its stem, and normally pressed upward by a spring 89 to hold said valve to its seat. By means of the pipe 23, compressed air is adapted to be admitted into the chamber 87 above said piston and thereby depress the same against the action of said spring, thereby permitting compressed air to pass from the compressed air slide valve to the cylinder of the engine, and also to escape therefrom to said slide valve. The sleeve 71 in the outer chamber 66 is formed with a port 92 adapted to register with one of two opposite ports 93, 93' leading through the inner wall 63.

Upon comparing Figs. 7 and 8, it will be seen that the port 93 in the inner wall through which compressed air passes to the chamber 66 and thence to the pipe 23 is larger than the port 69 through said inner wall in the chamber 65, while the ports 78 and 92 are of the same width. The object of this arrangement is to insure that the inlet and outlet valves of the engines are closed before attempting to start the same by means of compressed air, the necessity for which is obvious. It is insured that said inlet and outlet valves are so closed, because by admitting said compressed air to the pipes 22, 27, the cams are shifted, causing the rollers to drop, so that all of the inlet and outlet valves are closed by the action of their springs, and this takes place before the compressed air is admitted to the compressed air slide valve. Let it be supposed that the parts are in the position shown in Figs. 6, 7 and 8, which is the position in which the engines are being started by compressed air and run in the direction corresponding to the admission of compressed air to the pipe 52. In this position of the starting handle, indicated by the letter *a*, compressed air is being admitted to the full extent and while the handle is being moved from the position *a* to the position *b*, compressed air is still being admitted to the engine to the starting valve and also to the shifting cylinders, the latter having actuated the cams so that the inlet and outlet valves of the engine are closed. When the engine has been sufficiently started by the admission of compressed air, and is running by its own momentum, or, if starting under a load, then by the momentum of the boat or vehicle, the handle is moved up to the point *b*, closing the lower port 69 and shutting off the com-

pressed air from the engine, so that the engine runs only by said momentum, but the compressed air is still admitted to the shifting cylinders and starting valves, the inlet and outlet valves remaining closed. When the valve has been turned so that the handle arrives at the position indicated by the letter *c*, then the lower port 93 is also completely closed by the sleeve 71, and no longer is compressed air admitted to the shifting cylinder, and to the starting valves. When the valve is turned still farther, so that the handle arrives at the position indicated by the letter *d*, the lower port 93 now begins to be connected with the passage 71' in the sleeve 71, which is open to exhaust by the ports 79, 80. In this way the compressed air which has been supplied by the pipe 23 to the shifting to the cylinders and to the starting valves is exhausted therefrom, so that the starting valves close and the cams return to their normal position. The inlet and outlet valves are now no longer closed but are opened by the cams as the cam shaft rotates. This condition remains while the valve still continues to be turned until it arrives at the position indicated by the letter *e*, the latter indicating the position of the handle. During this time, by means which will be presently described, the admission of gas is regulated by the same handle, the maximum amount of admission being obtained when the valve is in its midway position, that is, when the handle is indicated by the letter *k*. If the valve be turned still farther in the same direction, then the port 69' connecting the exhaust with the other pipe 53 begins to be closed by the advancing portion of sleeve 71. When it is completely closed, which is when the handle has arrived at the position corresponding to the point *e'*, a pumping action takes place which will now be described. Compressed air passes through the interior of the pipe 70, then through the port 92, upper port 93' into the chamber 66. The compressed air then passes by the conduit 82 leading to the compressed air pipe 23, which leads to the starting valves and shifting cylinders. Thereby said starting valves are opened and the shifting cylinders are again actuated, so that the inlet and outlet valves of all the engines are again closed. The port 69' in Fig. 8 is closed by the sleeve 71, while the port 93' is already in communication with port 92 for the admission of compressed air to shifting cylinders and starting valve because the said port 93' is wider than the port 69'. Then the engines, reciprocating under their own momentum and that of the vehicle, begin to act as pumps, and thereby use the kinetic energy of their own motion and that of the vehicle so as to rapidly bring the vehicle to rest. This motion, more particularly described, is as follows and I

shall describe at first for the sake of clearness the operation of one cylinder only:—

Assuming that the parts are moving in the forward direction indicated in Fig. 20, and that the inlet and outlet valves have been closed and the starting valves opened. Then in the period of the cycle during which compression or exhaustion would take place the upper ports of the compressed air slide valve would be opened to the pipe 53 connected with chamber 65', Fig. 8. Consequently, if the port 69' leading to this compartment is closed by the advancing part of sleeve 71, which takes place when the valve-handle is between *c* and *b*' in Fig. 8, there is no outlet from said pipe, and the air in the engine and in pipe 53 must be compressed. The compression of the confined air reaches its maximum when the piston of the engine arrives at its dead point, and, as will be seen on reference to Fig. 20, immediately after the engine has reached and passed the dead point, the lower port 48 controlled by the compressed air slide valve is opened the upper port 49 leading to pipe 53 being already closed. On referring to Fig. 8, it will be seen that this lower port is then connected freely with the outside through the lower opening 69, then by the passage 71' of the valve, then through the opening 79 and out to exhaust by the passage 80. Therefore at the beginning of this period of the engine's cycle, the air which has been compressed immediately escapes from the cylinder only without restoring any of its energy to the engine, but compressed air remains in the pipe 53 and connected passages.

As soon as the air pressure is normal, that is, as soon as the piston of the engine is moving outward, suction takes place, and continues during the remaining portion of the outward movement of the piston, thus filling the cylinder of the engine with air. Then, upon the third or compression period of the engine's cycle, the lower port 48 is again closed and the upper port 49 opened, so that compressed air remaining in pipe 53, enters the cylinder and opposes the movement of the piston. The piston again moves inward in the cylinder, compressing the air which has been inclosed in the cylinder and pipe 53, and since, in the same manner as before this air cannot escape, through the closed port 69', increased compression takes place. Then in the beginning of the next suction stroke, part of the compressed air escapes, as previously described. This action is repeated with increasing pressure at each repetition until the engine stops. At that time pipe 53 is filled with compressed air which could be utilized for backward movement of the vehicle or boat, because for such backward movement of the engine compressed air from the reservoir 26 reaches the engine through said pipe 53. The action as above described

for one cylinder is of the same character for a plurality of cylinders. But having regard to the fact that with four cylinders two of them are during most of the time connected with the same pipe 53 at the same time, the pressures in the pipe 53 and in the cylinders are the same, notwithstanding the differences in the positions of the pistons. Therefore this connection of two cylinders with pipe 53 will give a pressure of exhausted air in each cylinder, in case of four cylinders, slightly different from the case before described for one cylinder; but the character of the action and the final result remain the same for one or for a plurality of cylinders; that is the vehicle would be brought to rest and the pipe 53 would be filled with compressed air. In this manner the engines can be used as pumps to compel the moving parts of the engines and vehicle to expend their energy in performing work, and thereby to be quickly brought to rest. If the valve is turned still farther, so that the handle moves from the position indicated by the letter *b'* to the letter *a'*, then as soon as the valve passes the position indicated by the letter *b'*, the port 78 begins to register with the upper port 69' so that compressed air begins to be admitted through the central pipe of the valve to the upper port of the slide valve. But it has already been seen that the direction in which the engine is started by the admission of compressed air depends upon which of the two ports, the upper port 49 or the lower port 48 the compressed air is admitted to. It follows therefore that when the valve is turned through two right angles, or nearly two right angles, so that compressed air is admitted to the upper port instead of the lower, the force of the compressed air is used to stop and then reverse the direction of motion of the engine. Obviously, if the engine is running in the direction indicated in Fig. 20, then the lower ports 48 are opened in the explosion and suction periods, and the upper ports 49 are opened in the compression and exhaust periods, and if when the engine is then running forward, the lower ports are connected to exhaust and the upper ports are connected to compressed air, the compressed air, being then admitted at the times when the piston is moving inward into the cylinder, will oppose the movement of said piston and thus tend first to bring the engine to rest, and then to reverse it. It will thus be seen that the movement of the handle is the natural movement from its central position to bring the engine to rest, first, by compelling the moving parts to expend their kinetic energy in doing work by compressing confined air, and then, if the handle is moved still farther, to positively resist the movement of said moving parts, by the force of compressed air applied in the reverse direction to the pis-

tons of the engines. Thus a continuous movement of the handle in the same direction first brings the engine to rest and then reverses it.

The arrangement illustrated in Figs. 6 to 8 is more particularly adapted for the use with boats propelled by internal combustion engines. In Figs. 9 to 11 is shown a modification of the engine particularly adapted for use with automobiles. The difference between the two is that in the latter case there is provided mechanism for setting air brakes, such mechanism being omitted when used with boats. This results in a difference in the arrangement of the valve, in that the valve is not moved through two right angles, or nearly so, to stop the vehicle, but only through a right angle. 95 indicates an outlet leading to a chamber 96 connected by a passage 97 with a pipe 98 leading to air brakes. The outer portion of the shell is now formed with two wings 99 and 99', which are disposed nearly opposite to each other, and symmetrically with regard to the port 78. One of these wings 99 is adapted to close the port 69 and the other 99' to close the port 69', while at the same time they are formed with passages 100 which permit free movement of the fluids between the pipe 70 and wall 63, except where obstructed by the shell 71. It will be readily noticed that the connection of pipes 52 and 53 is shown in Figs. 9, 10, and 11 directly opposite to that shown in Figs. 6, 7, and 8. With this construction, supposing the parts are in the position shown in Figs. 9 to 11, which is the position for starting the engine by means of compressed air forward in the direction shown in Fig. 20, and corresponds to the position of the handle indicated by the letter *a*, if the lever is moved to the left and reaches the point *b*, then the compressed air can no longer pass from the interior of the pipe 70 by the ports 69 and 78 and is shut off, and the engines run by their own momentum and the momentum of the vehicle. However, gas can not be admitted to the engines, to operate the same, because the inlet and outlet valves are still closed. This is the case because compressed air is still inclosed in the pipe 23 and in the shifting cylinder and holds the cams in their position at the left against the pressure of the springs. On moving the valve to the position indicated by the letter *d*, the compressed air is withdrawn from these cylinders and also from the starting valves, passing by the port 93 then into a passage 102 extending longitudinally in the sleeve of the valve to the inner chamber and there discharging into a compartment 103 which as will be later described connects with ports 104 leading to exhaust, whereby the cams are restored to their normal position.

for the proper direction, and, by the movement of the engine shaft, the inlet and outlet valves are at the proper time opened by the means of said cams, and the engines

begin to work.

The regulation of the amount of admission of gas as will be later described can be obtained by moving the valve from the position indicated by the letter *d* to the position indicated by the letter *e*. At this point the wing 99' closes the port 69'; at the same time air is again admitted to the starting and shifting cylinders by reason of the opening 92 registering with a port 106 and thence passing to the pipe 23. Thereby the starting valves are opened and the inlet and exhaust valves are closed. The engines now begin to operate as pumps, in the manner already explained in the former modification, because the passages from the upper ports 49 are closed and those from the lower ports 48 are opened, while the engine is still running forward. Upon moving the valve still farther into the position indicated by the letter *f* in Fig. 11, the port 95 is brought into communication with the port 78 leading from the source of supply of compressed air, and thereby compressed air is admitted to the pipe which leads to the air brakes. During this time, however, the pumping still continues and the energy of the moving parts in being abstracted not only by the brakes, but by the pumps. Now when the vehicle has been brought to rest, should it be desired to start in the same direction as before, the valve is moved back to the position indicated by the letter *a*, but should it be desired to start in the reverse direction the valve is moved into the position indicated by the letter *a'*. In the last position port 78 is in communication with port 69' and port 92 with port 93'. The position of the parts and the operations resulting from the movement of said parts are precisely the same for the backward movement as for the forward movement, and the handle assumes a symmetrical position for the same operations in the two directions of movement. The forward movement is regulated by turning the handle through one-quarter of a revolution, and the backward movement by turning it through another quarter of a revolution.

In Figs. 4 and 5 is illustrated the arrangement for controlling the admission of the carbureted gas by the movement of the same handle which controls the starting and stopping of the engines and vehicle or boat. For this purpose there is secured upon the inner end of the pipe 70 a crank arm 110 connected by a link 111 with the carbureter lever 112, the connection being by means of a pin 113 upon said lever entering a slot 114 in said link. A spring 115 is attached to said lever and pulls in such a direction that

when the handle is moved from the position indicated by the letter *d* to the position indicated by the letter *e*, the pin of the lever keeps its place in the end of the slot of the link, but when the pointer of the lever arrives at the stop 116, so that the lever can be turned no farther, then the handle can be turned still farther from the position indicated by *e* to the position indicated by *e'*. If the handle be now turned still farther in the same direction, the pin will then, as before, take its place at the end of the slot, being now pulled upward by the link as it ascends with the movement of the crank. It will thus be seen that regulation of the carbureter takes place only during the movement of the handle through the angle limited by the points marked *d* and *e* on either side.

It will readily be seen that, since the control of the engine is effected entirely by means of conduits, through which a pressure fluid is transmitted, this control may be regulated from a point at a considerable distance from the engine, if desired. Moreover, it follows, for the same reason, that a series or plurality of such engines may be simultaneously controlled from any desired point. Therefore, if the invention were applied, for instance, to propel a train of cars, all of them could be controlled by a single operator located at the head of the train.

I claim:—

1. In an internal combustion engine having inlet and outlet valves and shafts rotating in fixed bearings, loose cams on said shafts for controlling said valves in both directions of motion of said shafts, means for shifting the cams longitudinally upon the shafts, and means for shifting the cams circumferentially upon the shafts.

2. In an internal combustion engine having inlet and outlet valves, shafts rotating in fixed bearings, cams loose on said shafts for controlling said valves, clutch mechanism for locking the cams to the shafts in two positions, means for shifting the cams longitudinally on the shaft to disengage the clutch from either locking position, means for shifting the cams circumferentially on the shaft, and means for reengaging the clutch mechanism in the other locking position.

3. In an internal combustion engine, the combination of a driven shaft, a cam shaft actuated thereby, a fixed collar on the cam shaft, a longitudinally movable cam on said shaft, means for shifting said cam longitudinally, a spring for returning said cam when the shifting means is withdrawn, said collar and cam having teeth adapted to engage each other in either one of two relative positions on the cam shaft, substantially as described.

4. In an internal combustion engine, the combination of a driven shaft, a cam shaft,

- operated thereby, a fixed collar on said shaft, having a plurality of teeth, a cam sleeve movable on said shaft, also having a plurality of teeth adapted to engage teeth on the collar, means for moving said sleeve longitudinally on said shaft, and means for returning said sleeve to its normal position in which its teeth engage the teeth of the collar, substantially as described.
5. In an internal combustion engine, the combination of a driven shaft, a cam shaft operated thereby, a fixed collar on said shaft, having a plurality of teeth, a cam sleeve movable on said shaft, also having a plurality of teeth adapted to engage teeth on the collar, means for moving said sleeve longitudinally on said shaft, and means for returning said sleeve to its normal position in which its teeth engage the teeth of the collar, comprising a cylinder, a piston therein, an operative connection from said piston to said sleeve, and means for supplying compressed air to said cylinder, substantially as described.
6. In an internal combustion engine, the combination of a driven shaft, a cam shaft operated thereby, a fixed collar on said shaft, having a plurality of teeth, a cam sleeve movable on said shaft, also having a plurality of teeth adapted to engage teeth on the collar, means for moving said sleeve longitudinally on said shaft, means for returning said sleeve to its normal position in which its teeth engage the teeth of the collar, and means for resisting the circumferential movement of the cam when the teeth are out of engagement, substantially as described.
7. In an internal combustion engine, the combination of a driven shaft, cam shafts for the inlet and outlet valves, fixed collars thereon, sleeves on said shafts, said sleeves and collars, being adapted to engage each other in two relative positions of the cam sleeve, springs for pressing said sleeves and collars together, means for moving on each shaft a plurality of such cam sleeves, comprising a cylinder, a piston reciprocating therein, a bar attached to said piston, fingers attached to said bar and engaging said sleeves, springs for resisting the movement of said sleeves, and means for admitting a pressure fluid to said cylinder to move said pistons, substantially as described.
8. In an internal combustion engine, the combination of a driven shaft, cam shafts for the inlet and outlet valves, fixed collars thereon, sleeves on said shafts, said sleeves and collars being adapted to engage each other in two relative positions of the cam sleeve, springs for pressing said sleeves and collars together, means for moving on each shaft a plurality of such cam sleeves, comprising a cylinder, a piston reciprocating therein, a bar attached to said piston, fingers attached to said bar and engaging said sleeves, means for resisting the circumferential movement of each cam when disengaged, and means for admitting a pressure fluid to said cylinder to move said pistons, substantially as described.
9. In an internal combustion engine having inlet and outlet valves, a starting valve, mechanism operable by compressed air, for simultaneously opening said starting valve and closing the inlet and outlet valves, and means for supplying compressed air to said mechanism, and to the engine through said starting valve, substantially as described.
10. In an internal combustion engine having inlet and outlet valves, a starting valve, mechanism operable by compressed air, for simultaneously opening said starting valve and closing the inlet and outlet valves, means for supplying compressed air to the engine through said starting valve and to said mechanism, and means for controlling the time of admission of said compressed air corresponding to the period desired of the cycle of the engine, substantially as described.
11. In an internal combustion engine, the combination of a starting valve, means for simultaneously closing the inlet and outlet valves of the engine and opening said starting valve, means for passing compressed air to and from the engine through said starting valve, means for selecting the period of the engine's cycle during which the compressed air is admitted and exhausted, a valve for controlling the latter means, and means for operating said valve to cause the engines to act as pumps to absorb the kinetic energy of the moving parts, substantially as described.
12. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a valve, a handle for turning said valve, means for shifting the cams on the shafts of the engine by means of compressed air, said valve being arranged to control the shifting of said cams also to admit compressed air into the engine to start the same, also to convert all cylinders of the engines proper into pumps to absorb the kinetic energy thereof, by the movement of the same handle, substantially as described.
13. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a valve, a handle for turning said valve, means for shifting the cams on the shafts of the engine by means of compressed air, said valve being arranged to control the shifting of said cams also to admit compressed air into the engine to start the same, also to convert the engines into pumps to absorb the kinetic energy thereof by the movement of the same handle, and also to control the admission of gas to the engine, substantially as described.

14. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a valve, a handle for turning said valve, means for shifting the cams on the shafts of the engine by means of compressed air, air brakes, said valve being arranged to control the shifting of said cams, also to admit compressed air into the engine to start the same, also to convert the engines into pumps to absorb the kinetic energy thereof and also to set said air brakes, by the movement of the same handle, substantially as described.

15. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a valve, a handle for turning said valve, means for shifting the cams on the cam shaft of the engine by means of compressed air, and air brakes, said valve being arranged to control the shifting of said cams, also to admit compressed air into the engine to start the same, and also to set said air brakes, by the movement of the same handle, substantially as described.

16. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a valve, a handle for turning said valve, means for shifting the cams on the cam shaft of the engine by means of compressed air, and air brakes, said valve being arranged to control the shifting of said cams, opening a starting valve also to admit compressed air into the engine to start the same, and also to set said air brakes, by the movement of the same handle, substantially as described.

17. In an internal combustion engine having inlet and outlet valves and cam shafts for operating them, an independent starting valve, a compressed air supply, mechanism operated by compressed air to shift the cams upon their shafts for closing the inlet and outlet valves, and mechanism independent of said shifting mechanism and operated by compressed air for simultaneously opening the starting valve and for keeping it open.

18. In an internal combustion engine having inlet and outlet valves and a starting valve, mechanism operable by compressed air for closing the inlet and outlet valves, independent mechanism operated by compressed air for simultaneously opening the starting valve and holding it open, means for supplying compressed air to and exhausting it from the engine through the starting valve, and means for controlling the times of admission to and exhaust from the engine of said compressed air.

19. In an internal combustion engine, the combination of the engine proper, a source of supply of compressed air, a regulating valve, a handle for turning said valve, means for shifting the cams upon the cam shafts of

the engine by means of compressed air, a starting valve, and air-brakes; said regulating valve being arranged to control the shifting of said cams, to open the starting valve so as to admit compressed air into the engine to start the same, and to set said air-brakes, by the movement of the same handle.

20. In an internal combustion engine, the combination of a driven shaft, a cam shaft actuated thereby, a fixed member on said shaft, a cam movable on said shaft, said cam and said fixed member adapted to engage each other, means for moving said cam longitudinally on said shaft, and means for returning said cam to its normal position in engagement with said fixed member.

21. In an internal combustion engine, the combination of a driven shaft, a cam shaft actuated thereby, a fixed member on the cam shaft, a longitudinally movable cam on said shaft, means for shifting said cam longitudinally, a spring for returning said cam when the shifting means is withdrawn, said cam and fixed member adapted to engage each other in either one of two relative positions.

22. In an internal combustion engine, the combination of a shaft, a cam shaft operated thereby, a fixed member on said shaft, a cam movable on said shaft, said cam and said fixed member adapted to engage each other in one of two relative positions, means for moving said cam longitudinally on said shaft to break said engagement, said means comprising a cylinder, a piston therein, an operative connection from said piston to said cam, and means for supplying compressed air to said cylinder.

23. In an internal combustion engine, the combination of a driven shaft, a cam shaft operated thereby, a fixed member on said shaft, a cam movable on said shaft, said cam and fixed member adapted to engage each other in one of two relative positions, means for making this engagement secure, and means whereby an attendant may break said engagement, means for turning said cam circumferentially upon said shaft when disengaged, means for shifting said cam back on the shaft and securing a new engagement between it and said fixed member.

24. In an internal combustion engine, the combination of a driven shaft, cam shafts for the inlet and outlet valves, fixed members thereon, cams on said shafts, said cams and said fixed members being adapted to engage each other in two relative positions of the cams, springs for pressing said cams and fixed members together, means for moving on each shaft a plurality of such cams, said means comprising a cylinder, a piston reciprocating therein, a bar attached to said piston, fingers attached to said bar and engaging said cams, means for resisting the circumferential movement of each cam when

disengaged, and means for admitting a pressure fluid to said cylinder to move said piston.

25. In a gas engine, the combination of
5 the engine having usual inlet and exhaust valves, a source of supply of compressed fluid, a charge timing mechanism, a starting valve for closing a passage between the charge timing mechanism and the cylinder
10 of the engine, and means for simultaneously

closing the usual inlet and exhaust valves and opening the starting valve independently of said charge timing mechanism.

In testimony whereof I have hereunto set my hand in the presence of two subscribing
15 witnesses.

SZYMON JACHIMOVICZ.

Witnesses:

FRANCIS M. WRIGHT,
D. B. RICHARDS.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."