broken, the mother-liquor, still holding a large amount of soda, is run off for future use, and the crystals are broken up, drained, and dried for packing and use. Soda crystals contain 63 per cent. of water, and their principal employment is for domestic washing, for which their comparative non-causticity well fits them.

*Sulphur Recovery.—*Of the several raw materials of the Le Blanc process, sulphur, now always used in the form of pyrites, is by far the most expensive. The sulphuric acid employed passes out in valueless combination as crude sulphide of calcium, and accumulates in huge mounds. Under the influence of rain sulphide of calcium in these heaps gradually assumes the forms of sulphide of hydrogen and hydrated oxide of calcium,—CaS + 2H2O = CaOH2O + H2S. The hydrogen sulphide combines in its turn with another quantity of sulphide of calcium into CaS2H2, which being soluble in water runs off as yellow liquor to contaminate streams and give off sulphuretted hydrogen gas with its disgusting smell. By the action of atmo­spheric oxygen part of the CaS2H2 loses its hydrogen as water, and the remaining CaS2 passes into thiosulphate of calcium, CaS2O3, with simultaneous formation of polysulphides. Upon this latter tendency Mond founded his original method for recovering sulphur. He hastened the oxidation by blowing air through the moist waste till a certain proportion of the sulphide was converted into thiosul­phate, and the residue into sulphhydrate CaH2S2, or polysulphide. The mass is lixiviated with water, the liquor decanted off, and mixed with excess of hydrochloric acid, which produces H2S, and in general sulphur, from the sulphhydrate and sulphides of calcium, with SO2 and sulphur from the thiosulphate. But 2H2S + SO2 decompose each other into 3S + 2H2O. Hence it is obvious that, if the process of oxidation is stopped at the right point, the whole of the sulphur will be recovered as such. The precipitated sulphur is mixed with water placed in a closed cylinder and fused by raising the temper­ature of water round it in an outer casing above the melting point of sulphur. The sulphur then runs together in the lower part of the cylinder, whence it is drawn off by a pipe and cast into rolls. The Mond process, of all the many sulphur-recovery processes yet intro­duced, is the best ; but even it no more than pays working expenses, and enables the manufacturer to end his process with an innocuous chloride of calcium (CaCl2) without actual loss of money.

About 1880 considerable excitement was caused by a sulphur- recovery process patented by Schaffner aud Helbig in 1878, which was expected to revolutionize the soda trade. As these hopes have not been realized, we merely state the principle of the process. The soda waste is digested with a solution of chloride of magnesium, which in the first instance leads to the formation of CaCl2 and MgS. But the latter is at once decomposed, with formation of magnesia and sulphuretted hydrogen,—MgS + 2H2O = MgOH2O + H2S. The sulphuretted hydrogen is caused to act on sulphurous acid within a solution of chloride of calcium, when the sulphur settles in a filtrable form. The liquor remaining after the expulsion of H2S from the mixture of waste and chloride of magnesium consists of a precipitate of magnesia and a solution of chloride of calcium. By blowing carbonic acid into the mixture the following decomposi­tion is effected—MgO + CO2 + CaCl2 = CaCO3 + MgCl2—so that the magnesium is recovered in its original form and the calcium of the waste obtained as carbonate, which may again be returned to the black ash roaster. This very pretty and complete process might probably have been worked out as a practical success had the con­viction not arisen that even with profitable sulphur recovery the Le Blanc process will not long be able to hold its own against the ammonia process.

*Ammonia Soda Process.—*This process is based on the fact that bicarbonate of ammonia, when added to a strong solution of common salt, decomposes the salt with formation of a precipitate of bicar­bonate of soda and a solution of ammonium chloride (sal-ammoniac), thus NaCl + (NH4)HCO3 = NH4C1 + NaHCO3. The ammonia is re­coverable from the sal-ammoniac by distillation with lime, and, supposing no waste to occur, is usable *ad infinitum.* From bicar­bonate the normal salt is easily prepared by the application of heat —2NaHCO3 = Na2CO3 + CO2 + H2O. Thus by theory one-half of the carbonic acid is recovered, and, supposing the quicklime for the decomposition of the sal-ammoniac to be made by heating limestone, the loss of carbonic acid is made up incidentally from that source. The only waste product which remains for disposal is the entirely innocuous chloride of calcium made in recovering ammonia by means of lime from sal-ammoniac. The ammonia process was first enun­ciated and patented in England by Dyar & Hemming in 1833 ; and works on the system were established in Cheshire and some localities on the Continent, where it attracted great attention. Numerous patents, both English and Continental, followed, and many experi­mental works were erected, which all failed to sustain themselves in competition with the Le Blanc works. The principal difficulties to be overcome were imperfect conversion of the salt, and more especially the loss of ammonia ; and it was not till 1861 that real economical success in the ammonia recovery apparatus was attained by Ernest Solvay of Couillet near Charleroi, Belgium. Works on the Solvay principle were established at Couillet in 1863 ; and since that date by the inventor and others, among whom ought to be men­

tioned Ludwig Mond, the process has been so perfected that its general adoption now appears to be only a matter of time. Already on the Continent it has practically displaced the Le Blanc process, but in the United Kingdom there is as yet only one establishment manufacturing ammonia soda.

The first essential stage in Solvay’s process consists in saturating the brine with ammonia. The brine, treated with milk of lime and ammonium carbonate to precipitate magnesium and calcium salts, and of proper density, is placed in two cylindrical close iron tanks, which communicate by pipes at top and bottom with the ammonia dissolver placed between them. The ammonia dissolver is a cylin­drical vessel having the same height as the tanks and provided with a perforated false bottom, down to which a tube is led through the centre of the vessel, and by this tube the ammonia gas is introduced. Coiled within the cylinder is a worm pipe, through which cold water circulates. Each brine tank is put alternately in connexion with the dissolver. Circulation from the brine tank into the dissolver is kept up by mechanical agitation. As the ammonia becomes ab­sorbed by the brine the temperature of the liquid rises rapidly, and the cold water circulating within the coiled pipe keeps the temper­ature down. As soon as sufficient ammonia lias been passed into the brine the stirrers in the brine tank are stopped ; the sludge of lime and magnesia precipitate is drawn off as it settles at the bottom of the brine tank, or when such precipitate is abundant it is settled and withdrawn in a special decanting tank. The decanted liquor is filtered through fine cloth by pressure, and the filtrate is cooled down in a refrigerating apparatus previous to the next operation.

*Treating the Ammoniacal Brine with Carbonic Acid.—*For this purpose a cylindrical tower is employed, divided internally into a series of superimposed segments by diaphragms consisting of per­forated dome-shaped plates. The tower is about 40 to 50 feet in height and is kept nearly full of liquid, which is introduced by a pipe half way up its side. Carbonic acid under a pressure 1·5 to 2 atmospheres is forced in at the bottom of the tower and works its way gradually upwards through the perforations in the diaphragms, thus coming into intimate contact with the ammoniacal brine. Every half hour a part of the pasty mixture of bicarbonate of soda and ammonium chloride solution is drawn off and replaced by fresh liquor. The solid bicarbonate is separated out either by centrifugal action or by a vacuum filter ; as thus obtained it is still contaminated with ammonia, of which it smells. To free the bicarbonate from this impurity water is squirted over it till the smell almost entirely disappears.

*Conversion into Soda Ash* of the bicarbonate is essential, because there is a comparatively limited demand for bicarbonate, and that salt, moreover, obstinately retains an ammoniacal odour, which lessens its value. The preparation of soda ash is attended with considerable practical difficulties, owing to the necessity of retain­ing the contained ammonia. The bicarbonate is first exposed to a comparatively low heat in a closed roaster, after which it is finished in a muffle furnace at a bright red heat. The gases given off are drawn by an air-pump into a washing apparatus, where the ammonia is retained, and the carbonic acid, which passes on, is conducted to the absorption tower for again impregnating the ammoniacal brine. By this process the whole of the chlorine of common salt comes away as waste in the form of chloride of calcium. To obtain that body in combination as hydrochloric acid, Solvay proposed in his patent of 1872 to employ magnesia in place of lime in the decomposition of the sal-ammoniac, the solution of chloride of magnesium remaining after the distillation is boiled to dryness, and being by the action of steam separated into magnesia and hydro­chloric acid,—MgCl2 + H2O = MgO + 2HC1. The magnesia theoreti­cally works in a circle, being changed into chloride on the liberation of the ammonia from the sal-ammoniac, and recovered again as magnesia with the formation of hydrochloric acid, as above indi­cated. But the expense of the process has hitherto been greater than the value of the product obtained, and the one weak point of the Solvay process is the loss of the hydrochloric acid, which forms an important element in the Le Blanc cycle. The loss of ammonia calculated as sulphate in the early days of the Solvay process was as much as 9 per cent. on the carbonate of soda pro­duced ; but by successive improvements it has been reduced to not more than 5 per cent. The Solvay plant is very expensive, amount­ing, according to his own estimate, to £1600 per ton of soda ash produced daily ; but other authorities put the capital expenditure as high as £2400 per ton worked daily.

*Cryolite Soda.—Of* the many processes other than those above mentioned, which have been proposed for soda-making, the only one practically employed is that in which cryolite forms the raw material. Cryolite, a fluoride of aluminium and sodium, A1F3 + 3NaF, is a mineral substance found in extensive deposits at Ivikat (Ivigtut) (61° 34' N. lat.) in south-west Greenland. For soda­making the mineral is treated by a process discovered in 1850 by Professor Julius Thomsen of Copenhagen. It is ignited with chalk or limestone, whereby carbonic acid is driven off and fluoride of calcium and aluminate of soda are formed—2(AlF3 + 3NaF) + 6CaCO3 = 6CaF2 + 3Na2O,Al2O3 + 6CO2. The aluminate of soda is