O. M. STILLMAN.

STEAM ENGINE.

No. 48,321. Patented June 20, 1865.

Fig. 1.

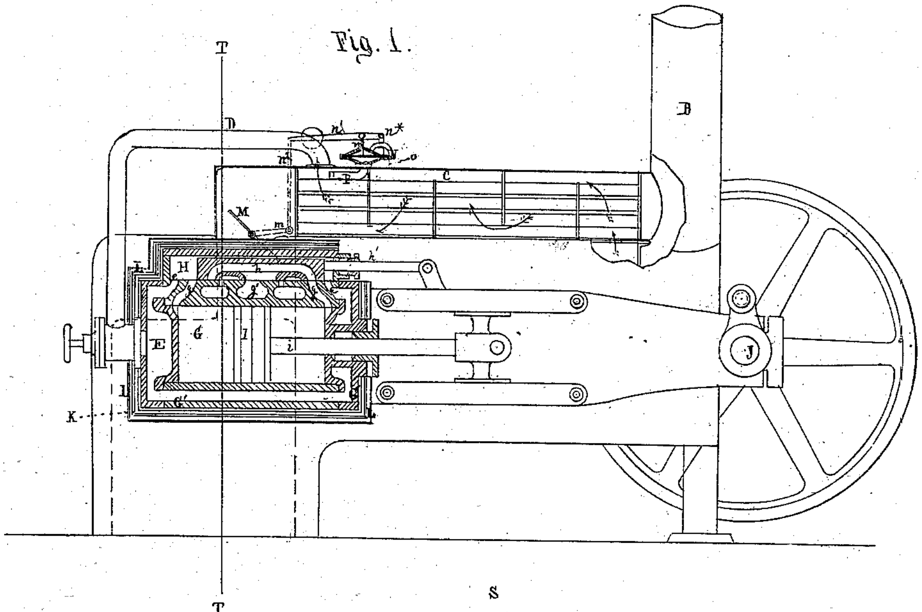
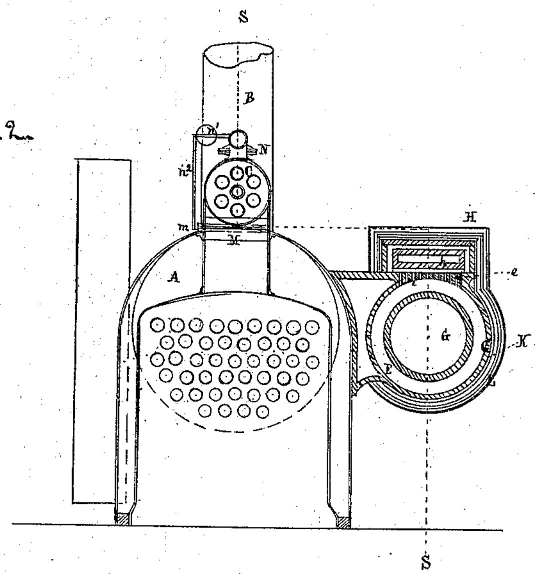


Fig. 2.



Witnesses.

William P. Coy

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Signature.

O M Stillman

UNITED STATES PATENT OFFICE.

O. M. STILLMAN, OF WESTERLY, RHODE ISLAND.

IMPROVEMENT IN STEAM-ENGINES.

Specification forming part of Letters Patent No. **48,321**, dated June 20, 1865.

To all whom it may concern:

Be it known that I, O. M. STILLMAN, of Westerly, in the county of Washington and State of Rhode Island, have invented certain new and useful Improvements in Steam-Engines; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, which form a part of this specification.

Figure 1 is a longitudinal section on the line S S in Fig. 2; and Fig. 2 is a transverse section on the line T T in Fig. 1.

Similar letters of reference indicate like parts in both the drawings.

The figures represent the parts containing the novelty, with so much of the other parts as is necessary to understand their relations thereto.

My invention relates to the use of superheated steam, or steam which has been heated after its disengagement from the water.

I conduct the steam from the boiler to the cylinder in a superheated condition and apply it, first, equally to the entire exterior of the cylinder, and afterward, in the usual manner, to the interior of the cylinder, realizing thereby advantages in the economy of fuel and moderation of heat on the working parts never before so simply and cheaply attained.

Before proceeding to describe the details of my construction, I will briefly present the theory on which my invention is based. This theory is not new.

Steam possesses the remarkable peculiarity of changing its temperature very greatly with changes of pressure. Steam at one or two pounds absolute pressure, which is far below the pressure of the atmosphere, exists as steam, but is only about blood warm, or 100° Fahrenheit. The same steam compressed to a small volume, so that its pressure shall equal that of the atmosphere has a temperature of 212° Fahrenheit, and if still further compressed, so as to attain a pressure of fifty pounds per square inch above atmosphere it assumes a temperature of about 300° Fahrenheit. This property induces a great loss of effect in steam-engines as ordinarily worked. This loss occurs in this wise: Suppose the steam to be thoroughly applied to the metal of the cylinder until the latter attains the same temperature throughout as that of the steam at full pressure; and suppose the cylinder to be so thickly clothed that no heat can escape from its exterior surface. Now, the admission of steam through the steam-valve into one end of the cylinder acts as desired to impel the piston to the end of the stroke. Then the exhaust-valve opens and the steam is allowed to escape into the atmosphere or into the condenser, as the case may be; but a certain quantity remains in the cylinder, because the space where it was remains filled with steam, but at a much lower pressure than before. (The temperature of the remaining steam is very greatly lowered by reason of its diminished pressure.) Now, during this state of things the thin steam stands inclosed within a metallic cylinder of a much higher temperature than itself. The natural result follows: It absorbs heat from the metal and assumes a condition known to steam engineers as "superheated"—that is to say, the thin steam which is tardily expelled from the cylinder assumes a temperature some ten or more degrees above that corresponding to its pressure. The heat required to produce this condition is transferred from the solid cylinder into the steam by a process known as "convection." The convection is similar to the conduction of heat between solids, except that the particles of the fluid are in motion, and a great number are presented very rapidly to the metal to be heated. The heat is taken away by this process from the inner surface of the cylinder and diffused throughout the steam. After this rare and superheated steam has been all driven out into the condenser or into the atmosphere by the returning stroke of the piston, steam at full pressure is again admitted from the boiler to impel the piston, and the round of operations above described commences to be repeated; but now the condition of the cylinder is not the same as was supposed for the preceding stroke. The metal of the cylinder in the preceding stroke was assumed to be at exactly the same temperature as the steam. Now, it is cooler, because heat has been abstracted from the inner surface of the cylinder and conveyed away with the exhaust-steam, as above described. When the fresh steam at full temperature strikes the slightly-cooled interior of the cylinder it heats the metal again nearly or quite to its original temperature, but in doing so the steam is cooled. It necessarily parts with some of its own heat. The abstraction of this heat from the steam compels a small quantity of it to condense and assume the form of water. This water tends to adhere to the inner wall of the cylinder, where the condensation has necessarily occurred. A portion will undoubtedly remain like a fine dew, adhering to the interior of the cylinder. Now, the moment the stroke is completed and the exhaust-valve again opens the same phenomenon is repeated as before, with the addition of the evaporation of this thin stratum of water.

As ordinary steam-engines are actually started and operated the cylinder never attains the full temperature of the steam in the boiler. It is always cooler, and when the steam is admitted a portion is condensed and gives heat to the metal, and when the steam is exhausted the temperature of the metal of the cylinder, although insufficient before to equal that of the strong steam, now exceeds that of the weak cool steam which is presented to the interior surfaces of the cylinder during the return-stroke; and always under this latter condition (while the metal is hotter than the water and steam which is presented to it) it gives off heat to the particles of water and re-evaporates them into steam, and that steam flows away with the rest through the open exhaust-valve. This process is repeated at each stroke, and the quantity of heat thus stealing away from the boiler into the exhaust-pipe without having performed its proper work in the engine has been estimated by some French and other careful experimenters as high as one-third of all the heat used. It is important to understand this, and I will repeat. The heat enters with the steam through the steam-port in the ordinary way; but instead of remaining in the steam, maintaining its fully-expanded condition, so as to impel the piston properly to the end of the stroke, a part of it instantly, on being presented to the surface of the cylinder, enters the metal of the cylinder, allowing the steam to condense on its surface. This heat then remains concealed in the metal, while the other particles of steam, which remain expanded by the remaining heat, are compelled to do the work of pushing the piston alone; but immediately on the steam-pressure being reduced in the interior of the cylinder by the opening of the exhaust-valve, the heat which had thus entered the metal returns and again enters the water, causing it to assume the condition of steam and leave the surface of the metal in time to pass off with the exhaust. In short, when the steam is admitted to the cylinder, a portion is condensed, adhering to the inner surface of the cylinder until the exhaust is opened, when the heat of the cylinder causes the condensed particles to evaporate and pass off with the other steam, but having done no part of the labor. In order to obviate this difficulty, steam direct from the boiler was at an early date introduced into a jacket to assist in maintaining the requisite heat in the metal of the cylinder, the water condensing in the jacket flowing back to the boiler or escaping through a trap. Although this was of advantage, yet, owing to the resistance of the metal of the cylinder, the heat was not transmitted with sufficient rapidity to maintain the interior surface of the cylinder at a temperature sufficiently high to prevent all internal condensation. More recently common steam on its way from the boiler has been allowed to flow in a constant stream through the jacket, and thence into the steam-chest; but in such cases little advantage resulted, because as the heat imparted to the outside of the cylinder, by its absence from the steam, allowed a portion of the steam to condense, the resulting water was carried along with the current of steam into the cylinder and deposited on the interior surface, where, upon the opening of the exhaust, it re-evaporated and absorbed the heat it had just before imparted to the exterior surface. Later experimenters have recognized these facts, and some have jacketed their cylinders with stronger steam, or steam at higher pressure than that admitted into the cylinder. Haycraft, in Great Britain, and E. W. Smith, in our own country, have published plans for effecting this. Both use an additional boiler, in which steam is maintained at a higher pressure than that in the working-boiler. Haycraft placed his extra boiler lower than the steam-cylinder, and allowed the steam as it condensed in the jacket to trickle down in the form of water and return to the same boiler to be re-evaporated. Smith, whose invention was patented in this country in 1861, improved upon Haycraft's by placing the high-pressure boiler where he pleased, or employing the common donkey-boiler on shipboard to supply the high-pressure steam, and he discharged the same in the form either of steam or water, or of the two commingled, from the lower part of his jacket into his working-boiler. My invention is superior to either, by avoiding the necessity for any extra boiler, and yet obtaining the same desirable end of heating the exterior of the cylinder to a sufficiently high temperature to allow the heat to travel inward through its thickness, and maintain the interior surface of the cylinder at such a condition that the working-steam will not condense thereon.

In my engine the jacket is so arranged and combined that the steam from the boiler is first carried through a superheating apparatus, where its temperature is raised; thence through a pipe, where it acts on a device which regulates the amount of the superheating; next into the jacket, where it is distributed equally over all the surface of the exterior of the cylinder (including the ends) which can be made available, and it is afterward introduced directly into the steam-chest, and admitted into the cylinder in the ordinary manner to operate the engine. It comes from the superheater at about

450° Fahrenheit, may be perhaps cooled a few degrees in the transfer through the pipe to the jacket, then gives up its surplus heat rapidly by convection to all parts of the exterior of the cylinder, holding the entire exterior of the latter at about 350° Fahrenheit, and lowering its own heat nearly to that point; then it enters the cylinder at the proper time and urges the piston, presenting itself to the rubbing surfaces at a temperature which those surfaces can endure safely. As the metal on the interior of the cylinder has become slightly cooled by the heat given up during the preceding return-stroke, the fresh influx of steam, still slightly superheated, imparts some of its heat thereto, and aids the heat which is traveling through the metal from the outside in raising its temperature again without any steam being condensed. I prefer that the steam, after performing its work in driving the piston, shall be reduced to a condition very near that of saturated steam, but if it is still something hotter no evil results follow.

I have experimented with my invention several months, and found a marked economy of fuel to result therefrom.

I employ a steam-pressure of sixty pounds per square inch above atmosphere. The temperature due to this pressure is 311° Fahrenheit. I raise the steam by superheating to a temperature varying from 400° Fahrenheit to 450° Fahrenheit. The temperature is regulated and kept within these limits by the thermostat.

To guard against risk of fire from any derangement of the regulating apparatus, or any other cause, I inclose my jacketed cylinder and most of the other parts in a stratum of plaster, which is applied by pouring the plaster in a fluid state into a casing of thin metal previously provided around the exterior of the jacket. Outside of this I use wooden lagging with one or more layers of felt, if desired.

To enable others skilled in the art to make and use my invention, I will proceed to briefly describe its construction and operation by the aid of the drawings, and of the letters of reference marked thereon.

A is an ordinary boiler. B is the chimney, and C is a vessel filled with tubes, through which tubes a portion of the products of combustion from the furnace (not represented) is conducted. The steam generated in the boiler A is received into the superheater C at a point near the chimney B. It traverses the spaces in the superheater between the hot tubes, and rises in a superheated condition into the pipe D, which is thickly clothed to prevent the escape of heat. This pipe D delivers the superheated steam into a jacket, E, which surrounds the working-cylinder G. The superheated steam is distributed over both the ends and over the entire cylindrical surface of the cylinder, except the necessary spaces for the parts on the upper side.

H is a steam-chest, and *h* the steam-valve. From the steam-jacket E the steam is admitted into the steam-chest H through small holes *e*. These holes *e* are so distributed, as represented, that the steam is compelled to flow equally, or almost equally, over every part of the exterior of the cylinder G. The working-cylinder G contains a piston, I, and piston-rod *i*, as usual. The valve *h* is operated by the rod *h'* in the ordinary manner, and the connections from piston-rod *i* and the valve-stem *h'* to the main shaft J are of the usual character.

Exterior to the casing G', which incloses the steam-jacket E and steam-chest H, is a thick stratum of plaster, K. This non-combustible and non-conducting stratum is kept in place by an exterior casing, L, as represented. I make this exterior casing of iron or other suitable metal, and surround it finally by felting and wooden lagging of the usual character.

M is a damper, which may be adjusted, by the aid of the lever *m*, so as to allow more or less of the products of combustion to pass into the superheater C from the furnace.

N is a casing in which is inclosed a loaded diaphragm of vulcanized india-rubber. The under side of this diaphragm is in communication with a vessel of water, P, which is immersed in the superheated steam in the superheater C, or in the pipe D. The upper side of the diaphragm is connected by the pipe O to the interior of the superheater C in the manner represented. The lever *n'*, turning on the fixed fulcrum *n**, and caused to move up and down with the movements of the loaded diaphragm, is connected by the slight rod *n*² to the lever *m*, and thus turns the damper M.

The operation of my invention is as follows: The superheated steam flows through the pipe D into the jacket E, and is presented uniformly, or nearly so, to the exterior of the working-cylinder G, and imparts a temperature to said exterior considerably higher than that due to the pressure of the steam. The heat thus imparted travels inward through the metal of the cylinder G, and is expended in maintaing the temperature of the interior surface of the cylinder G. A sufficient quantity is so transmitted to keep the extreme inner surface of the cylinder nearly or quite up to, or, in most cases, slightly above the temperature of saturated steam of the same pressure. The considerable amount of heat abstracted from the steam in the jacket E, to be thus transferred through the metal of the cylinder, lowers its temperature, so that it passes into the steam-chest H, and from thence into the cylinder, only moderately superheated, where, after imparting the necessary amount of heat to the inner surface of the cylinder, it is discharged through the exhaust-port *g'* at just about the heat of saturated steam of the same pressure. At no time is any part of the steam condensed in its passage through the engine; consequently the great loss due in ordinary engines to the condensation and re-evaporation is avoided by my invention and without the necessity for any additional boiler, or for subjecting the steam-jacket to any higher pressure of steam than that to which the working parts of the apparatus are exposed. The water under the diaphragm in the casing N changes from the vaporous to the dense fluid condition in proportion as the extent of the superheating of the steam is increased and diminished beyond proper limits. If the degree of superheating becomes too high, the water boils with such force as to raise the diaphragm, and through the connection n^3, lever n', and connection n^2, raises the lever m and closes, or nearly closes, the damper M, and thus, by excluding the products of combustion from the superheater, soon reduces the extent of the superheating. A too low condition in this respect induces the opposite change of position of the damper M and increases the extent of the superheating. By this means the steam flowing through the pipe D is kept at a uniform, or very nearly uniform, temperature. I prefer a temperature of about 400° Fahrenheit.

If, by any chance, the temperature of the superheated steam becomes too high it might set fire to ordinary lagging around the cylinder, except for the protection due to the plaster K; but the incombustible and non-conducting character of this envelope enables it to withstand any required amount of heat and avoids the chance of such accident.

I propose to incase the pipe D and the superheater C in a similar manner.

Having now fully described my invention, what I claim as new therein, and desire to secure by Letters Patent, is as follows:

1. The jacket E and cylinder G, constructed and arranged as described, in combination with the superheater C, through which the steam passes on its way to the jacket, substantially as and for the purpose herein set forth.

2. The within-described arrangement of the steam-jacket E and cylinder G, whereby the steam is compelled to flow uniformly, or nearly so, over the cylindrical surface and through one or both heads of the cylinder, in the manner and for the purpose substantially as herein set forth.

3. The within-described arrangement of the superheater C, the automatic regulator N, and its connections, the steam-jacket E, and the cylinder G, so as to operate together in the manner and for the purpose substantially as herein set forth.

4. The incombustible clothing K, the jacket E, cylinder G, and superheater C, arranged to operate together, substantially in the manner and for the purpose herein set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

O. M. STILLMAN.

Witnesses:
WILLIAM P. COY,
S. WILCOX, Jr.