The invention relates to the utilization of high pressure hot water by means of a feed line or main connected with the same boiler, and a number of appliances for using the calorific energy of the high pressure hot water, these appliances being interposed between the feed and the return line. The calorific energy of the high pressure hot water may be used for many different purposes, especially heating, generating steam and generating kinetic energy. In some cases the nature of what may be called the consuming apparatus renders it undesirable to bring the hot water into contact therewith at the high pressure and high temperature which it has in the feed line, and according to the invention provision is made to have at the intake end of each consuming apparatus water or steam at the pressure and temperature appropriate to such apparatus, and to prevent any substantial loss of energy arising from the change of pressure and temperature between the feed line and the intake of the consuming apparatus.

Another object of the invention is to return the water discharged at an intermediate pressure from the consuming apparatus to the high pressure boiler without substantial loss of energy.

Another object of the invention is to attain the above mentioned purposes in such a way that the mains, which may be of very considerable length, contain always only hot or warm water, that is to say that they do not contain steam, as notwithstanding the higher velocity attainable with steam the very much greater volume of steam would necessitate the use of much larger and more expensive pipes with more expensive insulation for retaining heat.

All these advantages are attained according to the invention in an installation wherein in between the common feed line come from the high pressure boiler and the common return line leading back to the high pressure boiler various appliances for consuming calorific energy are interposed, as for example:

(1) Apparatus within which the high pressure hot water from the feed line is made to expand to an intermediate pressure in a chamber, and the steam generated during the expansion is separated from the remaining water whereupon the steam and the water, both at intermediate pressures, are used separately;

(2) Apparatus having, in addition to an expansion chamber for reducing high pressure water to intermediate pressure steam and intermediate pressure water, means whereby high pressure hot water is caused to heat the intermediate pressure water and vaporize the same.

With the above mentioned objects in view, and to the end of realizing other advantages hereinafter appearing, this invention consists in certain features of construction, combinations of parts and arrangements of apparatus, devices and pipe lines hereinafter to be described and pointed out in the appended claims, and illustrated in the accompanying drawings.

Figure 1 is a diagram illustrating a system for the employment of high pressure hot water for purposes of heating and steam generation, with apparatus for utilizing the steam, and regulating means for maintaining a water level in the steam generator.

Figure 2 is a modification of Figure 1, the steam generator and regulating means of Figure 1 being replaced by a jacketed steam generator and regulating means therefor to cause the generator to contain steam only.

Figure 3 is a sectional view of the injector pump or mixing device shown in Figure 2 for returning the low temperature water from a set of heat utilizing apparatus to the hot water generator.

Figure 4 discloses a hot water system somewhat similar to those shown in Figures 1 and 2, but having regulating and throttling means.
for permitting low pressure apparatus to be operated from a high pressure line.

Fig. 5 is a diagrammatical view of a hot water system as applied to an electric or other train.

Referring first to Figure 1, the high pressure hot water generator 1 may be of any suitable type, for instance, it may be a multitubular or fire tube boiler completely filled with water and provided with a furnace 2. It is to be borne in mind that the generator 1 does not contain a steam space. The hot water is taken out of the water space of the generator or boiler 1 at any suitable point, for instance at 3. A safety valve 4 prevents a predetermined pressure from being exceeded, but this valve is only intended to operate in exceptional circumstances tending to produce excessive pressure. The feed line 5 comprises an expansion vessel 6, as is usual and necessary in hot water pipe lines. In the return pipe line 7 there is a feed pump 8. The spent water delivered by the pump enters the water space of the boiler 1 at 9.

Any appropriate apparatus may be heated in well known manner directly from the high pressure feed line 5. For instance the heating jacket 11 of the apparatus 10 is traversed by water as indicated by arrows, and heated by the water, wherein the high pressure water, having given off calorific energy and therefore lowered its temperature, but preserved its pressure, passes into the return pipe line 7.

Between the ends of the feed line 5 and the return line 7 a small valve 12 is arranged, by means of which provision is made for the direct passage of hot water through both main lines in case all the consuming appliances are put out of action at the same time.

Other appliances are fed indirectly from the feed line 5, for instance a steaming vessel or receptacle 13, wherein some substance is to be treated with steam which must not exceed a certain pressure or temperature, as is frequently the case in the chemical industry. An expansion or pressure reducing chamber 14 is arranged in front of the said steaming vessel 13, and is connected with the same by means of a pipe 15 for the steam and a return pipe 16 for the water of condensation. A hot water pipe 17 leads from the feed line 5 to the expansion chamber 14 and terminates in a distributing tube 18 arranged within the steam space of the vessel (that is to say above the water level 19), this tube being provided with numerous openings or outlet nozzles. A pipe 20 coming from the chamber 14 close to, but below, the water level 19 connects the expansion chamber 14 with a pump 21, whose delivery pipe leads to the return line 7. Devices for throttling, regulating and shutting off, such as valves 23, 24, are provided in the pipes 17 and 20, the operating arms 23, 24 thereof being connected with each other by means of a link a serving as a common handle for the two valves.

The method of operation of the arrangement just described is as follows.

The temperature of the hot water in the feed line may, for example be 204° C. or 400° Fahrenheit, so that the pressure in the feed line is about 12 atmospheres or 171 pounds per square inch. Within the steaming vessel 13 steam at 157° C. or 315° Fahrenheit, at 3 atmospheres or 43 pounds per square inch may be required. The capacity of the chamber or expander 14 is appropriate to the requirements of the steaming vessel 13. At the beginning of the steaming process the valves 23 (with the valve 24) is opened, so that hot water of high temperature passes through the pipe into the expander 14, and is distributed by the openings or nozzles of the tube 18. At the moment of issuing from the tube a portion of the water expands to form steam. The heat becoming latent by the evaporation is taken from the water which remains in the liquid state, whereby the temperature thereof is lowered in proportion to the pressure drop.

The quantity of steam necessary for the steaming process is either definitely known or may be estimated approximately. According to the calorific theory it is possible to calculate how much steam is formed, in the given instance, out of water at 400 degrees Fahrenheit and 171 pounds pressure in the case of expansion to 315 degrees F. and 43 pounds pressure. With the given data it is calculated, or ascertained empirically, how much hot water must be delivered into the expander for providing the necessary quantity of low pressure steam.

When a state of balance has been attained the water level in the expander is kept at the level 19 to compensate for small pressure variations which are caused within the expander by varying steam consumption within the steaming vessel. For this purpose the pipe terminal at 24 is disposed on the expander at the level 19, which is to be the water level. The capacity of the pump 21 is also calculated according to the calorific theory.

Calculations have been made for various pressures and expansion rates, and it is found that for generating a useful quantity of steam at the rate of 7 pounds per hour a quantity of heating water ranging approximately from 8n to 20n is necessary.

Should the steam consumption in the steaming vessel 13 vary at different times, the generation of steam within the expander may be regulated easily by adjusting the two valves 23 and 24 simultaneously by means of the link a, whereby the action of the pump 21 is also regulated. If definite pressure and temperature variations are to be dealt with
the link a may be connected with an automatic regulator of any suitable known type. A safety valve 25 upon the expander prevents excess of steam pressure in the vessels 13 and 14 above a predetermined value.

The water of condensation produced within the steam vessel has the same pressure and approximately the same temperature as the fresh steam, and this water flows through the downwardly directed pipe 16 directly into the expander and is mixed therewith the intermediate pressure water produced by the expansion therein.

The pump 31 delivers the water cooled by evaporation and by the delivery of calorific energy within the steam vessel 13, and at the pressure existing in the return line. The water passes through the pipe 22 into the return line 7, where it is mixed with the spent water coming from other consuming apparatus. Consequently the whole of the water returns at a low average temperature to the heating boiler 1, to be heated to the required high temperature for return to the feed line.

Sometimes it is not necessary to separate the chamber wherein the steam is generated from the chamber wherein it is used. For instance the vertical tubes of an evaporator 25, such as is commonly used in the chemical industry, are exposed outside to steam, whereby liquor within the tubes is heated or boiled. In this case the heating chamber of the evaporator serves also as an expansion chamber. The high pressure hot water admitted through the pipe 26 passes from the distributing tube 28 into the heating chamber 25, from which the water remaining in the liquid state after the expansion, together with the steam developed during the expansion and then condensed outside of the heating tubes, is discharged through the pipe 27. Devices 29 and 30 serving for closing, regulating, and throttling, are provided in the pipes 26 and 27. The operating arms 29, 30 of the said devices are connected by means of a link a so as in the case of the valves 13, 14. In the case of the evaporator 25 no separate return pipe for the water of condensation is necessary. The great loss of heat and other disadvantages connected with the return pipe otherwise usual in steam heating systems is thus avoided. For this and other reasons the evaporator works very economically.

A safety valve 31 prevents the proper pressure within the heating chamber 25 from being exceeded.

Different temperatures are generally used for different processes in chemical manufactures, and some of the appliances are designed for low pressures. The heating plant according to the invention is adapted to these requirements in a very perfect manner. For each process of manufacture the advantage of the comparatively cheap hot water system is available, without expensive alterations of the plant. For example when the temperature of 315 degrees Fahrenheit, corresponding to a pressure of 43 pounds per square inch, is necessary for the heating chamber 25 of the evaporator 25, then the water flowing into the pipe 27 has approximately the same pressure and temperature. The sensible heat of the spent water is used preferably for heating other apparatus, such as a kettle 32 and heating plate 33. For this purpose the pipe 27 is branched, the branches 27, 27 leading respectively to the apparatus 32 and 33 to be heated. The pipes 34, 34 into which these appliances discharge are joined to the pipe 34 of the pump 33, whose delivery pipe 35 is joined to the main return line 7.

There may be several heating steps in series if the available temperature difference is sufficient. Furthermore several appliances such as the steam vessel 13 may be supplied with steam from a single expander 14, or several expanders such as the apparatus 14 and 25 may be connected with a single pump such as 21 or 33. Consequently according to the invention it is possible to provide a large number of appliances with steam or hot water of different temperatures and pressures from a single main feed line, with a single main return line, and this is a very important improvement over the known steam heating installations requiring separate supply pipes for steam of different pressures, and separate return pipes for the water of condensation. A large saving of cost and simplification of working are attained thereby.

The heating plant may be employed, apart from the chemical industry, for house heating from a distance, and also for heating railway trains, in which case it is true, the usual single steam pipe would be replaced by a feed line and a return line for hot water, but two hot water pipes are not as expensive as a single steam pipe. Such a hot water heating system for railway trains would have special advantages if adopted generally for railway railways, in which case a small high-pressure boiler B (Fig. 5) for producing hot water would be placed in the middle part of the train, so that the feed and return pipes F and R for the two halves of the train (consisting of a locomotive L and a plurality of cars C) would be relatively short, and the spent water passes directly from the feed pipe into the return pipe, without first going to one end of the train.

It frequently happens in the chemical industry that the steam used for steaming and then condensed, receives from the substances treated some detrimental admixture, such as an acid, which would destroy the pipes, and the boiler. In such cases the water of condensation is not retained in the system, but is
This regulator operates a throttling device 28 in the supply pipe 17 in such a way that at all times only so much water flows into the expander 14 as is necessary for generating the required quantity of steam at the required pressure.

Of course the pressure for which the safety valve is set is above the pressure normally maintained by the regulator 36.

As also seen in Figure 2, an evaporator 25 and several heaters 29, 30, 32 are disposed in series, and the quantity of the water which has given off the greater portion of its heat, and is to be returned, is relatively small so that the employment of the single pump 33 shown in Figure 1 would be uneconomical. The case is complicated by the fact that in certain circumstances several such small pumps with different pressures at the suction side would be necessary at different stations, increasing the cost of the plant.

A device for returning small quantities of water partly or completely expanded is shown at 39 in Figure 2, and in greater detail in Figure 3. A housing 39 with a central nozzle 40 similar to an injector is provided in the main return line 7 at the point where the low-pressure water enters. By means of the nozzle 40 the high-pressure water returning in the line 7 is brought to a lower pressure, and thereby acquires a higher velocity. The low-pressure water to be added enters laterally through a branch 41 and is drawn by the accelerated water in the well known manner, as in an injector. Accordingly the injector 39 shown in Figure 2 has the same function as the return pump 33 shown in Figure 1.

The principle of using high-pressure hot water in such a manner that it undergoes only relatively small reduction of pressure drop leads also to a more efficient use of existing steam boilers. Many steam boilers designed for a high pressure are in fact used at a lower pressure, and consequently with poor efficiency, the reason being that the apparatus to be fed with the steam from these boilers are in fact used at a lower pressure, and consequently with poor efficiency, the reason being that the apparatus to be fed with the steam from these boilers is preferably connected with the pipe 15.
a pressure substantially lower than the pressure in the main feed line 5 and the boiler. The throttling member 48 is arranged in the pipe in front of the inlet, and a second throttling member 49 is placed behind the outlet of each apparatus. The throttling members are adjusted by hand in the case of the apparatus 42, and by automatic regulators in the case of the apparatus 43, 44 and 45. Each regulator is itself controlled by the pressure prevailing within the respective apparatus 43, 44 or 45. In each vessel the heating chamber is filled completely with water. The high pressure water reaching the throttling member 48 is prevented from expanding and evolving steam. The throttling at the inlet has the effect that only a predetermined small quantity of high-pressure water, depending on the regulator, enters the apparatus, and is mixed therein with the cooler water already within the heating chamber, and giving off its surplus heat to this cooler water, whereby its pressure is lowered to the pressure desired for the apparatus. The throttling members 49 at the outlet have the effect of adapting the outlet-section in each case to the inlet section regulated by the throttling member 48 in such a way that no expansion and steam development within the heating chamber or the connecting pipes will take place. Between the main return line 7 and the boiler 8 a return pump 8 is interposed for the purpose of bringing the water in the main return line 7 to the pressure within the boiler 1. The combination of the throttling members 48 and 49, and the regulator 50 prevents the production of steam under the suctional effect of the pump 8, in the heating chamber of any of the appliances. Provided that the pressure in the main return line 7 is lower than in the main feed line 5, which will be attained by the arrangement and construction specified, the injector device 39, shown in Figure 2 as being placed at the outlet-pipe of consuming apparatus, leading to the main return line, may be omitted. For in this case the whole return pipe system contains only low-pressure water. Accordingly the main pump 8 has the function of bringing the whole of the spent water back to the pressure of the boiler 1. For this purpose a first throttling member 8 is provided in front of the pump, and a second throttling member 8 is provided behind the pump. The members 8 and 8 are either operated by hand or by an automatic regulator 51 controlled by the pressure in the return line 7. The regulation is effected in such a way that the pressure in the main return line 7 is slightly lower than the pressure in the outlet pipes of each consuming apparatus. What I claim is:

1. In an installation for utilizing the calorific energy of high pressure hot water, the combination with a high pressure hot water generator, of a hot water main leading from said generator, a main return line, an intermediate pressure container connected with the hot water main, means for regulating the quantity of hot water which flashes into steam in said container, steam utilizing apparatus connected to the steam space of said container, a drain pipe from said apparatus to said container, and means for discharging the accumulated water in the container into the main return line. 2. In an installation as set forth in claim 1, the combination of a first throttling member between the hot water main and the steam generator, a second throttling member between the steam generator and main return line, and means coupling the two throttling members together in a predetermined manner.

3. A method of heat generation and transfer, comprising the steps of converting water of relatively low temperature into water of high temperature and pressure, conducting it to a container and there permitting a portion of it to flash into steam of intermediate pressure, withdrawing the steam so formed and condensing it during a heating process, passing the condensate back into the container, and then transferring the intermediate pressure water from the container back to its original source of conversion.

4. In an installation for utilizing the calorific energy of high pressure hot water, the combination with a high pressure hot water generator of a main hot water line leading from said generator, a main return line, and a branch across the two lines, steam generating apparatus in said branch, and a pump in said branch between said steam generating apparatus and the return line.

5. In an installation for utilizing the calorific energy of high pressure hot water, the combination with a high pressure hot water generator of a main hot water line leading from said generator, a main return line, a steam generator connected with the main line, means interposed in the connection for regulating the amount of hot water supplied to the steam generator, a connection between the steam generator and main return line, a pump in the main return line, and a pump in said last-named connection.

6. In an installation for utilizing the calorific energy of high pressure hot water, the combination with a high pressure hot water generator, of a main hot water line leading from said generator, a main return line, a branch across said lines, steam generating apparatus in said branch, regulating members in said branch on each side of said apparatus, and means coupling the regulating members together in a predetermined relation.
7. In an apparatus for utilizing the caloric energy of high pressure hot water, the combination with a high pressure hot water generator, of a main hot water line leading from said generator, a main return line, a branch across said lines, steam generating apparatus in said branch, regulating members in said branch on each side of said apparatus, means coupling the regulating members together in a predetermined relation, a pump in said main return line, and a pump in said branch between said apparatus and the main return line.

In testimony whereof I have signed this specification.

OTTO FRITZ KARL BRANDT.