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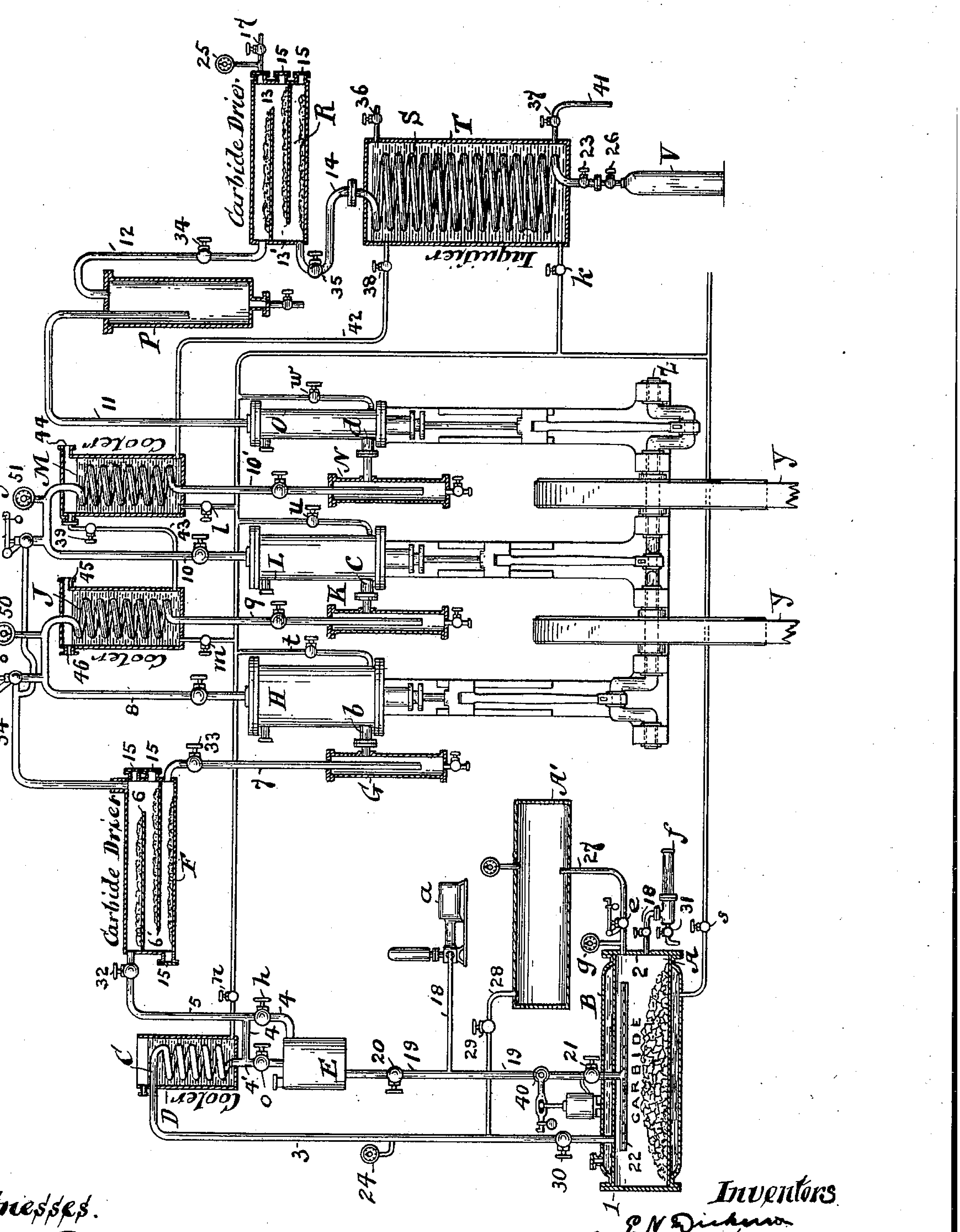
(Application filed Mar. 19, 1896.)

(No Model.) 2 Sheets—Sheet 1.



Witnesses.
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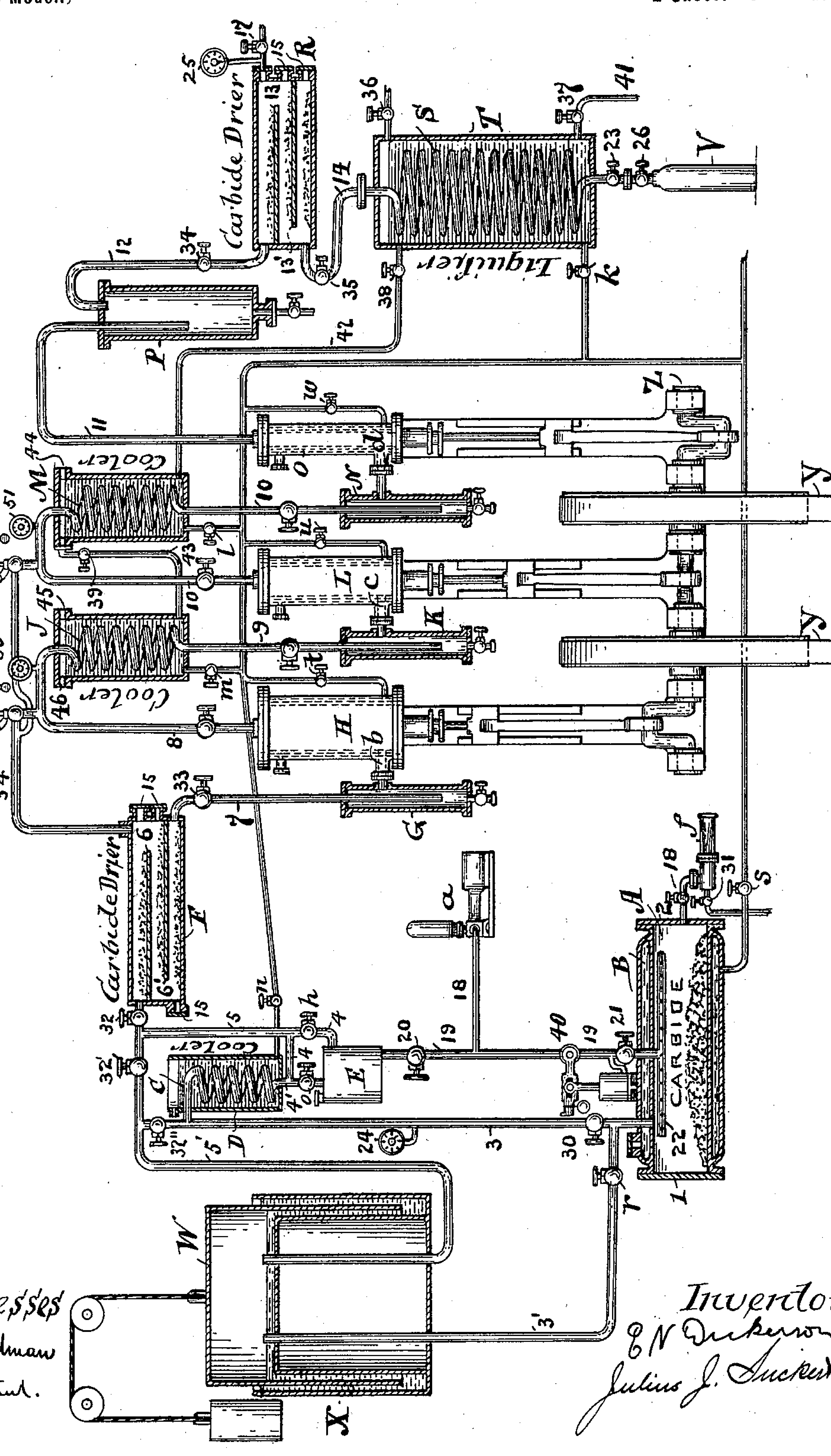
Fig. 2



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UNITED STATES PATENT OFFICE.

EDWARD N. DICKERSON AND JULIUS J. SUCKERT, OF NEW YORK, N. Y., ASSIGNORS TO THE UNITED STATES ACETYLENE LIQUEFACTION COMPANY, OF NEW YORK.

PROCESS OF PRODUCING AND LIQUEFYING ACETYLENE GAS.

SPECIFICATION forming part of Letters Patent No. 629,668, dated July 25, 1899.

Application filed March 19, 1896. Serial No. 583,875. (No specimens.)

To all whom it may concern:

Be it known that we, EDWARD N. DICKERSON and JULIUS J. SUCKERT, of the city, county, and State of New York, have invented a new and useful Process of Producing and Liquefying Acetylene Gas, of which the following is a full, true, and exact description, reference being had to the accompanying drawings.

We find in producing acetylene gas in large quantities that under certain conditions the liquefying pressure due to increased temperature of condensing-water might at times exceed seven hundred pounds pressure, and in order to meet this pressure very heavy generators have to be built. This not only increases the cost of the apparatus considerably, thereby rendering the production of the liquefied acetylene on a large scale somewhat expensive in first cost of apparatus, but, further, is found to tend to cause a decomposition of the gas in some cases. We further find that the cooling of the generators where large masses of carbid are being acted upon is also attended with some difficulty. To obviate these conditions, we in the first instance prevent the gas from attaining a liquefying pressure while being generated and thereafter employ mechanical compression in reaching the ultimate high pressures required for the liquefaction of the gas, and as the compression of the gas by mechanical means would result in a high temperature of the gas and its decomposition we provide means for preventing a decomposing temperature.

Our apparatus will be readily understood from the accompanying drawings, in which—

Figure 1 represents a diagrammatic view, generally in elevation and in part section, of our apparatus connected for operation; and Fig. 2, a modification thereof, substituting an expansible for a rigid receiver.

Similar letters and figures of reference refer to similar parts in our drawings.

In the drawings, A represents a wrought-iron generator provided with flanged head 1 and generating-chamber 2. The head 1 is removable and is used for filling in the carbid to be decomposed and also for cleaning out the spent material. The heat set free by the decomposition of the carbid and water is in great part taken up by the cooling-water surrounding the generator A in the jacketed space B.

3 is a gas-pipe leading the generated gas and intermingled aqueous vapor to the cooling-coil C, surrounded by water in the tank D. The aqueous vapor condensed in the coil passes as water though the pipe 4′ to the water-tank E, and the gas leaving the cooling-coil is conducted through pipes 4 and 5 to the drying-tank F, where the remaining moisture is absorbed by exposing the gas to large surfaces of the carbid contained in this tank on suitably-constructed shelves 6 6′. From the drier the gas passes through pipe 7 to the chamber G, from whence it is conducted to the suction-inlet of the pump H, where the gas is compressed and discharged through the discharge-pipe 8 and enters the cooling-coil J. From this cooling-coil the gas passes through the pipe 9 to the receiving and separating chamber K and through the suction-inlet of the compressor L. From the discharge-pipe 10 of this compressor the compressed gas is conducted to the cooling-coil M, and from this coil it is again led through pipe 10′ to receiving and separating chamber N, and thence to the suction-inlet of the compressor O, from which it is finally discharged through the pipe 11 to the drip-chamber P, and thence through pipe 12 to the drying-chamber R, where in a compressed condition it is again brought in contact with large surfaces of carbid contained on the shelves 13 13′. From this drying-chamber it passes through the pipe 14 to the condenser S, surrounded by a cooling medium contained in the tank T. The liquefaction of the gas takes place in this coil, and the liquid is finally withdrawn into the receiving and shipping tank V. In Fig. 2, however, the gas-tank A′ and its connections are not shown. In place thereof the gasometer W is shown with its containing-tank X and connecting-pipes 3′ and 5′.

In carrying out the process the following operations are followed: A known quantity of calcium carbid is introduced by removing the flanged head 1 into the generator A and is spread over the lower surface of the generator by means of a rake. The flanged head 1 is then replaced and bolted tight. Into the driers F and R calcium carbid is introduced through the openings 15 15 and spread to a uniform depth on the shelves 6 6′ and 13 13′ and also on the bottom surfaces of the driers. The openings are then securely closed. By opening the valves *s*, *k*, *l*, *m*, *n*, *t*, *u*, and *w* cold water is circulated around those portions of the apparatus requiring a cooling medium. With the exception of the blow-off valve 17 and gas-exhausting valve 18 all valves attached to the apparatus are opened, transporting-tank V being disconnected. The compressors H, L, and O are now set in operation through the belts Y Y, operating the three compressors through the cranks attached to the shaft Z, and a vacuum is formed in the generating side of the apparatus. The water-pump *a* is now started and water forced through pipes 18′ 19 and valve 20 into the water-tank E until a quantity sufficient to decompose the carbid in generator A has been introduced. The water-pump *a* is now stopped and valves 21 and pipe 19 gradually opened and a small quantity of water allowed to enter the generator A through the spray-pipe 22. The acetylene gas thus generated by contact of the water with the carbid displaces any remaining air in the apparatus, passes then through the compressors H, L, and O and their connecting-pipes, and forces out the air remaining in the liquefying portion of the apparatus until pure gas is discharged at the bottom of the condenser S. The valve 23 is then closed and the valve 21 so adjusted that a small and uniform quantity of water is sprayed on the carbid in the generator A. The pressure now gradually increases in the apparatus, which is indicated by the pressure-gages 24 and 25. Pressure-gages 50 51 are likewise connected with the intermediate pressure systems to the compressors. The water-pressure-regulating valve 40 is now adjusted to maintain the gas-pressure uniform and always below the liquefying pressure by regulating the quantity of water admitted to the generator, the valve 21 remaining open during this adjustment. The general construction of this regulating-valve is as follows: It consists of a piston attached by means of a rod to a lever, which in turn operates the valve 40. The lower part of this piston is exposed to the pressure which it is desired to maintain in the generator. By means of a weight attached to the lever operating the valve 40 the pressure operating below the piston can be increased or reduced. Any increased pressure over and above that at which the regulating-weight is set causes a rising of the piston and a closure of the valve 40. As soon as the pressure is reduced in the generator the valve 40 opens and allows water to feed into the generator. Such valves are well known. At the same time the speed of the shaft Z is regulated so that it will correspond to a certain extent with the water being admitted by the water-regulating valve 40 into the generator A. The gas generated in the generator A passes through the gas-pipe 3 to cooling-coil C, where a large portion of the aqueous vapor contained in the gas is condensed and, following the course of the coil, is discharged into the water-tank E, the gas, however, passing through pipes 4 and 5 into the drier F and by contact with the carbid contained therein the remaining moisture or a greater portion thereof is abstracted from the gas, generating at the same time acetylene gas, which intermingles with the gas contained in the drier. The united gases are then conducted from the drier through the pipe 7 to the receiving-chamber G, where any small particles of lime which may be carried over by the gas are deposited. The gas is then drawn into the opening *b* of the compressor H and is discharged from the compressor at an increased pressure through pipe 8 into the cooling-coil J, wherein the heat of compression is abstracted by the cooling medium surrounding this coil. The partly compressed and cooled gas now passes through pipe 9 to the second receiver K, wherein any lubricant or condensable vapor which might be contained in the gas is separated at this pressure. From the chamber K the gas is drawn through the suction-opening *c* into compressor L and is discharged therefrom at an increased pressure into the cooling-coil M, where the additional heat of compression imparted to the gas is removed. The compressed gas continues on its passage through pipe 10′ to separating-chamber N, which receives any condensable vapor which may have separated from the gas at this pressure, and the gas then continues on its passage through suction-opening *d* of the compressor O, wherein the final compression of the gas takes place, and it is discharged therefrom into the receiver P, wherein the separation of any vaporized lubricant from the last compressor can accumulate. The gas now passes from the final receiver through the conducting-pipe 12 to the drier R, wherein any additional moisture it may contain is absorbed by the calcium carbid contained on the shelves 13 13′, thereby adding additional acetylene gas to the gas already compressed. The combined gases pass from the drier through pipe 14 to the condenser S, where liquefaction takes place, the liquefied gas being withdrawn from this coil into the receiving-tank V, which when filled is replaced with a new one.

When it is found desirable to change the receiver V, the valves 23 and 26 are closed, the receiver disconnected, and a new one attached. If during the operation of generating gas an excessive pressure should occur in the generator A, it can readily escape by means of a safety-valve *e*, attached to the pipe 27, leading to the receiving-tank A′, from whence it can be fed to the compressors through the pipe 28 by opening the valve 29, which remains closed during the process of generating the gas, but which remains open upon starting when a vacuum is being formed in the apparatus.

In the operation just described the pressure maintained on the generating portion of the apparatus—that is, in the generator, connecting-pipes, cooling-coil, drier, and separating-chamber G—varies from fifty to one hundred pounds to the square inch, and can be increased, if desirable. The compressors H, L, and O therefore will have to increase the pressure from that stated to the liquefying pressure of the gas, which in case water of 70° or 80° Fahrenheit is used for condensing purposes will rise to seven hundred pounds per square inch.

When the apparatus shown in Fig. 1 is employed, suitable pressures are as follows: Feeding to the compressors with a pressure of one hundred pounds per square inch their volume is so proportioned that the gas is compressed in the first cylinder to two hundred pounds per square inch, as indicated on the gage 50, in the second cylinder to three hundred and fifty pounds per square inch, as indicated on the gage 51, and in the third cylinder to liquefying pressure, which is, approximately, seven hundred pounds per square inch, as indicated on the gage 25. Feeding to the compressors at fifty pounds pressure the volume of compressors can be so proportioned that the discharge from the first compressor will indicate a pressure of one hundred and thirty-five pounds per square inch, from the second compressor two hundred and twenty-five pounds per square inch, and from the third compressor the liquefying pressure of the gas. Feeding from the gasometer, as shown in Fig. 2, at atmospheric pressure the compressors can be so proportioned that the discharge from the first compressor will indicate a pressure of forty-five pounds per square inch and from the second compressor two hundred pounds per square inch.

Instead of proportioning the size of the compressors as above and connecting them on one shaft it may be found desirable when the apparatus is to be used at times for compressing the gas from one hundred pounds to initial pressure and from that down to atmospheric pressure or below to divide the compression in three equal stages—namely, from one hundred pounds to three hundred pounds in the first compressor, to five hundred pounds in the second compressor, and to seven hundred pounds or liquefying pressure in the third compressor, or from atmospheric pressure to two hundred and thirty pounds in the first compressor, to four hundred and sixty pounds in the second compressor, and to seven hundred pounds or liquefying pressure in the third compressor. In order to maintain these proportions of the final compressors, it will be necessary to separate the three compressors so that they can be operated at different speeds, thereby varying the amount of gas taken in and discharged from each compressor by proportioning the speed accordingly, so that the pressure-gages 50 and 51 may be used as an index for the regulation of their speed or of the volume of gas to be drawn in and expelled from each compressor.

The cooling-coils interposed between the compressors materially facilitate the compression of the gas, and an economy in power is thereby obtained and decomposition prevented. The water-jackets surrounding the compressors H, L, and O, which are fed with water by opening the valves *t*, *u*, and *w*, also maintain the compressors at a uniform temperature during the compression of the gas. It is obvious that the cooling of the compressor or compressors cools the gas in contact with their walls, and this we regard as exceedingly important for the reason that the heat which might tend to decompose the gas is generated in these compressors in the act of compression, and consequently should be abstracted at that point in order to prevent the decomposition within the compressor. It is obvious that the function of thus cooling the compressor and preventing the decomposition of the gas is entirely different from the function of cooling the ordinary compressor not operating upon a decomposable gas. After the charge of carbid in the generator A is exhausted a vacuum is formed in the generating portion of the apparatus by the compressors H, L, and O. The valve 29 on relief-tank A′ is opened and any gas contained in this tank is also drawn from this portion of the apparatus. The valve 30 on pipe 3 and the valve 21 on pipe 19 are now closed, the detachable head 1 is removed, and the spent carbid withdrawn from the generator. A new charge of carbid is then inserted and the head 1 replaced and secured, and the air is then discharged from the apparatus by opening the steam-valve 31, which, operating the exhaust-injector *f*, withdraws the greater portion of the air from the generator, when the valve 18 is opened. This having been accomplished, valve 18 is closed. The water-pump *a* is then started and a sufficient quantity of water is pumped into the water-tank E, and by slightly opening the valve 21 a small quantity of water is introduced on the carbid, so that sufficient gas is generated to again bring the interior of the generator to the atmospheric pressure which is indicated on the gage *g*. The valve 18 is now again opened and the gas contained in the generator discharged therefrom until a partial vacuum is again formed. Valve 18 is then closed, as is also steam-valve 31, and valve 30 opened, the water-regulating valve 40 having been previously adjusted. By opening the valve 21 the operation of the apparatus is repeated, as previously described, the valve 29 in the meantime having been closed.

In this manner under the conditions stated the pressure on the generating side of the apparatus is increased to one hundred pounds pressure, which is gradually reduced as the carbid becomes exhausted.

In case it is desirable at any time to replenish the carbid contained in the driers F and R the valves 32 and 33 on drier F and the valves 34 and 35 on drier R are closed, the various outlets 15 are opened, and the spent carbid withdrawn and replaced with fresh material. In case uncondensed gas or air accumulates in the liquefying portion of the apparatus it is expelled therefrom by opening the blow-off valve 17, attached to the drier R. At times it may be found desirable to use an artificially-cooled medium for facilitating liquefaction of the gas and also for cooling the gas compressed by the compressors. In that case the valves *k*, *l*, *m*, and 36 are closed, the valves 37, 38, and 39 opened, and the cooling medium circulated through pipes 41, 42, and 43, the outlets 44 and 45 being closed on the coolers J and M. From the outlet 46 the cooling medium is conducted through suitable pipes to be recooled and again circulated through the portions of the apparatus, as described.

In Fig. 2 an addition to the apparatus shown in Fig. 1 enables the generation of the gas in the generator at atmospheric pressure, the gas being conducted to the gasometer W through pipe 3′ and is withdrawn therefrom through the pipe 5′, carbid-drier F, and separator G to the compressor H, where the same operation takes place as described in Fig. 1—namely, the compression and subsequent liquefaction of the gas. It is very important that too much pressure and consequent heat shall not simultaneously exist in the liquefying gas. Consequently we provide relief-valves 52 53, carrying back such excess of pressure to the low-pressure side of the compressors. The relief-valve 52, for instance, in the apparatus shown in Fig. 1 may be set at two hundred and fifty pounds and the relief-valve shown in Fig. 2 at sixty pounds. They connect with the pipe 54, which may enter the carbid-drier F, or at some other suitable point on the suction side of the compressor H.

The cooling-coil C in Fig. 2 may not be necessary if the gasometer is large and the cooling effect of the atmosphere is taken into consideration; but where the gas is generated in large volume considerable aqueous vapor will no doubt pass through the gasometer, with the gas issuing therefrom, and can be separated in great part by the use of the cooling-coil C, as shown. By opening the valve 32′ and closing the valve 32″ the gas can be allowed to pass directly from the generator to the carbid-drier F, or by closing the valve 32′ and opening the valve 32″ it can be compelled to pass through the cooling-coil C prior to its entrance to the carbid-drier. If it is desired to form a combination of both apparatuses, the receiving-tank A′ in Fig. 1 can be readily attached to the apparatus shown in Fig. 2.

The use of the gasometer and generation of the gas at atmospheric pressure may at times be advisable when a carbid containing a large percentage of impurities is being operated upon. In that case it is found that the volume of gas generated from the carbid at a lower pressure is larger in amount than that obtained when the gas is generated from a carbid under pressure, as described in Fig. 1.

When in this specification we describe water as a means of decomposing the carbid compounds, we also mean to include thereby other equivalents, such as the vapor of water or suitable hydrates. It is also obvious that some portions of the process herein described may be advantageously used without employing the whole process and that some parts of the apparatus are also useful without the use of the entire combination.

We do not in this application claim any process in which in a single compressor the gas is compressed without cooling in such compressor, the subject-matter of this application being limited to the subject-matter of the claims. Part of the subject-matter of this application as filed has been applied for in separate applications—namely, Serial No. 640,505, filed June 12, 1897, and Serial No. 660,878, filed December 6, 1897.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. In the production of liquefied acetylene gas, first generating the gas by gradually bringing together water and an acetylene-producing carbid in such proportions and so regulated as to prevent a liquefying pressure, and then mechanically increasing the pressure upon the gas to the liquefying-point, meanwhile maintaining the gas below a decomposing temperature by abstracting the heat during the operation of compression as the same is there generated, substantially as described.

2. In the production of liquefied acetylene gas, first generating the gas by gradually bringing together water and an acetylene-producing carbid in such proportions and so regulated as to prevent a liquefying pressure, artificially cooling the mixture during the generation of the gas to prevent decomposition, and then mechanically increasing the pressure upon the gas to the liquefying-point, while maintaining the gas below a decomposing temperature by abstracting the heat during the operation of compression as the same is there generated, substantially as described.

3. In the production of liquefied acetylene gas, first generating the gas by gradually bringing together water and an acetylene-producing carbid in such proportions and so regulated as to prevent a liquefying pressure, and then mechanically increasing the pressure upon the gas to the liquefying-point by a series of operations, meanwhile maintain-

ing the gas below a decomposing temperature, substantially as described.

4. In the production of liquefied acetylene gas, first generating the gas by gradually bringing together water and an acetylene-producing carbid in such proportions and so regulated as to prevent a liquefying pressure, and then mechanically increasing the pressure upon the gas to the liquefying-point by a series of operations, meanwhile maintaining the gas below a decomposing temperature by abstracting the heat during the operation of compression as the same is there generated, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

E. N. DICKERSON.
JULIUS J. SUCKERT.

Witnesses:
H. COUTANT,
ERNEST HOPKINSON.