J. A. NICKELSON.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JAN. 5, 1906.

966,948.

Patented Aug. 9, 1910.

3 SHEETS—SHEET 1.

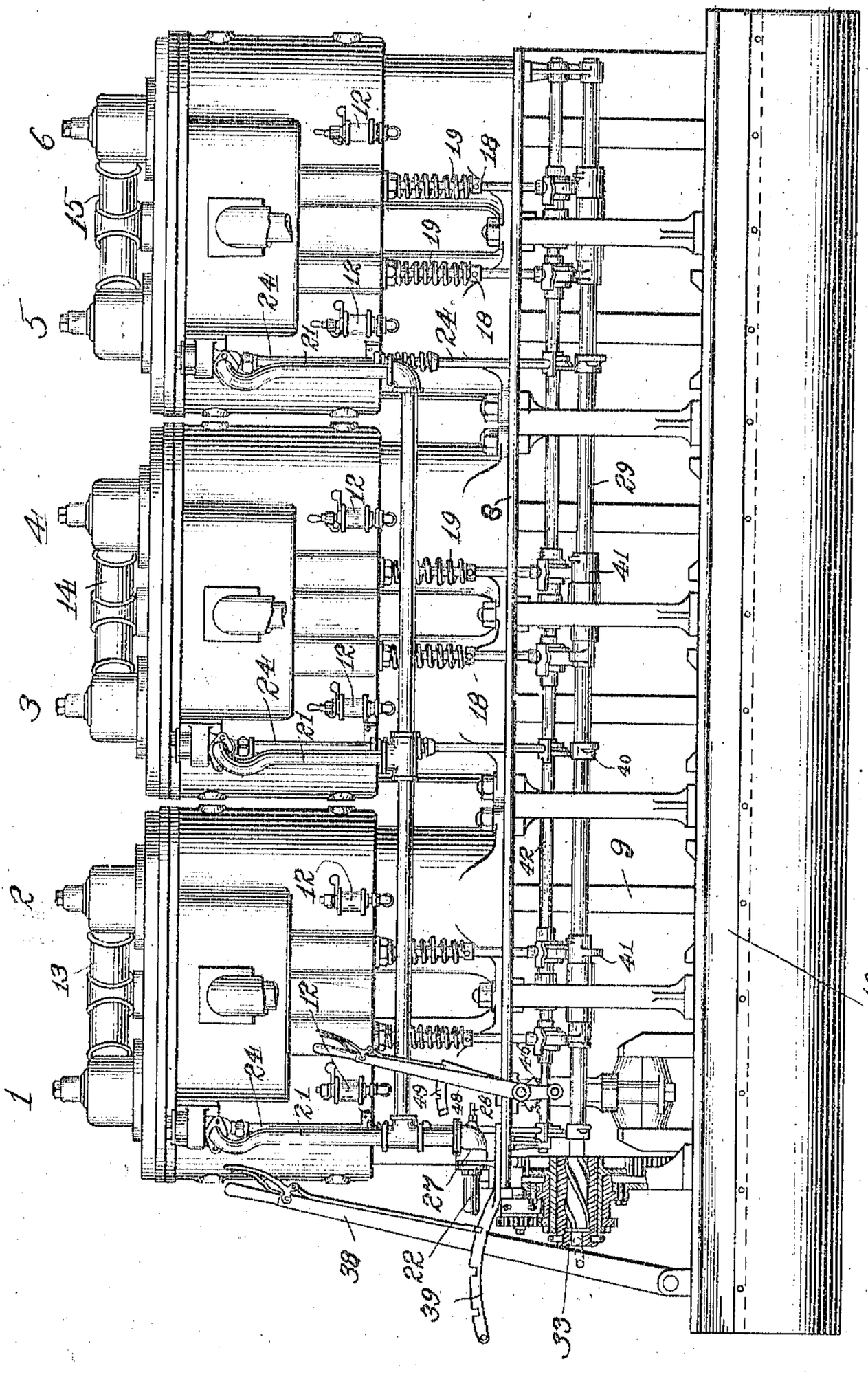

Fig. 1.

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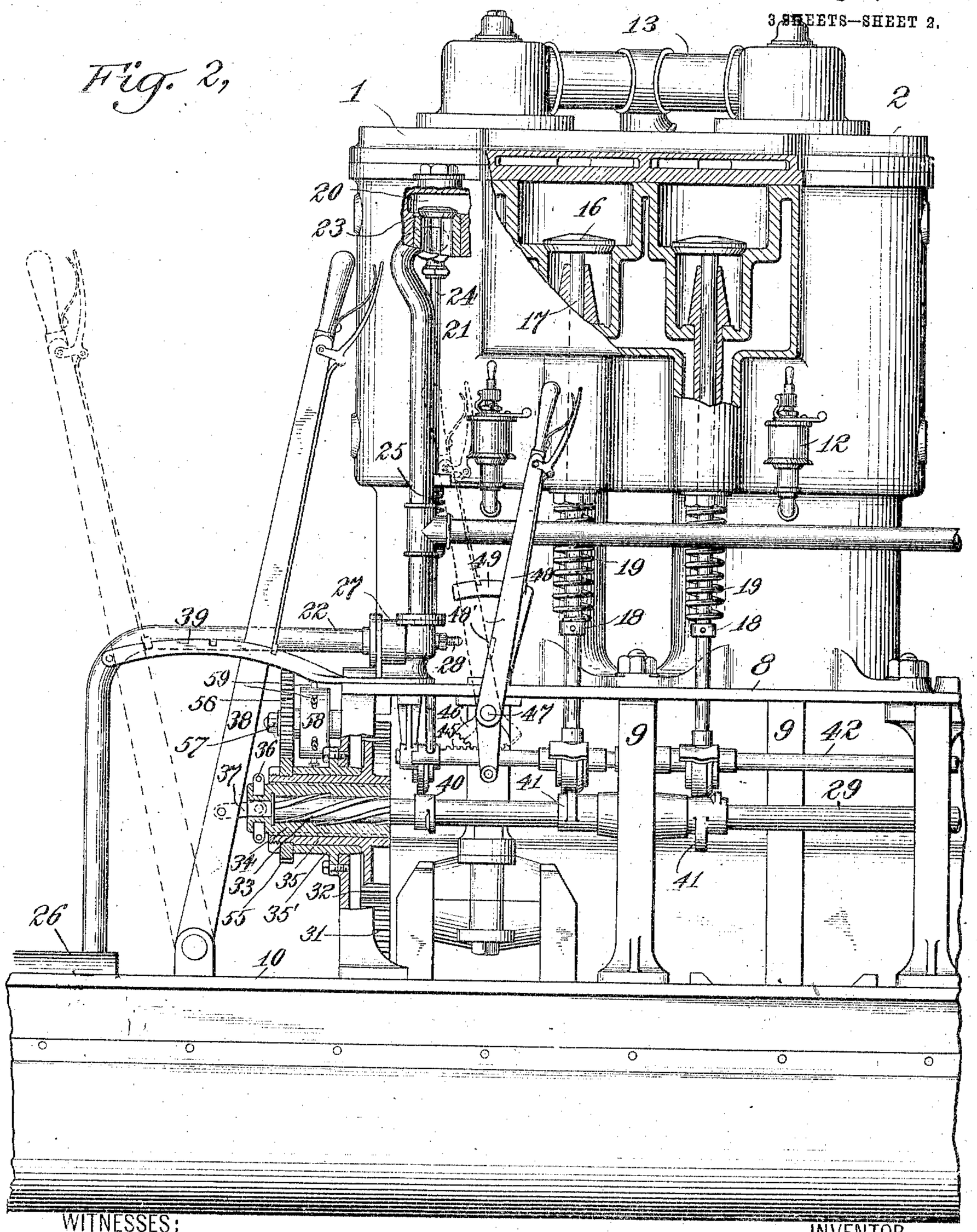
3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3,

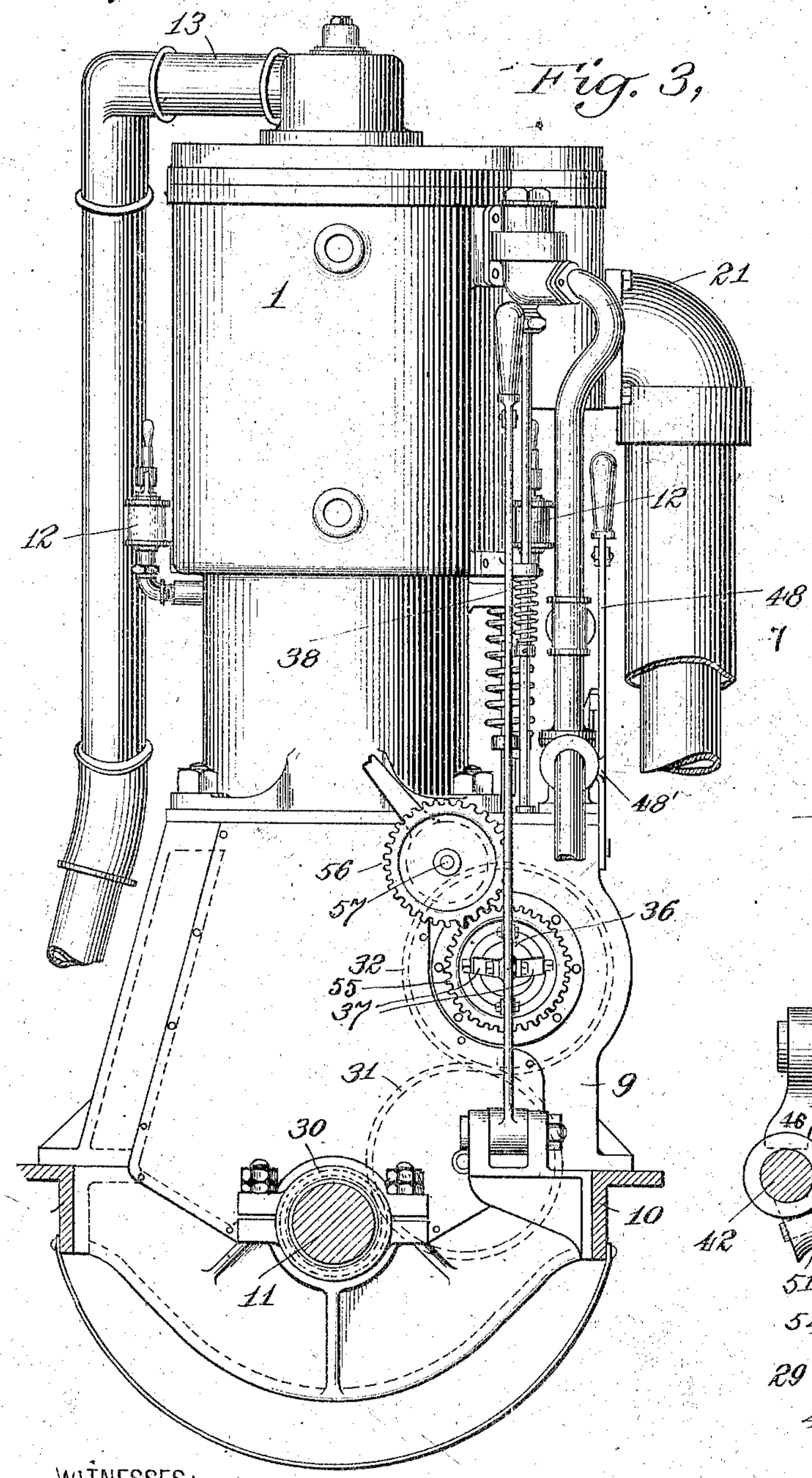


Fig. 4

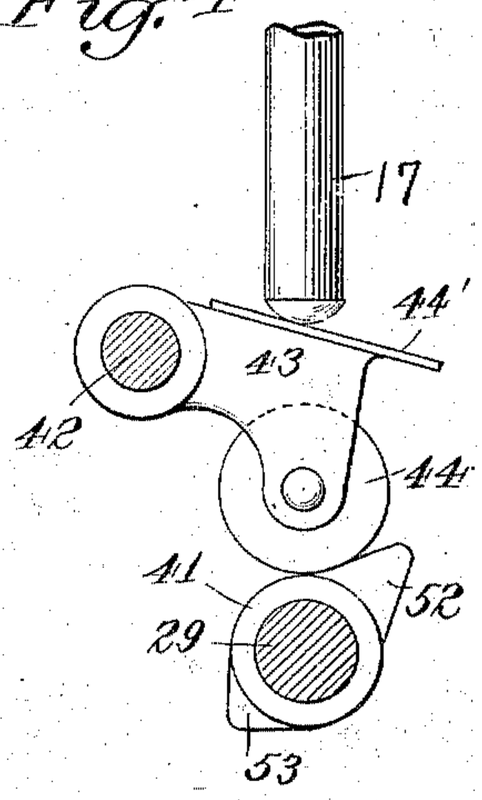
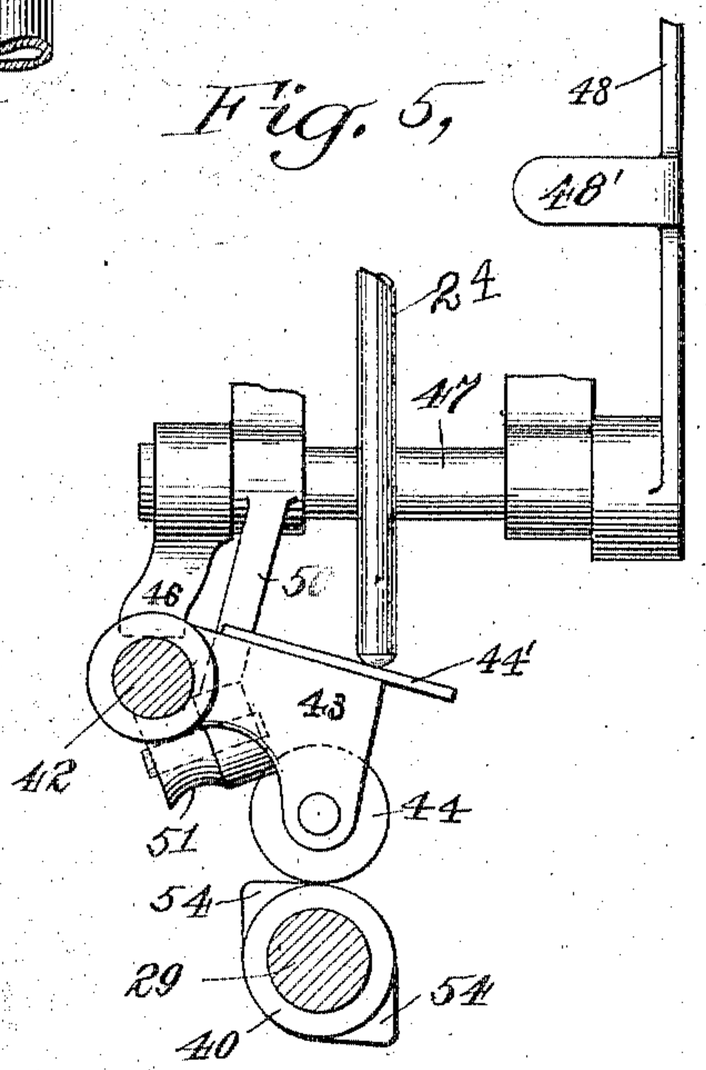


Fig. 5,



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JOSEPH A. NICKELSON, OF NEW YORK, N. Y., ASSIGNOR TO NEW YORK YACHT, LAUNCH & ENGINE COMPANY, OF MORRIS HEIGHTS, NEW YORK, A CORPORATION OF NEW YORK.

INTERNAL-COMBUSTION ENGINE.

966,948. Specification of Letters Patent. Patented Aug. 9, 1910.

Application filed January 5, 1906. Serial No. 294,705.

To all whom it may concern:

Be it known that I, JOSEPH A. NICKELSON, a citizen of the United States, residing at Morris Heights, in the city and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

This invention relates to internal combustion engines, and the object of the invention is to provide a motor of this type which is of simple and substantial construction, which is reversible and self-starting in either direction and which is provided with a compactly arranged and easily operated control system.

Reversible internal combustion engines have been constructed heretofore having a set of cams for actuating the various valves when the engine is running in one direction and another set of cams angularly displaced about the cam-shaft from the cams of the first-named set for actuating the valves when the engine is running in the opposite direction. This duplication of cams is highly undesirable, as it complicates and increases the cost of the engine and increases considerably the liability of breakage and faulty operation.

My invention contemplates the provision of an internal combustion motor which is reversible and which requires only a single set of cams to actuate the valves. I accomplish this by providing means for turning the shaft which carries the cam or cams on its axis independently of the driving mechanism therefor, as, for instance, the engine-shaft, so that a single set of cams will in one position actuate the valves to operate the engine in one direction, and in another position will perform the same function for running the engine in the opposite direction. The means which I prefer to employ for this purpose is simple and compact and is readily operated to rotate the cam-shaft on its axis without turning the engine-shaft and without affecting the gearing by which the engine-shaft drives the cam-shaft.

Internal combustion engines have commonly been provided with means for starting them by admitting compressed air to one or more of the cylinders. I adopt this expedient by providing one or more of the cylinders with valved inlets for admitting compressed air thereto and in combination therewith I provide a master air-valve in the pipe leading to these inlets and means whereby throwing into operative position the cams for operating the air-valves also operates to open the master air-valve.

I have illustrated the preferred embodiment of my invention in the accompanying drawings, in which—

Figure 1 is an elevation, partly in section, of a gas-engine; Fig. 2 is an enlarged elevation partly in section, of a portion of the same; Fig. 3 is an end view; and Figs. 4 and 5 are detail views illustrating the operation of the exhaust and compressed air valves respectively.

In these drawings, I have illustrated a six cylinder, internal combustion engine, but I wish it understood that my invention is not limited in this respect, as the principles thereof are equally applicable to an engine of one or any other number of cylinders desired. The cylinders are indicated by the numerals 1 to 6. As compressed air for starting is preferably admitted to three of the cylinders, I cast them in pairs and provide means for admitting compressed air to one cylinder of each pair, as similar castings can therefore be used for the several pairs of cylinders. Preferably, the cylinders are water-jacketed, the water for cooling being carried to and from the engine by the pipes 7 of a water circulating system in the usual manner. The cylinders are secured upon a frame 8 carried on suitable supports 9, which are secured at their lower ends to a base frame 10. Suitable pistons, not shown in the drawings, are adapted to reciprocate in the cylinders and are connected by connecting rods to cranks on the engine-shaft 11 in the usual manner. Sight-feed lubricators 12 are provided for admitting lubricating oil to the pistons. 13, 14 and 15 indicate branch pipes leading from a main gas-pipe to an opening in the upper end of each of the cylinders to carry gas thereto. The inlet for the gas to each of the cylinders is provided with a suitable valve, spring-pressed to the closed position, and these valves may be operated by suction or by cams coacting with the stems of the valves. In the engine illustrated, these valves are operated by suction, but it will be understood that they may be operated by cams in a manner similar to that which will be hereinafter described in connection with the operation of the valves for the ex-

haust from the cylinders of the products of combustion and the air which is used for starting.

Communicating with each cylinder is an exhaust outlet provided with a valve 16, the stem 17 of which extends through a suitable opening in the cylinder casting and is provided with a collar 18 between which and a portion of the cylinder casting a spring 19 is coiled about the valve-stem and adapted to move the valve to the closed position. Communicating with one cylinder of each pair, that is, cylinders 1, 3 and 5, is an inlet opening 20, for compressed air, to which openings are connected branch pipes 21 connected to a compressed air-pipe 22. In each of these air-inlet openings is a valve 23, the stem 24 of which extends down and is provided with a spring 25 for moving the valve to the closed position similar to the spring 19 of the exhaust-valve. The compressed-air pipe 22 leads to a suitable reservoir 26, in which compressed air is stored, the air being compressed in any suitable manner, as by an air-compressor geared to the engine shaft. Within a suitable casing 27 in the air-pipe 22 is a master air-valve adapted to be operated by a stem 28 and having a suitable spring to move the valve to the closed position.

Mounted for rotation in bearings carried by the supports 9, is a shaft 29 carrying the cams for operating the exhaust-valves 16 for all of the cylinders and the compressed-air valves 23 for admitting compressed air to cylinders 1, 3 and 5. As is usual in internal-combustion engines, this shaft is arranged to be driven by the engine-shaft at one-half the speed of the engine-shaft, but I provide means by which the shaft may be turned on its axis through a definite angle independently of the engine-shaft and without affecting the gearing by which the engine-shaft drives it. On the engine-shaft 11, is a pinion 30 (Fig. 3), which meshes with a gear 31 carried by a suitable stub-shaft. The intermediate gear 31 meshes with a gear 32, which is adapted to drive the cam-shaft 29. The arrangement of this gearing is such that gear 32 is driven at one-half the speed of the engine-shaft 11. On the end of the cam-shaft 29 are one or more spirally formed ridges or keys 33, and fitting on this end of the shaft is a bushing 34, the bore of which is provided with one or more spirally formed grooves or keyways corresponding with the ridges 33 and into which the ridges 33 extend, the arrangement being such that movement of bushing 34 axially of shaft 29 uses relative rotation of the shaft and bushing. On the exterior of bushing 34 are one or more keyways extending parallel to the axis of the bushing. The gear 32 is formed integral with a long sleeve 35 mounted for rotation in a bearing 35′ secured to the frame of the engine, and on the interior of this sleeve are one or more keys which extend into the keyways on the exterior of the bushing 34, the arrangement being such that bushing 34 and gear 32 must rotate together in any position of the movement of bushing 34 axially of shaft 29. In the end of bushing 34, beyond the end of sleeve 35, is a peripheral groove into which extends a two-part ring 36 and links 37 connect this ring with an operating lever 38 pivotally mounted upon the base 10, extending upward therefrom to a convenient position and provided at its upper end with an operating handle. The lever may also be provided with a suitable spring-pressed retaining latch coacting with a notched sector 39. Secured on the cam-shaft 29 are three cams 40 for actuating the compressed-air inlet valves 23, and six cams 41 for actuating the exhaust outlet valves 16 in a manner which will be hereinafter more fully described.

Mounted in suitable bearings depending from the under side of the frame 8 and arranged for axial movement in its bearings is a shaft 42 carrying the lifters for the valve-stems 17 and 24. The construction of these lifters is best shown in Figs. 4 and 5. Each of the lifters consists of a frame 43 loosely mounted on the shaft 42 but held against axial movement relatively thereto by suitable collars. Pivoted in the lower part of the frame 43 is a roller 44, which bears upon the periphery of the operating cam of the lifter and one edge of which is beveled off. Secured on the top of the frame 43 is a plate 44′ on which bears the lower end of the valve-stem which is to be operated by the cam on which the roller 44 bears. A rack 45 is formed in the shaft 42, with which meshes a toothed sector 46 carried by a shaft 47 mounted in suitable bearings and to which is secured a lever 48 having an operating handle. This handle may also be provided with a spring-pressed retaining latch coöperating with notches in a sector 49. In order to hold shaft 42 against a springing movement which would carry the teeth of rack 45 out of mesh with those of the sector 46, a bracket 50 extends downwardly from shaft 47 upon which it is loosely mounted and at its lower end carries a roller 51 on which the shaft 42 bears. On the lever 48 is a projection 48′ (Fig. 5) which when the lever is thrown to the position indicated by the dotted lines in Fig. 2, engages the stem 28 of the master air-valve and opens the valve.

Each of the exhaust-valve-operating cams 41 (Fig. 4) has a raised portion 52, which when the cam-shaft 29 is rotated, coacts with the roller 44 on the lifter 43 for that cam to raise the lifter and thus open the exhaust-valve. On the side of the cam opposite the

raised portion 52, is a second raised portion 53, one edge of which is beveled off as shown in Fig. 2. This is of less width than the raised portion 52, so that when the lifter-shaft 42 is in the position for normal running, as shown in Fig. 2, only the raised portion 52 on each exhaust cam 41 engages the roller 44 on the lifter for that cam; but when lever 48 is thrown to the position indicated by the dotted lines in Fig. 2, thus moving lifter-shaft 42 and the lifters thereon axially of the shaft, the lifters are carried to such a position that both of the raised portions 52 and 53 on each cam 41 engage the roller 44 on the lifter for that cam and actuate the lifter to open the exhaust valve whose stem rests thereon. Also, the raised portion 53, which operates to open the exhaust-valve while starting during the stroke of the engine corresponding to the compression stroke of normal running, is smaller than the raised portion 52, so that in starting the exhaust-valve is held open by this raised portion 53 for a shorter period and a slight compression is obtained, so that if any gas is admitted with the compressed air on the admission stroke, it will be compressed and ignited and its expansion will aid in driving the engine. Each of the cams 40 (Fig. 5) for operating the compressed-air inlet valves of cylinders 1, 3 and 5, is provided with two raised portions 54 diametrically opposite each other and beveled off at one edge; these are so disposed upon the cam that when lifter-shaft 42 is in the position for normal running, neither one of these raised portions on the cam operates the lifter 43 and movable valve-member corresponding thereto, but when lifter-shaft 42 is moved axially by lever 48 to the starting position, both of the raised portions operate the lifter. The three cams 40 for operating the compressed-air inlet-valves are secured on the cam-shaft 29 in such position that the raised portions on each of them are displaced angularly from those of the other two cams by 120 degrees, as will be well understood. Also the corresponding raised portions on the six cams 41 for operating the exhaust-valves are displaced one from another by sixty degrees.

The ignition of the charges of gas admitted to the cylinders during normal running of the engine may be effected in any suitable manner. I prefer to employ the jump-spark method, and for this purpose I provide on the sleeve 35 of the gear 32 a gear 55 meshing with a gear 56 carried by a shaft 57, on which shaft is mounted the movable member of a distributer 58, the other member of which is provided with six binding-posts 59, from which wires lead to spark-plugs in the several cylinders, and which is arranged to permit shifting it angularly about shaft 57 between narrow limits, in order to adjust the lead of the spark, by any suitable operating mechanism connected thereto and extending to a position convenient for the operator.

The operation of the engine will now be described. In order to start the engine, the operator turns lever 48 on its pivot to the position shown in dotted lines in Fig. 2, thus moving the lifter-shaft 42 axially by means of the rack 45 and sector 46. In moving the lever 48 in this manner, the projection 48′ thereon engages the stem 28 of the master air-valve, thus opening the valve and admitting compressed air from the reservoir 26, through pipe 22 and branch-pipes 21, to the air inlet-valves. When the lifter shaft 42 and the lifters thereon are shifted in this manner, the roller 44 on one of the three lifters for the compressed-air inlet-valves 23 is engaged by a raised portion 54 on one of the cams 40 and is raised thereby, the beveled sides of the roller and raised portion facilitating this, and the lifter being raised in this manner actuates its valve-stem 24 to open the compressed air inlet valve 23 of one of the three cylinders 1, 3 and 5. The air admitted to the cylinder acts on the piston thereof to turn the engine-shaft and the gearing between the engine-shaft and the cam-shaft causes the latter to rotate so that another cam 40 actuates its valve 23 and compressed-air is admitted to another one of the three cylinders as soon as the piston thereof begins a down stroke. The movement of the lifter-shaft 42 by lever 48 carries the lifters for the exhaust-valves into position for them to be operated by both of the raised portions 52 and 53 on the cams 41. As the raised portions 52 and 53 of the exhaust valve cam for a cylinder are angularly displaced from the raised portions 54 on the cam 40 for the air inlet-valves of that cylinder by 90 degrees, the exhaust outlet-valve will be opened on each up-stroke of the piston, in order to permit during the up-stroke the exhaust of the air which by its expansion acted on the piston on the down-stroke. The admission of compressed air to the three cylinders successively thus starts the engine and brings it up to speed in a very few revolutions, the engine running as a two-cycle air motor, and at the same time the other three cylinders draw in charges of gas which are exploded and exhausted in the usual manner and assist in starting the engine. The operator then throws the handle 48 to the position shown in full lines in Fig. 2, thus moving the lifter-shaft 42 to such a position that the rollers 44 of the lifters for the air inlet-valves are not actuated by the raised portions on the cams 40 and the rollers on the lifters for the exhaust-valves are operated by only the raised portions 52 of the cams 41. The engine will then operate in the usual manner in four-cycle gas-engines, the gas being admitted to each cylinder on one down-stroke

of the piston by the opening of the gas inlet-valve by suction, compressed on the up-stroke, ignited and expanded during the next down-stroke, and the products of combustion exhausted from the cylinder on the up-stroke by the opening of the exhaust-valve 16 by the raised portion 52 of cam 41.

In order to reverse the direction of rotation of the engine-shaft, the engine is brought to rest in the usual manner and the operator moves the lever 38 to the position shown in dotted lines in Fig. 2. By means of the links 37 and the ring 36, this operates to move the bushing 34 axially of the cam-shaft 29, and by means of the spirally-formed keys on the end of the cam-shaft extending into spiral keyways in the bore of the bushing, this movement of the bushing rotates the cam-shaft through a definite angle, preferably ninety degrees. This movement of the cam-shaft, however, is effected independently of the engine-shaft and without in any way affecting the gearing by which the engine-shaft drives the cam-shaft, as the keys on the interior of the sleeve 35, extending into keyways on the exterior of bushing 34, which are parallel to the axis of the cam-shaft 29, maintain the driving relation of gear 32 to the cam-shaft. The engine may then be started in the opposite direction as before by throwing lever 48 to the position shown in dotted lines, but in this position of the cam-shaft 29 the raised portion 54 of the air-inlet cam 40 which raises the lifter 43 when lifter-shaft 42 is moved axially, is the one corresponding to the cylinder whose piston is in such a position therein that the admission of compressed air to the cylinder will start the engine in the desired direction. As soon as the engine comes up to speed, the starting-lever 48 is thrown back to its normal position and the engine is run in the reverse direction as a four-cycle gas-engine. It will thus be seen that the engine is started by the movement of a single lever, holding the lever in the position to which it is moved for a few seconds and then moving it back to its initial position, the two positions of the lever being indicated by the notches in the sector 49. This movement of the lever operates to admit compressed air to the cylinder whose piston is in position to start the engine in the desired direction and as the cam shaft is rotated by the engine shaft air is admitted to three cylinders successively as their pistons begin down strokes. This is true for either direction of rotation of the engine. The reversal of direction is effected by a single movement of lever 38 which turns the cam-shaft on its axis ninety degrees relatively to the engine shaft. When the cam-shaft is in this relation air for starting would be admitted first to the cylinder whose piston is in the position for starting in the desired direction and then to all three cylinders successively as before as their pistons begin down strokes and the exhaust valves would be operated at the proper times both during starting and normal running to exhaust the air and the products of combustion to the atmosphere. When the engine is started in the same or reverse direction soon after stopping it would be unnecessary in many cases to use the compressed air, but whenever the engine does not start of itself the compressed air devices can be quickly brought into operation.

Having described my invention, what I claim is:

1. In an internal combustion engine, a plurality of cylinders, a gas inlet and exhaust outlet for each cylinder, air inlets for certain of said cylinders, valves for said inlets and outlets, a cam shaft driven by the engine shaft, a pair of cams on said shaft for each cylinder provided with an air inlet, each of said cams having two raised portions, a lifter for each cam, the lifter for one cam of each pair being adapted to actuate the air inlet valve and the lifter for the other cam being adapted to actuate the exhaust valve of the corresponding cylinder, means for moving the lifters simultaneously into position to be actuated by both the raised portions on the air-inlet and exhaust cams corresponding thereto, means for moving said lifters simultaneously into such position that the air-inlet cams do not operate their lifters and only one of the raised portions on each of the exhaust cams operates its lifter, and means for rotating said cam shaft through a predetermined angle relatively to the engine shaft to reverse the direction in which the engine shaft is driven, substantially as set forth.

2. An internal combustion engine having a plurality of cylinders, a gas inlet and exhaust outlet for each of said cylinders, an air inlet for each of a plurality of cylinders less than the whole number, a valve for each of said inlets and outlets, a pipe for compressed air connected to each of said air inlets, a master-valve in said pipe, a cam shaft driven by the engine shaft, cams on said cam shaft, means for rotating said cam shaft through a predetermined angle relatively to the engine shaft to reverse the direction in which the engine shaft is driven, and means for simultaneously opening said master-valve and effecting a relative movement of said air inlet valves and the cams therefor to cause operation of said air inlet valves as the cam shaft is rotated, substantially as set forth.

3. An internal combustion engine having a plurality of cylinders, a gas inlet and exhaust outlet for each of said cylinders, an air inlet for each of a plurality of cylinders

less than the whole number, valves for said inlets and outlets, two shafts extending parallel to the engine shaft, cams on one of said shafts for operating the exhaust and air inlet valves, each of said cams having two raised portions, gearing between the engine shaft and said cam shaft, means for turning the cam shaft through a predetermined angle relatively to the engine shaft to reverse the direction in which the engine shaft is driven, means for moving the second of said two shafts axially, means operated when said second shaft is in one position for causing both raised portions on each of said cams to operate its corresponding valve, and means operated when said second shaft is in another position for rendering said cams controlling the air inlet valves and one of the raised portions on each of the cams controlling the exhaust valves inoperative, substantially as set forth.

This specification signed and witnessed this 21st day of December, 1905.

JOSEPH A. NICKELSON.

Witnesses:
I. McIntosh,
E. C. Kucker.