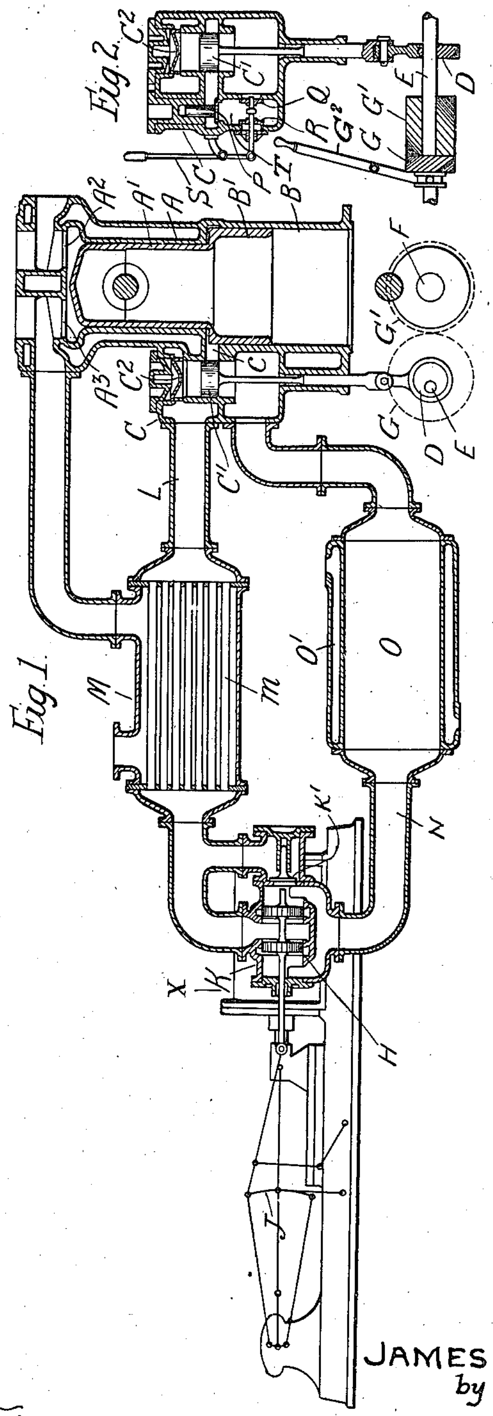
J. DUNLOP.

APPARATUS FOR TRANSMITTING POWER.

APPLICATION FILED APR. 30, 1909.

965,285. Patented July 26, 1910.



WITNESSES:

W. H. Berrigan

Alfred R. Anderson.

INVENTOR,

JAMES DUNLOP,

by F. Van Oldenneel

Attorney.

UNITED STATES PATENT OFFICE.

JAMES DUNLOP, OF DENNISTOUN, GLASGOW, SCOTLAND.

APPARATUS FOR TRANSMITTING POWER.

965,285. Specification of Letters Patent. Patented July 26, 1910.

Application filed April 30, 1909. Serial No. 493,155.

To all whom it may concern:

Be it known that I, JAMES DUNLOP, a subject of the King of the United Kingdom of Great Britain and Ireland, and residing at Dennistoun, Glasgow, Scotland, have invented a certain new and useful Improvement in Apparatus for Transmitting Power, of which the following is a specification.

This invention relates to apparatus for transmitting power by means of compressed air in a closed circuit, the invention, although applicable in connection with engines of other kinds, having for its primary object to provide improved means for enabling constantly running internal combustion engines to be used for variable and intermittent work, *e. g.*, for operating locomotives, rolling mills, ships' machinery and the like.

The said apparatus is designed to work with air initially compressed to a relatively high pressure, *e. g.*, about 150 lbs. per square inch—the higher the pressure the greater the economy.

The primary elements constituting a complete installation according to the invention are:—An internal combustion engine; an air compressor; valve actuating mechanism for the compressor, and a compressed air motor.

Figure 1 of the accompanying drawing is a diagrammatic view showing by way of example an installation embodying the invention: Fig. 2 is a section through the valve chest of the air compressor.

Referring to the drawing, A and B are cylinders of an internal combustion engine and air compressor respectively, disposed end to end and combined integrally with one another. The corresponding pistons A′ and B′, which are single acting, are also in one, the compressor piston B′ being formed by an annular shoulder projecting from the engine piston A′ so that the two perform their working strokes in opposite directions.

A^2 and A^3 are respectively the inlet valve opening and the exhaust valve opening of the engine.

The inlet or distribution valve of the air compressor is constituted by a piston C′ fitted to reciprocate in a chamber C over a port *c* connecting the chamber C with the cylinder B: the air delivery valve C^2 is of the automatic type.

The valve gear comprises an eccentric D fixed on a valve shaft E, the angular position of said eccentric D relative to the throw of the engine crank shaft F being capable of alteration through a range of 180° by the operation of skew gears G, G′, of different width, the narrow wheel G being connected to a handle G^2 and being movable endwise and feathered on the valve shaft E and meshing with and receiving motion from the wider wheel G′ which is fixed on the cank shaft F, so that when said narrow wheel G is moved longitudinally it is also constrained to make an angular movement and moves therewith the eccentric D.

As will appear from the drawing, when the eccentric is set at 90° behind the throw of the crank as shown in Fig. 1, the compressor draws in a full stroke volume of air for compression: but when the eccentric is 90° in advance of the crank the compressor does not compress any air and, consequently, will do no useful work. According to the relative angular positions of the eccentric and the crank-shaft any volume of air from full-stroke volume to zero may be admitted to the compressor cylinder, so that by suitable variation of such relative positions the power and speed of the compressed air motor may be regulated in accordance with the demand.

The distribution valve H for the compressed air motor X is of the piston type and is actuated by means of a link motion in which the curved link J is concave toward the crank shaft of the motor, affording two positions for the slide block within the link at which the motor can be operated, namely the end positions of the block within the link, so that, when the sliding block which engages the slot in the link J is in one of the extreme positions, the motor will run in a forward direction, but, when the block is moved to the other end of the slot in the link J, the direction of rotation of the motor will be reversed. The distribution valve H is shifted from the position of full operation when the said block is moved away from either of the two extreme positions, and when said block is in a position midway between the two ends of the slot in the link J, the valve H is moved so far to the right hand side of the air motor valve chamber K that a by-pass valve K′ of the mushroom type is opened and thereby allows escape of the compressed air from the inlet side to the exhaust side of

the air motor without any work being done inside the motor cylinder.

In order to prevent loss of heat by the air in its passage from the compressor cylinder to the compressed air motor cylinder, or, if desired, to further heat the air, a heater may be interposed in the course of the pipe L from the chamber C. This heater, in the construction illustrated, is composed of tubes *m* traversing a chamber M through which chamber the exhaust gases from the cylinder A of the internal combustion engine are caused to pass.

For the purpose of securing increased efficiency, a cooler may be interposed in the course of the pipe N whereby the air is returned to the compressor. The said cooler is, in the construction illustrated, in the form of a chamber O surrounded by a water jacket O′.

The initial charging of the circuit with air at any pre-determined pressure is effected in the following manner:—Alongside the piston valve C′ of the compressor is an automatic lift valve P forming a supplementary inlet valve which controls communication between the clearance space of the air compressor and the chamber T: below said valve P two other valves Q and R are fitted, and of these the valve Q controls communication between the chamber T and the return pipe of the closed circuit, while the valve R controls the opening to the atmosphere. By means of a lever S one or other of these two valves Q and R may be opened. When the eccentric D is adjusted so that it is 90° in advance of the crank on the shaft F, then the upper side of the piston valve C′ will be exposed to the clearance space of the compressor cylinder B during the whole of the downward stroke of the compressor piston B′: the air is thus prevented from entering the cylinder, except through the lift valve P. If, now, the valve R is opened, and the valve Q is closed, air at atmospheric pressure will be admitted into the compressor cylinder by way of the valves R and P. During the upward stroke of the compressor piston, the air will be discharged to the air-motor exhaust pipe N by way of the under side of the piston valve C′, and, passing through the air cooler, the compressed air motor valve chest, the by-pass valve K′ and the air heater, will finally be trapped by the air delivery valve C^2 which is situated directly over the piston inlet valve C′. This action may be continued until the whole system has become charged with air at any required pressure. The valve R may then be closed, and the valve Q opened. When this has been effected, the action of the compressor is merely to draw air from the underside of the piston valve C′ past the valve P and to discharge it again by way of the valve C′, to the underside of that valve. This is the cycle of operation when the internal combustion engine is running idle. For any other position of the eccentric, except 90° behind the crank, this action will continue to take place to a greater or less extent as the eccentric is adjusted in one direction or the other. When the eccentric is adjusted to a position 90° behind the crank, the compressor cylinder will receive a full charge at each stroke of the piston, and the whole cylinder contents will be discharged into the air heater.

The atmospheric valve R may be opened at any time while the compressor is working at less than full load, and, by such opening of the valve, any loss of air due to leakage may be compensated for.

It will be observed that the air is not worked expansively, but is admitted into the air motor cylinder throughout practically the whole length of the piston's stroke. Ordinarily, this would prove a very inefficient way of employing the air pressure, but, in the present system, the advantages which would arise from the expansion of the air within the cylinder have already been obtained by reason of the compression of the air to the desired working pressure. That is to say, in a closed circuit, compression of any one volume of air can only take place simultaneously with the expansion of an equal volume, or, in other words, the energy which is not expended in the air motor is still available in the form of pressure and temperature in the air in the return pipe to the compressor.

Having now described my invention what I claim and desire to secure by Letters Patent of the United States is:—

1. In apparatus for transmitting power by means of compressed air, the combination of an air compressor and a compressed air motor connected together in a closed circuit, an engine for driving said compressor, a crank shaft for said compressor, a valve shaft for said compressor, a valve for said compressor connected to said valve shaft, and manually operable means for varying the angular relation of said valve shaft and said crank shaft and thereby varying the time of movement of the valve.

2. In apparatus for transmitting power by means of compressed air, the combination of an air compressor and a compressed air motor connected together in a closed circuit, an engine for driving said compressor, a crank shaft for said compressor, a valve shaft for said compressor, a valve for said compressor connected to said valve shaft, skew gears in mesh with one another and in driving connection with the valve shaft and crank shaft, and manually operable means for effecting relative displacement of said gears in axial direction so as to vary the

angular position of the valve shaft relatively to the crank shaft and thereby vary the time of movement of said valve.

3. In apparatus for transmitting power by means of compressed air, the combination of an air compressor and a compressed air motor, inlet and outlet pipes connecting the compressor and the motor in a closed circuit, an engine for driving the air compressor, an air heater on the outlet pipe comprising a chamber connected to the exhaust side of said engine and having a passage for the air, an air cooler on the inlet pipe, a crank shaft for said compressor, a valve shaft for said compressor, a valve for said compressor connected to said valve shaft, and manually operable means for varying the angular relation of said valve shaft and said crank shaft and thereby varying the time of movement of the valve.

4. In apparatus for transmitting power by means of compressed air, the combination of an air compressor, an engine for driving said compressor, a compressed air motor, inlet and outlet pipes connecting the compressor and the motor in a closed circuit, a valve for controlling the delivery of compressed air by said compressor to the circuit, manually operable devices for moving said valve, a distribution valve for said motor, a by-pass between said outlet and inlet pipes, a valve normally serving to close said by-pass, and actuating mechanism for said distribution valve adapted at will to simultaneously shift the distribution valve and open the by-pass valve.

5. In apparatus for transmitting power by means of compressed air, the combination of a compressed air motor and an air compressor connected together in a closed circuit, an engine for driving said compressor, a valve for controlling the delivery of compressed air by the compressor to the circuit, manually operable devices for moving said valve, a distribution valve for said compressor, means for reversing the functions of the distribution valve, and a supplementary inlet valve for said compressor adapted to be automatically operated at such times as the distribution valve is in a position at which less than the full stroke volume is compressed by the compressor so as to maintain the pressure in the compressor cylinder equal to the pressure on the exhaust side of the motor.

6. In apparatus for transmitting power by means of compressed air, the combination of an air compressor, and a compressed air motor connected together in a closed circuit, an engine for driving said compressor, a valve for controlling the delivery of compressed air by said compressor to the circuit, manually operable devices for moving said valve, a distribution valve for said compressor, a chamber located adjacent the inlet of the compressor, a supplementary inlet valve controlling communication between said chamber and the clearance space of the compressor, and manually operable valves serving to control communication between said chamber and the atmosphere and between said chamber and the return pipe of the circuit.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JAMES DUNLOP.

Witnesses:

WALLACE CRANSTON FAIRWEATHER,

JOHN MCCLEARY, Jr.