S. A. REEVE.

INTERNAL COMBUSTION MOTOR APPARATUS.

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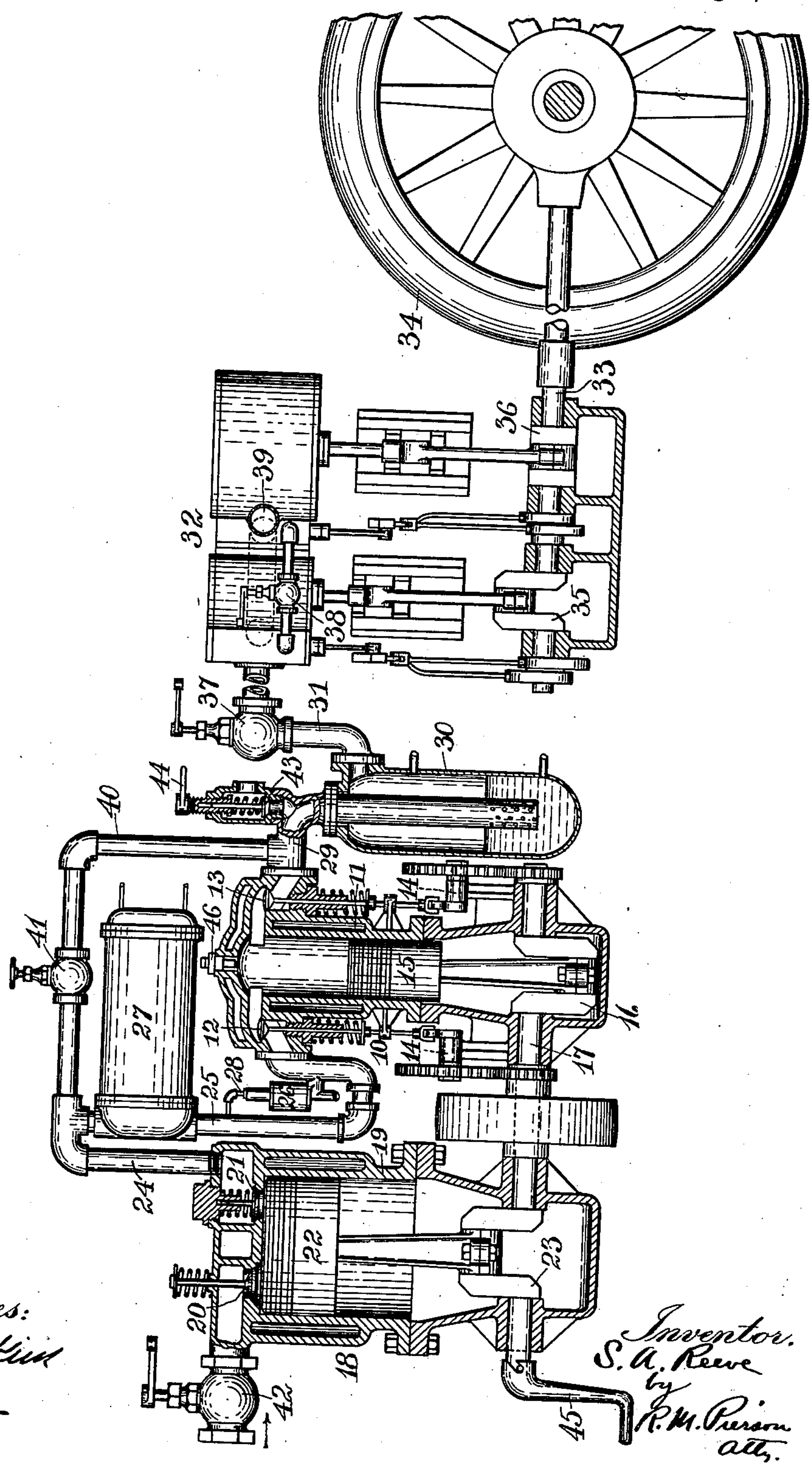
999,873.

Patented Aug. 8, 1911.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION-MOTOR APPARATUS.

999,873. Specification of Letters Patent. **Patented Aug. 8, 1911.**

Application filed December 22, 1906, Serial No. 349,019. Renewed December 30, 1910. Serial No. 600,088.

To all whom it may concern:

Be it known that I, Sidney A. Reeve, a citizen of the United States, residing at Worcester, in the county of Worcester and State of Massachusetts, have invented certain new and useful Improvements in Internal-Combustion-Motor Apparatus, of which the following is a specification.

This invention relates to internal-combustion engines, and particularly to a system embodying a prime mover adapted to furnish a compressed elastic fluid for transmission through a conduit to a receiving motor disconnected from the prime mover and furnishing power to the driven element.

The object of the invention, generally speaking, is the attainment in an internal-combustion system of increased flexibility of power-transmission combined with improved regulation and a high efficiency in the utilization of fuel.

In its preferred form my invention involves the employment of an internal-combustion prime mover such as an explosion-engine performing the final stage of a plural compression and the initial stage of a plural expansion, together with an external air-compressor driven by the prime mover and a disconnected taker-engine which performs the final stage or stages of the expansion and which may also at times use a portion of the compressed air which has not participated in combustion.

The invention is particularly adapted for automobile propulsion since it dispenses with the change-gearing commonly employed with automobile motors of the explosion type, but it is also useful for stationary and marine plants.

The accompanying drawing represents a diagrammatic view showing a motor system embodying my invention, with parts of the apparatus in section.

The drawing indicates an internal-combustion prime mover 10 of the four-stroke-cycle explosion type, having a cylinder 11 with admission and exhaust valves 12, 13 operated from a half-speed shaft 14 and piston 15 connected with a crank 16 on a crank-shaft 17.

46 is an electric igniter in the combustion-space of the cylinder.

The shaft 17 is continued as the crank-shaft of an air-compressor 18 having a cylinder 19 with automatic admission and discharge valves 20, 21 and piston 22 connected with a crank 23 set at 180° from the crank of the prime mover or "exploder" 10. The discharge-pipe 24 of compressor 18 is continued to form the admission-pipe 25 of exploder 10 and in this line is interposed a carbureter 26 and an intercooler 27. The carbureter may be of the ordinary float-feed type for volatile fuels such as gasolene, with a pipe 28 leading to its float-chamber to carry the compressor discharge pressure to the surface of the fuel in the float chamber, said fuel being pumped into the carbureter under pressure. The intercooler 27 is of any suitable kind employed with plural-stage compressors and its office is to reduce the temperature of air-compression to a degree which will avoid preignition of the combustible mixture of air and fuel-vapor which issues from the carbureter 26. This compressed mixture passes the exploder inlet-valve 12 into the cylinder 11 and is there given a second stage of compression on the compression stroke of piston 15 and exploded in the usual manner, being then discharged past the exhaust-valve 13 into the exhaust-pipe 29 on the exhaust stroke of said piston.

The exploder exhaust-pipe 29 leads into a cooling-chamber 30 in the lower part of which a pool of water is maintained by suitable means at a constant level, and in passing through the water in this chamber the hot exhaust has its high-temperature heat converted into steam-heat, the resulting mixture of steam and burned gases passing out through a pipe 31 into the taking or receiving motor 32 whose crank-shaft 33 is connected with the element to be driven, such as the ground-wheel 34 of an automobile vehicle. Motor 32 may be of the steam-engine type and I have shown a reversible compound-engine with cranks 35, 36 at 90°. Any other suitable type of taker-engine may however be employed.

37 is the throttle-valve in the inlet line of the taker-engine 32 and 38 is a live-steam low-pressure by-pass inlet-valve for starting purposes.

39 is a final-exhaust-pipe.

40 represents a compressed-air by-pass pipe leading direct from the compressor-

discharge line 24, 25 into the exploder-exhaust line 29, 31, and containing a stop-valve 41 whereby it may be put out of use if desired.

42 is an intake throttle-valve in the admission line of the air-compressor 18.

In the exploder-exhaust-pipe 29 is a spring-loaded escape-valve 43 affording an outlet for the exploder exhaust when the taker-engine 32 is not running, said valve having a spring-tension adjuster 44.

In operation the air-charge drawn into the compressor cylinder 19 is expelled into the compressor-discharge-pipe 24 at a pressure which depends upon the relation between the initial pressure in the compressor-cylinder and the fluid resistance in the discharge-pipe 24. On the admission-stroke of piston 15 the exploder 10 takes in a cylinder-full of this air which has become charged with fuel-vapor in combustible proportions in the carbureter 26, and on the succeeding compression-stroke of said piston the explosive charge is compressed in a further stage to a pressure depending upon the admission-pressure and the relation between the initial and final volumes attained in cylinder 11. The maximum compression-pressure will ordinarily be quite high, for if the first stage is, say, six atmospheres absolute, and the final stage is in the same ratio, the ultimate compression-pressure will be thirty-six atmospheres or five hundred and forty pounds absolute, and consequently the explosion pressure will be very greatly in excess of that ordinarily attained in single-cylinder engines. For this reason the exploder should be of comparatively-small diameter and robust construction. Such form of general construction and of mechanical connection between the exploder and compressor should be adopted as will involve the best balance and the minimum of friction losses which are naturally engendered by the high pressures handled. I do not restrict myself in this regard and have merely shown that form of compressor-and-exploder unit which most simply and clearly sets forth the character of the invention. The high explosion-pressure obtainable permits the development of a large proportion of the total power by a final expansion in the taker-engine 32. If the taker-engine is a compound one as shown, the total expansion embodies three stages, one in the exploder 10 and two in the taker 32, but this final compounding is useful mainly for the purpose of avoiding dead-centers in the taker-engine.

The heat-conversion between expansion stages, while perhaps not essential, I regard as very important for the best results, because much of the heat-value remaining in the exploder-exhaust, which on leaving the exploder is in an evanescent high-temperature form, is saved and used as steam-heat in the taker, and the transmission, without great heat loss, of the exploder-exhaust to a taker which may be at a considerable distance from the prime mover, is thus made possible.

This system as shown is capable of two different methods of regulation according to whether, on the one hand, the compressor intake-throttle 42 or some equivalent method of reducing compressor performance, or on the other hand, the by-pass 40 for disposing of excess air non-combustively, be employed. It is proposed to run this system in many instances under a variable pressure, and it will be apparent that if the compressor intake-throttle 42 be left wide open so that the compressor delivers the same quantity of compressed air at each stroke, this air, if the delivery pressure be low, will not all of it enter the explosion-cylinder 11 on the admission-stroke of the latter's piston, because said cylinder is a meter of fixed volume per stroke, and at low pressures the volumes delivered by the compressor are not sufficiently compact. To dispose of the excess air the stop-valve 41 in by-pass 40 is opened and the excess passes on into the taker-engine 32 unburned, or out through the escape-valve 43 when the taker is not running. This by-passing of air (which might be made a through-passing by holding the admission and exhaust valves 12, 13 open at the same time) affords a highly useful regulating result in that it tends to automatically increase the power of the exploder 10 as the resistance of the taker 32 increases, or in other words the harder the taker 32 resists (as in climbing a grade in an automobile) the harder the exploder pushes through the fluid-transmission medium, for the compressor delivery being constant and divided between the explosion-cylinder 11 and the by-pass 40, the explosion-cylinder will get a greater proportion of the total air, carburized, as the back-pressure in the line 29, 31 increases. The limit of this power-increase is reached when the pressure becomes so high that all of the air delivered by compressor 18 in two working-strokes is admitted to the explosion-cylinder 11 in one admission-stroke of the latter. The limit of power of the apparatus is then reached and if motor 32 then fails to overcome its mechanical resistance the machine is overloaded.

By closing the by-pass 40 and adjusting the power of the exploder with the compressor-intake-throttle 42, a simple alternative method of regulation is afforded and the exploder 10 burns all of the air which it compresses.

In starting the exploder-compressor unit when the taker-engine 32 is at rest, the prime mover may be cranked with a starting handle 45 and will gradually accumulate pressure from atmospheric up to an exhaust pressure determined by the set of the loaded valve 43, whereupon the exhaust escapes to the atmosphere through said valve. As stated, the standard of escape pressure may be varied with the spring-adjuster 44, this loaded valve affording a resistance equivalent to that of the taker 32 when the latter is in operation. The natural tendency of the exploder-and-compressor unit is to gravitate toward the maximum pressure determined by the escape-valve 43, this tendency being due to the fact that the compressor 18 delivers fixed quantities at each stroke with any fixed adjustment of the intake-throttle 42. Any resulting tendency to stall the exploder 10 before it has accumulated a certain power from the rise in its admission pressure may be overcome during this starting operation by manipulating the throttle 42 or using any of the standard devices for diminishing the output of a compressor at low load and thus diminishing its resistance.

The system which I have described possesses all the flexibility of power-transmission characteristic of pure-compressed-air transmission, while it is considerably more efficient and capable of manual or automatic regulation. It will be understood that various forms of explosion-engines may be used as the prime mover, and in fact I do not wholly confine myself to burning the fuel explosively, although of the various types of internal-combustion motors I prefer the internal-compression explosion type for reasons already set forth. This type of motor when located at the apex, so to speak, of a compound-compressing and compound-expanding cycle constitutes together with its associated members for performing the low-pressure compressing and expanding functions and cooling the charge, a motor apparatus which I believe to be new and have claimed in a separate application Serial No. 267,719.

I am aware that it has been proposed to operate dissevered motors of the impact or turbine type by the exhaust of an ordinary explosion motor and I do not include this within my invention. Only a small proportion of the total power, however, can be obtained from such an exhaust-operated motor and it is necessary to transform the pressure of the exhaust from the explosion motor into longitudinal velocity of the gases. The turbine must operate under very high peripheral speed. This practice is not adapted to the use of pressure or reciprocating dissevered motors operated by the exhaust, since the ordinary explosion motor, as is well known, cannot work under any considerable back-pressure. The exhaust-operated turbine may be considered in the nature of a waste-heat utilizer or addendum and its use does not vary the cycle of the explosion engine.

My present invention may be further explained by considering that its dissevered taker performs the lower stage of an interrupted expansion and that the exhaust of the high-pressure expander still contains some of the energy of the working air imparted by mechanical compression. In the familiar Otto engine which expands only to the original volume which the charge had before compression, the energy of the gases escaping from the exhaust in form of pressure above the atmospheric is due wholly to combustion-heat and represents the residue of such heat which has not been otherwise lost or converted into work. If the exploded gases in the cylinder were cooled to atmospheric temperature just before exhaust they would possess no pressure above the atmosphere. It is evident from the accompanying drawing that my engine, when embodied in the explosive type, has a high-pressure exhaust which even if no combustion heat were added would be in excess of the atmospheric pressure, the combustion-cylinder being smaller than the external compressor. In thus interrupting the expansion process it is desirable, in order to obtain plenty of power in the taker without making it unduly large or highly-speeded, to adopt measures for considerably increasing the maximum pressure so as to make good the inevitable losses and leave the high-pressure expander able to do all the compressing. These measures may be of various kinds and I have described the expedient of intercooling the compression in order to substantially raise the pressure of preignition.

I of course obtain considerable benefit from the residual heat of combustion remaining in the charge at the time of high-pressure exhaust as such heat raises the pressure and increases the capacity of the compressed charge for doing work. The reduction of temperature and generation of steam effected in the cooling-chamber 30 or by any equivalent method constitutes a useful measure for transmitting the working substance from one stage to the other of the interrupted expansion through a considerable distance without such loss of temperature and pressure as the gases would undergo if transmitted at their exhaust temperature.

I claim:—

1. The combination of an internal-combustion prime-motor device operating under a relatively-high pressure, an external air-compressor driven by said motor and adapted to charge the same at a relatively-lower pressure, a mechanically-separate power-delivering motor operated by the pressure of the exhaust from said prime motor, and means to pass compressed air unburned

from said compressor to said power-delivering motor.

2. A motor apparatus comprising an internal-combustion high-pressure prime-motor device, a low-pressure external air-charging compressor driven by said prime-motor device, a mechanically-separate low-pressure expansion-motor supplied by the exhaust from said prime-motor device, and means for passing low-pressure compressed-air unburned from said compressor to said low-pressure motor during the charging period of the high-pressure motor device.

3. A motor system comprising an internal-combustion high-pressure prime motor device having means for measuring predetermined volumes of charge, an external low-pressure air-charging compressor mechanically driven by said device, a mechanically-separate low-pressure expansion motor operated by the pressure of the exhaust from said prime-motor device, and means for passing per cycle of said prime-motor device, unburned, from the air-compressor to the low-pressure motor, volumes of compressed air variable according to the charging pressure.

4. The combination of an explosive motor adapted to finally compress the charge in its combustion cylinder and to exhaust against a back pressure, means to initially compress the air-charge outside of said motor, a mechanically-separate low-pressure motor operated by the exhaust from said explosive motor, and means to pass compressed air unburned from the initial-compressing means to the low-pressure motor.

5. The combination of a high-pressure explosive motor whose combustion cylinder on alternate pairs of piston strokes is a final charge-compressor and an initial expander adapted to exhaust against a back pressure, a first-stage air-compressor mechanically driven by said explosive motor and adapted to charge the latter against the exhaust back-pressure, a mechanically-separate low-pressure motor operated by the exhaust from said explosive motor, and means for by-passing compressed air unburned from the first-stage compressor to the low-pressure motor.

6. A motor apparatus comprising an internal-combustion high-pressure motor device adapted to exhaust against a back pressure, an air compressor mechanically driven by and adapted to charge said high-pressure motor, a mechanically-separate low-pressure motor operated by the exhaust from said high-pressure motor, an air by-pass conduit connecting the compressor with the low-pressure motor, and a stop-valve adapted to open and close said conduit.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses, the seventh day of December, 1906.

SIDNEY A. REEVE.

Witnesses:
R. M. Pierson,
G. Blake.