THE COLLISION ON LONG ISLAND SOUND.*

By C. H. THOMPSON.

THE peculiar accident to the two great Sound steamers, the "Plymouth" and the "City of Taunton," both Fall River Line boats, cannot be attributed to carelessness of the officers or crew of either vessel. Just at the mouth of Long Island Sound conditions are peculiar. The route that it is necessary for deep-draft craft to take lies through a swift-running and very deep channel known as the Race, a narrow portion of the Sound between Little Gull Island and Race Rock Light. In fair weather it is a difficult place to navigate, and every master of a vessel compelled to pass through this waterway is cautious to the extreme, even during the most favorable weather conditions. From the statements of the captains of both of the vessels concerned, the only conclusion to be drawn is that it was accident, pure fate, that drove the prow of the "City of Taunton" into the forward starboard side of the "Plymouth." The illustrations show the force with which the vessels struck. Seven cabins were utterly destroyed on the "Plymouth," and an immense hole was stove in her hull. While all the cabins but one were occupied, only a single passenger lost his life. The other victims were members of the vessel's crew, who occupied quarters in the forward hold. The bow of the "Taunton" shows the extent of her injuries, which were entirely above the water line, though they placed her in considerable danger, because there was a possibility of the waves washing into her. This they did to the extent of almost flooding the vessel's forward compartment.

From authentic reports, the "City of Taunton" and the "Plymouth" approached each other, sounding signals, and steering in the prescribed course, which at the point where the collision occurred is so extremely narrow, that navigators familiar with the locality are sure that it would be something of a feat to pass these huge vessels in the bright sunshine and calm waters of a June day.

It is sure to develop, after careful investigation, that the masters of these craft did everything within the power and thought of capable navigators to save the property of their employer, and also that they took more than ordinary care of the precious lives carried aboard the steamers.

The appearance of these vessels naturally gives rise to the thought that they struck with considerable force—no doubt they did; but it is an acknowledged fact that even when the machinery, powerful though it is, of these Sound leviathans is reversed, their headway is not checked and the momentum not overcome for some time after the backward movement of the wheels has started. This is best illustrated to the lay mind by observing a ferryboat enter its slip. It approaches with the machinery at a standstill; yet the momentum is sufficient to bump it hard against the pier, even when the engines are reversed a considerable distance from the entrance to the slip.

THE INDUSTRY OF COMPRESSED AND LIQUEFIED GASES.

IN the report of the Eleventh Census, Part III., page 279, it is stated that "the use of compressed ammonia gas has reached large proportions in the last decade, and has proven a valuable aid in the preservation of food, the refrigeration of malt liquors, and the manufacture of ice. The introduction of the use of anhydrous ammonia has given great impetus to the manufacture of special machinery adapted to its employment in the departments named. Taken as a whole, its manufacture may be classed as a distinct industry." Although Prof. A. C. Twining,† of New Haven, Conn., had in 1850 received a patent for an ice machine using ethyl ether, or other compressed gas, and had in 1855 a machine of 1 ton capacity in operation in Cleveland, Ohio,‡ and although in 1867, and probably earlier, the ammonia ice machines of Ferdinand Carré were in active operation, this seems to have been the first allusion in the census reports to compressed gases, and no data are there given for them. At the census of 1900 returns were made not only for compressed or liquefied ammonia (known technically as anhydrous ammonia), but also for sulphur dioxide, carbon dioxide, nitrogen monoxide (known technically as nitrous oxide), oxygen, and liquid air, the manufacture being carried on during the census year in 30 different establishments regularly devoted to this business. In addition there were six establishments reported in which liquefied gases were produced as a subordinate part of the product, the major part of the product being in some instances other than chemicals. Besides, one idle establishment was reported. Taking the returns together, it is found that there were 37 establishments devoted to this manufacture, producing \$1,220,297 of products and giving employment to 251 wage earners and \$2,185,535 of capital.

Of these establishments 19, employing 181 wage earners and \$1,650,094 of capital, were engaged in producing liquefied carbon dioxide, and the output for the census year amounted to 12,196,061 pounds, of a value of \$708,864. In addition, 1 establishment using carbon dioxide in manufacture reported having produced and consumed 165,000,000 pounds of this gas during the year; but, though it was compressed, it was not liquefied for use. There was employed in the manufacture of the liquefied carbon dioxide reported above, 7,027 tons of magnesite, 2,011 tons of limestone, 774 tons of coke, and 4,771 tons of sulphuric acid, and among other products there were obtained 3,095,000 pounds of Epsom salts, 3,278 tons of calcined magnesite, and 5,000 bushels of lime. About 3,500,000 pounds of the carbon dioxide reported came from fermentation or from effervescent springs.

Ten establishments employing 52 wage earners and \$453,328 in capital were engaged during the census year in producing anhydrous ammonia, and the output for the year amounted to 2,443,729 pounds, having a value of \$448,157, and there were consumed in this manufacture 2,148 tons of ammonium sulphate, 4,199,

708 pounds of aqua ammonia, and 83,402 bushels of lime.

Carbon Dioxide (carbonic acid gas, CO₂).—Carbon dioxide was liquefied by Faraday in glass tubes as early as 1823, through the pressure resulting from the gas being set free from combustion. In 1834 Thilorier operated this method on a much larger scale by the use of wrought-iron cylinders in place of the glass tubes. He discovered that by allowing the liquid to rapidly evaporate the reduction in temperature was so great that a portion of the CO₂ became solid. By moistening this solid CO₂ with ethyl ether he obtained a temperature of -100 deg. C. In 1837 Dr. John Torrey, of New York, liquefied this compound in tubes and applied the liquid to guns as a propellant. In 1844 Natterer invented a pump by which very high pressures were obtained, and through which the liquefaction of carbon dioxide could be better accomplished than by the self-compression method previously used. In all these cases when liquefying carbon dioxide the gas was not only subjected to pressure, but it was also cooled. In 1869 Prof. W. N. Hill, at the United States naval torpedo station, Newport, R. I., proposed the use of liquefied CO₂ in torpedoes. In June-August, 1873,* he made more than 500 pounds of the material, and the manufacture was continued at the station at intervals for some years.

In a private communication from John B. Stobaueus, of Charles Cooper & Co., Newark, N. J., it appears that he began the liquefaction of carbon dioxide on a commercial scale in the United States in July, 1884, and put the product on the market. The gas was generated from magnesite imported from Greece, by reaction with sulphuric acid, and the by-product was Epsom salts. The material was sent to the trade in steel tubes weighing about 27 pounds each, and these tubes were fitted with a valve, having a conical seat, which was invented by Mr. Stobaueus. The books of this firm show that 1,188 cylinders, containing 14,256 pounds of CO₂, were produced in 1885, and 10,704 cylinders, containing 128,448 pounds of CO₂, in 1891. The manufacture has since been taken up by others, and in addition to the method used by Mr. Stobaueus the carbon dioxide is now obtained by burning magnesite, by which magnesia is obtained as the by-product; or dolomite, by which a cement is obtained as the by-product; or marble or limestone, by which quicklime is obtained as the by-product; by treating marl with sulphuric acid; and by burning coke. The carbon dioxide issuing from effervescent mineral springs, and that produced in the fermenting tubs during the brewing of beer, is also collected and liquefied. In all of these processes the gas is washed and otherwise purified before compression.

From the data given by Mr. Stobaueus it appears that the cylinders supplied by his firm held 12 pounds of CO₂ each. The American Carbonate Company, of New York, advertise to supply cylinders in two sizes, containing 10 and 20 pounds of CO₂, respectively, representing 600 and 1,200 gallons of gas, the net weight of the cylinders being 27 and 70 pounds. Several of the companies announce that the cylinders are tested for a pressure of 3,700 pounds per square inch.

Compressed carbon dioxide is used in charging soda water, mineral waters, cider, beer, and other effervescent drinks. By attaching a charged cylinder of the gas, governed by a proper regulating valve, to a barrel of beer or other beverage the liquid is not only continuously charged with the gas, but by the gas pressure the liquid is forced to the point where it is desired to serve it. By its use the old art of "Kraeusening," which consisted in adding to stored beer, as it was being casked or bottled, some beer in the first stages of fermentation, has been displaced. Carbon dioxide is used in the manufacture of salicylic acid and of many carbonates. It is proposed for use as a medicinal agent by inhalation and in baths; for raising dough in the manufacture of aerated bread; as a refrigerating medium; as a buoyant material in raising wrecks or preventing disabled ships from sinking; and for extinguishing fires. R. Ogden Doremus having found that but 20 per cent of CO₂ in the air of the locality where fire exists is sufficient to arrest the progress of the flames. It has been used by the government as a motive power for automobile torpedoes.

Anhydrous Ammonia.—This material is the chemical substance ammonia (NH₃) in a pure and dry condition and in a compressed and liquefied state, and it is manufactured by the distillation of the ordinary 26 deg. ammonia of commerce in a suitable apparatus. This apparatus, which should be of sufficient strength to stand a pressure of 65 pounds to the square inch, comprises a still, a condenser, three separators, and a drier or dehydrator. The still is heated by a suitable steam coil to a temperature of about 212 deg. F., when the ammoniacal gas, together with a certain amount of water, passes off into the first separator, which latter is usually situated on the top, and forms an upward extension of the still. In this first separator the greater portion of the watery particles carried over are eliminated by a series of perforated plates, through the perforations of which the gas had to pass, and are returned to the still through a dip pipe. From this first separator the partly dried gas passes through a water-cooled worm in the condenser, and then successively through the two other separators to the drier or dehydrator, where it is passed through a set of similarly perforated plates to those in the first separator, but having small-sized lumps of freshly burnt lime placed upon them, by which any moisture that may still remain in the gas is removed, and the completely anhydrous product can then be passed into the ammonia pump or compressor. It is found advisable to work the still at a pressure above 30 pounds to the square inch, so as to admit of the liquid being raised to a slightly higher temperature than the boiling point of water at atmospheric pressure, without causing the water to boil, the result of this being that the whole, or practically the whole, of the ammonia will be set free, while at the same time the least possible amount of the water will be vaporized and passed over with the ammonia gas.

Or it may be obtained from ammonium salts by heating them with lime and treating the gas as above described. The salt usually employed is ammonium sul-

phate. Aqua ammonia, or ammonia water, is of different strengths, according to the amount of NH₃ dissolved in it, but the standard strength has a specific gravity of 26 deg. Baumé, and it contains 38.5 per cent by volume, or 28.6 per cent by weight of anhydrous ammonia. Thus 3.76 pounds of 26 deg. ammonia will be required to make 1 pound of anhydrous ammonia. An excellent table of yields of anhydrous ammonia from 26 deg. ammonia is given by Iltyd I. Redwood.* The ammonium sulphate or sulphate of ammonia of commerce is reckoned as containing 25 per cent of anhydrous ammonia.

It is believed that some at least of the owners of ice machines produce the anhydrous ammonia that they employ, either in originally charging their machines, or in making good any loss which may take place, but there are no returns on this point. It appears also that there is some anhydrous ammonia imported, the report on "The Foreign Commerce and Navigation of the United States" from the Treasury Department placing this at 14,210 pounds, having a value of \$5,870 for the year 1891, but the data for such importations as may have occurred in other years of the past decade do not appear separately.

Although Fourcroy and Vauquelin and, at about the same time, Guyton de Morveau, announced that they had accomplished the liquefaction of ammonia gas, it is believed that, as they had no suitable means for drying the gas, they failed to obtain the anhydrous ammonia. It was first certainly liquefied by Faraday in 1823, and it was not long before it was being produced in considerable quantities. Larkin and Scheffer began the commercial manufacture in St. Louis, Mo., in 1879.

Anhydrous ammonia appears, as stated above, to have first been used for refrigeration by Ferdinand Carré in his absorption machine, but it was not long before it was employed in compression machines of the type invented by Perkins and Twining, based on the refrigerating principle, which was demonstrated by Doctor Cullen in 1755; and although it has had to compete with ethyl ether, carbon dioxide, sulphur dioxide, and air, it is to-day the material which is most largely used in ice machines, and this is the principal use for this substance, though recent researches indicate that other uses will soon be found for it in chemical manufacture and in other arts.

Sulphur Dioxide (sulphurous acid gas, SO₂).—This substance is produced by burning sulphur in air or oxygen, 1 pound of sulphur giving 2 pounds of sulphur dioxide. It was liquefied by Monge and Clouet about the beginning of the nineteenth century. The liquefied sulphur dioxide is now a regular article of commerce, and is sent into the trade in glass "siphons" and in iron flasks, as being a convenient means of transportation and storage of the substance for use in chemical laboratories and in manufacture. The liquid has found some use in ice machines. The substance is used as a reducing agent, as a bleaching agent, and as a disinfectant. Hardin† states that at present (1899) "about 4,000,000 kilogrammes of this liquid are being prepared annually."

Nitrogen Monoxide (hyponitrous oxide, nitrous oxide, laughing gas, N₂O).—This body is prepared by heating ammonium nitrate to a temperature not exceeding 258 deg. C., when the gas is evolved. It is carefully purified, well washed, and then compressed in steel cylinders. This gas was first liquefied by Faraday in 1823. The Lennox Chemical Company began the liquefaction of the gas for the trade at Cleveland, Ohio, in 1883. The exhilarating properties of the gas were discovered by Sir Humphry Davy, who was the first to inhale it, in 1809, and it then received the name of laughing gas. It is now used as an anesthetic agent in minor surgical operations, especially in dentistry, its use for this purpose having been suggested by Dr. Horace Wells, and it was first applied to him in the extraction of a tooth at Hartford, Conn., December 11, 1844.

Oxygen.—This gas, as commercially supplied in the compressed condition, is produced by heating potassium chlorate mixed with black oxide of manganese. It is sold in the market for use in medicine by inhalation, when it is usually mixed with nitrous oxide, essential oils, and other bodies which are believed to possess therapeutic qualities. Liquid oxygen is not known to be produced commercially except as referred to under liquid air, but it was the first of the so-called permanent gases to be liquefied, this having been independently effected by Pictet and Cailletet in 1877.

Liquid Air.—Atmospheric air is a mixture of approximately 21 per cent of oxygen and 78 per cent of nitrogen by volume, with ninety-four one-hundredths of 1 per cent of argon, about four one-hundredths of 1 per cent of carbon dioxide, and variable quantities of water vapor, ammonia, and other bodies, according to locality and conditions. After 1823, when Perkins‡ erroneously believed that he had liquefied air, numerous unsuccessful attempts were made to accomplish this result, but in 1877 Raoul Pictet and Louis Cailletet, working independently in Switzerland and in France, achieved the result on a small laboratory scale, and it was later repeated by Wroblewski, Olszewski, and Dewar, who improved the methods so as to notably increase the yields, and in 1893 Dewar froze air into a clear, transparent solid. The liquefaction of air on an industrial scale began about this time with the invention of the machines of Linde, Hampson, and Tripler, and later those of Ostergren and Burger, Dewar, Kuhn, Chase, Code, O'Doherty, Johnson, and others.

The methods may be classified as the cascade method of Pictet, Cailletet, Wroblewski, and Onnes; the self-intensive motor method of Siemens, Kuhn, and Johnson; the countercurrent free-expansion system of Linde, Hampson, Tripler, and Ostergren, and Burger; and the self-intensive work method of the American Liquid Air Company, known as the Ala system. Emmens§ states that the principal features of the method by which the liquefaction of air can be effected on a commercial scale were clearly described in the speci-

* Theoretical and Practical Ammonia Refrigeration, page 113.

† The Rise and Development of the Liquefaction of Gases, page 234.

‡ Annals of Philosophy, vol. 6, page 46.

§ Liquefied Air, page 2.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

† Barnard's Report on Paris Exposition of 1867, pages 363 to 386.

‡ Refrigerating and Ice-Making Machinery, page 24.

* Liquid Carbonic Acid, page 4.