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O. H. HARTMANN

METHOD OF CONVEYING STEAM THROUGH LONG DISTANCE PIPE LINES

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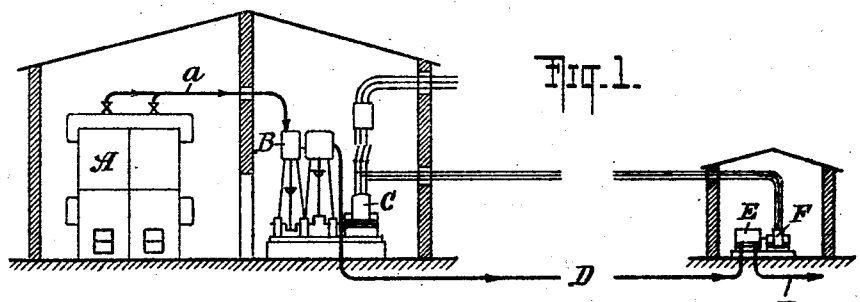


Fig. 1.

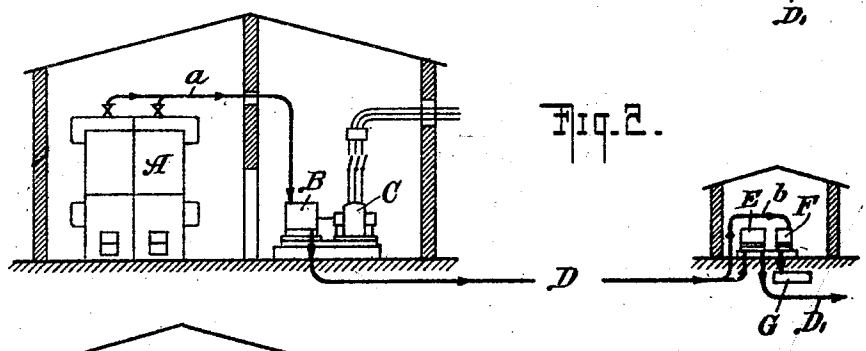


Fig. 2.

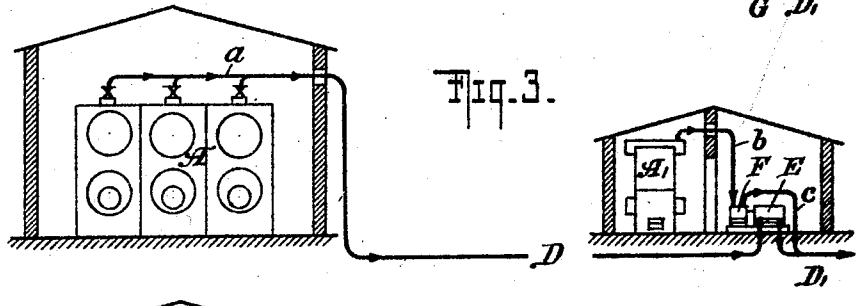


Fig. 3.

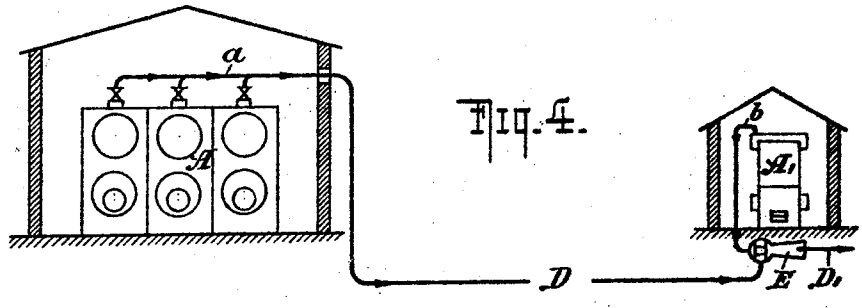


Fig. 4.

WITNESS

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UNITED STATES PATENT OFFICE.

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METHOD OF CONVEYING STEAM THROUGH LONG-DISTANCE PIPE LINES.

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The conveying of steam through long-distance pipe-lines has already been proposed and in exceptional instances carried into effect but even with the highest live-steam pressures hitherto usual, (about 18 atmospheres) the distance between the point of generation and the point of consumption of the steam has not greatly exceeded one kilometer. This is due to the fact that with the comparatively small diameters necessitated in long pipe-lines by the high first cost and the losses due to cooling, the drop in pressure is extremely great. An essential factor in this relation is the circumstance that the pressure, which drops comparatively slowly in the first portion of the pipe-line, falls very rapidly after the steam has travelled a certain distance and so acquired a high velocity in a manner well understood. For small quantities of steam, the permissible length of the pipe-line is therefore very soon reached, and even in the case of large quantities of steam, the practicable length of the pipe-line is not great.

If, by overcoming these difficulties, it became possible to increase the permissible distance between the point of generation and the point of consumption of the steam, the use of piping for conveying steam to long distances would come into more general use than is now the case. For example, it would then be possible to avoid to a greater degree than hitherto the high cost of transporting fuels, especially those of low calorific value, and their resulting ashes and clinker; in addition it would be possible to eliminate the considerable losses due to the distribution of the fuel to a number of comparatively small furnaces and its inefficient utilization therein.

The present invention obviates the above-mentioned difficulties and renders it possible for steam to be conveyed over a distance of 12 kilometers and more according to the quantity dealt with.

With the above object, according to the present invention, the steam is conveyed through a long-distance pipe-line to its point of consumption in such a manner that the loss of steam pressure due to the length of the pipe-line is made up wholly or partly by compression.

For comparatively short distances the compression may be effected in close proximity to the point of consumption, but when it is desired to convey the steam over the longest distance possible, the compression is preferably effected at one or more intermediate points of the pipe-line. By thus restoring the pressure, the steam is enabled to travel over a further stage, compression being effected once or more as required according to the length of the stages and the pressure drop.

The compressor itself may be of the piston, turbine or injector type receiving its power from any convenient source; preferably the "long-distance" steam itself is utilized either wholly or in part as a source of energy for effecting the compression.

Either live steam or exhaust steam may be conveyed over long distances in this manner.

The invention is particularly advantageous as applied to the exhaust steam of a high-pressure back-pressure engine with an initial pressure of not less than 25 atmospheres. It is possible in such a case to give to the exhaust steam a pressure of 10 to 15 atmospheres and to extract from the steam before it is admitted into the long-distance pipe-line, a quantity of work depending on the live-steam pressure, which can be utilized for other purposes than that of compression. In this manner, the economical working of long-distance steam pipe-lines is put on an entirely new basis.

The compressing plant is preferably installed at a point of the long-distance pipe-line, where the steam pressure has dropped at most to one half of the initial pressure so that the power absorbed in compression may be kept within permissible limits.

The invention may be carried into effect in various ways, as illustrated diagrammatically in Figures 1 to 4 of the accompanying drawings.

For instance:—

(1) The power required for compressing the "long-distance" steam may be generated at the starting-point of the pipe-line and

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transmitted thence to the compressing station.

A case of this kind is illustrated in Figure 1 of the accompanying drawings.

Steam from the high-pressure boiler, A, is led through the pipe, *a*, to a high-pressure back-pressure steam engine, B, driving the dynamo, C, the exhaust steam from the back-pressure engine passing into the long-distance pipe-line, D. At a distance of a few kilometers from the boiler, a compressor, E, is provided, which raises to any desired extent the pressure of the steam now reduced owing to its passage through the pipe-line, D, and passes the steam so compressed into the continuation, D_1, of the pipe-line on its way to the point of consumption. The compressor, E, is driven by an electric motor, F, receiving its current from the dynamo, C.

(2) The power required for compressing the "long-distance" steam may be provided by utilizing a part of the latter at the compressing station for driving a condensing steam-engine which in turn drives the compressor.

Figure 2 shows an installation of this kind.

The boiler is again represented by the letter, A, while B denotes a back-pressure turbine receiving steam through the pipe, *a*, from the boiler. The turbine drives a dynamo, C, which generates electric current for an industrial installation situated at a distance, the exhaust from the turbine passing into the long-distance pipe-line, D. As in the previous example, the "long-distance" steam that has suffered a drop in pressure, is compressed in a compressor, E, which may conveniently be a turbo-compressor, to a higher pressure and is thus rendered capable of travelling a further stage. The compressor, E, is driven by a steam turbine, F, fed with a part of the "long-distance" steam through the pipe, *b*, and exhausting into the condenser, G.

(3) The compression of the "long-distance" steam may be effected by a steam engine operated from a high-pressure boiler plant, the exhaust steam from the engine passing into a continuation of the long-distance pipe-line.

Figure 3 illustrates a suitable installation for carrying the invention into effect according to this form.

The boiler, A, in this case delivers its steam through a pipe, *a*, direct into the long-distance pipe-line, D, the compressor plant consisting of a high-pressure boiler plant, A_1, and a turbo-compressor, E, driven by a turbine, F. The high-pressure steam is conveyed by the pipe, *b*, to the steam turbine, the exhaust from the latter passing through the pipe, *c*, into the continuation, D_1, of the pipe-line.

(4) Steam from a high-pressure boiler plant may be utilized to operate an injector compressor and so compress the steam after its passage through the long-distance pipe-line.

This arrangement is illustrated diagrammatically in Figure 4.

The boiler plant, A_2, again delivers its live steam through the pipe, *a*, direct into the long-distance pipe-line, D. At the point of consumption, or in proximity thereto, a high-pressure boiler, A_1, is provided, steam from which is led through the pipe, *b*, to the injector compressor, E, thereby serving to compress the steam at the end of the pipe-line to the pressure at which it is to be used.

If it is desired to avoid completely any transport of fuel and it is necessary to employ at the compressing station high-pressure steam which cannot be generated by waste fuel available on the spot, the high-pressure boiler may be heated by gas likewise supplied through a long-distance pipe-line.

A heat-storage apparatus may be provided in the long-distance pipe-line or at the end thereof without departing from the nature of the invention as set forth in the appended claims.

It will be understood that in my present invention the steam is conveyed through a conduit until such steam has lost a substantial proportion of its utilizable properties, and is then revivified by compressing it.

I claim:

1. The method which consists in conveying steam from a source to a remote point at which such steam undergoes a substantial drop in pressure, utilizing such steam to produce electricity adjacent to the said source, transmitting such electricity to said remote point, utilizing such electricity at said remote point for compressing the steam thereat, and utilizing the steam thus compressed.

2. An apparatus comprising a source of steam, a conduit leading therefrom to a remote point, an electric transmission line likewise leading from said source to said remote point, a generator of electricity located at said source and operated by said steam, an electric motor located at said remote point and operated by electricity received from said generator, and a compressor driven by said motor and arranged to increase the pressure of the steam received from said conduit.

3. The method which consists in generating steam at extra high pressures, (not less than 25 atm.), and transmitting it at high pressure through pipe lines from the place of generation to a place of utilization distant from the steam generator not less than 2 km. by utilizing the high pressure of said steam to force it through the pipe line to a distant intermediate point at which the steam pressure has dropped to approximately one half of the pressure prevailing at the

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entrance end of said pipe line, then compressing said steam at said intermediate point to raise its pressure sufficiently to compensate for pressure drops occurring during its passage through the pipe line and to deliver it at the place of utilization at the pressure required at such place.

4. The method which consists in conducting high pressure steam to a point remote from its source, whereby the steam loses not more than half its initial pressure, increasing the pressure of said steam at said point to substantially restore it to its initial pressure, and conducting said steam to a point of utilization remote from said first mentioned point.

5. The method which consists in conducting high pressure steam to a point remote from its source, whereby the steam loses not more than half its initial pressure, utilizing a part of the energy of said steam at said point to substantially restore it to its initial pressure, and conducting said steam to a point of utilization remote from said first mentioned point and from said source.

In testimony whereof, I have hereunto set my hand.

OTTO HERMANN HARTMANN.

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