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2 SHEETS—SHEET 1.

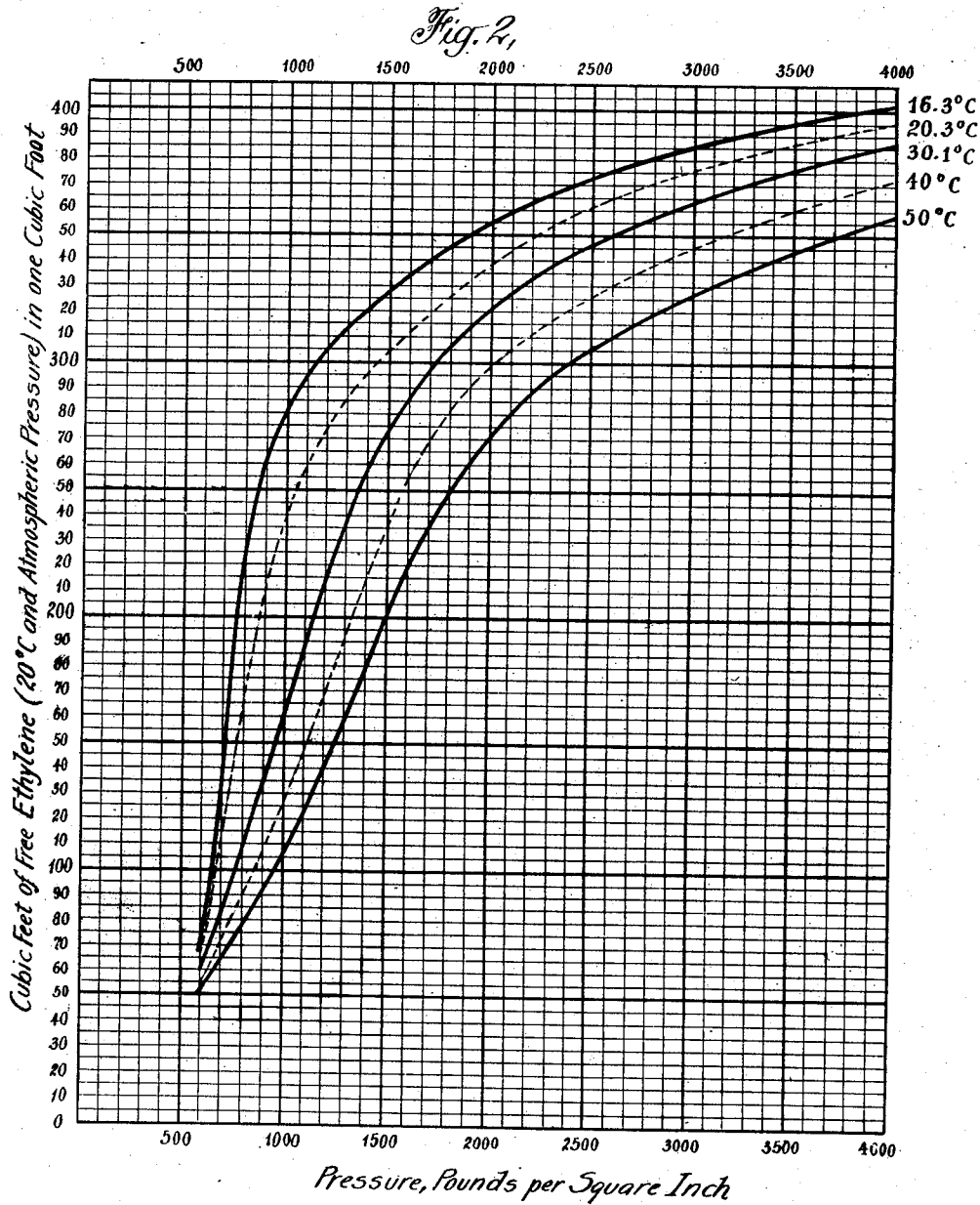


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 COMPRESSION, STORAGE, &c., OF ETHYLENE.
 APPLICATION FILED JUNE 6, 1919.

1,339,431.

Patented May 11, 1920.
 2 SHEETS—SHEET 2.



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UNITED STATES PATENT OFFICE.

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COMPRESSION, STORAGE, &c., OF ETHYLENE.

1,339,431.

Specification of Letters Patent.

Patented May 11, 1920.

Application filed June 6, 1919. Serial No. 302,209.

To all whom it may concern:

Be it known that I, ARTHUR A. BACKHAUS, residing at Baltimore, State of Maryland, have invented certain new and useful
5 Improvements in the Compression, Storage, &c., of Ethylene; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it
10 appertains to make and use the same.

The present invention relates to improvements in the compression, storage, etc., of ethylene, whereby the ethylene, in large
15 amount, can be advantageously stored, shipped and made available for use in a highly compressed state, for example, as a blow-pipe fuel, or for other purposes.

Various combustible gases have heretofore been provided in containers under
20 pressure for use in combustion processes, as in the production of a blowpipe flame for use in heating, welding, cutting, etc., or for other purposes. The combustible gases which have been most commonly supplied
25 in this way have been hydrogen, Blau gas and acetylene. Hydrogen can be readily compressed to a high degree, but it is deficient in heating power and is of relatively little importance as a fuel for commercial
30 purposes. Blau gas is supplied in special containers or cylinders in a liquefied state, but its evaporation and use require special precautions, and are attended with certain well recognized disadvantages. The gas
35 most commonly employed as a combustible gas, and supplied under pressure in containers, is acetylene, and this gas, in spite of its objectionable characteristics, and the danger attendant upon its manufacture,
40 compression, storage and use, prevails, at present, in the commercial field.

The danger incident to the manufacture, compression, storage and use of acetylene is well appreciated in the art. In order to
45 make acetylene available at all for transportation and use in a compressed state, various expedients must be resorted to, but these have been only partially successful, and have served merely to reduce and not
50 to eliminate the inherent and constant menace and peril of spontaneous explosion.

Thus, in practice, the cylinders in which acetylene is compressed must be first completely filled with a porous material, and
55 this material must be charged or soaked with acetone, or its equivalent, which serves as

a solvent for the acetylene. The acetylene is then introduced and dissolved in the solvent. It is important for the cylinder to be completely filled with the porous material
60 charged with the solvent, and it is impossible to leave voids or pockets in the cylinder unoccupied by the filling, without correspondingly sacrificing the protective function of the solvent. The permissible pressure of the
65 charged cylinder is limited to about 250 pounds per square inch at a temperature of about 70° F. Acetylene is well known to be explosive when in a compressed state and a rise in temperature and pressure of the
70 cylinder and its contents due to exposure of the cylinder to a high temperature, will often bring about an explosion. The formation of explosive acetylids is also a source
75 of danger.

Further disadvantages incident to the compression, storage and supply of acetylene are the inevitable loss by evaporation of a part of the acetone solvent, which must be replaced when the cylinder is recharged;
80 the presence of deleterious constituents, such as phosphids, which may be present when acetylene is obtained from carbid; and the instability of the acetylene which results in its decomposition when it is heated
85 to a high temperature during use. So also, particularly in extremely cold weather, the lowering of temperature due to the evaporation of the acetylene and acetone may result in a partial "freezing" of the contents of
90 the cylinder, so that the user is unable to obtain from the cylinder the same quantity of acetylene, as is obtainable therefrom in summer. Moreover, in some instances the user, unaware of the danger of the expe-
95 dient, is tempted to warm up the cylinder for the release of the residual acetylene, and is exposed to peril incident to that procedure.

Furthermore, the protective filling and
100 solvent, required in an acetylene cylinder, not only involve an additional expense in initial expense and in subsequent maintenance and replacement, but they materially increase the weight of the cylinder,
105 so that the handling and transportation of both the charged and "empty" cylinders involves added effort and expense.

According to the present invention, the difficulties and objections referred to are
110 avoided, and there is provided a compressed fuel gas, namely, compressed ethylene,

which can be compressed, stored, shipped and used without danger, and which, in addition, presents certain features of advantage over acetylene and the other available compressed fuel gases.

Chemically considered, ethylene is closely related to acetylene. Both are unsaturated hydrocarbon gases containing two carbon atoms, and the only two such gases. They differ, chemically, only in their degree of unsaturation, *i. e.*, in the number of hydrogen atoms which they contain, and, by hydrogenation, both gases can be converted into the same saturated hydrocarbon, namely, ethane. It might, therefore, be expected that ethylene, because of its close chemical similarity to acetylene, would likewise require special precautions in its compression, storage and use, and be subject to like limitations.

I have found, however, that ethylene can be directly compressed to a high pressure, far in excess of that to which acetylene can be safely compressed, and that ethylene can be stored in cylinders or containers without the use of an absorbent filling and solvent, and without the danger and disadvantages incident to the compression and storage of acetylene. The entire space of the cylinder can, accordingly, be filled with the compressed ethylene. Moreover, since the ethylene is present in a gaseous, rather than a "dissolved" or liquid state, the entire content of the cylinder can be made available, even in the coldest weather, without objectionable lowering of temperature due to evaporation.

I have made the further surprising discovery that the amount of ethylene which can be safely charged into a cylinder of standard construction is more than twice as great as the amount of hydrogen (likewise a combustible gas and a component of ethylene), or of oxygen (the common combustion-supporting gas), which can be safely charged into a cylinder of the same size and construction.

This important difference between ethylene and gases such as hydrogen and oxygen is further emphasized by the profound influence which the temperature of compression and charging has upon the pressure required for the charging operation. Thus, if the limiting condition of the cylinder is a pressure of about 2200 lbs. at a maximum temperature of about 50° C. or 122° F., a cylinder, the cubical content of which is 1 cu. ft., will contain about 288 cu. ft. of free ethylene, whereas this same amount of ethylene need only be compressed to a pressure of about 1320 lbs. (per sq. inch abs.) if the temperature of the ethylene is lowered to about 20.3° C.

In the charging of cylinders with oxygen it is customary to charge the oxygen at or-

dinary temperatures, and at a pressure approximating the maximum limiting pressure of the cylinder, for example, at a pressure of about 2000 lbs. and at a temperature of about 20.3° C. and an increase in temperature up to about 50° C., will cause but a relatively small increase in pressure to about 2200 lbs. The amount of free oxygen so charged will be about 147 cu. ft. In the case of ethylene, however, if the cylinder were charged at the same temperature and pressure, the amount of ethylene will be about 360 cu. ft., and, if the temperature should increase to 50° C., the pressure would increase to about 3900 lbs.—far beyond the pressure for which the ordinary cylinder is constructed.

The compression of ethylene is accompanied by the evolution of considerable heat, and by a corresponding rise in temperature. It is, therefore, important, in order to avoid too high temperatures and pressures, to subject the ethylene to cooling during its compression, and thereby absorb and neutralize the heat of compression. This cooling is also of advantage in enabling a lower pressure to be used at the lower temperature, owing to the greater ease of compression of ethylene at the lower temperatures, as above indicated.

The invention will be further described in connection with the accompanying drawings, in which,

Figure 1 shows, in a somewhat conventional and diagrammatic manner, an arrangement of apparatus for compressing and cooling the ethylene and charging it into the containers; and

Fig. 2 shows a chart by means of which the proper charging pressure can be ascertained for any usual charging temperature.

In the apparatus of Fig. 1, the ethylene, from the generator or storage tank, is introduced through the pipe 1 to the first cylinder 2 of a three stage compressor. The three cylinders of the three successive stages are indicated at 2, 6 and 10, respectively, and are each provided with a cooling jacket for absorbing part of the heat of compression and thereby keeping down the temperature of the compressed ethylene. From the three compression cylinders the compressed ethylene passes through the three respective coolers or exchangers, where it is brought into indirect contact with water or other cooling agent, and its temperature is still further lowered. The connecting pipes are indicated at 3, 5, 7, 9 and 11.

From the last cooler 12, the compressed and cooled ethylene passes through the pipe 13 to the charging manifold 14, having branches with valves 16 and flexible pipe connections or "pig-tails" 17 through which the cylinders 15 may be charged. Each cylinder is provided with the usual

valve 18. Pressure gages and one or more thermometers (not shown) enable the pressure and temperature of the compressed ethylene to be readily ascertained.

The pressure to which the ethylene will require compression or to which it can be safely compressed, will vary with the temperature, as above stated. The extent of this variation will be apparent from Fig. 2, which is based upon observed figures. Assuming a maximum pressure of about 2200 lbs., at a maximum temperature of 50° C. as the limiting conditions, the charging pressure for any lower temperature can be readily ascertained, inasmuch as the volume of the cylinder, and the number of cubic feet to be charged (about 288 cu. ft. of free ethylene at 20° C. and atmospheric pressure) will remain the same. At 16.3° C. this pressure will be only about 1050 lbs.; at 20.3° C., about 1350 lbs.; at 30.1° C., about 1630 lbs.; and at 40° C., about 1880 lbs. If the cylinder has a higher safe charging pressure, *e. g.*, about 3000 lbs., at a maximum temperature of 50° C., it will require a charging pressure of only about 1500 lbs. at 16.3° C., or about 1800 lbs. at 20.3° C. The correspondingly greater ease of compression, and the much less power required for the compression, at lower temperatures, will thus be apparent, as well as the profound effect of increase in temperature on the pressure of the ethylene so charged. A very important economy in the power required for compression and charging of the ethylene will result from even a few degrees lowering of the temperature. Accordingly, by providing for the after-cooling of the compressed ethylene, and thereby reducing its temperature, it becomes possible not only to use less power for the compression, but also to use a compressor of less expensive construction, thereby economizing both in the initial expense of the compressor and in the cost of its operation. With hydrogen and oxygen, there is no particular advantage to be gained by after-cooling of the compressed gases, inasmuch as the power required is but slightly reduced by such after-cooling. In this respect, accordingly, as well as in other respects elsewhere pointed out, the process of compression and charging of ethylene differs radically from that of hydrogen and oxygen.

Whereas with hydrogen or oxygen the variations in pressure due to the variation in temperature commonly met with, are so small as to be within the margin of safety of the common metal cylinders, (which are commonly provided with safety devices that will be ruptured at excessive pressures, *e. g.*, about 400 lbs. in excess of the charging pressure for which the cylinders are tested), the variations in pressure with ethylene due

to like variations in temperature are far in excess of the safety limit.

It is accordingly necessary, with ethylene, to take precautions not required in the handling of these other gases. With the observation of these precautions, however, and by proper cooling and regulation of the charging temperature and pressure, it is nevertheless possible to charge the compressed ethylene, so that it can be safely stored, handled, transported and used, and so that it will, nevertheless, contain a far greater number of cubic feet of ethylene than a like cylinder would contain of other combustible gases, such as hydrogen or acetylene. It is thus readily possible to charge more than one and a half or two times as much ethylene as hydrogen into a standard cylinder (about 1.54 cu. ft. capacity) at the same or a lower pressure, and such cylinders with their far larger amount of ethylene, can nevertheless be stored, handled, transported and used with substantially the same ease and safety as the ordinary hydrogen cylinders. That is, whereas a cylinder having a cubical capacity of about .777 cubic foot is commonly called a 100 cubic foot hydrogen or oxygen cylinder, and a cylinder having a cubical capacity of about 1.54 cubic feet is commonly called a 200 cubic foot hydrogen or oxygen cylinder; the amount of ethylene which can be safely charged into these same cylinders will be more than one and one-half times as much, and may amount to twice as much or even more. Expressed in terms of cubic feet of ethylene per cubic foot of cylinder capacity, it is thus easily possible to charge more than 200 cubic feet of ethylene, and even more than 250 cubic feet of ethylene, per cubic foot of cylinder capacity, without danger, whereas, with hydrogen or oxygen the cylinders above referred to contain only about 130 cubic feet of hydrogen or oxygen per cubic foot of cylinder capacity.

When the cylinder of compressed ethylene is maintained at ordinary temperature, or at cooler temperatures, the pressure exerted by the ethylene will be correspondingly less and the margin of safety of the cylinder correspondingly increased.

When in use, the far larger amount of ethylene which a cylinder of compressed ethylene will contain, as compared with cylinders of hydrogen or acetylene of like size, will enable the ethylene to be used for a much longer time, and with less frequent change of cylinders. The number of cylinders required to be purchased and kept on hand can thus be radically reduced, resulting saving in transportation charges, and in initial expense of the cylinders.

Ethylene can be readily produced in a state of comparative purity, *i. e.*, containing 95% or more ethylene, and without the

presence of such deleterious compounds as may be present in acetylene obtained from carbid. For the manufacture of the ethylene, any process may be employed which will insure its production in sufficient amount and in a suitable condition of purity. Thus, for example, it may be obtained by the liquefaction and fractional separation of oil gas or cracked oils or other gaseous mixtures in which it is present in available quantities. I recommend, however, as the preferred source of the ethylene, obtaining it by the catalytic dehydration of ethyl alcohol, employing, for example, alumina, clay or other like catalytic body at a suitable temperature. The ethylene may be produced in a continuous manner and supplied directly to the compressor, or it may conveniently be stored in a suitable holder and supplied to the compressor as required.

I claim:

1. A commercially transportable metal cylinder containing compressed ethylene which can be safely stored, handled, shipped and used, said cylinder having its interior free from absorbent filler and solvent and containing the ethylene compressed to a high pressure, the amount of ethylene being more than one and one-half times the amount of hydrogen in a cylinder of the same size under the same pressure; substantially as described.

2. A commercially transportable metal cylinder containing compressed ethylene which can be safely stored, handled, shipped and used, said cylinder having its interior free from absorbent filler and solvent and containing the ethylene compressed to a high pressure, the amount of ethylene being more than 200 cubic feet of ethylene per cubic foot of cylinder capacity; substantially as described.

3. A commercially transportable metal cylinder containing compressed ethylene which can be safely stored, handled, shipped and used, said cylinder having its interior free from absorbent filler and solvent and containing the ethylene compressed to a high pressure, the amount of ethylene being more than 250 cubic feet of ethylene per cubic foot of cylinder capacity; substantially as described.

4. The method of compressing ethylene in cylinders, for storage, shipment and use, which comprises compressing the ethylene, cooling the ethylene during compression and thereby neutralizing the heat of compression and materially lowering the pressure

required, and charging the cooled compressed ethylene under a regulated pressure and in a gaseous state into cylinders having their interiors free from packing and solvent, the charging pressure being so regulated that the amount of ethylene charged into the cylinders will be more than one and one-half times the amount of hydrogen in cylinders of the same size under the same pressure; substantially as described.

5. The method of compressing ethylene in cylinders for storage, shipment and use, which comprises subjecting the ethylene to progressively increased compression, cooling the ethylene during such progressive compression and thereby neutralizing the heat of compression, and materially lowering the pressure required, and charging the cooled compressed ethylene at a temperature of about 20° C. to 40° C., and under a regulated pressure into cylinders having their interiors free from packing and solvent, whereby the ethylene is contained in the cylinders in a compressed gaseous state, the charging pressure being so regulated that the amount of ethylene charged into the cylinders will be more than 250 cubic feet per cubic foot of cylinder capacity; substantially as described.

6. The method of compressing ethylene in cylinders for storage, shipment and use, which comprises compressing the ethylene, and charging the compressed ethylene into cylinders having their interiors free from packing and solvent, the charging temperature and pressure being so regulated that the amount of ethylene charged into the cylinders will be more than one and one-half times the amount of hydrogen in cylinders of the same size under the same pressure; substantially as described.

7. The method of compressing ethylene in cylinders for storage, shipment and use, which comprises compressing the ethylene, cooling the ethylene both during and after compression and thereby neutralizing the heat of compression and materially lowering the pressure required, and charging the cooled compressed ethylene into cylinders having their interiors free from packing and solvent, the charging temperature and pressure being so regulated that the amount of ethylene charged into the cylinders will be more than one and one-half times the amount of hydrogen in cylinders of the same size under the same pressure; substantially as described.

In testimony whereof I affix my signature.
ARTHUR A. BACKHAUS.