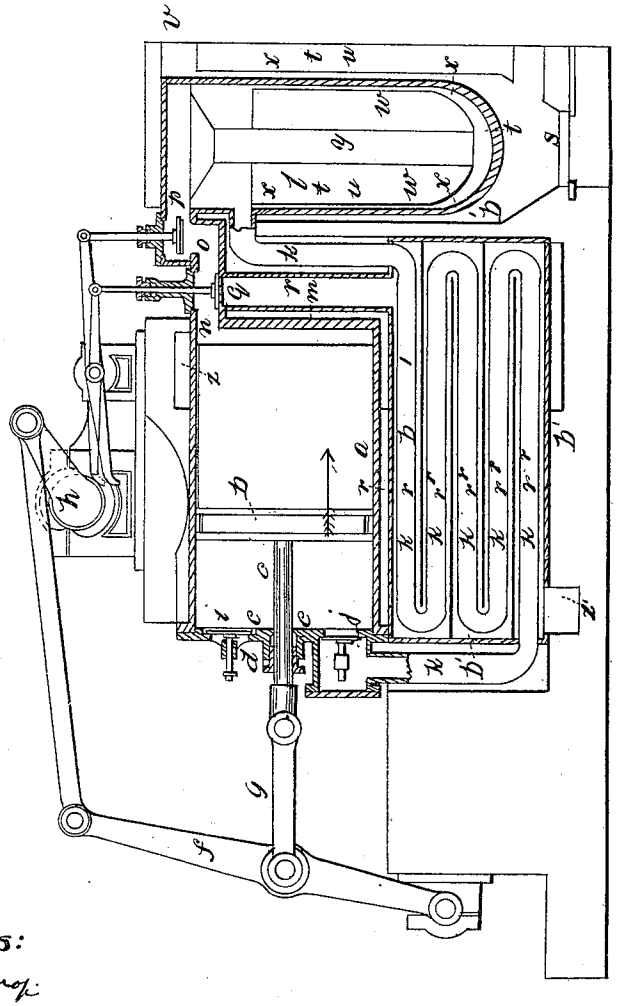
J. ERICSSON.

AIR ENGINE.

No. 14,690. Patented Apr. 15, 1856.



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JOHN ERICSSON, OF NEW YORK, N. Y.

AIR-ENGINE.

Specification of Letters Patent No. 14,690, dated April 15, 1856.

To all whom it may concern:

Be it known that I, JOHN ERICSSON, of the city, county, and State of New York, have invented a certain new and useful Improved Air-Engine; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawing, making part of this specification, which represents a sectional side elevation of my said improved engine.

The principle of economizing caloric in this engine by means of a regenerator, if one be employed, is identical with that of the air engine for which I obtained patents in England in the year 1833, and published in that year in the *Dictionary of the Arts of Life and Civilization* by Sir Richard Philips and other works. And my present invention relates to an improvement of the air engine for which I obtained Letters Patent bearing date the 31st day of July, 1855, and involves the essential features thereof such as, first dispensing with a separate supply cylinder by making the working cylinder subserve the double purpose of compression cylinder and working cylinder. Second, compressing the cold air by the direct force of the entering hot air on the opposite side of the piston. And third, causing the cold air to enter the cylinder during the inward movement of the working piston, and while the hot air is exhausting at the opposite end of the cylinder. Ample experience acquired in building air engines enabled me twenty five years ago to demonstrate that the previous method of obtaining motive power from heated air by simply transferring the air from a cold to a hot location within the engine, rendered such engine of very limited practical utility. My labors since have been devoted to the production of an air engine, which by means of a constant supply of air kept up in certain receivers would resemble in its principal operation a high pressure steam engine. I have built a variety of engines on this plan of continuous supply, and have succeeded in obtaining a satisfactory action and very rapid motion. Leakage and friction of the pistons have however proved serious defects.

The obviating of these and other defects is the object of my present invention, the leading feature of which consists in operating with one piston within a cylinder in such manner that one side of it shall compress the cold air, which on the previous stroke entered one end of the cylinder, and cause it to pass through the regenerator and heater or either, at the same time that the other side of the said piston is receiving the motive force of the heated air entering the cylinder from the opposite direction, which simultaneous operation will result in avoiding all friction on the packing of the piston other than what will be caused by the differential pressure of the hot and cold air on the opposite sides of the piston; and also that leakage through the packing of the piston will not occasion any loss of air out of the engine, as the compression on one side of the piston and the motive action of the heated air on the other side take place simultaneously at the time that all communication with the atmosphere is closed.

In the accompanying drawings *a* represents a cylinder closed at both ends except certain parts to be presently described, to which is fitted a pison *b* which may be made of considerable thickness with suitable bad conducting substance interposed between the two heads thereof, to prevent, as far as convenient, the transmission of caloric from the one side to the other. The rod *c* of the piston passes through a suitable packing box *d* in one head *e* of the cylinder, in the manner of a steam engine, and the outer end is connected with the working beam *f* by a connecting rod *g* for the purpose of imparting motion to the crank shaft *h;* or the piston rod may be connected in any other suitable manner to impart the motive power as this makes no part of my invention. As the piston moves in the direction of the arrow cold air is forced in by atmospheric pressure through a valve *i* in the head *e* of the cylinder which valve opens inward as the piston moves toward the opposite end of cylinder. In the same head *e* of the cylinder there is another self acting valve *j*, opening outward, and the port which it controls communicates with a coil of pipes *k* leading to the heater *l* so that when the piston moves in a direction the reverse of the arrow the valve *i* is closed and the air which entered this end of the cylinder is first compressed until its tension becomes sufficient to open the valve *j*, resisted by a counter pressure to be presently described, and then the air is ejected from the cylinder through the coil of pipes *k* to

the heater *l*. The moment that the piston again starts in the direction of the arrow the pressure inside of the cylinder is reduced to atmospheric pressure and the valve *j* is instantly closed by the counter pressure alluded to which cuts off, for the time being, all communication between that end of the cylinder and the coil of pipes *k* and the heater.

The opposite head *m* of the cylinder has one port *n* which opens into a channel way *o* and this channel way has two ports one governed by an induction valve *p* and communicating with the upper or discharge end of the heater *l*, and the other by an eduction or exhaust valve *q* and communicating with a passage *r* surrounding the coil of pipes. These valves may be operated by the valve gear represented in the accompanying drawing or by any suitable valve gear having the periods of motion to be described; but as the valve gear has no peculiar feature of novelty it is deemed unnecessary to describe it.

The heater *l* consists of a cylindrical, or other formed, outer casing of masonry or other suitable materials, with a furnace *s* at the bottom. Within the outer casing there is a hollow cylindrical vessel *t* suspended by its upper open end, and with its lower end of a semi-spherical form over the furnace so that the radiation from the fire below and the products of combustion may act on the outer surface thereof and as the cylindrical part of this vessel is surrounded by the flue space *u* leading to the exit pipe *v*, the heat evolved will act efficiently on the said vessel with the greatest intensity at the lower or semi-spherical end and with gradually less intensity toward the upper end. Within this vessel *t* is suspended another vessel *w* of corresponding shape, but of less size, and in like manner suspended from the upper end, leaving a passage *x* all around between the two for the passage of a thin film of air, which enters at the upper end from the coil of pipes *k*, and descends all around between the two to the bottom where it enters and passes up a central pipe *y* the upper end of which communicates with the port governed by the induction valve *p* before described. The air in thus passing in a thin film between these two vessels highly heated by the fire in the furnace, will be charged with caloric which will have the effect of greatly increasing its tensive force. But the air may be heated by means of any other suitable heater. The exit pipe *v* of the furnace flue communicates on its way to any suitable chimney with a flue *z*, *z* surrounding the working end of the cylinder to heat it, and thereby prevent the condensation of the heated air when introduced.

The manner in which cold air is admitted by atmospheric pressure, compressed, and then discharged at one end of the cylinder has already been described, as also the manner in which it is caused to pass through the coil of pipes *k* and through the heater to be heated on its way to the induction pipe *p*.

The moment the piston reaches the end of its stroke in the direction of the arrow the induction valve *p* is opened which admits the heated air to the end *m* of the cylinder to act on the piston, and to impel it, in a direction the reverse of the arrow, by the tensive force which the air acquired by the absorption of caloric in passing through the heater. The force by which the piston is thus impelled compresses the cold air on the other side of the piston which was introduced in the manner before described.

Now it will be observed that as atmospheric air is an elastic gas, when heated in the heater its increased tension acts equally in all directions and hence it will exert as much pressure against the valve *j* in the head *e* of the cylinder, to keep that valve closed, as it does on an equal area at the other end of the cylinder, so that if the valve *j* were opened the piston would be balanced between two equal pressures acting in opposite directions; but as the valve *j* is closed the tensive force of the heated air cannot act on the piston in that direction, and the induction valve *p* at the other end being open the tensive force of the heated air will act on that side of the piston and impel it toward that end of the cylinder where the valve *j* is located compressing the cold air in that end of the cylinder until the cold air is thereby compressed to a degree of tension equal to that of the impelling heated air, and then the valve *j* being balanced between two equal pressures, and the engine being continued in motion by the momentum acquired, the valve *j* will be opened, and the cold air, thus compressed, transferred to the coil of pipes, and thence in its circuit to the heater, to be heated for a succeeding operation.

Thus it will be seen that the impelling force by which the engine is impelled is equal to the difference between the pressure of the heated air exerted on the area of one face of the piston minus the gradually increasing resistance presented to the other face of the piston, of equal area, by the cold air which is being compressed, such differential force being exerted during that portion of the stroke of the piston from the beginning up to the time when the resistance of the cold air becomes equal to the tension of the heated air. With the view to economize heat, the induction valve *p* can be closed at any desired portion of the stroke of the piston to cut off the connection with the heater that the impulse may be com-

pleted by the expansion of the heated air. This is a matter to be governed by the judgment of the constructor and operator.

So soon as the piston has completed the stroke last above described, and after the induction valve has been closed, the eduction or exhaust valve q is opened that the heated air which has performed its office may be discharged into the atmosphere; but in escaping, it passes through the passage r which surrounds the coil of pipes k escaping at z into the atmosphere, and in its passage imparts its heat to the coil of pipes and to the cold compressed air within the pipes on the way to the heater, thus partially heating such air preparatory to the final heating in the heater, and thereby saving nearly all the heat not actually expended in the energy of the impulse.

This apparatus for imparting the waste heat to the ingoing, by the outgoing air, is constructed, as represented in the drawing, with the view to economize space, and expense of construction, and at the same time present a large and extended surface to the outgoing and to the ingoing air, by making several coils in the pipe k through which the air passes from the receiving end of the cylinder to the heater, and forming the passage way r, for the exhaust heated air to pass in contact with the entire outer surface of the pipe, by means of an outer casing b' surrounding the entire coil and horizontal partitions extending alternately from opposite ends and extending between the coils to within a short distance of the end thereof. The said partitions should be made of some bad conductor of caloric, such as two sheets of metal with plaster of paris interposed. But it should be observed that although I prefer to work my said engine with a regenerator, on account of economy of fuel, nevertheless it may be worked without by simply connecting the port of the valve j with the heater by a pipe for directly transferring the cold compressed air from the cylinder to the heater. In this case the exhaust valve will open directly into the atmosphere.

From the foregoing it will be seen that as the piston makes its stroke in the direction of the arrow both ends of the cylinder are opened to the atmosphere, and the piston being in equilibro no pressure will be exerted on the packing of the piston and that therefore there will be no tendency to leak and no more friction than will be due to the rubbing of the packing without pressure. And that during the impelling stroke of the piston in the opposite direction the packing will only be exposed to such friction and leakage as will be due to the differential pressure of the heated air on one side and the cold air on the other, which difference of pressure will be great only for a moment of time. And in case of any leak during the first portion of the outward stroke it will be of the hot air passing to the cold side, which will only be a transfer and not a waste, for the air thus partially heated will eventually pass through the heater to the impelling side of the piston.

It will be obvious from the foregoing that if desired the valve i for the admission of cold air, and the valve j for the transfer of the cold compressed air instead of being self-acting may be operated by any suitable valve gear; but the use of valve gears would be useless as the nature of the operations is such as may be best performed by selfacting valves. And it will be obvious that two such engines may be used together connected by a crank shaft having the cranks so arranged relatively to each other, that when one engine is impelled with its maximum force the other will be at its minimum. But for locomotives and marine purposes I contemplate the use of four such engines connected with four cranks on the driving shaft, for the development of the power of each engine will be such that when acting in succession on the circle a uniform and constant power will be applied to the shaft. The use of three such engines connected with a three throw crank on the driving shaft will very nearly approximate to a uniform and constant power, but I prefer the use of four.

What I claim as my invention in the engine for producing motive power with heated air is—

By means of a piston working within a cylinder under a mode of operation substantially such as described, performing the successive combined operations of simultaneously discharging the heated air and taking in the charge of cold air, compressing and transferring it to a regenerator and heater or either and thence to the opposite end of the cylinder to act upon and impel the piston as herein described.

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