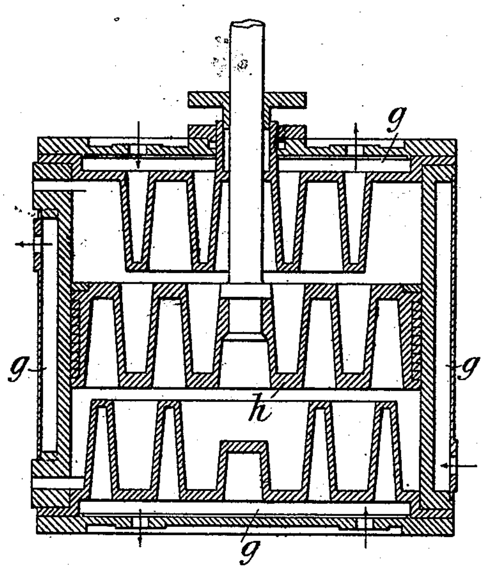
(No Model.) 3 Sheets—Sheet 1.

A. KRANK.

PRODUCTION OF MOTIVE POWER AND APPARATUS THEREFOR.

No. 501,083. Patented July 11, 1893.

Fig. 1.



Witnesses

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(No Model.) 3 Sheets—Sheet 2.

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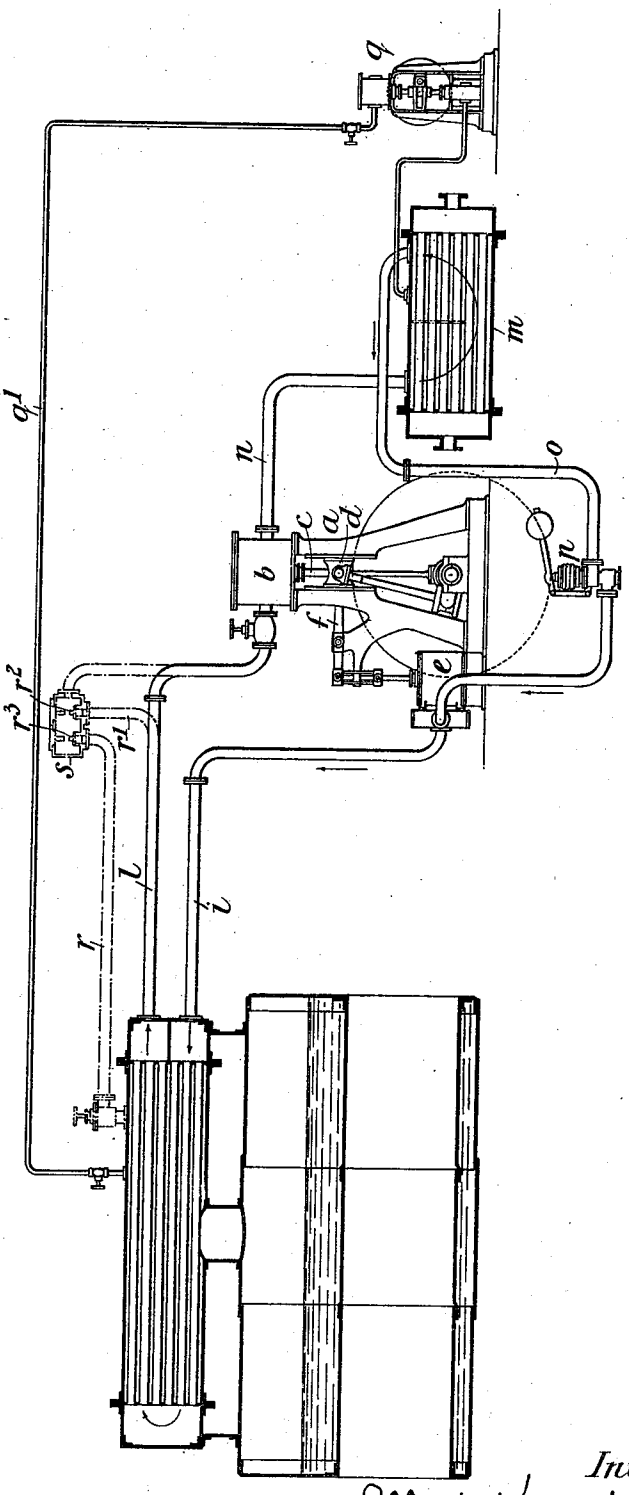

Fig 2.

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(No Model.) 3 Sheets—Sheet 3.

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Fig. 3

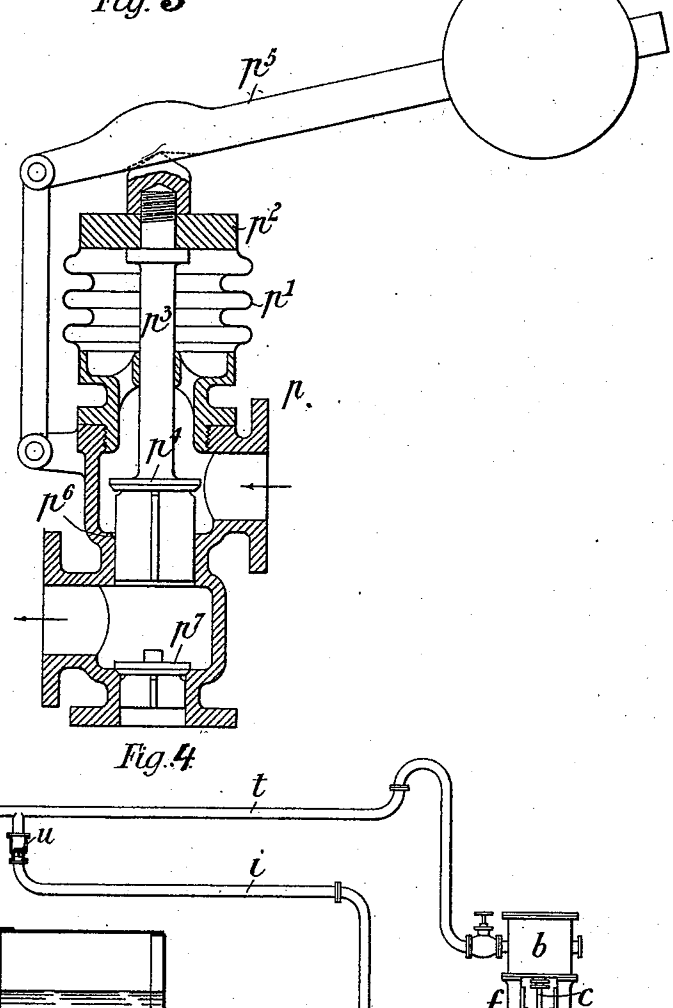
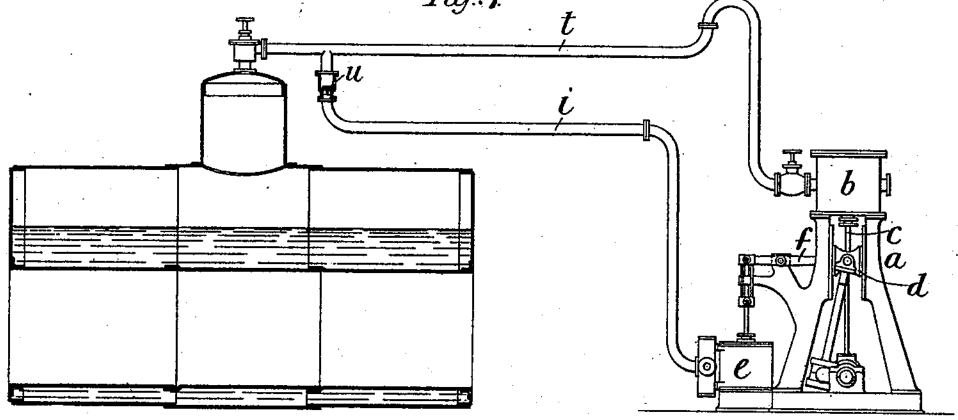


Fig. 4



Witnesses.

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UNITED STATES PATENT OFFICE.

ALBERT KRANK, OF TAIPALE, RUSSIA.

PRODUCTION OF MOTIVE POWER AND APPARATUS THEREFOR.

SPECIFICATION forming part of Letters Patent No. 501,083, dated July 11, 1893.

Application filed January 26, 1892. Serial No. 419,346. (No model.)

To all whom it may concern:

Be it known that I, ALBERT KRANK, a subject of the Emperor of Russia, residing at Taipale, Finland, Russia, have invented certain new and useful Improvements in the Production of Motive Power and in Apparatus Therefor, of which the following is a specification.

My invention has for its object to utilize more effectively and economically than heretofore the power produced by the heating and consequent expansion of air or other permanent gas, and, in carrying out my invention I compress the air or other gas previous to heating the same, abstracting the heat which is produced during the compression so that the air is delivered to the heater in a cool condition whereby it is capable of taking up more heat and thus of greater expansion than if delivered to the heater in a warm state, and I thus practically reduce to a mimimum the power necessary for effecting the compression.

To enable my invention to be fully understood I will describe how it can be carried into practice by reference to the accompanying drawings, in which—

Figure 1 is a sectional view drawn to an enlarged scale cf the air-compressing pump which I advantageously employ. Fig. 2 is a view showing the general arrangement of apparatus which I employ with advantage when the compressed air is heated by means of steam; and Fig. 3 is a sectional view of a valve drawn to an enlarged scale and hereinafter described. Fig. 4 is a view showing an arrangement of apparatus suitable for use when the compressed air is heated by mingling it with steam.

Similar letters of reference indicate corresponding parts in the several figures.

a indicates a vertical engine of ordinary construction having the cylinder *b*, the piston rod *c* and the cross-head *d*.

e indicates an air-pump or compressor which in the drawings is represented as being operated by means of a beam *f* pivoted at a point intermediate of its ends upon the frame-work of the engine, and at one end connected to the piston-rod of the compressor, the other end being connected to the cross-head *d* of the engine, so that, as the said cross head reciprocates, a corresponding motion will be imparted to the piston of the air-pump.

In order to abstract the heat from the air during the compression thereof, as hereinbefore stated, the cylinder of the air compressor is surrounded by water jackets *g*, *g*; as, however, such water-jackets would not be sufficient to effectually reduce the temperature, I provide the cylinder-covers and the piston with very large conducting surfaces.

As shown in Fig. 1 the piston which is indicated by the letter *h* is provided with several wedge-shaped grooves arranged alternately upon opposite sides cf the piston, so that the said piston in central section is of a zigzag form, and upon the cylinder covers I arrange corresponding ribs adapted to enter the grooves of the piston during the reciprocations thereof as will be readily understood. As shown in Fig. 2, the ribs upon the cylinder covers are hollow so as to admit the cooling water from the jackets, but the said ribs may be made solid provided the stroke of the piston is moderate and the covers are constructed of a good conducting material such as brass.

I advantageously arrange a steam-heater which is placed outside a boiler, as shown in Fig. 2, or inside the same and provided internally with a series of tubes through which the air delivered by the air-compressor is caused to pass before reaching the engine. This heater is so arranged that, as the steam is condensed by contact with the pipes which are cooled by the incoming air, the water of condensation will flow back into the boiler. In conjunction with this apparatus I have shown a cooler or condenser *m* into which the air exhausted from the cylinder *b* is delivered through the pipe *n*, and from which the air for supplying the air compressor is drawn through the pipe *o*. In practice I prefer to exhaust the air or gas from the cylinder *b* into this cooler at a pressure above that of the atmosphere, so that the air which is pumped by the air-compressor shall have an initial pressure before the compression commences. The cooler *m* is, as shown in Fig. 3, constructed of a casing having a series of internal tubes between which the air to be cooled passes and through which water for

cooling the tubes flows. In order that, in case of leakage in the apparatus, the pressure therein should be reduced, I provide for shutting off communication between the said cooler and the air-compressor and establishing communication between the air-compressor and the atmosphere; for this purpose I provide a valve p which is arranged in the pipe o and is shown drawn to an enlarged scale in Fig. 3. This valve has at its upper part a flexible corrugated cylinder p', to the cap p^2 of which the rod p^3 of a valve p^4 is connected. A weighted lever p^5 bearing upon the top of the cap p^2 serves to normally tend to close the valve p^4 upon its seat p^6; so long, however, as there is sufficient pressure in the cooler m this pressure maintains the corrugated cylinder p' in an extended position, as shown in Fig. 4; should, however, the pressure decrease to a sufficient extent the weight of the lever p^5 would lower the valve p^4 onto its seat to cut off the communication between the cooler m and the air-compressor; a valve p^7 in this case would serve to admit air for supplying the compressor.

In order to provide for obtaining the initial pressure in the cooler m and for starting the engine I make use of a small power air-pump q which is operated by means of steam drawn from the boiler through the pipe q'. I prefer to provide for starting the engine by arranging a steam pipe r between the boiler and the engine cylinder, as indicated by dotted lines in Fig. 2. This pipe r is connected with a valve-box s, with which also the pipe l for conveying the heated air from the heater to the working cylinder is also connected by a branch pipe r'. The branch pipe r' and the pipe r are normally closed by valves r^2, r^3 respectively; with this arrangement when steam is allowed to flow through the pipe r, the valve r^3 is lifted so that the steam enters the valve box s and thence flows to the engine cylinder b, the valve r^2 preventing the entrance of steam into the air-pipe l; when, however, the air is sufficiently compressed the air-pressure lifts the valve r^2 and closes the valve r^3, thus preventing the air from entering the steam-pipe r.

In the arrangement for carrying out my invention shown in Fig. 4, it will be noticed that the air-delivery pipe of the air-compressor i communicates with a pipe t between the boiler and the engine cylinder, so that the air, as it is delivered from the pump, mingles with the steam and is thereby heated and expanded, the air condensing the steam and absorbing its latent heat. A back pressure valve u in the air pipe i prevents the entrance of steam into the said pipe.

Although I have described my invention as applied to a single acting engine it is to be understood that it is also applicable for use in connection with compound engines and, in this case, I advantageously arrange for the gases, after leaving one cylinder, to pass through an auxiliary heater before entering the next cylinder and so on as will be understood without further description.

I do not wish to be limited to the exact details of construction herein shown and described as variations may be made therein without departing from the spirit of my invention. For instance I sometimes arrange in conjunction with the heater described a second heater heated directly by products of combustion for superheating the air; also instead of using a single air compressor I may use a series of such compressors which may be either single or double acting and such compressor or compressors may be driven by auxiliary engines independent of the engines to be driven, the said auxiliary engines being operated by a part of the heated gases.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. The combination with an engine cylinder and piston, of a steam pipe connected with said cylinder, an air compressor device, a pipe connecting said air compressor with said steam pipe, an automatic valve located in said air pipe and an automatic valve located in said steam pipe whereby the pressure of the air in said air pipe will open its valve and close the valve in said steam pipe, substantially as described.

2. The combination with an engine cylinder and piston, of a steam pipe provided with a valve box having an automatic valve controlling said steam pipe, and a connection between said valve box and the cylinder, of an air compressor, a pipe connecting said air compressor with said valve box and an automatic valve in said box independent of the valve controlling the steam pipe, for controlling said air pipe whereby an excess of pressure in one of said pipes will open its valve and close the other valve, substantially as described.

3. The combination with an engine cylinder, of an air compressor, a pipe connecting said air compressor with a valve box, a steam heater interposed in said air pipe, a steam pipe connecting said heater and said valve box, said valve box having independent automatic valves for controlling the air and steam pipes, and a connection between said valve box and the cylinder whereby an excess of pressure in one of said pipes will open its valve and close the other valve, substantially as described.

4. The combination with an engine cylinder and piston, of an air compressor, a connection between said compressor and said cylinder, an exhaust pipe for said cylinder, an air cooler connected therewith, a pipe connecting said cooler with the said compressor, an automatic valve in said pipe for closing the connection with said cooler and establishing a connection between said compressor and the atmosphere, substantially as described.

5. The combination with an engine cylin-

der and piston, of an air compressor connected with said cylinder, an air cooler for receiving the exhaust from said cylinder, a pipe connecting said air cooler with said compressor, a valve casing in said connecting pipe, an air inlet pipe connected with said valve casing having communication with the open air, a valve for controlling said air inlet pipe and said connecting pipe, said valve being connected with an exhaustible portion of said valve casing for operating the valve, substantially as described.

6. The combination with an engine cylinder and piston, of an air compressor connected with said cylinder, an air heater for heating the air before its delivery to said cylinder, a cooler for receiving the exhaust from said cylinder, a connection between said cooler and said air compressor a valve casing in said connection having a connection with the outside air, said casing being provided with the expansible portion, a valve in said casing adapted to control the connections between said casing and the cooler and between said casing and the outside air, said valve being connected to the expansible portion of the casing and the weighted lever connected with said valve, substantially as described.

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