with the Fresenius method in spite of these impurities they concluded there was a loss of potash in the determination, and tests of the alcoholic washings showed potash. A sample of sylvinite contained 15.45 per cent. potash by the Fresenius method and 14.85 per cent. potash by the Lindo-Gladding method. The platinum precipitate of the former was free from sulphuric acid, lime, magnesia, or ammonia. The ammonium chloride and alcoholic washings in the Lindo-Gladding method contained potash equivalent to 1.46 per cent. potash for 0.5 gram of substance. Analysis of the platinum precipitate showed ammonia equivalent to 0.0176 gram of ammonium-platinic chloride or in weight to 0.0034 grams potassium-platinic chloride or 0.68 per cent. potash for 0.5 gram of substance. Sulphuric acid and magnesia were also recognized qualitatively in the potassium-platinic chloride.

Holleman (*Chem. Ztg.*, *1892*, 1920–21) explains the unsatisfactory results obtained by Breyer and Schweitzer in that, notwithstanding the large quantity of alcohol used for washing the precipitate, the soluble platinum salts were not all removed and consequently in the washing with ammonium chloride, ammonium-platinic chloride was formed which remained on the filter as an impurity. To this Holleman attributed the presence of ammonia in the platinum precipitate and not to a partial replacement of the potash of the platinum salt by ammonia in washing.

ALUMINUM.

BY R. L. PACKARD.

ASIDE from the merely industrial aspect of the subject, the history of aluminum is unique in affording an opportunity to study the growth, absolutely *ab initio* and within the space of one generation of men, of a metallurgical industry operating upon a new metal. Thirty-five years ago aluminum was as much a chemical curiosity as any one of the rare metals is to-day. Through the efforts of Deville it first acquired a commercial character, and its extraction was transferred from the sphere of laboratory experiments to become a metallurgical process. Since

[1] From *Bulletin of the U. S. Geological Survey*, April, 1893.

his day the development of electro-metallurgy, largely due to the attempts to produce aluminum economically, has increased to such an extent that the chemical process founded by him has now given way to the electrical form of metallurgy in extracting the new metal. Following this change in metallurgy and the increase in its production, attention has been drawn to other materials as sources of the metal than the cryolite formerly used, and new occurrences of the ore of aluminum, which has now acquired an increased value, are sought for. This increase of commercial demand, in turn, has caused the new ore and its deposits to be studied and explained by the aid of the most recent scientific methods. From the technical and industrial point of view, we have now to deal with ores of aluminum as well as ores of iron. From the scientific standpoint, while much is known of the origin of iron ores, little special attention has yet been paid to the genesis of ores of aluminum on account of the recent appearance of the latter metal in the arts. This metal, however, has the advantage of making its debut in the full light of every known modern means of investigation—chemical, mineralogical, geological, and petrographical—and the scientific explanation of its origin will doubtless be speedy and full. To supplement the technology of the metal, it is deemed advisable to collect and introduce here what is at present known of its ores and their occurrence and origin.

In the census bulletin on aluminum, prepared under the supervision of this Division, it was stated that the aluminum produced in this country (by the Pittsburg Reduction Company) was then (1889) mainly obtained from Greenland cryolite. No workable deposits of cryolite have been authentically reported in this country. The deposit at the southern base of Pike's Peak, Colorado, described by Messrs. Cross and Hillebrand, in Bulletin No. 20, of the U. S. Geological Survey, was shown by them to be only of mineralogical interest. Bauxite deposits and "alum beds" of considerable extent have, however, been found, and the former mineral is used as a source of aluminum. It is the ore of aluminum and occurs in Georgia, Alabama, and Arkansas.

The mineral received its name from Baux, a village in the south of France, where it was first found, and the more highly ferriferous variety was regarded and worked as an iron ore, but proved too refractory. It sometimes ran as high as forty-two per cent. metallic iron. The analysis by Berthier revealed its true character. The geological occurrence of the bauxite of Baux was studied by H. Coquand (*Bull. Soc. Geolog. de France*, **28**, 98, 1871), who describes the mineral as of three varieties, pisolitic, compact, and earthy. The pisolitic variety does not differ in structure from the iron ores of Franche Comté and Berry, although the color and composition are different. It occurs in highly tilted beds alternating with limestones, sandstones, and clays, belonging to the upper cretaceous period, and in pockets or cavities in the limestone. The limestone containing the bauxite and that adjacent thereto is also pisolitic, some nodules being as large as the fist, and the pisolitic bauxite has sometimes a calcareous cement, and at others is included in a paste of the compact mineral. M. Coquand supposed that the alumina and iron oxide composing the bauxite were brought to the ancient lake bed in which the lacustrine limestone was formed by mineral springs, which, discharging in the bottom of the lake, allowed the alumina and iron oxide to be distributed with the other sediment. In some cases the discharge occurred on land, and the deposit then formed isolated patches. He refers to other similar deposits of bauxite of the same period in France. Sometimes the highly ferriferous mineral predominates over the aluminous (white), at others diaspore is found enveloping the red mineral, while in other cases it is mixed with it, predominating largely, and sometimes manganese peroxide replaces ferric oxide. In some places the ground was strewed with fragments of tuberous menilite, very light and white.

M. Augé (*Bull. Soc. Geolog. de France*, **16**, 345, *1888*) describes the bauxite of Var and Hérault and gives analyses of it. Over 20,000 tons were being mined in this region annually at the time of writing his report (1888). In the red mineral of Var druses occur with white bauxite running as high as eighty-five per cent. alumina, and fifteen per cent. water, corresponding to the formula $Al_2O_3 + H_2O$. He refers to the prevailing theory of the formation of bauxite, according to which solutions of the chlorides of aluminum and iron in contact with carbonate of lime undergo double decomposition, forming alumina, iron oxide, and calcium chloride. Other deposits in the south of France, in Ireland, Austria, and Italy, he says, confirm this view, because they also rest upon or are associated with limestone. The bauxite deposit in Puy de Dome which he studied, could not, however, be explained by this theory because it was not associated with limestone, but rested directly upon gneiss and was partly covered by basalt. The geological sketch map of the deposit near Madriat, Puy de Dome, which he gives, shows gneiss, basalt, with uncovered bauxite largely predominating, and patches of miocene clays, while the geological section of the deposit near Villeveyrac, Hérault, shows the bed of bauxite conformably following the flexures of the limestone formation when covered by more recent beds, and when exposed and denuded occupying cavities and pockets in the limestone. This occurrence is substantially the same as that of the neighboring Baux. M. Angé agrees with M. Coquand in attributing the bauxite to geyserian origin. He uses as an illustration of the contemporaneous formation of bauxite the deposits from the geysers of the Yellowstone Park, which is evidently due to a misunderstanding. He made no petrographical examination of the bauxite of Puy de Dome, nor did he attempt to trace any genetic relation between the latter and the accompanying basalt. The occurrence is, however, noteworthy, and an examination might show that it is another instance of the direct derivation of bauxite from basalt, which is maintained in the two following instances, sowewhat imperfectly in the first to be sure, but with greater detail in the second.

The first is a paper by Lang in the *Ber. d. chem. Ges.*, **17,** 2892, *1884*. He describes the bauxite in Ober-Hessen, which is found in the fields in round masses up to the size of a man's head, embedded in a clay which is colored with iron oxide. The composition varies very widely. The petrographical examination showed silica, iron oxide, magnetite, and augite. The chemical composition and petrographical examination shows the bauxite to be a decomposition product of basalt. By the weathering of the plagioclase feldspars. augite, and olivine, nearly ail the silica had been removed, together with the greater part of the lime and magnesia; the iron had been oxidized and hydroxid of alumina formed as shown by its easy solubility in hydrochloric acid. The residue of the silica had crystallized as quartz in the pores of the mineral.

The more detailed account of the derivation of bauxite from basalt is given in an inaugural dissertation by A. Liebreich, abstracted in the *Chem. Centrbl.*, *1892*, No. 3, p. 94. This writer says that the well-known localities of bauxite in Germany are the southern slope of the Westerwald near Mühlbach, Hadamar, in the neighborhood of Lesser Steinheim, near Hanau, and especially the western slope of the Vogelsberg. Chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably Gibbsite (hydrargillite). The bauxites of Ireland, of the Westerwald, and the Vogelsberg, show by certain external indications their derivation from basalt. The bauxite of the Vogelsberg occurs in scattered lumps or small masses, partly on the surface and partly imbedded in a grayish white to reddish brown clay, which contains also similar masses of basaltic iron ore and fragments of more or less weathered basalt itself. Although the latter was associated intimately with the bauxite, a direct and close connection of the two could not be found, but an examination of thin sections of the Vogelsberg bauxite showed that most specimens still possessed a basaltic (anamesite) structure, which enabled the author to determine the former constituents with more or less certainty. The clays from different points in the district carrying basalt, basaltic iron ore, and bauxite were examined, some of which showed clearly a sedimentary character. Some of the bauxite nodules were a foot and a half in diameter and possessed no characteristic form. They were of an uneven surface, light to dark brown, white, yellowish, and gray in color, speckled and pitted, sometimes finely porous and full of small colorless or yellowish crystals of hydrargillite. The thin sections showed distinct medium-granular anamesitic structure. Lath-shaped portions filled with a yellowish substance preponderated (the former plagioclases) and filling the spaces between these were cloudy, yellow, brown, and black transparent masses which had evidently taken the place of the former augite. Laths and plates of titanic iron, often fractured, were commonly present and the contours of altered olivine could be clearly made out. The anamesitic basalt of the neighborhood showed a structure fully corresponding with the bauxite. Olivine and titanic iron oxide were found in the clay by washing. The basaltic iron ore also showed the anamesite structure.

The American occurrences of bauxite so far observed are in Alabama, Georgia, and Arkansas. Prof. Eugene A. Smith, State Geologist of Alabama, has kindly furnished the following information in regard to the bauxite of that State. He writes:

"The mining of bauxite was begun in Alabama in November, 1891, by the Southern Bauxite Mining and Manufacturing Company, of Piedmont Alabama, which has shipped up to date (November, 1892) about 3,600 tons. In July, 1892, the Republic Mining and Manufacturing Company, of Hermitage, Georgia (which is the pioneer in the business), secured a lease of the mines of the Bass Furnace Company, at Rock Run, Cherokee county, and has shipped up to date, about 1,300 tons. In addition to this both companies have several hundred tons under sheds drying out. The ore goes to Philadelphia and Natrona, Pennsylvania; Syracuse, Buffalo, Brooklyn, New York, and other places. * * * It comes into competition with the ore from Baux, in France, which can be purchased at a lower price than that at which this region can furnish it; but it is claimed by the manufacturers that our ore is more soluble, and therefore more valuable, though containing slightly less alumina. * * * [Our] alumina runs from fifty-six per cent. to sixty per cent. average carload analysis. Of the insoluble matter silica is the chief ingredient. The ore contains from two to three per cent. of titanic acid, and will average from twenty-five per cent. to thirty per cent. of water. The ore occurs associated with limonites and kaolins in irregular beds, in the region underlaid by the Knox dolomite of the Lower Silurian formation. In Alabama these occurrences are always near to the foothills of the mountains formed of the Weisner quartzite or sandstone, which is a member of the Cambrian in this State. The bauxite therefore seems to be associated chiefly with the lower beds of the Knox dolomite. The best known occurrences are near Rock Run furnace in Cherokee county, where it has been followed for a few miles towards the Georgia line. This is the only place in Alabama where any systematic mining is done, and this by the two companies above named whose mines are closely contiguous. Near Jacksonville, Alabama, in Calhoun county, the ore has also been discovered, but not yet mined commercially.

"The mines are in S. twenty-five, T. eleven, R. eleven, about three and one-half miles northeast of Rock Run furnace and close to the Georgia line. In mining the limonite in one place great quantities of bauxite were moved and lie now in the dump pile. This was before it was recognized as bauxite."

The statistical information in the foregoing was furnished to Prof. Eugene A. Smith, State Geologist of Alabama, by Mr. J. M. Garvin, superintendent of the Rock Run Furnace Company.

He sends analyses, which are included with the others on a subsequent page.

The Georgia bauxite occurs in the same formation. The Bureau is indebted to Mr. J. W. Spencer, State Geologist of Georgia, for the following account of its occurrences:

"It occurs in the residual clay from decomposition of the Knox (calciferous) dolomite formation, which series is greatly developed in Georgia. The principal belt commences near Adairsville and widens out, extending in a southwest direction to Alabama. It occurs in the vicinity of brown iron and manganese ores. Indeed, the bauxite-bearing portion of the Knox series is nearly coincident with the manganese deposits. It occurs in pockets, often of great extent, and is usually covered with a few feet of clayey surface. A kaolin is often associated with it. It is mostly in concretionary nodules forming large masses or small kidney-shaped masses scattered through the clay. Much of the bauxite is light colored, but other portions contain much iron. At one locality Gibbsite occurs associated with it. It evidently has a similar origin with the brown iron or manganese ores, and was probably deposited in lagoons from solution of decomposed crystalline rocks, which occur eighteen or twenty miles to the east. Alumina is slightly soluble in water containing CO_2, as are also the other metals." The analyses of the Georgia bauxite by Prof. H. C. White are given below.

An estimate of the quantity of bauxite mined in Georgia, furnished to this division by Mr. Wm. G. Neilson, of Philadelphia, gives 728 tons for 1889, 1,850 tons for 1890, and 3,300 for 1891. The total output for Alabama up to June, 1892, was 3,200 tons.

The Arkansas bauxites occur in Tertiary areas and in the neighborhood of eruptive syenites, to which they seem to be genetically related. The mineral is pisolitic in structure, and varies in color and chemical composition (analysis below). It has been mined for iron ore, some specimens yielding fifty per cent. metallic iron, and is of great abundance (Prof. J. C. Branner, *American Geologist*, **7**, 181).

Having now traced the ore of aluminum to its origin, as far as present information will allow, the following analyses will show the wide variations in its composition :

Analyses of bauxite, from Baux :

[ANALYST, DEVILLE.]

	Compact variety. Per cent.	Pisiform. Per cent.	Hard and compact calcareous paste. Per cent.	Bauxite from Calabres. Per cent.
SiO_2	2.8	4.8	...	2.0
Al_2O_3	57.6	55.4	30.3	33.2
Fe_2O_3	25.3	24.8	34.9	48.8
H_2O	10.8	11.6	22.1	8.6
TiO_2	3.1	3.2	...	1.6
$CaCO_3$	0.4	0.2	12.7	...
Corundum	...	...	...	5.8
Total	100.0	100.0	100.0	100.0

French bauxites of two different types :

	Red bauxite from Thoronet, Var. Per cent.	White bauxite from Ville-veyvae Hérault. Per cent.
SiO_2	0.30	2.20
Al_2O_3	69.30	76.90
Fe_2O_3 and FeO	22.90	0.10
H_2O	14.10	15.80
TiO_2	3.40	4.00
Total	110.00	99.00

Analyses of German bauxite:

FROM WOCHEIN.

[ANALYST, LILL.]

SiO_2	6.29	per cent.
Al_2O_3	64.24	“ “
Fe_2O_3	2.40	“ “
CaO	0.85	“ “
MgO	0.38	“ “
SO_3	0.20	“ “
P_2O_5	0.46	“ “
H_2O	25.74	“ “
Total	100.56	“ “

FROM LANGSDORF.

[ANALYST, LANG.]

	Brownish red. Per cent.	Light red. Per cent.
SiO_2	5.14	10.27
Al_2O_3	50.85	49.02
Fe_2O_3	14.36	12.90
FeO	0.35	not det.
CaO	0.41	0.62
MgO	0.11	trace
K_2O	0.09	0.11
Na_2O	0.17	0.20
H_2O (ign.)	27.03	25.88
H_2O (100°)	1.35	0.93
CO_2	trace.	0.26
P_2O_5	0.48	0.38
Total	100.34	100.57

FROM VOGELSBERG.

[ANALYST, LIEBREICH.]

SiO_2	1.10	per cent.
Al_2O_3	50.92	“ “
Fe_2O_3	15.70	“ “
CaO	0.80	“ “
MgO	0.16	“ “
H_2O (ign.)	27.75	“ “
H_2O (100°)	0.85	“ “
TiO_2	3.20	“ “
Total	100.48	“ “

Analyses of Alabama bauxite:

[ANALYST, DR. WM. B. PHILLIPS.]

	From Cherokee county. Per cent.	Jackson-ville, Calhoun county. Per cent.	Jackson-ville, Calhoun county, red. Per cent.	Jackson-ville, Calhoun county, white. Per cent.
SiO_2	37.87	18.67	7.73	23.72
Al_2O_3	39.44	45.94	47.52	41.38
Fe_2O_3	2.27	11.86	19.95	0.85
H_2O hygroscopic	9.20	1.40	23.57	23.72
H_2O combined	12.80	21.20		
TiO_2	....	....	....	....

Analyses of bauxite from Jacksonville, Calhoun county, Alabama :

[ANALYST, W. F. HILLEBRAND.]

	Red. Per cent.	White. Per cent.
SiO_2	10.25	21.08
Al_2O_3	41.00	48.92
Fe_2O_3	25.25	2.14
TiO_2	2.53	2.52
P_2O_5	trace	trace
H_2O (100°)	0.65	0.45
H_2O (ign.)	20.43	23.41
Total	100.11	98.62

CaO, MgO, and alkalies, not looked for.

Analyses of bauxite from Floyd county, Georgia :

[ANALYST, NICHOLS.]

	Per cent.	Per cent.	Per cent.
SiO_2	2.80	....	2.30
Al_2O_3	52.21	57.25	56.88
Fe_2O_3	13.50	3.21	1.49
TiO_2	3.52	3.60	3.55
H_2O	27.72	....	....
P_2O_5	....	....	0.07
Total	99.75	....	....

Other analyses of bauxite from Georgia :

[ANALYST, PROF. H. C. WHITE.]

	1 Per cent	2 Per cent.	3 Per cent.	4 Per cent.	5 Per cent.	6 Per cent.	7 Per cent.
SiO_2	19.56	41.47	2.56	8.29	6.62	35.88	1.98
Al_2O_3	52.13	39.75	56.10	58.61	59.82	45.21	61.25
Fe_2O_3	1.12	1.62	10.64	2.63	2.16	0.52	1.82
H_2O	24.21	16.14	30.10	27.42	31.10	17.13	31.43
TiO_2	2.08	....	....	3.15	....	....	2.38
Total	99.10	98.98	99.30	100.10	99.70	98.74	98.86

Number seven is on the Barnsley estate, Dinwood Station. It is a large deposit and is being now largely opened for working. It always contains titanic acid and usually traces of alkalies, etc.

Bauxite from Pulaski county, Arkansas :

	Black.			Red.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	10.13	11.48	5.11	4.89	3.34
Al_2O_3	55.59	57.62	55.89	46.40	58.60
Fe_2O_3	6.08	1.83	19.45	22.15	9.11
H_2O	28.99	28.63	17.39	26.68	28.63
Total	100.79	99.56	97.84	100.12	99.68

	Per cent.	Per cent.	Per cent.
SiO_2	2.00	10.38	16.76
Al_2O_3	62.05	55.64	51.90
Fe_2O_3	1.66	1.95	3.16
TiO_2	3.50	3.50	3.50
H_2O (ign.)	30.31	27.62	24.86
Total	99.52	99.09	100.28

Metallurgy.—The electrolytic process by which aluminum is extracted from its oxide, alumina, is now well understood by all persons interested in the subject. In this country it is carried on by the Pittsburg Reduction Company. The principle is that alumina is decomposed in the presence of a melted fluoride by the electric current, and metallic aluminum is liberated. Powerful dynamos furnish the current for this purpose. In practice the alumina is dissolved in the fused flux, consisting of fluorides of aluminum and sodium, which is regarded as serving as a vehicle for the alumina. The furnace for effecting the operation is made in the form of an open iron-cased box which is thickly lined with carbon and is provided with a spout at the bottom for tapping off the aluminum. A large block, or series of bars of carbon, carried on an adjustable support and arranged to dip into the center of the furnace, forms the anode, the furnace itself forming the cathode. After the flux and alumina have been introduced the carbon anode is brought well down into the furnace and the current turned on. At first considerable resistance is offered, but as the materials in the furnace become highly heated this decreases, and the anode can be raised somewhat. Decomposition soon begins, the alumina being resolved into oxygen and metallic aluminum, the former being liberated at the anode, and, combining with the carbon of which it is composed, passes off as carbonic oxide, while the metallic aluminum, being heavier than the melted bath, sinks to the bottom of the latter and is tapped off from time to time. As the alumina is used up the increase in resistance indicates the progress of the reduction, and fresh alumina is added. The operation is therefore continuous.

Several new processes were patented during the year 1891 in Europe and in this country, the published character of which describe variations (improvements) on those already well known.

It would be without the scope of this report to describe these processes until there is evidence to show that they have been put in operation in this country. The Pittsburg Reduction Company and the Cowles Company were the only producers in 1891.

Production.—The amount of aluminum produced in this country during 1891, including small experimental concerns and that contained in alloys, amounted to 150,000 pounds. The Pittsburg Reduction Company's plant was in operation only five months of the year, owing to its removal to Kensington. In the preceding year the production was 47,881 pounds; and in 1889, 19,200 pounds.

In 1889 it was estimated that the total amount of aluminum extracted up to that date was about 116 tons, but that the indications then were that the annual production would soon exceed that amount. This prediction has been more than verified. The Neuhausen Company was producing at the rate of 1,000 kilos a day at the close of 1891. (*Dingler's poly. J.*, **282,** No. 2, 431). A branch of this company at Fuges produces about 400 kilos daily, and altogether it is safe to say that over 500 tons of aluminum are being produced annually in this country and Europe. Although the American production has been far outstripped by the European there are indications that the year 1892 will show an improvement in this industry in this country.

Price.—In the United States the price of aluminum ranged from seventy-five cents to ninety cents per pound, according to quantity. At the beginning of 1892 it was quoted at fifty cents wholesale in the market reports. The European price was five marks per kilo at the latter date.

Uses.—Besides the metallurgical use of aluminum in casting iron and steel, to be referred to below, the metal is used for an infinity of small articles as has always been the case, and for which its lightness, strength, and freedom from tarnish eminently adapt it. Indeed, with a total production of between 500 and 600 tons, of which, perhaps, 300 only are available for manufactured articles, no extensive use on the large scale could be expected. The newspapers have frequently spoken of the Swiss steam launch of aluminum. A life-boat of aluminum was under construction at Stralsund, Prussia, in December, 1891. It was expected that the lightness of the metal would be of great advantage in dragging the boat over the sands and in hoisting and lowering it. The list of proposed uses continues to increase. Disregarding them, the actual use is sufficiently varied. Small articles, viz., drinking cups, rulers, and paper-cutters, perfumery stands, smokers' sets, ash receivers, toothpick and match holders, watch cases, lemonade shakers, card-receivers, butter dishes, rings, spoons, picture frames, bracelets, napkin rings, sleeve and collar buttons, scarf and shawl pins, penracks, dog collars, key chains, padlocks and chains, hairpins, pencil cases, and pannikins are advertised.

In Germany aluminum tubing is used for penholders, umbrella handles, walking sticks, billiard cues, chair legs, photograph frames, and newspaper-holders.

Powdered aluminum mixed with chlorate of potassium has been used for flash lights instead of magnesium. It is said to make an excellent light and to give no smoke like magnesium.

Mr. Alfred E. Hunt, president of the Pittsburg Reduction Company, in a lecture delivered in March, 1891, gives some information in regard to the use of aluminum in railroad work. He says that the metal has been used, on account of its lightness, for slide valves (experimentally); for valves to control the passage of the air from the storage to the brake cylinders in the new and larger forms of the Westinghouse air brake, the inertia of the heavy iron or brass valves being a serious consideration; for the fan blades and frames of windmills; in semaphore signal disks and their moving frame work.

The use of aluminum for canteens and military equipments in the German army has suggested a similar use in this country, and aluminum curb bits, saber-belt plates, canteens, meat cans, cartridge-belt plates, and spoons and forks have been submitted to the War Department in Washington for consideration. The object is to save weight and avoid rust.

The substitution of aluminum for glass flasks for the army and its use in general for vessels which are designed for holding foods and drinking fluids have given rise to experiments in Germany to test the action of various fluids upon the metal. The results are on the whole favorable to its employment for such purposes. It must be remembered that the aluminum of commerce contains small quantities of other metals and metalloids, sometimes amounting to two per cent., so that it is virtually an alloy. The resistance of aluminum to acids has long been a popular belief, and, before giving the results of the experiments as to the action of drinking fluids upon aluminum, the following account of some experiments with nitric and sulphuric acids is given to show that the former belief in the resistance of the metal to all acids except hydrochloric must be modified. Undoubtedly the physical condition of the metal operated on as well as its chemical composition makes a great difference in its power to resist the action of acids, a finely divided metal being much more easily attacked than the same metal in large pieces. G. A. LeRoy (*Chem. Centrbl.*, *1892*, **1**, No. 2, 51) found that nitric and sulphuric acids of different strengths acted upon aluminum as shown below under the condition specified. He used aluminum foil having the composition 98.29 per cent. to 99.6 per cent. aluminum, 1.60 per cent. to 0.30 per cent. iron, 0.10 per cent. to 0.25 per cent. silicon. The foil was polished, freed from fat with caustic soda, washed with alcohol, dried in the air bath, cut up, weighed, and introduced into the acids. In this fine condition the action of the acids was as shown in the following table, the weight being the amount of metal dissolved expressed in grams per square meter. The action lasted twelve hours.

Action of various acids on aluminum foil :

Acids.	Specific gravity.	Temperature (centigrade).	Samples.			
			A. grams.	B. grams.	C. grams.	D. grams.
Pure H_2SO_4	1.842	15°-20°	18.40	18.90	16.40	14.50
Common H_2SO_4	1.842	15°-20°	21.00	21.30	17.50	16.40
Pure H_2SO_4	1.711	15°-20°	24.50	25.00	22.00	20.00
Common H_2SO_4	1.711	15°-20°	25.80	25.70	24.60	22.40
Pure H_2SO_4	1.580	15°-20°	19.00	18.00	17.90	16.30
Pure H_2SO_4	1.263	15°-20°	4.60	....	2.60	3.40
Pure HNO_3	1.383	15°-20°	17.00	16.00	15.50	14.50
Common HNO_3	1.383	15°-20°	20.50	19.60	18.00	16.60
Common HNO_3	1.332	15°-20°	16.30	16.30	14.00	13.40
Pure H_2SO_4	1.842	150°	240.	225.	150.	200.
Common H_2SO_4	1.842	150°	267.	250.	210.	220.
Pure HNO_3	1.382	100°	....	....	Violent action.	Violent action.
Common HNO_3	1.382	100°	....	....		

According to these results almost pure aluminum, 99.5 per cent., is attacked even in the cold by nitric and sulphuric acids, so that the metal should not be used in apparatus for preparing these acids.

As to the action of drinking fluids, coffee, tea, beer, wines, brandy, etc., the following appears to be the state of the case: Messrs. Lübbert and Roscher (*Chem. Centrbl.*, *1891*, **11**, No. 18, 780) tested the resistance of aluminum to the action of alcohol, ether, aldehyde, coffee, tea, wines, and antiseptics, by allowing aluminum leaf to remain in concentrated solutions of the different liquids four days at the temperature of the room, and the fluids were examined either directly for alumina or were evaporated and the ignited residue so examined. The conclusion reached was that aluminum possesses only a slight degree of resistance to the agents named, except alcohol, ether, and aldehyde, and that it is therefore unsuitable for wares which are to be used for acid drinks, coffee, tea, etc., or articles which are to be cleaned with soda or soap. Its application in daily life would therefore be very limited.

On the other hand, G. Rupp (*Dingler's poly. J.*, **283**, No. 1, January 21, *1892*), criticises the methods employed by Lübbert and Roscher for determining the action of the fluids by estimating the alumina contained in them, as well as the use of aluminum leaf for their experiments, which is attacked much more easily than the compact metal, the former being acted on even by boiling water, while the latter is unaffected. His own experiments were made upon aluminum vessels (canteens, drinking cups, etc.), and foil, the object being to determine the availability of the metal for use in the army. The carefully dried and weighed vessels were filled with the different fluids or the foil was immersed in them, and the action was allowed to continue four, eight, and twenty-eight days, at the temperature of the room with frequent stirring. The fluids included wines of different kinds, beer, kirschwasser, cognac, coffee, tea, milk, drinking water, one per cent. solution of tartaric acid, acetic acid (one per cent., four per cent., ten per cent., solutions), vinegar (ten per cent.), soda solution (one per cent.), besides butter, honey, and preserved fruits. The articles were then cleaned, dried, and weighed, to determine the loss of weight. The results, which fill a large table, showed that in most cases there was absolutely no action and in the few cases where there was a perceptible loss of weight it was so trifling as to be disregarded. To the objection that continued drinking of fluids containing a small quantity of alumina would eventually be dangerous, the author points out that the ash of all the fluids usually drank contains alumina, as well as most foods and drinking water itself. His conclusion is that there is no objection to the use of aluminum for canteens and similar vessels.

These conclusions of Rupp were confirmed by Dr. A. Arche (*Dingler's poly. J.*, **284**, No. 11, 255), whose experiments show that the purity of aluminum (using the percentage of silicon as a means of classification) has much to do with its power of resisting the solvent action of fluids, and they also show that the mechanical preparation of the metal is an important factor. He found that hammered aluminum was least attacked, rolled metal came next, and then the drawn metal, while cast metal was much more easily attacked (by acetic acid).

(*To be continued.*)

PATENTS OF INTEREST TO CHEMISTS.

EDITED BY ALBERT H. WELLES.

Iron and Steel.—Finely powdered wood charcoal with animal charcoal is a combination given by H. A. Harvey for supercarburizing steel (498,390). John A. Hunter has three patents: 498,061 is a process for increasing the per cent. of carbon in low steel by subjecting molten metal in a suitable converter to the action of a blast composed of the gases resulting from heating together hydrochloric acid, calcium chloride, carbon, and sodium chloride; 498,062 is a method for converting iron into steel by heating in a crucible or retort, subjecting to action of a gas containing chlorine, oxygen, and hydrogen evolved from hydrochloric acid, calcium chloride, and sodium choride; 498,063 is another patent on a process for increasing the per cent. of carbon in steel by subjecting the red hot metal in a crucible or retort to the action of chlorine and oxygen, which have first been brought into contact with heated carbon. To concentrate and separate ores, John W. Meier heats and converts into ferric oxide, then into magnetic oxide by heating with carbonaceous substance, and reducing gases as carbon dioxide and then separates with the magnet (497,804).

Sulphur and Carbon Disulphide.—A process for roasting sulphur bearing ores and obtaining sulphur in the solid form, Charles W. Stickney, inventor, consists in roasting one portion by means of steam and