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RECENT PROGRESS IN CHEMICAL TECHNOLOGY.

BY SAMUEL P. SADTLER, PH.D.,
Professor of Chemistry in the Institute.

[*An introductory lecture to the Chemical Course at the Franklin Institute, 1893-94.*]

It having fallen to my lot as Professor of Chemistry in this time-honored Institute to open the course of chemical lectures for the season of 1893-94, the question presents itself at the outset as to how the subject should be taken up. This question is not difficult of solution if we first determine what bearing the science of chemistry has upon the fundamental aims and purposes of the Institute. We have clearly stated in the official title of the Institute the fact that it is constituted for the "Promotion of the Mechanic Arts." Obviously then it is essentially chemistry as applied in the arts that we should concern ourselves with. A thorough grounding in the principles and theories of the science

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as preparatory to this study of its applications might be included in this field to be occupied by the Institute if her means and facilities allowed of it. But for the present, and until the Institute can boast of those newer quarters and larger resources that her friends have been hoping for, she will have to content herself with endeavoring to fill in a narrower sense the object of her organization.

Looking at the specific relations of chemistry to the mechanic arts, therefore, it has seemed to me desirable to open the series of chemical lectures with a "Review of Recent Progress in Chemical Technology."

In the production of the metals, the most notable advances made in recent years are those which concern the light metals, aluminum, magnesium and sodium, and these advances have been largely coincident and connected with the great improvements in applications of electricity. Thus, until the issue of the Grätzel patents in 1883, aluminum was manufactured solely by the Deville process, at Salindres, France, and later at Oldbury, near Birmingham, England, under Webster's patents. In 1885, the Cowles electric process was made public and has continued in use to the present time. Heroult's process, also an electrical one, was patented in 1887, and is at present being worked on a large scale, both in Switzerland and France. Hall's process, patented in 1889, and Minet's, which is practically identical with Hall's, however, represent the most successful applications of the electrolytic method to the production of the metal aluminum. So it has come about that the Aluminum Company, of Oldbury, England, although it has cheapened the price of sodium under Castner's patents and controls Webster's improvements on Deville's process is unable to make aluminum in competition with the electrolytic methods and has retired from that field. In this country and in England, the two processes now in use are those of Hall and Cowles, while on the Continent, the Heroult and the Minet processes are followed.

The production of aluminum in 1892 was as follows: In the United States, 133,779 kilos; by the Aluminium Industrie Actien-Gesellschaft, at Neuhausen, in Switzerland, 286,100

MEAN TEMPERATURE, RAINFALL AND PREVAILING WIND DIRECTION FOR NOVEMBER, 1893

ISOTHERMAL LINES,
SHOWING THE
NORMAL TEMPERATURE OF PENNSYLVANIA FOR NOVEMBER.

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR NOVEMBER, 1893.

COUNTY.	STATION.	BAROMETER REDUCED TO SEA LEVEL.			TEMPERATURE.										RELATIVE HUMIDITY.	DEW POINT.	PRECIPITATION.			NUMBER OF DAYS.			WIND.		OBSERVERS.	
		Elevation above Sea Level (feet).	Mean.	Lowest.	MAXIMUM.		MINIMUM.		Mean of Maximum.		Mean of Minimum.		Greatest.	DAILY RANGE.			Total Inches.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.			
					Highest.	Date.	Lowest.	Date.	Mean.	Mean of Minimum.	Greatest.	Date.		Least.									Date.			
Allegheny.	Pittsburgh, A.	240	30.12	30.66	42.0	68	2, 6, 9	50.2	33.0	17.2	31	12	9	4	74.0	33.0	1.4	9	W	W	W	O. D. Stewart, Weather Bureau				
Berks.	Hamburg.	380	30.12	30.66	42.0	62	2, 6, 9	48.0	33.0	15.0	29	1	0	4	...	...	3.54	11	22	6	...	...	Franklin Shippe.			
Berks.	Reading, A.	280	30.12	30.66	42.0	62	2, 6, 9	48.0	33.0	15.0	29	1	0	4	...	...	3.39	11	22	6	...	...	Dr. C. B. Dudley.			
Blair.	Altoona, B.	1,181	30.12	30.66	42.0	63	3	51.8	37.0	13.8	25	17	6	5	...	...	1.48	6	...	...	...	...	A. H. Boyle.			
Blair.	Blue Knob, A.	2,500	30.12	30.66	42.0	58	3	26	29.2	10.8	26	26	2	44	...	...	2.79	11.5	5	12	13	...	...	Prof. J. A. Stewart.		
Blair.	Hollidaysburg, A.	917	30.12	30.66	42.0	65	2	49.0	25.2	23.8	43	2	7	4	...	...	2.13	1.5	10	12	8	...	...	Charles Beecher.		
Braford.	Wysox, A.	718	30.12	30.66	42.0	65	2	49.0	25.2	23.8	43	2	7	4	...	...	2.13	1.5	10	12	8	...	...	G. W. T. Warburton		
Bradford.	Le Roy.	1,400	30.12	30.66	42.0	62	7	44.3	29.3	15.0	31	7	1	4	...	...	2.07	3.0	13	13	14	...	...	J. C. Hilsman.		
Bucks.	Forks of Nesquehanna (15 days).	304	30.16	30.76	39.3	62	2	49.8	39.7	49.1	32	27	7	24	...	...	4.46	1.0	7	13	10	...	...	J. L. Heacock.		
Bucks.	Quakertown, A.	536	30.16	30.76	39.3	62	2	49.8	39.7	49.1	32	27	7	24	...	...	4.46	1.0	7	13	10	...	...	E. C. Lorentz.		
Cambria.	Johnstown, A.	1,184	30.16	30.76	39.3	63	2, 9	46.5	29.7	16.8	37	17	3	4	...	...	2.05	1.5	11	3	12	...	...	T. B. Lloyd.		
Carbon.	Emporium, A.	1,050	30.16	30.76	39.3	63	2, 9	46.5	29.7	16.8	37	17	3	4	...	...	2.05	1.5	11	3	12	...	...	F. C. Wintermute.		
Carbon.	E. Mauch Chunk.	550	30.16	30.76	39.3	60	2, 9	47.0	30.1	17.8	32	1, 2	3	4	...	...	3.26	...	8	8	14	...	...	Prof. Wm. Frear.		
Centre.	State College.	1,191	30.07	30.66	40.0	59	2	46.2	26.7	19.5	32	22	6	17, 25	...	...	3.04	4.0	3	15	12	...	...	J. C. Green, D.D.S.		
Chester.	Agricultural Experiment Station.	455	30.11	30.64	41.3	60	2	49.0	34.2	21.4	37	27	5	28	...	...	5.69	1.2	10	13	4	...	...	W. T. Gordon.		
Chester.	West Chester, A.	386	30.11	30.64	41.3	66	2	51.5	30.1	21.4	37	27	5	28	...	...	5.69	1.2	10	13	4	...	...	B. P. Kirk.		
Chester.	Coatesville, A.	275	30.15	30.68	42.1	65	2	51.3	30.0	20.0	28	21	4	8	...	...	4.34	0.5	7	10	5	...	...	Knowles Crooksey.		
Chester.	Kennett Square, A.	190	30.15	30.68	42.1	63	18	50.5	33.7	16.5	28	1	4	24	...	...	4.74	...	9	5	16	...	...	Harry Alger.		
Chester.	Phoenixville, A.	350	30.15	30.68	42.1	62	1	47.8	30.4	17.4	26	11	5	5	...	...	1.72	2.0	7	11	12	...	...	Nathan Moore.		
Chester.	Westtown (29 days).	1,450	30.15	30.68	42.1	62	1	47.8	30.4	17.4	26	11	5	5	...	...	1.72	2.0	7	11	12	...	...	Prof. J. A. Robb.		
Clearfield.	Grampian, A.	560	30.15	30.68	42.1	65	9	40.4	28.3	12.1	32	2	4, 28	...	...	...	1.53	1.0	8	7	10	...	...	Prof. J. G. Cope.		
Clinton.	Lock Haven, A.	500	30.15	30.68	42.1	65	9	40.4	28.3	12.1	32	2	4, 28	...	...	...	1.53	1.0	8	7	10	...	...	Chas. Graves.		
Columbia.	Bloomersburg, A.	500	30.15	30.68	42.1	65	9	40.4	28.3	12.1	32	2	4, 28	...	...	...	1.53	1.0	8	7	10	...	...	J. E. Pague.		
Crawford.	State Normal School.	1,200	30.15	30.68	42.1	65	6, 13	48.2	31.8	16.4	29	28	6	24, 25	...	...	0.1	...	6	12	12	...	...	F. Ridgway, Weather Bureau.		
Crawford.	Meadville.	1,200	30.15	30.68	42.1	65	6, 13	48.2	31.8	16.4	29	28	6	24, 25	...	...	0.1	...	6	12	12	...	...	Prof. Susan J. Cunningham.		
Crawford.	Divinity Hall, A.	1,200	30.15	30.68	42.1	65	6, 13	48.2	31.8	16.4	29	28	6	24, 25	...	...	0.1	...	6	12	12	...	...	C. F. Sweet.		
Cumberland.	Siegstown, A.	480	30.15	30.68	42.1	65	6, 13	48.2	31.8	16.4	29	28	6	24, 25	...	...	0.1	...	6	12	12	...	...	P. Wood, Weather Bureau.		
Dauphin.	Carlisle, A.	361	30.15	30.68	42.1	65	6, 13	48.2	31.8	16.4	29	28	6	24, 25	...	...	0.1	...	6	12	12	...	...	Wm. Hunt.		
Delaware.	Harrisburg, A.	190	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	G. W. Ludwig.		
Delaware.	Swarthmore College.	1,400	30.14	30.71	41.0	56	2	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	T. F. Sloan.		
Erie.	Edinboro, A.	681	30.14	30.71	41.0	56	2	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Prof. W. J. Swigart.		
Erie.	Erie, A.	1,000	30.14	30.71	41.0	65	2	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Prof. S. C. Schucker.		
Fayette.	Uniontown (28 days).	618	30.15	30.65	41.5	65	10	49.8	35.2	10.6	29	12	5	4, 18	...	...	2.34	0.5	8	13	7	...	...	R. J. Mickey.		
Franklin.	Chambersburg, A.	875	30.15	30.65	41.5	65	10	49.8	35.2	10.6	29	12	5	4, 18	...	...	2.34	0.5	8	13	7	...	...	W. E. Bushong.		
Fulton.	McConnellsburg, A.	650	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Wm. T. Butz.		
Huntingdon.	Huntingdon, A.	1,350	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	G. W. Hayes, C.E.		
Indiana.	The Normal College.	475	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	J. R. Wagner.		
Indiana.	Kilmer, A.	413	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	A. W. Betterly.		
Lancaster.	Lancaster, A.	932	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Armstrong & Brownell.		
Lawrence.	New Castle, A.	458	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Charles Moore, D.D.S.		
Lebanon.	Lebanon, A.	520	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	B. W. Dambly.		
Luzerne.	Coopersburg, A.	1,683	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	J. W. Moore.		
Luzerne.	Drifton (23 days), A.	575	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	Richard Callin.		
McKean.	Smithport, A.	150	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	L. M. Dey, Weather Bureau.		
Montgomery.	Pottstown, A.	150	30.14	30.71	41.0	61	18	26.27	35.0	13.8	29	27	4	24	...	...	3.04	...	15	6	13	...	...	John Grathwohl.		
Montgomery.	Skipack, A. (20 days).	325	30.14	30.71	41.0	61	18	26.27																		

kilos; and by the Société Electro-Metallurgique Française, Isère, France, 60,000 kilos. The English production I have not seen stated.

At the Columbian Exposition the raw materials and the products of the aluminum industry were very satisfactorily shown by the Pittsburgh Reduction Company, and some individual exhibitors in the galleries of the Mining Building. The *beauxite* used as the source of the alumina is now mainly supplied from the Alabama and Georgia deposits, which were also well illustrated in this connection.

As the Aluminum Company, of Oldbury, England, as just stated, have had to retire from the competition with the electrolytic processes, they have devoted themselves to the production of sodium and, in looking for new utilizations for the metal, have brought out sodium peroxide as a commercial product. This has already found a large sale for wool and silk-bleaching and other purposes for which hydrogen peroxide has been used. As compared with barium peroxide and hydrogen peroxide (10 volume solution) it contains available oxygen as follows:

	<i>Available Oxygen. Per Cent.</i>
93 per cent. sodium peroxide	19.5
91 per cent. barium peroxide	8.6
10 volume solution hydrogen peroxide	1.6

It is made, according to Castner's patent, by treating metallic sodium contained in aluminum vessels at a temperature of 300° C. to the gradual oxidizing action of a mixture of oxygen and nitrogen in which the proportion of oxygen is gradually increased. This is done in an iron pipe which passes through the furnace and along which a current of air is passed from one end. The vessels containing the sodium pass along the entire length of the pipe, the sodium being oxidized at first by air which has almost been deprived of its oxygen, the proportion of the latter gradually increasing until it is finally oxidized by air containing the full amount of oxygen. The product is a yellowish white partially powdered substance, which dissolves in water with considerable evolution of heat. It may be used to develop hydrogen peroxide just as the barium peroxide

is used, or used direct with the addition of a magnesium salt in order to convert it into the magnesium peroxide, the alkalinity of the sodium peroxide when taken alone being injurious.

In turning to the metallurgy of the heavier metals, there are improvements capable of being discussed in the case of many of them, but for the purposes of this review we will have to choose only the most prominent for mention. The one which has certainly attracted the most attention on the part of chemists is the so-called "cyanide process" for the extraction of gold and silver from their ores. While the fact of the solubility of gold and silver in cyanide of potassium solution has been known for years and applied in electro-metallurgical processes, the application of this solvent power of the cyanide for the extraction of the finely disseminated metal from the ore has only been made in the last few years. The process has been applied in the United States under the patents of Simpson and others and on a larger scale in the South African gold fields under the patents of MacArthur and Forrest. The process as applied to gold ores is in outline as follows: The damp tailings are charged into wooden vats of a capacity of fifty to seventy-five tons and the vats filled to within a few inches of the top. Cyanide solution of 0.6 to 0.8 per cent. strength is then allowed to flow into the tank until it is completely filled. This solution is allowed to remain undisturbed in contact with the ore for twelve hours. Each vat is provided with a false bottom covered with some straining material, usually cocoanut matting. Below this is a layer of coarse sand and pebbles, through which the solution percolates. An iron pipe communicating with the vat below the false bottom takes the filtered solution to the "zinc boxes," when precipitation takes place. As the liquor is drawn off during the leaching process, it is replaced by fresh solution. This operation is continued from six to twelve hours, according to the value of the tailings. At the end of this period, which is known as the "strong solution leaching," a weaker solution (containing 0.2 to 0.4 per cent. of cyanide) is turned on and allowed

to filter through the ore for about eight to ten hours. When this is drawn off a quantity of wash-water about equivalent to the moisture originally contained by the ore is run in and the weak cyanide solution so displaced. The amount of cyanide solution used is about half a ton of strong and half a ton of weak solution for every ton of ore treated. This part of the process has been modified by pumping back the solution as it filtered through the bottom of the vat and so keeping up a circulation of the original solution for some thirty-six hours. The extraction of gold by this circulation system was equal to that obtained by the ordinary method and the consumption of cyanide was much less. The cyanide solution carrying the gold dissolved now goes through wooden troughs, commonly known as "zinc boxes," where shavings of zinc cause the deposition of the gold as a finely divided black slime upon their surface. After passing the "zinc box," the "exhausted solution," which should not retain more than a trace of gold, flows into a storage tank to be pumped back to the leaching tanks when a fresh charge has to be treated. Very great loss of cyanide takes place by secondary decomposition of the potassium salt, due to the galvanic action of the gold-zinc couple that is formed. The slime of finely divided gold and silver with a large proportion of zinc and lead and smaller amounts of tin, antimony and accidental impurities after thorough settling and transferred to enamelled iron pans and carefully dried. It is then mixed with sand, borax, and bicarbonate of soda and melted in a crucible yielding a bullion about 650 fine.

In the Molloy process, which is said to be in successful operation in South Africa, the use of zinc is dispensed with altogether. The cyanide solution from the leaching tanks passes through a shallow trough containing mercury, in which is an inner cylindrical vessel filled with solution of carbonate of soda; the edges of the cylinder just dip beneath the mercury so that its contents are entirely cut off from the outer portion of the vessel. A rod of lead dips into the soda solution; the lead and mercury are connected with opposite poles of a battery, and the solution is electro-

lyzed by the passage of a current. The sodium combines with the mercury to form sodium amalgam which at once decomposes the gold cyanide solution with formation of ordinary gold amalgam, sodium cyanide being simultaneously produced. It is claimed that much less decomposition of the cyanide takes place than with zinc, and moreover that the outflowing solution is better adapted for dissolving fresh quantities of gold. In the ordinary method a large accumulation of zinc in the solution must take place, which in time renders them valueless for gold extraction whereas sodium cyanide is just as effective as the potassium compound.

Turning now to the acid and alkali industries not much of fundamental importance is to be noted in the former. At the Columbian Exposition were shown in the exhibit of Heræus, of Hanau in Germany, large platinum stills of the Faure and Kessler system, in which the interior of the still was plated throughout with gold. It has been found that this surface of gold will stand the action of concentrated sulphuric acid much longer than one of platinum. I have since seen two such stills in operation in a large chemical works and understand that the claim is thoroughly borne out in practice.

Perhaps the most important matter of interest in connection with the alkali industry, is the attempt now being made by numerous experimenters to accomplish a commercially successful electrolysis of salt solution with chlorine and caustic soda as the products. The results, with two of the most prominent processes (the Greenwood and the Le Sueur) were summed up some months ago by Messrs. Cross and Bevan, of London, England, and from their article (*Jour. Soc. Chem. Ind.*, 1892, p. 963) we shall quote. The chief difficulties met with were the devising of a diaphragm of such low resistance as would allow the electrolysis to proceed with a reasonable low electro-motive force, and which would at the same time effectually prevent the recombination of the products of electrolyzer; and the construction of an anode which would stand wear and tear. In the Greenwood process, "the electrolysis consists of a rectangular

tank of slate or other suitable material divided into compartments by means of diaphragms. These are made of a number of V-shaped shelves of glass or slate placed in a mahogany frame. The spaces between the shelves are filled with asbestos. On one side of the diaphragm is the cathode made of iron and on the other side is the anode. This is of peculiar construction, being built up of a number of pieces, of hard retort carbon cemented together by first impregnating with tar and subsequently heating to a high temperature. The inside is filled with type metal. The cathodes and anodes in every electrolyzer are connected together in parallel circuit, the electrolyzers themselves being in series. Arrangements are made by means of pipes for allowing the salt solution, which is about half-saturated, to flow through all the anode and cathode sections, respectively. The chlorine which is evolved passes into the chlorine main. The caustic solution after passing through a sufficient number of electrolyzers is evaporated, and the excess of undecomposed salt removed." In the Le Sueur process, the electrolyzers consist of an iron tank fitted with a sloping floor on which rests the cathode. This is formed of a ring of iron filled with several pieces of iron wire gauze. Several small holes are drilled in the top part of the ring to allow of the easy escape of the hydrogen. The diaphragm, which rests upon the cathode, consists of two parts, a sheet of ordinary parchment paper, and a double sheet of asbestos cemented together by means of coagulated blood albumen. The anode consists of pieces of ordinary retort carbon imbedded in a mass of lead through which electrical contact is obtained. In this process the diaphragms have to be renewed every forty-eight hours, and the carbon anodes in from six to eight weeks. When the electrolysis has been continued long enough for the solution of caustic to reach a strength of about ten per cent. the liquor is run away, and the alkali precipitated as bicarbonate. The Le Sueur process is now in operation at Rumford Falls, Me., on a scale of three tons of bleach per day. E. Hermite and A. Dubosc (*Zeitsch. für Angew. Chem.*, 1892, p. 729) claim that all these attempts at simple electrolysis of salt solutions will

remain unsatisfactory, because the heat of the combination of sodium and oxygen is less than that of sodium and chlorine, so that a current of sufficient electro-motive force to decompose sodium chloride will also decompose the sodium oxide as fast as formed. Thus the electro-motive force used is practically wasted. They have proposed and patented two methods for preventing this. The first is to cause the sodium oxide in the moment of its formation to enter into combination to form a sodium salt possessing a higher heat of chemical union than sodium chloride, so that the electro-motive force of the current may remain constant. Such a compound they find in sodium aluminate, which will form if pure gelatinous alumina be present in the salt solution undergoing electrolysis. As soon as all the alkaline chloride is decomposed, the current is stopped, and carbon dioxide is led into the solution when the alumina hydrate is again set free while sodium carbonate is formed. Their other proposal is to use as cathode plates of amalgamated copper or other metal over which a thin layer of mercury is continuously made to pass. As the alkali metal separates out, it is amalgamated, and this sodium amalgam is, by a special device, removed promptly into another receptacle where it is decomposed by water, with the formation of caustic soda solution.

I am not aware that these proposed processes are as yet carried out on a practical scale. Cross and Bevan, however, state that the original Hermite process for the continued electrolysis of magnesium chloride solutions for bleaching purposes is proving highly successful on the continent of Europe, and that it is now replacing 3,000 tons of bleaching powder per annum.

While the two great products sought to be obtained in all of these processes above described are chlorine and caustic soda, it must not be overlooked that these are side products. In the solution will be found hypochlorites and chlorates also. In connection with the Greenwood process it has been proposed to extract the latter salt.

An entirely different utilization has, however, been proposed for weak electrolyzed brine solutions, depending upon

the development of hypochlorites therein. I refer to their use as disinfecting agents. The Woolf process, as taken up for experiment by the New York City Board of Health, proposes to disinfect large quantities of liquid sewage by adding to it weak electrolyzed brine solutions, and it is stated by Dr. Cyrus S. Edson to have accomplished very remarkable results in the experiments made under his direction in New York.

In the class of nitrated mixtures for explosive purposes there has been much published and patented in the last few years. The improvements have been mainly in two lines, viz: smokeless powders and high explosives which combine safety of transport and handling with great energy of decomposition. The former are largely mixtures of nitro-cellulose and nitro-lignin (both soluble and insoluble varieties) with alkaline or alkaline-earth nitrates. A very interesting series of analyses of such smokeless powders, by Prof. C. E. Munroe, formerly of the United States Naval Torpedo Station, at Newport, will be found in the January number of the *Journal of the American Chemical Society*. The second class include mainly mixtures of substances very rich in oxygen, whether solid or liquid, and highly condensed carbon compounds. To these belong the series of Sprengel explosives, rack-a-rock (chlorate of potash and nitro-benzene) and similar compounds. These can be mixed frequently on the spot just before use, and so safety of transport insured as the compounds taken singly are inexplusive or in some cases peculiar detonating fuses are needed to develop their explosive power.

Very great interest has attached in recent years to the discovery of large and valuable deposits of native phosphates of value in the manufacture of fertilizers, but as a special lecture on this subject by a gentleman who has had exceptional opportunities of studying these deposits, will follow later in the course, I will leave the matter, feeling that it will be thoroughly discussed at that time. Similarly the cement industry and especially the manufacture of Portland cement, which has made great advances in the United States in the last few years, will be left for a special lecturer

to follow later in the winter, a gentleman engaged himself in the manufacture of cement, and by the newest and most improved methods. A lecture is also down on our list on the subject of "Emery and other Abrasives." In this will doubtless be mentioned the very interesting new compound, known by the trade name of "carborundum." By heating together a mixture of 100 parts of sand, twenty-five parts of salt and twenty-five parts coke in an electrical furnace for several hours is formed along with graphite a new and interesting chemical compound SiC (silicon carbide), to which the trade name of "carborundum" has been given. This forms crystals of a greenish-gray color of the hexagonal system, of specific gravity 3.22, and of a hardness little if any inferior to the diamond. A full account of the discovery and properties of this interesting compound by the discoverer, Mr. Ed. G. Acheson, will be found in the September and October numbers of the *Journal of the Franklin Institute*.

Turning now to the organic side of Chemical Technology, and beginning with the subject of petroleum and mineral oils, we may notice the interesting results of Professor Engler, of Carlsruhe, of which he presented a brief abstract in a paper read before the Chemical Congress at Chicago, in August last. He finds that almost all the animal fats and fatty oils when distilled under strong pressure yield hydrocarbons of the paraffin series. Besides the oil some water and combustible gas was always formed. By fractional distillation the oils yielded gasoline, benzine, illuminating and lubricating oils and even paraffine wax. Samples of all these prepared from train oil were shown in connection with the reading of his paper. The bearing of all this on our theories of the formation of petroleum is very important. Many prominent geologists have expressed the view that the origin of petroleum was to be sought in marine animal life, of which we find the mineral remains in the oil-bearing strata. Engler first distilled quantities of salt-water fishes and shells under strong pressure, but only obtained a mixture of nitrogenous bases, such as pyridine, bearing no relation to petroleum. But, as before said, the results were very different with train and fish oils. He therefore

believes that while the easily decomposable nitrogenous material of marine animal life has disappeared, the accumulated fatty oils and blubber under the pressure of sedimentary strata, and aided perhaps by heat, have undergone destructive distillation with petroleum as the main products.

A new class of products of considerable practical interest derived from the class of semi-drying oils, like cotton-seed and rape-seed oils, is that known as "blown oils." These are produced by heating the oils to a temperature of about 200° C. for some hours while a current of air is forced through them by a blowing machine. The changes effected are quite marked. Thus, while common cotton-seed oil has a specific gravity of 0.925 and a very moderate viscosity, after the blowing operation is complete its specific gravity is raised to 0.960 and the viscosity is raised in an extraordinary degree. Moreover the thorough oxidation thus effected has improved its character as an ingredient in lubricating oils in other respects. It is no longer liable to acidity when used as a lubricant, and so is especially adapted for mixing with paraffin oils for the manufacture of the best heavy lubricating oils. Numerous other uses have also been found for these blown oils, such as the manufacture of artificial leather and other products.

In the domain of the essential oils, very important discoveries have been made in the identification of the essential odoriferous constituents of several of the essential oils and the consequent synthetic preparation of these constituents. It has been established that the esters of certain alcohols of the composition $C_{10}H_{18}O$ and $C^{10}H_{20}O$ are the principal constituents of a large number of essential oils which owe their aroma in the main to the esters in question. Thus, for instance, linalyl-acetate and other esters of linalool, $C_{10}H_{18}O$, have been recognized as constituents of lavender oil, bergamot oil and petitgrain oil, while geranium oil, lavender oil and lemon-grass oil contain esters of geraniol, $C_{10}H_{18}O$, principally geranyl-acetate. In pine oils finally esters of borneol, $C_{10}H_{18}O$, have been found. It is similarly found that citral, $C_{10}H_{16}O$, the aldehyde of geraniol is the main constituent of oil of lemon and that

rhodinal, $C_{10}H_{18}O$, is the fluid constituent of oil of rose. All of these compounds of definite composition are now prepared in a pure state and are coming into use in the perfumery trade as much more reliable than the natural oils themselves.

Another interesting class of products closely related to those just spoken of are the so-called "ester-gums," recently offered to the varnish trade as substitutes for copal, dammar, mastic, sandarac and other natural varnish gums. These ester gums are the glyceryl, methyl and ethyl esters of abietic and pinic acids and are prepared by saponifying ordinary colophony resin (or common rosin) under pressure and then freeing the ester so formed from water, etc., by distillation in vacuo. The artificial gums so obtained are soluble in all the varnish-forming solvents and form varnish films of great brilliancy and durability.

In a lecture which I delivered here in January, 1892, I spoke of the chemistry of starch and the decomposition products obtained from it under the influence of the diastase of malt. The importance of the industries based upon starch and its alteration products makes this a subject of practical as well as theoretical interest. Dr. Lintner, of Munich, has recently published the results of studies made by him on this action of diastase. He considers the existence of the complicated dextrine molecules of high molecular weight, described by Brown and Morris (an account of which was given in the lecture before referred to) as very unlikely. By the aid of phenyl-hydrazine as reagent, Lintner established the presence of isomaltose as an invariable ingredient in the product of the diastatic action. By the use of four different methods of study, viz: the determination of specific rotatory power, the reducing power of Fehling's solution, the molecular weight determination, according to Raoult's method, and the addition of phenyl-hydrazine as reagent, Lintner determines that five well-characterized products can be obtained from the action of diastase on starch. These are the three dextrines already known under the names of amylo-dextrine, erythro-dextrine, and achroo-dextrine, isomaltose and maltose. Supported upon the results of the

molecular weight determination, Lintner gives to amylo-dextrine the formula $(C_{12}H_{20}O_{10})_{54}$; to erythro-dextrine the formula $(C_{12}H_{20}O_{10})_{18}$; and to achroo-dextrine $(C_{10}H_{16}O_8)_5$. Brown and Morris' complex dextrines he considers to have been mixtures of these simpler dextrines with either isomaltose or maltose, as all five products of the diastatic action may exist together in the infusion at the same time.

The chemistry of cellulose and its derivatives has attracted the attention of many experimenters. Among the most important results have been those of Cross and Bevan on the new forms of cellulose obtained from what they term cellulose sodium xanthate. This is formed by treating the cellulose with a concentrated solution of sodium hydrate, and exposing this product to the action of carbon disulphide vapor. Action ensues, and in the course of an hour or two a yellowish mass is obtained, which swells up enormously on treatment with water, and finally dissolves completely. This crude solution containing yellow bye-products, yields the cellulose derivative in a pure state on treating it with saturated brine or with strong alcohol. These precipitate it either in a flocculent condition or in leathery masses which may be washed with sodium chloride solution or sixty-five per cent. alcohol, respectively. On re-dissolving in water, an almost colorless solution of extraordinary viscosity is obtained. A seven per cent. solution of the compound, *i. e.*, containing (say) five per cent. of cellulose to 100 of water has a viscosity equal to that of glycerin measured by the rate of flow. The solutions of this cellulose-sodium xanthate undergo decomposition, however, spontaneously after a time, more rapidly by heating or the addition of reagents. There separates out then a firm coagulum of hydrated cellulose, easily capable of purifying by simple washing with water. The spontaneous gelatinization of the solutions appears to take place without change of volume, the coagulum invariably reproducing the details of the surface of the containing vessel. Shrinkage then ensues, the form of the coagulum being perfectly retained. Solutions exceeding ten per cent. strength (in cellulose) give a coagulum of great solidity; even when diluted to 0.5 per cent. strength the

cellulose jelly obtained has sufficient consistency to be handled. Among the many applications of the solution or of the pure cellulose separating from it, may be mentioned the following, which have been pointed out by the authors :

(1) As an adhesive substance, replacing glue, flour-paste, gums, india-rubber solution, etc.

(2) For sizing and filling textiles. In this direction the important advantage of depositing a substance of the same chemical composition and physical properties of the textile does not need to be insisted upon. The authors in this way have introduced from fifteen to thirty per cent. of additional cellulose without the possibility of its presence being appreciated except by comparison with the unfilled fabric.

(3) For purposes of producing casts and moulds. By coating surfaces with the solution or filling hollow vessels, perfect reproduction of form and structural details can be obtained in the form of a more or less solid mass of cellulose hydrate. The cellulose when fully de-hydrated by drying, forms a transparent mass, resembling horn, which can be worked in the lathe, taking a brilliant surface under cutting and polishing tools.

(4) The applications of the various forms of the solid cellulose in block or film form are evident to any one who has followed the utilizations of celluloid or nitro-cellulose, over which this has the advantage of lack of dangerous inflammability.

One of the industries in which great changes have been made in the last few years, owing to the introduction of new chemical processes, is the tanning and leather industry. While the tanning of heavy leather has been improved by the widespread introduction of oak and hemlock bark extracts of definite and uniform composition, it is in the tanning of lighter leathers, such as calf and kid, that the greatest advances have been made. For these, the "dongola" tanning and the newer "chrome" or mineral tanning processes have almost entirely displaced older methods. The dongola process is a combination process using gambier, alum and salt together in the same liquor and following the tanning proper by a treatment of the

leather with "fat liquor," or oil emulsified with borax or soda solution.

It is, however, the successful introduction of the mineral tanning processes which is now revolutionizing the manufacture of lighter leathers in this country. The process generally in use at present involves treating the skins at first with a weak solution of bichromate of potash, to which sufficient hydrochloric acid is added to liberate the chromic acid. After the skins have taken up a bright yellow color through their entire texture, they are drained and transferred to a bath of hyposulphite of soda, to which some acid is added to liberate sulphurous acid, which reduces the chromic acid to green chrome oxide, while the sulphurous acid is at the same time oxidized to sulphuric acid, which liberates a further portion of sulphurous acid until the whole of the chromic acid is reduced. The leather so produced is of a pale bluish-green color, tough and flexible, and thoroughly resistant to water. Indeed, it is this latter property which distinguishes it from all other forms of leather, as the combination of the hide fibre or coriin with the chromium oxide is apparently more stable than its combination with tannin, and yields less to boiling water. The leather also can be dyed and produced in a variety of colors, but the dyeing must be done before the leather dries, as its water-repellent character is such that once dried it cannot be wetted sufficiently to take up a full color. The process is now carried out in this city at several morocco tanneries on a very large scale, and with perfectly satisfactory results.

Chrome-tanning processes involving the use of chrome alum and other salts of the sesquioxide of chromium as the basis of the tanning vat have been used, but apparently the combination does not take place so readily as where the chromium oxide is obtained in *statu nascendi* by reduction from the bichromate under the influence of reducing agents. Basic chromium salts have also been recently proposed as mineral tanning agents, but of their practical success I cannot speak from personal knowledge. That mineral tanned leather has taken a strong hold upon the industry was made evident by the many and fine exhibits of such leather

at the recent Columbian Exposition, and can also be gathered from the testimony of foreign experts who visited this country during the past summer. Prof. Henry Procter, of the Yorkshire College, Leeds, England, in a lecture delivered since his return, says of the chrome process that "it may be said to be the most striking new departure in tanning which has taken place within my memory."

With this brief and partial survey of the field I will conclude, simply drawing attention to the fact that we will have the pleasure this winter, in our course of lectures, of hearing several of their subjects taken up in detail by eminent specialists.

THE LUMIÈRE-LIPPMANN COLOR PHOTOGRAPHY.

BY F. E. IVES.

[*Read at the stated meeting of the Institute, held Wednesday, Nov. 15, 1893.*]

In the spring of 1892, there were exhibited in the Photographic Exhibition in the Champ de Mars, in Paris, photographs, by the Lippmann process, of a parrot, a branch of holly, pieces of colored glass, etc., which M. Alphonse Berget and others declared were true reproductions of the colors of the objects. I could see in these photographs only the colors of thin films, metallic and changeable as such colors usually are, and in some instances not even confined to the colored objects themselves, but spreading over objects that were uncolored in the original. These pictures were also devoid of either whites or blacks, the high lights of the objects being rendered more like blacks than the shadows. Others, notably Mr. Cameron Swan, who wrote a letter on the subject to the *London Times*, noticed the same defects in these photographs, and Captain Abney, who had experimented with the process, found that by varying the time of exposure he was able to make a blue photograph with red light, and *vice versa*, and a colored photograph with white light. It was generally admitted that the results obtained by Profes-

sor Lippmann did not sustain the claims made for the process; and when it was announced, this year, that the brothers Lumière had succeeded in so far improving upon Lippmann's method as to obtain really satisfactory color photographs of natural landscapes, those who had seen the photographs for which such extravagant and inaccurate claims were made a year before, were naturally and very justly skeptical.

Now, however, the Lumière photographs have been shown in London, and although there is still a certain amount of mystery surrounding them, it is possible to form a truer estimate of their character and importance, and to make an intelligent comparison with another and more successful method based upon quite different scientific principles.

The Lumière photographs are about three inches square, and by light reflected from their surface at most angles, they have much the same appearance as the French albumen process lantern positives, the high lights of the picture looking like clear glass and the shadows having the appearance of an albumen or gelatine film filled up with a dense, dark-colored deposit of silver. It is said that by transparency they are negative images; but those shown are sealed up so that they cannot be examined by transmitted light.

Unlike Lippmann's photographs, these examples show color only when the light is reflected from the surface at one particular angle, and for that reason the colors are not "changeable." This in itself is really a very important improvement, although it carries us further away from, instead of nearer to, the popularly desired conditions in color photography. It is, indeed, a significant fact that real and undoubted improvement intensifies instead of lessening a characteristic defect of the original Lippmann photographs, which some writers have not hesitated to say would "undoubtedly" be overcome, namely, the inability to see the colors at all angles.

If the pictures were uncovered the critical angle would undoubtedly be perpendicular to the surface of the plate; but it would then be necessary to provide some means for

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illumination and vision in precisely the same direction. It is also necessary that the source of light be large enough to illuminate the entire surface of the photograph equally with parallel rays coming from it. A rough approximation to these conditions is secured by covering the picture with a shallow prism, and then examining it by the reflected light of a sufficient exposure of even white or gray sky, holding the picture at nearly arm's length away from the eye. More satisfactory results could doubtless be obtained by means of a special device, which could be used like the stereoscope or photochromoscope. It would be quite easy in this way to exactly fulfil the theoretical requirements for illumination and vision, and at the same time to magnify the picture, which must now be made to occupy only a very small angle of vision in order to be seen all at once.

The pictures are also projected upon a screen by means of the megascope or aphengescope lantern, and in the absence of a special device for examining them by daylight, this is the only really satisfactory way of seeing them. It is, however, necessary to employ a powerful electric arc light in order to project them with satisfactory brilliancy up to even two feet diameter, as compared with ten feet or twenty-five times greater area, for the photochromoscope pictures with the same light.

Seven pictures were shown at the Photographic Congress, and at the Camera Club: four landscapes, two portraits with accessories, and one reproduction of a chromo-lithograph, a rather poor result, the original of which was not shown. Unlike Lippmann's photographs, they rendered the deepest shadows black, and the high lights white, and showed many delicate shades of color which impressed the spectators as being something more than the ordinary colors of thin films. One of the landscapes was beautiful, although the foliage appeared to be that of autumn, and it was understood that the photographs were made in early summer. In parts of some, the chlorophyl green was fairly well represented, but in others, where autumn foliage was not suggested, the green was raw and metallic. The red of a tile roof looked dull and faded, the blues of the skies were criti-

cised by some of the spectators, and the flesh in the portraits had an unnatural purplish hue; but in my opinion these defects are only such as one ought to expect, from the manner in which the process was carried out, even assuming that it be really capable of making accurate color reproductions if carried out in a thoroughly rational manner. From a theoretical point of view (and it follows, from a practical point of view,) it is not reasonable to expect that a mixed color like chlorophyl green will be accurately reproduced on a plate not sensitive into the red of the spectrum below the first absorption band of chlorophyl or which is disproportionately sensitive to that red as compared to the sensitiveness to green. In the first case, the green rays only would act in producing the picture, resulting in a raw, metallic color, and in the other case the red rays would act too much, or the green too little, and result in a brown or red hue, suggestive of autumn tints. Flesh color, if the plate be disproportionately sensitive to blue, and not sufficiently corrected by yellow screen, must take on a purplish hue, or if over-corrected by yellow screen, a yellow hue must result. It follows that the plates must not only be sensitive to all colors, but the sensitiveness must also be properly distributed along the spectrum, or, what amounts to the same thing, must be modified by the use of a quantitatively selective color screen, made up and adjusted by experiment in photographing the spectrum itself, just as I have for years made selective color screens for carrying out the photochromoscope process and for orthochromatic photography until the spectrum photographs correspond to the spectrum itself in the relative visual intensity of the different colors. Until this is done, it is not reasonable to expect that delicate shades of compound colors will be accurately reproduced by any process. It would appear from this that by no evident possibility can this method ever possess any advantage over the photochromoscope process in the matter of accuracy, because in both cases it depends (admitting every possibility for the Lumière-Lippmann process) upon the relation of sensitive plates and color screens, which must be regulated in the same way for both processes.

One of the most remarkable things about this Lumière process is its rendering of blacks and whites. According to Lippmann's theory, the blacks should be rendered by clear glass, and the whites by a film filled up with laminæ of deposit which would reflect light of every wave length. In short, the greatest amounts of deposit and opacity would be in the whites of the picture, and the smallest amounts in the blacks, as in an ordinary photographic negative. I have already observed that the Lumière photographs when seen by ordinary reflection resemble a positive instead of a negative. It is further remarkable that the greatest amount of light reflected from these photographs comes from the parts which look like clear glass, and that even this amount, which makes the whites of the picture, is only equal to the reflection from a black glass, or the surface of the gelatine film itself. The shadows appear black, not because there is no deposit there (in which case the deepest shadows of the picture would be as "white" as the high lights in the examples shown), but because the glass is obscured by a deposit so heavy and matt that it scatters the light striking upon it, instead of reflecting it straight back at the critical angle. In other words, we appear to have a positive where we are told that there is a negative; if this be true, is the positive the result of a "reversal" of the image by the long exposure, and, if so, is this reversal one of the conditions of success?

Does not this image built up by photographic action upon the sensitive plate act by a process of subtraction from the white light, which would otherwise be reflected from all parts of its surface alike, instead of by reflection from internal laminæ in the manner assumed by Lippmann?

Lippmann's theory, as I understand it, calls for a different series of laminæ within the film for every wave length of light, amounting, where white light acts, to over 30,000 laminæ in a film no thicker than a single wave length of red light! Would not such a series of laminæ reflect a great deal of light instead of adding nothing whatever to the normal reflection from its surface, which is all we appear to have in the examples shown? Cannot every color actually

shown in the Lumière photographs be reproduced by means of a single interference film of varying thickness, backed up and broken by a granular deposit of varying density? Have we anything more than this in the Lumière photographs?

It seems reasonable to suppose that the long exposure given to these plates would produce a reversal of the image. The dense deposit in the shadows might result from the action of scattered light in the camera, or to preliminary exposure, or to the use of a too active developer, or to any or all of these causes combined. May we not be given an opportunity to learn the truth, in order either to prove Lippmann's theory, or to formulate a new and more rational one?

At first glance, it would appear that an examination of the Lumière photographs by transmitted light might yield an answer to all of my questions, by showing that the image is really a negative one; but it is not even necessary, in order to explain the "whites" of these pictures, to assume that the image is positive throughout, but only that there is a superficial reversal, just sufficient to prevent the production in development of a deposit superficial enough to obscure the normal surface reflection of the gelatine film.

I have some hesitation in putting forth views which a more thorough examination of the Lumière photographs might lead me to modify; but since such examination is forbidden, I can only hope that the questions which I raise may help to bring about such a thorough investigation of the subject as its importance demands.

In conclusion, it is worthy of note that the Lumière-Lippmann process, whatever its capabilities as to accuracy may prove to be, when it is carried out according to theoretical requirements, is necessarily subject to limitations similar to, and in some respects greater than, the already successful photochromoscope process, which is carried out with commercial sensitive plates and ordinary development. Knowledge of this fact, which cannot be gainsaid, will doubtless lead many people to take an active interest in the friendly rivalry which promises to attend the further development and application of the two methods.