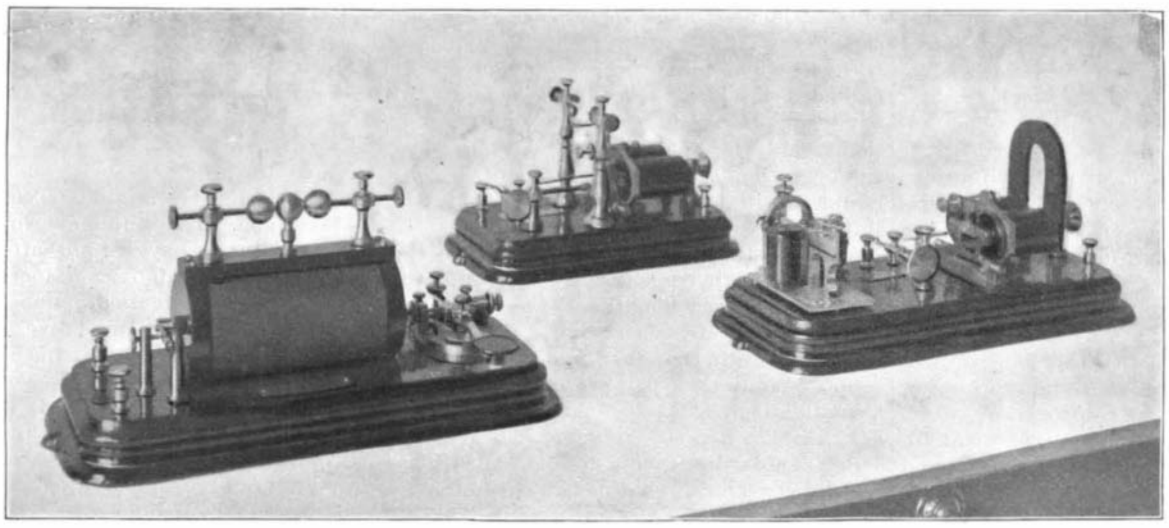
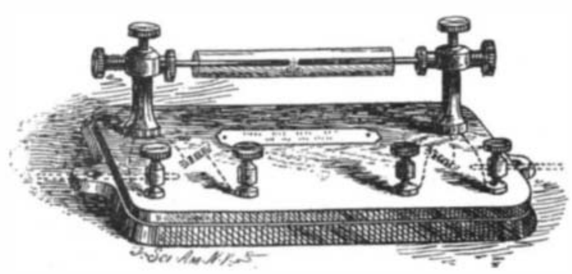
WIRELESS TELEGRAPHY.

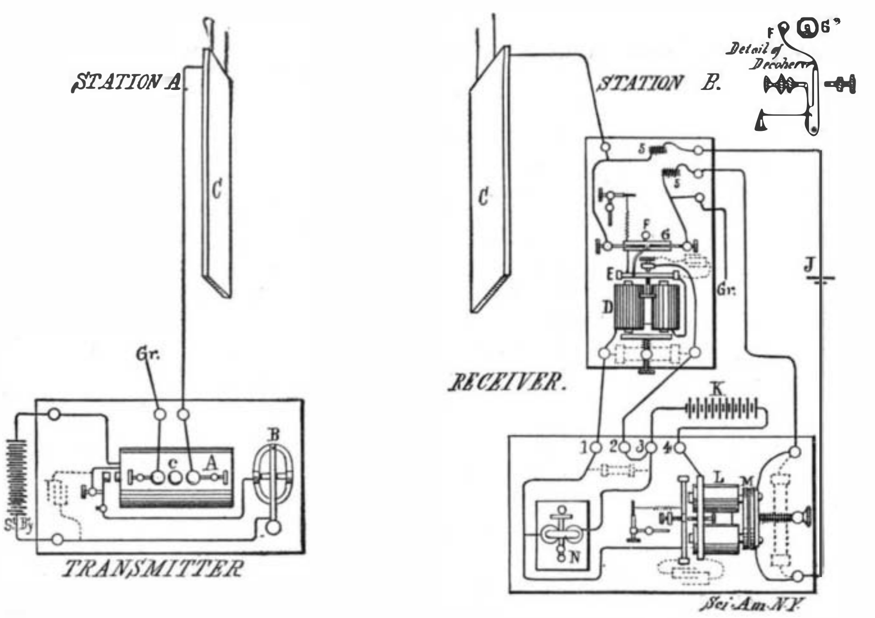
At the present moment, when such strained relations exist between Spain and this country, nothing could be more welcome than the announcement of a practical method of carrying on electrical communication between distant points on land, and between ships at sea, without any prearranged connection of any kind between the two points. Many years ago it was found possible to transmit signals through space at a very short range by means of electrical vibrations, but not until the spring of last year had anything of much practical value been accomplished in this direction, with the exception, perhaps, of the method of telegraphing from moving trains which was patented in this country in 1881, and used for a limited period on short sections of two of our eastern railroads. During last year Guglielmo Marconi, an Italian student, devoted considerable time to the development of a system of wireless telegraphy, and although he has made use of well known principles, he has so arranged and designed his instruments that he has found it possible to transmit intelligible Morse signals to a distance of over ten miles. It has been left, however, for the American inventor to design apparatus suitable to the requirements of wireless telegraphy in this country. After months of experimenting Mr. W. J. Clarke, of the United States Electrical Supply Company, of this city, has designed, and his company is placing upon the market, such a complete set of wireless telegraphy apparatus that it will in all probability come rapidly into use. For the information of our readers, we illustrate the various pieces of apparatus used, and also explain, with the aid of diagrams, its internal construction and method of operation.



INSTRUMENTS FOR TRANSMITTING MORSE SIGNALS BY MEANS OF WIRELESS TELEGRAPHY.

By reference to the diagrams it will be seen that both the transmitting and receiving stations are shown, station A being the transmitting and stations B and C the receiving. The transmitter shown at station A consists of an induction coil, A, specially constructed so as to give the most efficient kind of spark for the purpose. The coil is fitted with an ordinary vibrating make and break, constructed so as to give just the requisite number of interruptions. A special Morse key, B, is placed in the primary circuit, and the condenser is so connected as to kill the spark at the key contact as well as at the vibrating contact. Mounted on the upper part of the coil are three solid brass balls, C, the center one being stationary, and the outside ones adjustable, so that their distance from the center ball can be regulated at will. The two outside balls are connected to the terminals of the secondary coil, as are also the binding posts shown at the side of the coil. It will now be readily seen that when the key, B, is depressed, sparks will pass between the balls and will immediately cease when the key is released. By means of the two binding posts at the side of the coil, one terminal of the secondary coil is connected to earth, and the other terminal to the large metallic plate, C, which should be placed high in the air. The coil may be operated by any suitable battery, but a small storage battery is very much to be preferred.

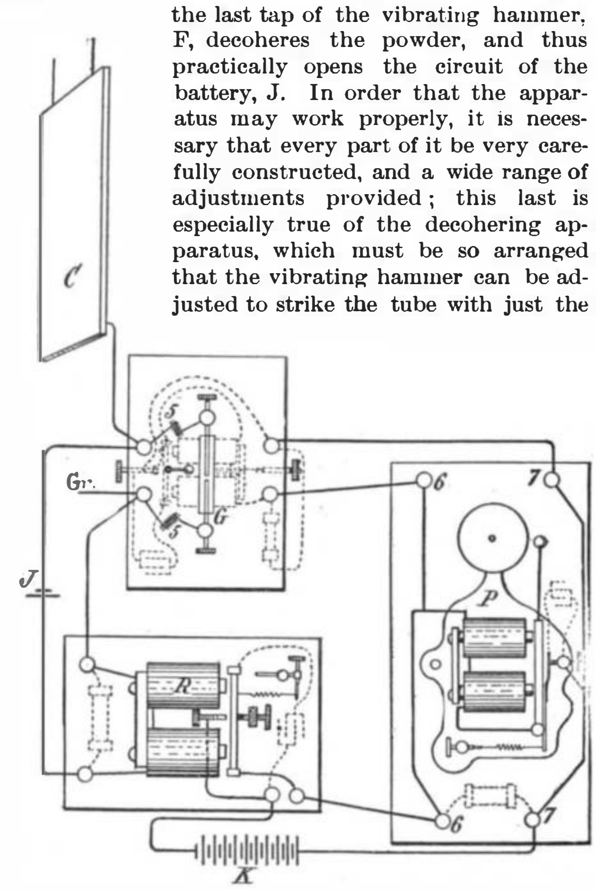




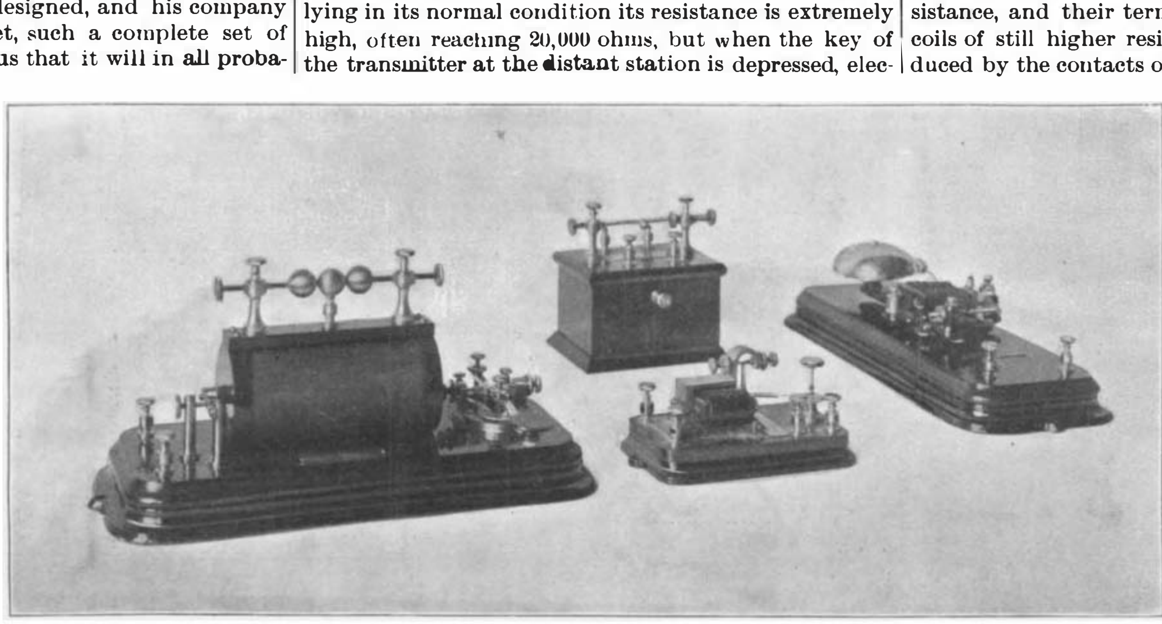
WIRELESS TELEGRAPHY—INSTRUMENTS AND CIRCUITS.

The receiver at station B consists of two separate instruments, the Clarke coherer relay being mounted on one base, and the polarized receiving relay and sounder upon another. The coherer, G, is a small glass tube made of selected glass, and carefully fitted with two metallic plugs, whose distance from each other in the tube can be readily and accurately adjusted by means of the screw and spring adjustments shown at each end of the tube. The space in the tube between the plugs is partly filled with specially prepared metallic powder, and the two plugs are connected to the binding posts shown, through the small choking coils, 5. These posts are connected to the magnets, L, of the receiving relay through the main battery, J, and binding posts of polarized receiving relay as shown.

One terminal plug of the coherer, G, is connected to earth as shown, and the other terminal plug is connected to the large metallic plate, C, which like the plate at the transmitting station should be placed high in the air. When the powder between the plugs in the tube is lying in its normal condition its resistance is extremely high, often reaching 20,000 ohms, but when the key of the transmitter at the distant station is depressed, electric waves are sent out into space; these waves travel from the plate, C, of the transmitter to the plate, C, of the receiver, and finally reach the powder in the tube, G. Under the action of the waves, the particles of powder in the tube immediately cohere, and their resistance instantly drops down to between 7 and 25 ohms, which great decrease in resistance permits the current from the battery, J, to pass through the circuit, and energize the magnets, L, of the polarized receiving relay, which in turn operates the sounder, N, using the large local battery, K. When the powder in the tube once coheres, it remains in that state until the tube receives a sharp tap, when the powder instantly decoheres and its resistance rises again to an extremely high point. In order that Morse signals can be transmitted it is necessary, of course, that the tap on the tube be automatically accomplished. In order to secure this the decohering magnets, D, are provided and placed in multiple with the magnets of the sounder, so that the sounder and decohering apparatus will operate simultaneously; the decohering magnet operates the vibrating hammer as shown, which it will be seen will keep constantly tapping the tube as long as the key at the distant station is depressed, the powder refusing to decohere as long as the waves are passing through it; but the moment that the key at the transmitting station is released, the last tap of the vibrating hammer, F, decoheres the powder, and thus practically opens the circuit of the battery, J. In order that the apparatus may work properly, it is necessary that every part of it be very carefully constructed, and a wide range of adjustments provided; this last is especially true of the decohering apparatus, which must be so arranged that the vibrating hammer can be adjusted to strike the tube with just the necessary strength of blow. It is also found necessary to have all the magnets wound to a very high resistance, and their terminals provided with resistance coils of still higher resistance; and as the sparks produced by the contacts of the polarized receiving relay, and also by the vibrating contacts of the decohering apparatus, send out waves which affect the coherer, these sparks must be almost entirely suppressed by the use of suitable condensers in the bases of the instruments. This set of apparatus is used for the transmission of Morse signals to moderate distances only, but for longer distances it is simply necessary to use a much larger and properly designed induction coil in connection with the transmitter.



WIRELESS TELEGRAPHY—APPARATUS FOR BELL SIGNALS.



INSTRUMENTS FOR TRANSMITTING ELECTRIC SIGNALS BY MEANS OF WIRELESS TELEGRAPHY.

It is frequently desirable to dispense entirely with Morse signals, and this is especially true on shipboard or in places where there is much noise and where a much louder signal or a visual signal is required. To meet these requirements a much less expensive set of apparatus has been designed. The transmitter is precisely the same as in the preceding case, but the polarized receiving relay, R, is much smaller and is not provided with as sensitive adjustments, it having been found that for bell signals they are not necessary. The sounder is entirely dispensed with, and is replaced by a high class vibrating bell, shown at P in the diagram of receiving station C. This bell is so arranged that it can be adjusted to work in unison with the vibrations of the decohering apparatus. The Clarke coherer relay in this case is mounted on top of a mahogany box which contains the decohering magnets, resistance coils for bridging the terminals and also condenser for suppressing the spark at the vibrating contact, as fully shown in the diagram at station C. The plugs in the cohering tube, G, are provided with the same adjustment as in the more elaborate set. The working of the apparatus is perfect in every respect. When required, the vibrating bell, P, can be replaced by an incandescent lamp which can be readily turned on and off from the distant station. It is certainly extremely interesting to place the transmitter of this set in one room and the receiver in another and then listen to the vibrating bell ring out loudly in response to every impulse of the waves. No ground connection, however, or air plate is required for either set of apparatus when the distance between the transmitter and the receiver is comparatively short. For the benefit of those who wish to experiment, and perhaps endeavor to build their own apparatus, a simple coherer is provided which is shown in perspective in one of our half tone illustrations and in detail in the lower engraving. The outer binding posts of this coherer are intended to hold two light rods of metal of equal length projecting out on either side. These rods or wings are necessary when it is desired to transmit to any considerable distance without using the earth connection or air plate.

LIQUID AIR AND ITS PHENOMENA.

PROF. W. C. PECKHAM, ADELPHI COLLEGE.

Renewed interest has recently been awakened in the liquefaction of air by the announcement that it can be produced in practically unlimited quantities. This result has been brought about by the development of the method of expansion, and its use in a new and ingeniously devised apparatus. Credit for this is due to Mr. C. E. Tripler, of New York, who has for many years been engaged in the study of this problem.

Our first page illustration shows the appearance and arrangement of his plant. It consists of a triple air compresser, a cooler and a liquefier. The compresser is of the ordinary form, having three pumps upon one piston shaft working in a line. The first gives 60 pounds pressure; the second raises this to 750 pounds, while the third brings the air under a compression of 2,000 pounds per square inch.

After each compression the air flows through jacketed pipes, where it is cooled by city water. For this work about 40 horse power is employed. After the third compression the air flows through an apparatus which disposes of some of its impurities, and it passes on to the liquefier. It is this part of the apparatus which constitutes Mr. Tripler's special invention. By means of the peculiarly constructed valve, whose details are not made public, a portion of the compressed air is allowed to expand into a tube surrounding the tube through which the remaining air is flowing. This expanded air absorbs a large amount of heat from the air still under compression in the inner tube. The contents of the inner tube are thus cooled. In this way the air is brought below the temperature of liquefaction and its pressure is very much reduced, so that, upon opening the valve at the bottom of the apparatus, a stream of liquid air is received, flowing out with scarcely more force than the water from our ordinary city service pipes. Thus the liquefaction of the air is accomplished by the "self-intensification of cold" produced by the expansion of a portion of the compressed and cooled air, without employing any other substance to bring about this result.

In this lies the difference between the process employed by Wroblewski and Olzewski many years ago, in the liquefaction of various gases, and finally, in the liquefaction of air by Olzewski and Dewar.

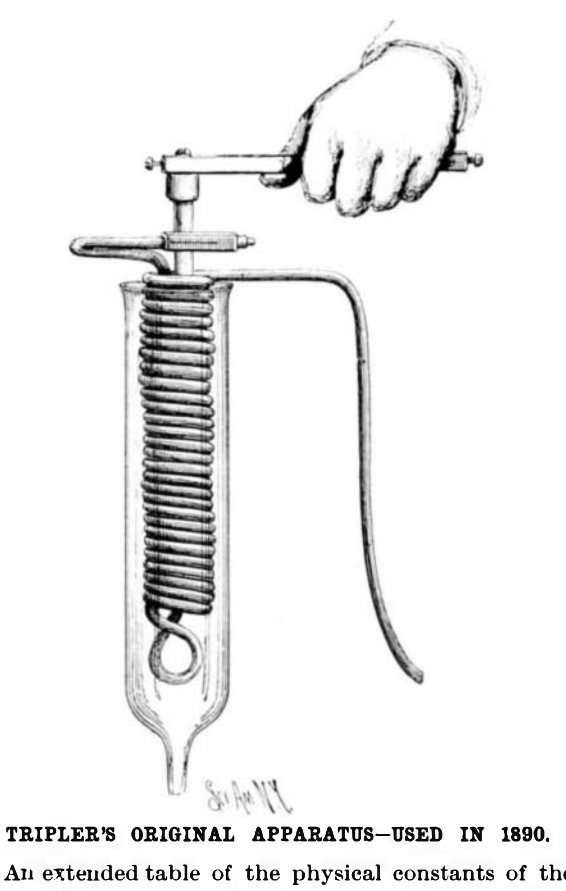
Through the courtesy of Mr. Tripler, we are able to present a cut of the original apparatus by means of which, in January, 1890, the first liquid air was made in America, and probably in the world, by this means. It is known that the method by expansion of air under pressure has been employed both in England and Germany, but the earliest published date connected with any of these experiments is 1895, and previous to that time, as Mr. Tripler states, his application for an English patent was on file in the English Patent Office.

Our cut of this original apparatus shows the tube through which the air under compression flowed into the spiral coil. Having traversed this coil, it rose through a tube (not seen) in the middle of the coil and passed the valve shown at the top. The whole was surrounded by a glass tube open at the bottom. By the expansion of the escaping air the coil and the inner tube were so cooled that liquid air trickled down the pipes and dropped out at the bottom of the tube.

This most interesting piece of historical apparatus is only 12 inches long and $1\frac{3}{16}$ inches in diameter. Its capacity was of course extremely small as compared with the great plant which will deliver from 30 to 40 gallons of liquid air per day of 10 hours, with an expenditure of from 40 to 50 horse power, and its operation must have been extremely slow, as compared with the operation of the modern plant, which will give liquid air in less than 15 minutes after the pump is started.

As fast as the liquid air is drawn from the liquefier it is placed in tin cans, packed in felt, in which it can be kept for a very long time. Cans have been sent as far as Lynn, Mass., in one direction, and Washington, D. C., in the other, and the contents were not seriously diminished by evaporation in transit. Such a can holding 3 gallons would not wholly evaporate in less than 8 to 10 hours.

Prof. Dewar invented a double walled glass bulb, in which between the walls a high vacuum is formed (see Fig. 8). In this the air will last five to six times as long as in an ordinary packed dish. Indeed, it lies practically quiet without boiling, while in an open dish (see Fig. 9) the boiling is quite violent, and very soon the walls are covered with ice frozen from the moisture of the air. This is doubtless the coldest free liquid that has ever been produced. Its boiling point at the ordinary pressure of the atmosphere is —191° C.



TRIPLER'S ORIGINAL APPARATUS—USED IN 1890.

An extended table of the physical constants of the "so-called" permanent gases is embodied in this article and will doubtless interest our readers. A glance at this will show that the boiling point of the air is the lowest temperature thus far attained at atmospheric pressure. Only hydrogen and helium having lower boiling points, and neither of these has been liquefied up to this time in a free state, that is, at atmospheric pressure. The same statement can be made with regard to air boiling in a vacuum. This has the lowest temperature yet attained.

The possession of a large quantity of a liquid at so low a temperature makes it possible to perform many experiments of a very startling and marvelous character. When a dishful of the liquid air is dipped from the can, it boils so violently that drops of it are projected to quite a distance. This continues until the dish is cooled to the temperature of the liquid, when it becomes quiet, simmering gently. In this condition it is turbid, containing solid particles of carbonic acid and possibly ice. These may be filtered out through filter paper, and the liquid is seen to be of a delicate shade of blue, clear as water.

Since the boiling point of nitrogen is 13° C. below that of oxygen, it follows that, in the first boiling, nitrogen is distilled from the oxygen as alcohol may be distilled from a mixture of alcohol and water through the difference between their boiling points. By this means the liquid air becomes very much richer in oxygen. The liquid air would at first contain only 20 per cent of oxygen, but after boiling for a while the proportion of oxygen increases to 75 per cent. If the liquid be poured upon a block of ice, it bounds off like water from a hot stove. The ice at the freezing point is 344° F. hotter than the liquid air—a distance of 132° greater than separates boiling water from ice. We cannot comprehend it any better than we can comprehend the space which separates us from the sun. Although so cold, the hand may be dipped into the liquid or the liquid may be poured into the hand without producing much sensation, since the heat of the hand evaporates the liquid so quickly that a layer of vapor is formed around the hand; in other words, the liquid is thrown into a spheroidal state with reference to the hand. If, however, contact does take place between the skin and the liquid air, a most serious burn results. One day, when Pictet had a burn upon his hand from fire, he also produced one accidentally by liquid air; the ordinary burn healed in ten or twelve days, but the other was open for six months.

Fig. 4 shows a copper tube 2 inches in diameter, with walls one-eighth of an inch thick. On pouring a couple of fluid ounces of liquid air into the tube, and driving a wooden plug firmly in with a hammer, it is driven out almost immediately, and with such violence that boards overhead are indented by it. About 100 cubic feet of air are compressed into one gallon of the liquid, occupying 231 cubic inches. The liquid therefore occupies but $\frac{1}{748}$ of the space filled by the gas at first, and on returning to its gaseous form at atmospheric pressure, it must expand to 748 times its volume. The enormous pressure produced in this transformation is thus apparent. It would scarcely seem to be possible to construct apparatus in which it could safely be stored and allowed to come to atmospheric temperatures.

Fig. 3 shows the effect produced upon iron by reducing its temperature to that of liquid air. An ordinary tin dipper placed in the liquid and allowed to cool till boiling ceases becomes brittle and breaks like glass upon being struck against a table or thrown upon the floor. Copper and platinum, on the other hand, remain tough at the lowest temperatures. The tensile strength of iron would be increased very greatly by cooling.

Fig. 7 shows a dish of liquid air in which a rubber ball is floating. It will be noticed that the vapor flows over the edge of the dish, not rising in a cloud from it, as does steam, since it is much heavier than gaseous air at ordinary pressures. This vapor presents the appearance of a cloud of steam and would be easily mistaken for it. The chill which the hand receives on being exposed to it would, however, quickly convince one of the difference. When the rubber ball has been cooled to the temperature of the liquid, it becomes exceedingly brittle, and on being thrown against a wall flies into many pieces. A very curious effect produced upon a billiard ball or other article of ivory by cooling it to the temperature of liquid air has not been explained. On exposing it to the arc light for a few seconds and viewing it immediately in a darkened room, it shines with a brilliant green phosphorescence. It is possible that many other substances, such as eggs and bone, may be found to possess the same property. Whisky and alcohol are frozen with little difficulty by means of this liquid. It is a curious experiment (see Fig. 12) to hold

PHYSICAL CONSTANTS OF (SO-CALLED) PERMANENT GASES.

	Critical Temperature. Centigrade.	Critical Pressure. Atmospheres.	Boiling Point at Ordinary Pressure. Centigrade.	Freezing Point. Centigrade.	Freezing Pressure. Mm.	Density of Gas.	Density of Liquid at Boiling Point.	Color of Liquid.
Carbon dioxide, CO_2	31° [1]	77·0	—78·2° [3]	—79° [2]	760 [2]	22	0·83 @ 0° [4]	Colorless.
Ethylene, C_2H_4	95·0	44·0 58·0	—110 [5]			14		
Hydrogen, H_2	—234·5 [6] (Theor.)	20·0	—243·5 [6] (Theor.)			1		Colorless.
Nitrogen, N_2	—146	35·0	—194·4	203 —214 Mean 208	60	14	0·885	Colorless.
Carbonic oxide, CO	—139·5	35·5	—190·0	—207·0	100	14		Colorless.
Argon, A	—121·0	50·6	—187·0	—189·6		19·9	About 1·5	Colorless.
Air	—140·0	39·0	—191·0	—207 [9]			0·933	Bluish.
Oxygen, O_2	—118·8	50·8	—182·7			16	1·124	Bluish.
Nitric oxide, NO	—93·5	71·2	—153·6	—167·0	138	15		Colorless.
Marsh gas, CH_4	—81·8	54·9	—164·0	—185·8	80	8	0·415	Colorless.
Helium, He			Below —264 [7] (Theor.)			2·02 [8]		
Fluorine			—187					

[1] Andrews. Deschanel Nat. Phil., II., 352.
[2] Villard & Jarry. Comptes Rendus, 1895, 120, 1413.
[3] Regnault. Muspratt's Chemie, IV., 1626.
[4] Thilorier. Muspratt's Chemie, IV., 1626.
[5] Fownes. Elem. Chem., 12th ed., p. 534.
[6] Olzewski. Phil. Mag., 1895 (5), 40; 202.
[7] Olzewski. Ann. Phys. Chem., 1896 (2), 59, 184.
[8] Clève. Compt. Rend., 1895, 120, 1212.
Dewar.