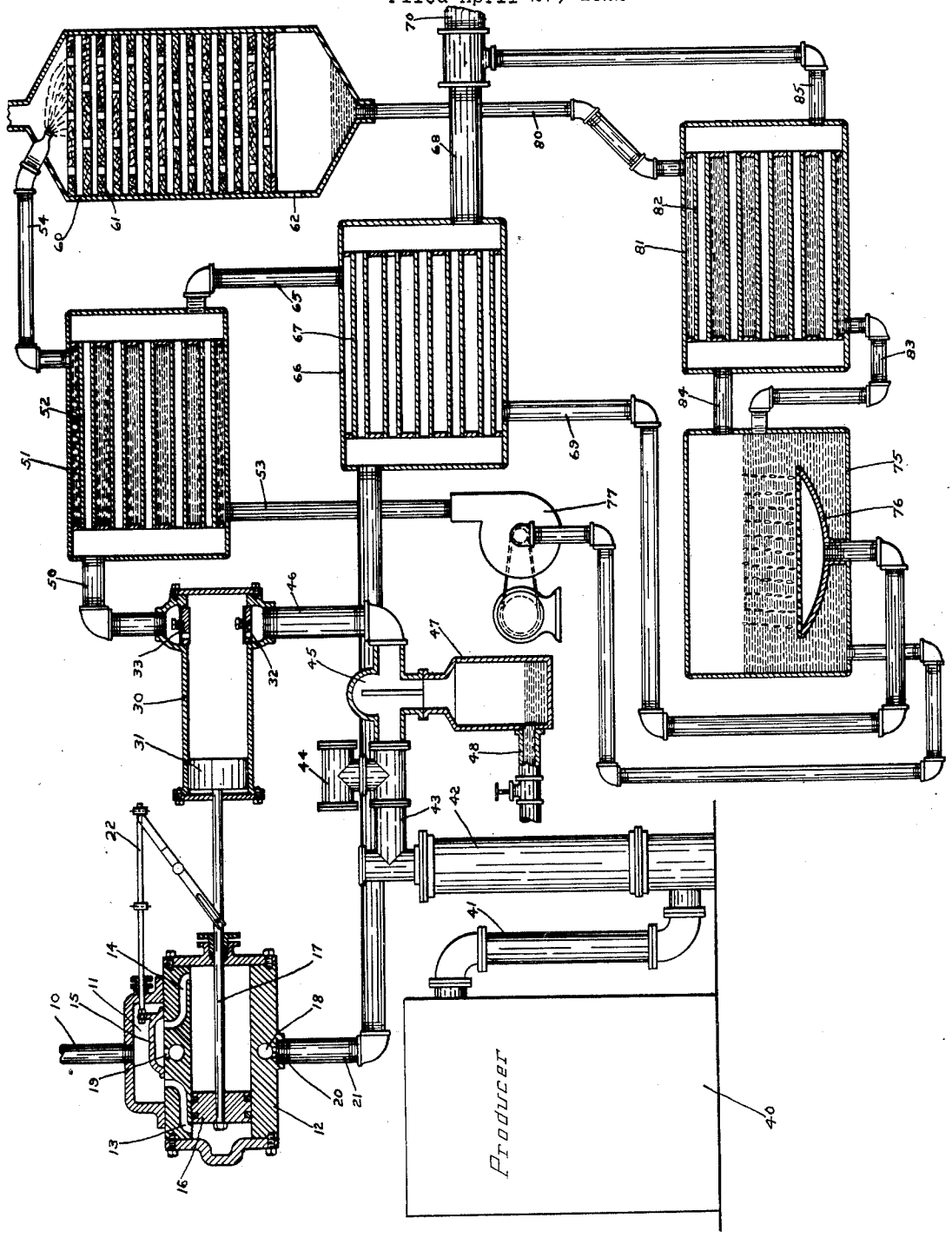
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NATURAL GAS DILUTION SYSTEM

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NATURAL-GAS-DILUTION SYSTEM.

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This invention relates to a gas supplying system for supplying a combustible gas, consisting of a gas of higher heat value, such as natural gas, in admixture with a combustible gas of lower heat value.

One of the objects of the invention is to provide a method of admixing two gases, or other fluids, of varying characteristics and supplying them to a delivery main for transmission to any desired place of use or storage.

Another object of the invention is to provide a method of diluting natural gas with another combustible gas of lower heat value.

Another object of the invention is to provide a method of diluting natural gas with a comparatively low heat value gas, such as producer gas, the pressure of the natural gas being utilized for causing the generation of the producer gas, for causing the admixture of the natural gas and producer gas, and for supplying the resulting mixture at any desired pressure to the delivery main, or place of use.

Still another object of the invention is to provide suitable apparatus for carrying out this method.

Other objects and advantages will be apparent from the description thereof set out below when taken in connection with the accompanying drawing.

The apparatus for carrying out this method is illustrated diagrammatically in the drawing, in which some of the parts are shown in vertical section in order to more clearly disclose the invention.

As is well-known the supply of natural gas available for domestic and industrial use, in this country, has been failing rapidly during the last few years. In addition to the evident failing of the supply, the demand has increased tremendously, so that every day there is a wider gap between production and demand. Under these circumstances the gas companies, particularly in winter, have difficulty in supplying even the domestic consumer, the industrial consumers in most cases being entirely deprived of natural gas during the winter months. In some places this condition has been somewhat relieved by diluting the natural gas with artificially prepared gas, such as producer gas. Naturally the resulting gas has a lower heat value than the natural gas itself, but by varying the proportions of natural gas and producer gas any desired B. t. u. may be secured.

In this invention the pressure of the natural gas as it comes from the wells, which pressure is often in excess of five hundred pounds and is seldom less than two or three hundred pounds per square inch, is utilized for driving the pump or exhauster which operates the producer, the natural gas being expanded to a lower pressure, and the producer gas being compressed to a higher pressure during this operation. Furthermore the natural gas as it is expanded to do work has its temperature very much lowered, the temperature reached being dependent upon operating conditions, but under general operating conditions reaching a temperature of 0° Fahr. or lower and this cooled gas may then be used in the cooling of the producer gas, which is at a very high temperature as it leaves the generating chamber of the producer but which is subjected to a cooling action before it is brought into heat interchanging relation with the natural gas. The producer gas during this cooling is itself brought to a comparatively low temperature, about 32° Fahr., and, being at the same time under substantial pressure, is passed through water where the carbon dioxide contained in the gas is absorbed, the result being an increase in the heat value of the gas and also the generation of a valuable by-product, namely carbonated water.

As shown in the drawing, natural gas under well pressure, is introduced through the pipe 10, which opens into the valve chest 11, of the engine cylinder 12. This cylinder is substantially identical in construction with an ordinary steam engine cylinder, and the entire engine is shown conventionally, and somewhat diagrammatically, since any suitable type of pressure operated motor will function satisfactorily. The cylinder has two passages 13 and 14, each of which is connected at one end, to the interior of the steam chest and, at the other end, to one end of the interior of the engine cylinder. These two passages are controlled by means of a conventional D type distributor valve 15, the construction being such that as the valve 15 is properly moved within the valve chest, pressure gas from the pipe 10 will be admitted first to one end of the cylinder and then to the other to cause reciprocation of the piston 16 and the piston rod 17 attached thereto. Arranged substantially midway of the cylinder is an outlet or exhaust

passage 18, to which the valve chest 11 is connected by means of the passage 19, the construction of the valve 15 being such that when one end of the cylinder is connected to pressure gas through one of the passages 13 or 14, the other end will be connected to the exhaust passage through the other of said passages. The exhaust passage 18 also has an outlet port or passage 20 opening thereinto, to which is connected the outlet pipe 21. The distributor valve 15 has connected thereto suitable actuating mechanism designated generally by the numeral 22, which is also operatively connected to the piston rod 17, the construction being such that as the piston and the piston rod carried thereby reciprocate, during operation of the engine, suitable sliding of the distributor valve will be secured to properly control the flow of pressure gas to, and the exhaust of the expanded gas from, the cylinder 12.

Cooperatively positioned with respect to the cylinder 12 is a pump cylinder 30, which is coaxial with the cylinder 12, the piston rod 17 extending into the cylinder 30 and being connected to the piston 31, within that pump cylinder. As the piston 16 reciprocates within the cylinder 12, under the expanding action of the natural gas, the piston 31 will be caused to correspondingly reciprocate within the cylinder 30. The cylinder 30 is provided with an inlet port, controlled by a suitable inlet valve 32, and with an outlet port, controlled by a suitable outlet valve 33, the two valves 32 and 33 being shown as conventional disc valves.

The pump 30, during operation functions as the pump or exhauster for causing operation of a suitable gas producer, by blasting the fuel bed therein, and for forcing the generated producer gas under suitable pressure through proper treating apparatus and then into the natural gas for admixture therewith. Any desired type of producer may be used, but a suction producer is quite satisfactory, and a producer of this type is therefore illustrated diagrammatically herein. This producer is designated generally by the numeral 40 and details of construction thereof are not included inasmuch as the specific construction of the producer is a matter of no importance, so long as it is of a type adapted to make a good grade of producer gas. Also the producer may be adapted to generate gas from any suitable type of fuel, such as anthracite, coke, bituminous coal, lignite or the like. The character of the gases generated from these various fuels in the producer is, generally, the same. But where lignite or bituminous coal is used the gases must be subjected to suitable cleaning action to remove the tar which is produced during the gas generation, whereas with an anthracite or coke producer the gas may be, generally, sufficiently cleaned by passing it through an ordinary sawdust scrubber. So far as this method of dilution is concerned, however, it is a matter of indifference what character of fuel is used in the generation of the gas so long as the producer gas itself is of suitable character. By way of illustration, however, the producer is shown as one adapted to generate gas from soft coal, since this is a more generally available fuel than anthracite, and consequently suitable cleaning apparatus for removing the tar during the generation of said gas is illustrated.

The producer being suction operated, the air and moisture for the gas making reactions is drawn through the producer under the suction action of the pump 30 the generated gas passing off through the offtake pipe or downcomer 41 into the bottom of a cooler or condenser 42. This condenser may be of any conventional type, such for instance as a cylindrical shell having a plurality of baffles therein, water being sprayed into the upper end of the shell to trickle down over these baffles and thus come into intimate contact with the gas as it passes upwardly through the condenser, the gas being thus cooled and at the same time washed by the water with which it comes in contact. The gas, after washing and cooling, passes from the upper end of the condenser through the pipe 43 to a tar separator or extractor illustrated diagrammatically at 44. Any suitable type of tar extractor may be used, but the form shown herein is that illustrated and described in the patents to Harry F. Smith No. 1,099,773, dated June 9, 1914, and 1,140,198, dated May 18, 1915. In this type of extractor or separator the tar is not actually removed from the gas within the separator itself, but it is so acted upon that it is caused to agglomerate into large drops which will fall out of the gas under the action of gravity after they pass out of the separator. In order to accomplish this phase of the cleaning the gas after it leaves the separator passes through the fitting 45, within the delivery pipe 46, which has a baffle therein which helps to throw down the drops of tar contained in the gas. Connected to the fitting 45 is a tar tank or sump 47 into which the separated tar drains. Preferably the tar is removed from this sump through the pipe 48, and returned to the generating chamber of the producer, where it is sprayed over the top of the fuel bed and assists in the gas making reactions. This method of tar return is shown in the patent to Harry F. Smith No. 1,394,043 dated October 18, 1921. Of course this method of tar return is not in any way an essential feature of this particular invention, it being only desirable that a suitable producer gas be generated and fed through the pipe 46 to the inlet port of the cylinder 30. As the producer gas passes

through the pump 30 it is suitably compressed and delivered through the outlet valve of that pump into the pipe 50. The pressure to which the producer gas is raised by means of the pump 30 is considerably below the pressure of the natural gas within the pipe 10, but the construction and arrangement of the natural gas motor and of the pump 30 is such that when the natural gas and the producer gas are fed into the delivery main, they will be under substantially the same pressure. In actual practice the natural gas is expanded, within the cylinder 12, and the producer gas is compressed within the cylinder 30, so that when finally admixed these two gases will have a pressure of about 30 pounds per square inch. This pressure is not in any way essential, but it has been found quite satisfactory. Any other desired pressure may be used, and by properly constructing and arranging the natural gas engine and the producer gas pump the natural gas can be expanded down to any desired pressure and the producer gas compressed to a corresponding pressure.

The compressed producer gas, which is at a temperature considerably above atmospheric temperatures, is passed into a heat interchanger or cooler 51, which may be of any suitable form, but which, as shown diagrammatically, has somewhat the same construction as a fire tube boiler, the warm or hot producer gas passing through the tubes 52, and a cooling fluid, such as water, which is introduced through the pipe 53 passing upwardly over those tubes to cool the gas in them and then out through the pipe 54. The warm water passing from this cooler through the pipe 54 is introduced into the upper end of a cooling tower 60, which also may be of any suitable form, but which is illustrated diagrammatically as a cylindrical shell provided with wooden slats or blocks 61 therein so arranged that the water introduced through the pipe 54 will spread out in thin sheets over the surface of these blocks and thus be more readily aerated and cooled by the air which passes in through the openings 62 in the bottom of the cooling tower.

The cooled producer gas, still under pressure, passes from the cooler 51 through the pipe 65, which opens into another cooler 66, which is substantially identical in construction with the cooler 51 described above. But in this cooler 66 the natural gas from the pipe 21 passes through the tubes 67, and thence out through the pipe 68, while the producer gas from the pipe 65 passes into the shell 66 and around over the tubes 67 and thence out through the pipe 69. The natural gas in the pipe 21, after expansion within the cylinder 12 to do work, is at a quite low temperature, the temperature being dependent upon the amount of expansion. Presuming a well pressure of some 200 pounds, and an expansion to about 30 pounds per square inch, this temperature will probably be in the neighborhood of 0° Fahr. The producer gas going from the cooler 51 will be at a considerably higher temperature probably around atmospheric temperature, say 60 to 70° Fahr. As the two gases pass through the cooler 66, the natural gas will have its temperature raised and the producer gas will have its temperature lowered. The resulting temperature of the natural gas and the producer gas, as these two gases leave the cooler 66 will be dependent upon the relative quantities of the two gases passing through the cooler, the relative temperatures of the two gases as they pass into the cooler, and the relative specific heat of the two gases. The relative proportions of producer gas and natural gas will be entirely dependent upon the amount of dilution that is desired. Of course the greater the proportion of producer gas that is introduced the lower the heat value, for while natural gas will average around 1000 to 1100 B. t. u. per cubic foot, producer gas will range around 140 to 180 B. t. u. per cubic foot. Obviously the greater the proportion of producer gas the lower the heat value. It has been found, however, that with admixture of substantially 40% producer gas and 60% natural gas practically the same results can be secured in use as are secured with undiluted natural gas. With the two gases in substantially this proportion, and with the temperature of the natural gas entering the cooler 66 at substantially 0° Fahr. and the temperature of the producer gas entering that cooler at substantially 60° Fahr, the producer gas will be cooled to around 30 to 32° Fahr. without any correspondingly great rise in the temperature of the natural gas. This is due to the fact that the specific heat of natural gas is substantially twice the specific heat of producer gas.

The natural gas after passing from the cooler 66 through the pipe 68 is led into a delivery main 70, which leads to any desired place of use or storage. The producer gas passes off through the pipe 69 which opens into an absorbing tank 75. This tank contains some absorbing medium, preferably water at a temperature about freezing. The gas from the pipe 69 is broken up into fine streams by means of the nozzle 76, and bubbles through the water within the absorbing tank 75. The gas and water within the absorbing tank 75 being under a pressure in excess of one atmosphere, say 30 pounds per square inch, and at a temperature substantially freezing, the water has a capacity for absorbing considerable quantities of carbon dioxide. And as there will be in practice substantial quantities of carbon dioxide in the producer gas, probably from four to

ten percent, it will be absorbed by the water within the tank 75. This results in increasing the heat value of the producer gas as it is finally delivered and admixed with the natural gas. Furthermore it offers a means of obtaining a valuable by-product since carbonated water is secured within the tank 75. As shown the apparatus is so constructed that the water from the tank 75 is passed through the pipe 53 into the cooler 51, a suitable pump 77 being located within the pipe for feeding the water from the tank 75 to the cooler. And inasmuch as the water from the cooler 51 passes into the cooling tower 60 where the pressure upon it is removed, while it is at temperatures in excess of atmospheric temperatures, the carbon dioxide previously absorbed therein will escape into the atmosphere. Of course if desired the cooling tower could be entirely dispensed with and water fed through the cooler 51 from some outside source, so that the carbonated water from the tank 75 could be utilized as a by-product. In the construction shown, in which this carbonated water is not utilized as a by-product, but is recirculated through the heat interchangers or coolers, the aerated water from the cooling tower 60 passes downwardly through the pipe 80 into the heat interchanger 81 which is substantially identical in construction with those heretofore described the water passing around the tubes 82, and thence through the pipe 83 into the absorbing tank 75, while the producer gas with its carbon dioxide removed, passes through the pipe 84, where, as it moves through the tubes 82, it is heated by the water surrounding those tubes, this water being it is to be remembered, at about atmospheric temperature while the gas coming from the absorber 75 is at a temperature close to freezing. The producer gas leaves the heat interchanger 81 through the pipe 85, which opens into the delivery main 70, the gas within this main being admixed with the natural gas delivered through that tube to the pipe 68. If desired the natural gas and producer gas may be fed into a mixing chamber before being fed into the delivery main 70; but in practice sufficiently intimate admixture of the two gases is secured in the delivery main.

As set out above the natural gas is so expanded within the cylinder 12 and the producer gas is so compressed within the pump 30 that they are finally delivered into the main 70 under substantially the same pressure, and satisfactory results will be obtained if this pressure is approximately 30 pounds per square inch.

As the water passes through the heat interchanger 81, not only is the producer gas warmed up, but the water is in turn cooled down, so that the water passing therethrough to the absorbing tank will be at a temperature considerably below atmospheric temperatures, and consequently within the absorbing tank 75 that water, as the cold producer gas bubbles through it will have this temperature still further lowered so that conditions within the absorbing tank are such as to facilitate the ready absorption of the carbon dioxide.

The cooling tower should be so positioned with respect to the heat interchanger 81 that sufficient heat is provided to give a pressure within that heat interchanger and the absorbing tank at least equal to the pressure of the gas within the absorbing tank. Or a pump should be provided for delivering this water under the desired pressure.

It should be also borne in mind that with some types of coal certain undesirable impurities are obtained in the gas which are not removed in the conventional purifying apparatus. For example where a coal is high in sulphur it is not unusual to get such quantities of hydrogen sulphide or sulphur dioxide in the gas that it would be unpleasant for domestic use. These impurities are also, however, subject to absorption in water at a low temperature under pressure, and consequently where such sulphur compounds are in the gas they will also be removed within the absorption tank 75. Of course where these impurities are present within the gas and are absorbed within the tank 75 the carbonated water could probably not be used without some treatment. Under these conditions, however, recirculation of the water from the absorbing tank through the cooling tower would be in no way interfered with since the sulphur compounds would escape into the atmosphere within the absorbing tower just as does the carbon dioxide.

It is sometimes found desirable to have more than one absorbing tank. This may be desirable either because one tank does not remove all of the carbon dioxide, sulphur impurities and the like, or because the gas contains certain impurities which would not be removed by the water within the tank 75 but might be easily removed by passing them through some other material. Obviously as many absorbing tanks may be used as circumstances require.

If for any reason the expansion of the natural gas does not liberate enough energy to satisfactorily operate the pump 30, then added means may be provided. In the form of apparatus shown, for example, a gas engine, adapted to operate on the admixed gases, may be used as a supplementary power source. Any other form of supplementary power source may be used as desired.

Also it is not at all essential that a reciprocating gas engine be used, for a turbine might be used in place thereof.

While the method herein described, and the form of apparatus for carrying this method into effect, constitutes preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and form of apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. The method in the dilution of natural gas with a low value heat gas, such as producer gas, the natural gas being under higher pressure than the producer gas, in which the natural gas is expanded within an engine to cause operation of a blasting pump connected with a producer gas generator, with resultant lowering of the temperature of the expanding natural gas, and withdrawal of the generated producer gas from the producer and delivery of this producer gas under a predetermined pressure from the pump; which comprises lowering the temperature of the producer gas to substantially freezing, and at the same time maintaining said gas under a pressure in excess of one atmosphere, passing said cold producer gas through water maintained at a temperature approximately the temperature of the producer gas to absorb undesirable constitutents from said producer gas, and then admixing the said producer gas and the natural gas.

2. The method of diluting natural gas with a gas of lower heat value, such as producer gas, the natural gas being under greater pressure than the producer gas, which comprises expanding the natural gas to operate a pump for compressing the producer gas, with resultant cooling of the natural gas, bringing the expanded natural gas and the compressed producer gas into heat interchanging relation, to effect heating of the one and cooling of the other, and then admixing the two said gases, the natural gas being so expanded and the producer gas being so compressed, that after the heat interchanging they will be at substantially the same pressure.

3. The method of diluting natural gas with producer gas, the natural gas being under high pressure, which comprises expanding the natural gas to operate a pump for blasting the fuel bed of a producer to cause the generation of producer gas, and for compressing that producer gas to a pressure substantially the same as the pressure of the expanded natural gas, subjecting the expanded natural gas to heating and the compressed producer gas to cooling to bring them to substantially the same temperature, and then admixing the two said gases.

4. The method of diluting natural gas with producer gas, the natural gas being under high pressure, which consists in expanding the natural gas to effecting operation of a pump, with resultant lowering of the temperature of the natural gas, to cause a blast to be drawn through the fuel bed of a producer to cause the generation of producer gas, to withdraw the generated gas from the producer, to compress the said producer gas and to force it under suitable pressure through delivery pipes, and admixing said producer gas with the natural gas, the expanded natural gas and the compressed producer gas being brought into heat interchanging relation with each other before admixture.

5. The method of diluting natural gas with a low heat value gas, such as producer gas, the natural gas being under high pressure, which comprises expanding the natural gas to effect pumping action with resultant lowering of the temperature of the expanding natural gas to withdraw the generated gas from a producer and force it from the pump under predetermined pressure; subjecting the compressed producer gas to cooling action; then passing the compressed producer gas and the expanded natural gas through a heat interchanger to cause further cooling of the producer gas and heating of the natural gas; and then admixing the two gases.

6. The method of diluting natural gas with a low heat value gas, such as producer gas, the natural gas being under high pressure, which comprises expanding the natural gas to cause operation of a pump with resultant lowering of the temperature of the expanding natural gas, said pump being connected to the delivery pipe of a producer to withdraw the generated gas from the producer and force it from the pump under predetermined pressure; subjecting the compressed producer gas to cooling action; then passing the compressed producer gas and the expanded natural gas through a heat interchanger to cause further cooling of the producer gas and heating of the natural gas; then absorbing undesirable constituents from the cooled producer gas, and then admixing the producer gas and the natural gas.

7. The method of diluting natural gas with a low heat value gas, such as producer gas, the natural gas being under high pressure, which consists in expanding the natural gas to cause operation of a pump with resultant lowering of the temperature of the expanding natural gas, said pump being connected to the delivery pipe of a producer to withdraw the generated gas from the producer and force it from the pump under predetermined pressure; subjecting the compressed producer gas to cooling action; then passing the compressed producer gas and the expanded natural gas through a heat inter-

changer to cause further cooling of the producer gas and heating of the natural gas; passing the cooled producer gas through an absorption tank containing water at a temperature approximating freezing temperature and at a pressure of several atmospheres, to cause absorption of the carbon dioxide within said water; then admixing the treated producer gas with the natural gas; and aerating the water from the absorption tank to remove the carbon dioxide therefrom, and recirculating said aerated water through said absorption tank.

8. A natural gas dilution system comprising a natural gas supply pipe; a gas producer; an engine within said natural gas supply pipe adapted to perform work while expanding natural gas therein; a pump operated by said engine, the inlet of said pump being connected to the delivery pipe of the said producer, so that during operation of the pump it will withdraw gas from the producer under suction and delivery such gas under any desired predetermined pressure, the outlet pipe of the natural gas engine and the outlet pipe of the pump being connected to a delivery main, to introduce the expanded natural gas and the compressed producer gas into said delivery main.

9. A natural gas dilution system comprising, in combination, a natural gas supply pipe; a gas producer; an engine connected to said supply pipe and adapted to expand the natural gas to perform work; a pump operated by said engine and connected to said producer to withdraw generated gas from the producer under suction and compress said gas; means for effecting heat interchange between the natural gas expanded within the engine and the producer gas compressed within the pump; and separate means for connecting said heat interchanging means to a delivery main, for effecting admixture of the two gases.

10. A natural gas dilution system comprising, in combination, a natural gas supply pipe, connected to a source of supply of natural gas under well pressure; a gas producer; an engine connected to said supply pipe and adapted to expand the natural gas to perform work, with resultant lowering of the temperature of the natural gas; a pump operated by said engine connected to said producer to withdraw generated gas from the producer under suction and compress said gas, means for cooling the compressed producer gas; means for effecting heat interchange between the expanded natural gas and the cooled compressed producer gas; and means for introducing the natural gas and the producer gas from the heat interchanging means into a delivery main for admixing the two gases.

In testimony whereof I hereto affix my signature.

HARRY F. SMITH.