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O. P. OSTERGREN.

METHOD OF UTILIZING THE LATENT HEAT OF STEAM IN STEAM POWER APPARATUS.

(Application filed June 19, 1900.)

(No Model.)

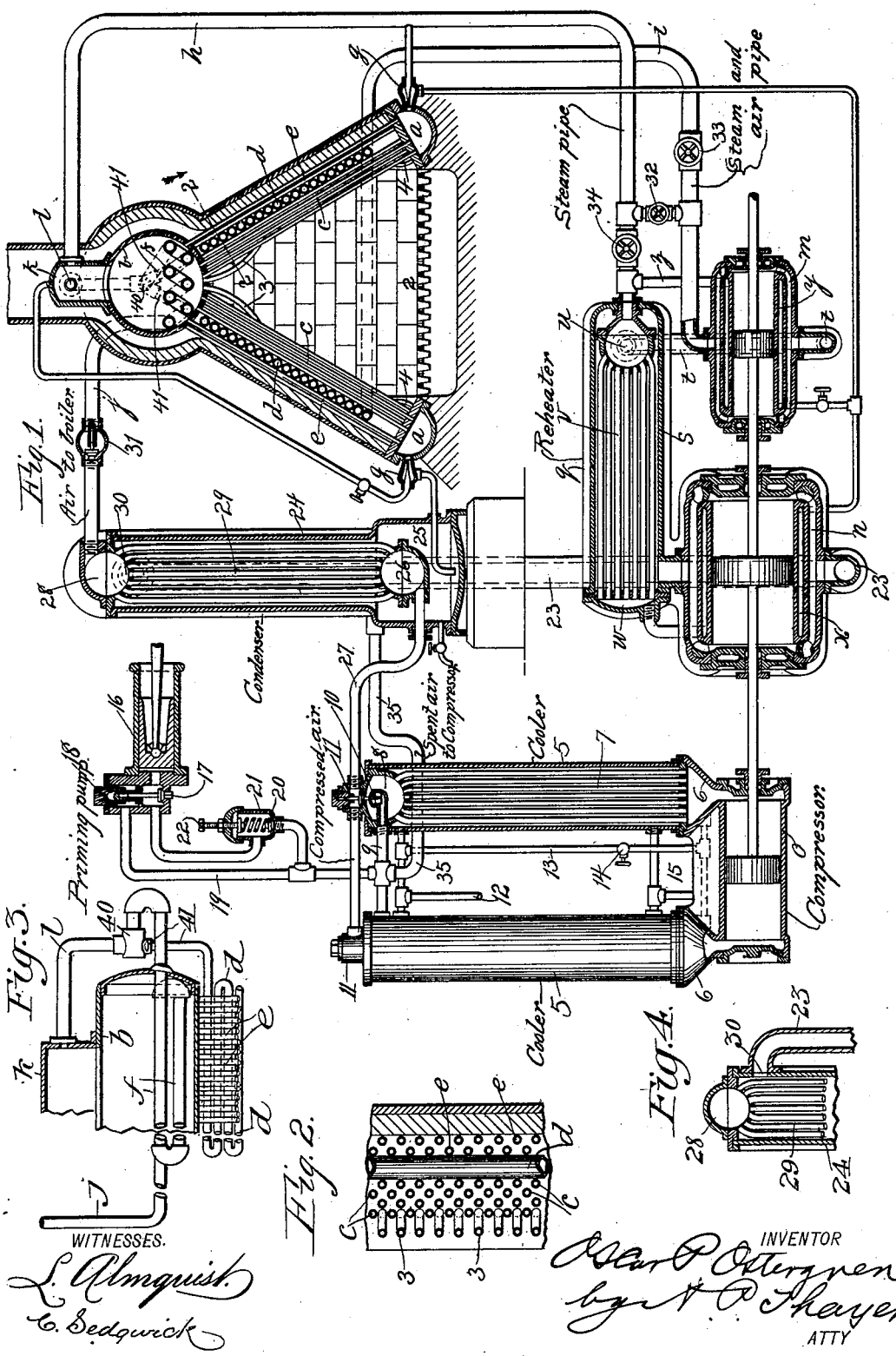

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

WITNESSES.

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METHOD OF UTILIZING THE LATENT HEAT OF STEAM IN STEAM-POWER APPARATUS.

SPECIFICATION forming part of Letters Patent No. 676,685, dated June 18, 1901.

Application filed June 19, 1900. Serial No. 20,807. (No model.)

To all whom it may concern:

Be it known that I, OSCAR P. OSTERGREN, a subject of the King of Sweden and Norway, and a resident of Bedford Park, borough of the Bronx, city and State of New York, have invented certain new and useful Improvements in Methods of Utilizing the Latent Heat of the Steam in Steam-Power Apparatus, of which the following is a specification.

My invention consists of an improved method of utilizing the latent heat of the steam for useful effect in steam-power apparatus.

Various contrivances of apparatus may be employed for carrying out the invention.

The form of apparatus that I have chosen for illustration in the present case is represented in the accompanying drawings, in which—

Figure 1 is mainly a sectional elevation of the apparatus; but some of the parts are represented in side view. Fig. 2 is a detail in section in the line 2 2, Fig. 1. Fig. 3 is a detail consisting of a vertical section through the boiler to show the pipe connections more clearly. Fig. 4 is a detail consisting of a vertical section of the upper portion of the preheater and condenser to show the connection of the exhaust-pipe of the motor-engine.

The basis of the apparatus is a steam-generator, motor-engine and compressed-air heater, air-compressor, steam-condenser, mixer of the air and steam, and preferably a superheater.

The steam-generator, air-mixer, and superheater may of course be constructed in various ways; but the most desirable form at present developed consists of the A-shaped boiler, comprising the base-drums *a*, steam-drum *b*, two sets of inclined water-tubes *c*, respectively connected at their lower ends in the drums *a* and at their upper ends connected into the steam-drum *b*, two other sets of inclined water-tubes *e*, also connected at their lower ends into the drums *a* and at their upper ends connected into the steam-drum *b*, also the two series of horizontal superheating-tubes *d*, intermediate of the tubes *c e* of each side, respectively, and also the coil of air-heating tubes *f* in the steam-drum. The tubes *c* of the inner rows are placed close together to form a baffling-wall against the hot gases from the fire-grate 2 upward nearly to the steam-drum, where the alternate tubes of said row are deflected inward, as represented at 3, for passages through said wall, and the inner rows of said tubes *c* are more openly disposed for downward passage and for direct impingement of the gases on tubes *d*, and the outer tubes *e* are also separated for upward passages. Alternate tubes of the inner rows of series *c* are also deflected inward at the bottom 4 to facilitate connection with the drums. Feed-water is injected into the drums *a* at *g* and circulates upwardly through the tubes *c* into the steam-drum and downwardly through tubes *e*. The steam-pipe *h* takes steam away from the boiler directly, and pipe *i* takes combined steam and air from the superheating-tubes *d*, the compressed air being supplied thereto from the pipe *j* through the coil *f* in steam-drum *b*, and thence into tubes *d*, and steam enters coil *f* from the steam-dome *k* at *l*.

The motor-engine is in this case a tandem compound comprising a high-pressure jacketed cylinder *m* and the low-pressure cylinder *n*, also jacketed, with an air-compressing cylinder *o* and piston directly connected on the same piston-rod.

A reheater for the exhaust-vapor from the high-pressure cylinder *m* is provided at *q* for heating said exhaust by live steam from the boiler before entering the low-pressure cylinder, which consists of the hollow cylinder *s*, receiving the exhaust from cylinder *m* through pipe *t* and containing the live-steam-receiving head *u* at one end and a multitude of tubes *v*, discharging from said head into the collecting-chamber *w* at the other end, from which the steam enters the jacket *x* of cylinder *n* through pipe *r*.

The jacket *y* of cylinder *m* is in connection with the steam-pipe *h* by the branch *z* for heating it by steam directly from the steam-drum. The water of condensation in the jackets is returned as feed-water to the boiler by one of the injectors *g*.

For combining compressed air with steam as a means of utilizing the latent heat of the steam for useful work, as before stated, an air-compressor is employed and with it a

heater for the compressed air for preheating the air by the exhaust-vapor of the motor-engine intermediately of the compressor and the boiler. Any form of compressor may be used; but the one herein represented comprises the compressing-cylinder *o*, before mentioned, and a pair of coolers forming part of the compressing apparatus, as follows, said coolers consisting of the hollow cylinders 5, set upright on the funnel-mouths 6 of the cylinder-ports, respectively, and each containing a multitude of tubes 7, communicating with a collecting-chamber 8 in the upper end of said cylinder, into which the air is received through suction-pipe 9 and valve 10. Water packing is employed in the cylinder and coolers in such quantity in each that the air will be forced out through the eduction-valves 11 alternately on its way to the preheater as the piston arrives at the ends of its strokes, respectively. Cooling-water admitted through a supply-pipe 12 and discharged through pipe 15 circulates through the cylinders 5 around the tubes 7 for cooling the air to facilitate compression. A pipe 13 connects with the supply-pipe for cooling-water and with the funnels 6 of the coolers to replenish the supply of packing-water from time to time as it may be reduced by absorption by the air. Said pipe is controlled by a cock 14. This form of compressor is particularly favorable for use as an element of my improved engine because of the isothermal distribution by the water packing of the heat generated by the compression, whereby higher efficiency is obtained both in compressing and cooling.

A feed-pump 16 is connected with the suction-pipe 9 of the compressor. When starting the engine, the pump receives the air through a suction-valve 17 and discharging it into the suction-pipe 9 of the compressor through eduction-valve 18 and pipe 19. It is desirable that the pressure of air in the compressor be maintained at a certain limit, for which a relief-valve 20 is attached to the pipe 19, which is controlled by a spring 21, provided with an adjusting-screw 22, which may be set for escape of pressure above any predetermined point. Most of the air to be compressed will, however, be recovered from the preheater, into which the exhaust of combined air and steam from the low-pressure cylinder is discharged through pipe 23, this air being drawn by the suction of the compressor-pump *o* through pipe 35 into suction-pipe 9, said pipe 35 being suitably connected with the preheater.

The preheater consists of the upright hollow cylinder 24, having an enlargement of the lower end for a hot-well 25 and containing in the upper part of said hot-well a receiving-chamber 26 for reception of the compressed air through discharge-pipe 27 of the compressor. The receiving-chamber 26 is connected with a collecting-chamber 28 in the upper part of cylinder 24 by a multitude of tubes 29, through which the compressed air passes and which are surrounded by the exhaust from cylinder *n*, which enters at 30 near the upper end of cylinder 24, passing downward along the tubes in the opposite direction of the ascending air in the tubes. The cold air from the cooler condenses the steam, which gives up most of its heat, especially the latent heat, to the air and falls into the hot-well 25 as water, from which it is returned to the boiler as feed-water by one of the injectors *g*. Some heat is also contributed by the hot air combined with and exhausting with the steam. The air thus compressed and then heated, being in a gaseous state, expands in due proportion for every increment of heat absorbed, and thus converts the latent heat of the steam into power without any loss, while water either preheated or heated in the boiler must first be supplied with its enormous proportion of latent heat before being endowed with effective power, the latent heat going to waste without contributing effective force. The air thus heated enters the superheating-coil *f* through pipe *j*, in which is a check-valve 31, preventing backflow, and steam enters along with the air issuing from coil *f* at 40, and they enter the superheaters *e* together through branches 41 and mix therein.

When starting the engine, live steam from the pipe *h* is first admitted to cylinder *m* through-valve 32 in a connecting-passage between steam-pipe *h* and the combined steam and air pipe *i*, valve 33 in the latter pipe being closed. This serves to operate the engine until a sufficient amount of air is accumulated in the system by means of the feed-pump 16 and compressor for the proper working of the engine, backflow from the boiler being in the meantime prevented by the check-valve 31. When air-pressure has accumulated sufficiently in the compressor and preheater to pass check-valve 31 into the generator, valve 32 is to be closed and valve 33 opened for the regular operation of the engine. Valve 34, admitting live steam into the preheater *q* and the steam-jackets of the cylinders, may be opened to begin with. The air after being compressed isothermally will first absorb all available heat from the exhaust-vapors and will then in passing through the tubes *f* in the steam-drum rise to the temperature of the surrounding steam, and therefrom will branch out, along with the steam entering from the steam-drum through pipe 1, into the two systems of superheating-tubes *e*, where the steam and air will be more thoroughly mixed and superheated for greater efficiency before entering the motor-engine.

Whatever waste of heat there is in this engine is what is carried away in the cooling-water of the compressor in preparing the compressed air to take up the heat of the exhaust-vapors, no part of which is wasted, provided the preheater be properly insulated, and which, including the latent heat, is largely in excess of that expended in the cooling-

water and manifestly greater than the power expended in compressing the air.

Good results may be had without the superheater in the steam-generator, and the invention is not therefore limited to the use of it; but greater efficiency is obtained by the use of it. Nor is the invention limited to the use of a reheater intermediate of the high and low pressure cylinders of the motor-engine.

What I claim as my invention is—

1. The method of utilizing the latent heat of the exhaust-steam of a steam-engine for useful effect in said engine, which consists in using air or other gaseous body together with steam as the motor fluid, condensing the spent steam and transferring the heat given up in the condensation of said spent steam to such gaseous body, and injecting said body into the boiler as a vehicle for returning said heat thereto for further useful effect in said engine.

2. The method of utilizing the latent heat of the exhaust-steam of a steam-engine for useful effect in said engine, which consists in using air or other gaseous body, together with the steam as the motor fluid, condensing the spent steam, recooling and compressing the gaseous body separated from the condensed steam, and using it for effecting the condensation and for recovering the heat thereof, and returning said reheated gaseous body to the boiler for use together with the steam in the engine.

Signed at New York city this 13th day of June, 1900.

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Witnesses:

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