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THE BRITISH ASSOCIATION.

[Illustration: *The British association at Manchester portraits of the president and presidents of sections*]

The fifty-seventh annual meeting of the British Association was opened on Wednesday evening, Aug. 31, 1887, at Manchester, by an address from the president, Sir H.E. Roscoe, M.P. This was delivered in the Free Trade Hall. The chair was occupied by Professor Williamson, who was supported by the Bishop of Manchester, Sir F. Bramwell, Professor Gamgee, Professor Milnes Marshall, Professor Wilkins, Professor Boyd Dawkins, Professor Ward, and many other distinguished men. A telegram was read from the retiring president, Sir Wm. Dawson, of Montreal, congratulating the association and Manchester on this year’s meeting. The new president, Sir H. Roscoe, having been introduced to the audience, was heartily applauded.

The president, in his inaugural address, said Manchester, distinguished as the birthplace of two of the greatest discoveries of modern science, welcomed the visit of the British Association for the third time. Those discoveries were the atomic theory of which John Dalton was the author, and the most far-reaching scientific principle of modern times, namely, that of the conservation of energy, which was given to the world about the year 1842 by Dr. Joule. While the place suggested these reminders, the time, the year of the Queen’s jubilee, excited a feeling of thankfulness that they had lived in an age which had witnessed an advance in our knowledge of nature and a consequent improvement in the physical, moral, and intellectual well-being of the people hitherto unknown.

PROGRESS OF CHEMISTRY.

A sketch of that progress in the science of chemistry alone would be the subject of his address. The initial point was the views of Dalton and his contemporaries compared with the ideas which now prevail; and he (the president) examined this comparison by the light which the research of the last fifty years had thrown on the subject of the Daltonian atoms, in the three-fold aspect of their size, indivisibility, and mutual relationships, and their motions.

SIZE OF THE ATOM.

As to the size of the atom, Loschmidt, of Vienna, had come to the conclusion that the diameter of an atom of oxygen or nitrogen was the ten-millionth part of a centimeter. With the highest known magnifying power we could distinguish the forty-thousandth part of a centimeter. If, now, we imagine a cubic box each of whose sides had this length, such a box, when filled with air, would contain from sixty to a hundred millions of atoms of oxygen and nitrogen. As to the indivisibility of the atom, the space of fifty years had completely changed the face of the

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inquiry. Not only had the number of distinct, well-established elementary bodies increased from fifty-three in 1837 to seventy in 1887, but the properties of these elements had been studied, and were now known with a degree of precision then undreamt of. Had the atoms of our present elements been made to yield? To this a negative answer must undoubtedly be given, for even the highest of terrestrial temperatures, that of the electric spark, had failed to shake any one of these atoms in two. This was shown by the results with which spectrum analysis had enriched our knowledge. Terrestrial analysis had failed to furnish favorable evidence; and, turning to the chemistry of the stars, the spectra of the white, which were presumably the hottest stars, furnished no direct evidence that a decomposition of any terrestrial atom had taken place; indeed, we learned that the hydrogen atom, as we know it here, can endure unscathed the inconceivably fierce temperature of stars presumably many times more fervent than our sun, as Sirius and Vega. It was therefore no matter for surprise if the earth-bound chemist should for the present continue to regard the elements as the unalterable foundation stones upon which his science is based.

ATOMIC MOTION.

Passing to the consideration of atoms in motion, while Dalton and Graham indicated that they were in a continual state of motion, we were indebted to Joule for the first accurate determination of the rate of that motion. Clerk-Maxwell had calculated that a hydrogen molecule, moving at the rate of seventy miles per minute, must, in one second of time, knock against others no fewer than eighteen thousand million times. This led to the reflection that in nature there is no such thing as great or small, and that the structure of the smallest particle, invisible even to our most searching vision, may be as complicated as that of any one of the heavenly bodies which circle round our sun. How did this wonderful atomic motion affect their chemistry?

ATOMIC COMBINATION.

Lavoisier left unexplained the dynamics of combustion; but in 1843, before the chemical section of the association meeting at Cork, Dr. Joule announced the discovery which was to revolutionize modern science, namely, the determination of the mechanical equivalent of heat. Every change in the arrangement of the particles he found was accompanied by a definite evolution or an absorption of heat. Heat was evolved by the clashing of the atoms, and this amount was fixed and definite. Thus to Joule we owe the foundation of chemical dynamics and the basis of thermal chemistry. It was upon a knowledge of the mode of arrangement of atoms, and on a recognition of their distinctive properties, that the superstructure of modern organic chemistry rested. We now assumed on good grounds that the atom of each element possessed distinct capabilities of combination. The knowledge of the mode in which the atoms in the molecule are arranged had given to organic chemistry an impetus which had overcome many experimental obstacles, and organic chemistry had now become synthetic.

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Liebig and Wohler, in 1837, foresaw the artificial production in the laboratories of all organic substances so far as they did not constitute a living organism. And after fifty years their prophecy had been fulfilled, for at the present time we could prepare an artificial sweetening principle, an artificial alkaloid, and salacine.

SYNTHESIS.

We know now that the same laws regulate the formation of chemical compounds in both animate and inanimate nature, and the chemist only asked for a knowledge of the constitution of any definite chemical compounds found in the organic world in order to be able to promise to prepare it artificially. Seventeen years elapsed between Wohler's discovery of the artificial production of urea and the next real synthesis, which was accomplished by Kolbe, when in 1845 he prepared acetic acid from its elements. Since then a splendid harvest of results had been gathered in by chemists of all nations. In 1834 Dumas made known the law of substitution, and showed that an exchange could take place between the constituent atoms in a molecule, and upon this law depended in great measure the astounding progress made in the wide field of organic synthesis.

Perhaps the most remarkable result had been the production of an artificial sweetening agent, termed saccharin, 250 times sweeter than sugar, prepared by a complicated series of reactions from coal tar. These discoveries were not only of scientific interest, for they had given rise to the industry of coal tar colors, founded by our countryman Perkin, the value of which was measured by millions sterling annually. Another interesting application of synthetic chemistry to the needs of everyday life was the discovery of a series of valuable febrifuges, of which antipyrin might be named as the most useful.

An important aspect in connection with the study of these bodies was the physiological value which had been found to attach to the introduction of certain organic radicals, so that an indication was given of the possibility of preparing a compound which will possess certain desired physiological properties, or even to foretell the kind of action which such bodies may exert on the animal economy. But now the question might well be put, Was any limit set to this synthetic power of the chemist? Although the danger of dogmatizing as to the progress of science had already been shown in too many instances, yet one could not help feeling that the barrier between the organized and unorganized worlds was one which the chemist at present saw no chance of breaking down. True, there were those who professed to foresee that the day would arrive when the chemist, by a succession of constructive efforts, might pass beyond albumen, and gather the elements of lifeless matter into a living structure. Whatever might be said regarding this from other standpoints, the chemist could only say that at present no such problem lay within his province.

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Protoplasm, with which the simplest manifestations of life are associated, was not a compound, but a structure built up of compounds. The chemist might successfully synthesize any of its component molecules, but he had no more reason to look forward to the synthetic production of the structure than to imagine that the synthesis of gallic acid led to the artificial production of gall nuts. Although there was thus no prospect of effecting a synthesis of organized material, yet the progress made in our knowledge of the chemistry of life during the last fifty years had been very great, so much so indeed that the sciences of physiological and of pathological chemistry might be said to have entirely arisen within that period.

CHEMISTRY OF VITAL FUNCTIONS.

He would now briefly trace a few of the more important steps which had marked the recent study of the relations between the vital phenomena and those of the inorganic world. No portion of the science of chemistry was of greater interest or greater complexity than that which, bearing on the vital functions both of plants and of animals, endeavored to unravel the tangled skein of the chemistry of life, and to explain the principles according to which our bodies live, and move, and have their being. If, therefore, in the less complicated problems with which other portions of our science have to deal, we found ourselves often far from possessing satisfactory solutions, we could not be surprised to learn that with regard to the chemistry of the living body—-whether vegetable or animal—in health or disease, we were still farther from a complete knowledge of phenomena, even those of fundamental importance.

Liebig asked if we could distinguish, on the one hand, between the kind of food which goes to create warmth and, on the other, that by the oxidation of which the motions and mechanical energy of the body are kept up. He thought he was able to do this, and he divided food into two categories. The starchy or carbo-hydrate food was that, said he, which by its combustion provided the warmth necessary for the existence and life of the body. The albuminous or nitrogenous constituents of our food, the flesh meat, the gluten, the casein out of which our muscles are built up, were not available for the purpose of creating warmth, but it was by the waste of those muscles that the mechanical energy, the activity, the motions of the animal are supplied.

Soon after the promulgation of these views, J.R. Mayer warmly attacked them, throwing out the hypothesis that all muscular action is due to the combustion of food, and not to the destruction of muscle.

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What did modern research say to this question? Could it be brought to the crucial test of experiment? It could; but how? In the first place, we could ascertain the work done by a man or any other animal; we could measure this work in terms of our mechanical standard, in kilogramme-meters or foot-pounds. We could next determine what was the destruction of nitrogenous tissue at rest and under exercise by the amount of nitrogenous material thrown off by the body. And here we must remember that these tissues were never completely burned, so that free nitrogen was never eliminated. If now we knew the heat value of the burned muscle, it was easy to convert this into its mechanical equivalent and thus measure the energy generated. What was the result?

Was the weight of muscle destroyed by ascending the Faulhorn or by working on the treadmill sufficient to produce on combustion heat enough when transformed into mechanical exercise to lift the body up to the summit of the Faulhorn or to do the work on the treadmill?

Careful experiment had shown that this was so far from being the case that the actual energy developed was twice as great as that which could possibly be produced by the oxidation of the nitrogenous constituents eliminated from the body during twenty-four hours. That was to say, taking the amount of nitrogenous substance cast off from the body, not only while the work was being done, but during twenty-four hours, the mechanical effect capable of being produced by the muscular tissue from which this cast-off material was derived would only raise the body half way up the Faulhorn, or enable the prisoner to work half his time on the treadmill. Hence it was clear that Liebig’s proposition was not true.

The nitrogenous constituents of the food did doubtless go to repair the waste of muscle, which, like every other portion of the body, needed renewal, while the function of the non-nitrogenous food was not only to supply the animal heat, but also to furnish, by its oxidation, the muscular energy of the body. We thus came to the conclusion that it was the potential energy of the food which furnished the actual energy of the body, expressed in terms either of heat or of mechanical work.

But there was one other factor which came into play in this question of mechanical energy, and must be taken into account; and this factor we were as yet unable to estimate in our usual terms. It concerned the action of the mind on the body, and although incapable of exact expression, exerted none the less an important influence on the physics and chemistry of the body, so that a connection undoubtedly existed between intellectual activity or mental work and bodily nutrition. What was the expenditure of mechanical energy which accompanied mental effort was a question which science was probably far from answering; but that the body experienced exhaustion as the result of mental activity was a well-recognized fact.

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CHEMISTRY OF VEGETATION.

The phenomena of vegetation, no less than those of the animal world, had, however, during the last fifty years been placed by the chemist on an entirely new basis.

Liebig, in 1860, asserted that the whole of the carbon of vegetation was obtained from the atmospheric carbonic acid, which, though only present in the small relative proportion of four parts in 10,000 of air, was contained in such absolutely large quantity that if all the vegetation on the earth’s surface were burned, the proportion of carbonic acid which would thus be thrown into the air would not be sufficient to double the present amount. That this conclusion was correct needed experimental proof, but such proof could only be given by long-continued and laborious experiment.

It was to our English agricultural chemists, Lawes and Gilbert, that we owed the complete experimental proof required, and this experiment was long and tedious, for it had taken forty-four years to give a definite reply.

At Rothamsted a plot was set apart for the growth of wheat. For forty-four successive years that field had grown wheat without the addition of any carbonized manure, so that the only possible source from which the plant could obtain the carbon for its growth was the atmospheric carbonic acid. The quantity of carbon which on an average was removed in the form of wheat and straw from a plot manured only with mineral matter was 1,000 lb., while on another plot, for which a nitrogenous manure was employed, 1,500 lb. more carbon was annually removed, or 2,500 lb. of carbon were removed by this crop annually without the addition of any carbonaceous manure. So that Liebig’s prevision had received a complete experimental verification.

CHEMICAL PATHOLOGY.

Touching us as human beings even still more closely than the foregoing was the influence which chemistry had exerted on the science of pathology, and in no direction had greater progress been made than in the study of micro-organisms in relation to health and disease. In the complicated chemical changes to which we gave the names of fermentation and putrefaction, Pasteur had established the fundamental principle that these processes were inseparately connected with the life of certain low forms of organisms. Thus was founded the science of bacteriology, which in Lister’s hands had yielded such splendid results in the treatment of surgical cases, and in those of Klebs, Koch, and others, had been the means of detecting the cause of many diseases both in man and animals, the latest and not the least important of which was the remarkable series of successful researches by Pasteur into the nature and mode of cure of that most dreadful of maladies, hydrophobia. The value of his discovery was greater than could be estimated by its present utility, for it showed that it might be possible to avert other diseases besides hydrophobia by the adoption of a somewhat similar method of investigation and of treatment.

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Here it might seem as if we had outstepped the boundaries of chemistry, and had to do with phenomena purely vital. But recent research indicated that this was not the case, and pointed to the conclusion that the microscopist must again give way to the chemist, and that it was by chemical rather than biological investigation that the causes of diseases would be discovered, and the power of removing them obtained. For we learned that the symptoms of infective diseases were no more due to the microbes which constituted the infection than alcoholic intoxication was produced by the yeast cell, but that these symptoms were due to the presence of definite chemical compounds, the result of the life of these microscopic organisms. So it was to the action of these poisonous substances formed during the life of the organism, rather than to that of the organism itself, that the special characteristics of the disease were to be traced, for it had been shown that the disease could be communicated by such poisons in the entire absence of living organisms.

Had time permitted, he would have wished to have illustrated the dependence of industrial success upon original investigation, and to have pointed out the prodigious strides which chemical industry in this country had made during the fifty years of her Majesty's reign. As it was, he must be content to remark how much our modern life, both in its artistic and useful aspects, owed to chemistry, and therefore how essential a knowledge of the principles of the science was to all who had the industrial progress of the country at heart. The country was now beginning to see that if she was to maintain her commercial and industrial supremacy, the education of her people from top to bottom must be carried out on new lines. The question how this could be most safely and surely accomplished was one of transcendent national importance, and the statesman who solved this educational problem would earn the gratitude of generations yet to come.

In welcoming the unprecedentedly large number of foreign men of science who had on this occasion honored the British Association by their presence, he hoped that that meeting might be the commencement of an international scientific organization, the only means nowadays existing of establishing that fraternity among nations from which politics appeared to remove them further and further, by absorbing human powers and human work, and directing them to purposes of destruction. It would indeed be well if Great Britain, which had hitherto taken the lead in so many things that are great and good, should now direct her attention to the furthering of international organizations of a scientific nature. A more appropriate occasion than the present meeting could perhaps hardly be found for the inauguration of such a movement. But whether this hope were realized or not, they all united in that one great object, the search after truth for its own sake, and they all, therefore, might join

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in re-echoing the words of Lessing: “The worth of man lies not in the truth which he possesses, or believes that he possesses, but in the honest endeavor which he puts forth to secure that truth; for not by the possession of truth, but by the search after it, are the faculties of man enlarged, and in this alone consists his ever-growing perfection. Possession fosters content, indolence, and pride. If God should hold in his right hand all truth, and in his left hand the ever-active desire to seek truth, though with the condition of perpetual error, I would humbly ask for the contents of the left hand, saying, ’Father, give me this; pure truth is only for thee.’”

At the close of his address a vote of thanks was passed to the president, on the motion of the Mayor of Manchester, seconded by Professor Asa Gray, of Harvard College. The president mentioned that the number of members is already larger than at any previous annual meeting, namely, 3,568, including eighty foreigners.

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THE CRIMSON LINE OF PHOSPHORESCENT ALUMINA.

Crookes has presented to the Royal Society a paper on the color emitted by pure alumina when submitted to the electric discharge *in vacuo*, in answer to the statements of De Boisbaudran. In 1879 he had stated that “next to the diamond, alumina, in the form of ruby, is perhaps the most strikingly phosphorescent stone I have examined. It glows with a rich, full red; and a remarkable feature is that it is of little consequence what degree of color the earth or stone possesses naturally, the color of the phosphorescence is nearly the same in all cases; chemically precipitated amorphous alumina, rubies of a pale reddish yellow, and gems of the prized ‘pigeon’s blood’ color glowing alike in the vacuum.” These results, as well as the spectra obtained, he stated further, corroborated Becquerel’s observations. In consequence of the opposite results obtained by De Boisbaudran, Crookes has now re-examined this question with a view to clear up the mystery. On examining a specimen of alumina prepared from tolerably pure aluminum sulphate, shown by the ordinary tests to be free from chromium, the bright crimson line, to which the red phosphorescent light is due, was brightly visible in its spectrum. The aluminum sulphate was then, in separate portions, purified by various processes especially adapted to separate from it any chromium that might be present; the best of these being that given by Wohler, solution in excess of potassium hydrate and precipitation of the alumina by a current of chlorine. The alumina filtered off, ignited, and tested in a radiant matter tube gave as good a crimson line spectrum as did that from the original sulphate.

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A repetition of this purifying process gave no change in the result. Four possible explanations are offered of the phenomena observed: “(1) The crimson line is due to alumina, but it is capable of being suppressed by an accompanying earth which concentrates toward one end of the fractionations; (2) the crimson line is not due to alumina, but is due to the presence of an accompanying earth concentrating toward the other end of the fractionations; (3) the crimson line belongs to alumina, but its full development requires certain precautions to be observed in the time and intensity of ignition, degree of exhaustion, or its absolute freedom from alkaline and other bodies carried down by precipitated alumina and difficult to remove by washing; experience not having yet shown which of these precautions are essential to the full development of the crimson line and which are unessential; and (4) the earth alumina is a compound molecule, one of its constituent molecules giving the crimson line. According to this hypothesis, alumina would be analogous to yttria.”—*Nature.*

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CARBONIC ACID IN THE AIR.

By *Thomas* C. *Van Nuys* and *Benjamin* F. *Adams*, *Jr*.

During the month of April, 1886, we made eighteen estimations of carbonic acid in the air, employing Van Nuys’ apparatus,[1] recently described in this journal. These estimations were made in the University Park, one-half mile from the town of Bloomington. The park is hilly, thinly shaded, and higher than the surrounding country. The formation is sub-carboniferous and altitude 228 meters. There are no lowlands or swamps near. The estimations were made at 10 A.M.

[Footnote 1: See *Sci*. *Am*. *Supplement* No. 577.]

The air was obtained one-half meter from the ground and about 100 meters from any of the university buildings. The number of volumes of carbonic acid is calculated at zero C. and normal pressure 760 mm.

Date.	Bar. Pressure	Vols. Co_2 in 100,000 Vols. Air.	State of Weather.
April 2	743.5	28.86	Cloudy, snow on ground.
" 5	743.5	28.97	" " " "
" 6	735	28.61	Snowing.

"	7	744.5	28.63	Clear, snow on ground.
"	8	748	27.59	" thawing.
"	9	747.5	28.10	" "
"	12	744	28.04	Cloudy.
"	13	744	28.10	Clear.
"	14	743.5	28.98	"
"	15	750.5	28.17	Raining.
"	19	748	28.09	Clear.
"	20	746	27.72	"
"	21	746	28.16	"
"	22	741.5	27.92	"
"	23	740	28.12	"

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" 24	738.5	28.15	"
" 25	738.5	27.46	"
" 28	738	27.34	"

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The average number of volumes of carbonic acid in 100,000 volumes of air is 28.16, the maximum number is 28.98, and the minimum 27.34. These results agree with estimations made within the last ten or fifteen years. Reiset[2] made a great number of estimations from September 9, 1872, to August 20, 1873, the average of which is 29.42. Six years later[3] he made many estimations from June to November, the average of which is 29.78. The average of Schultze's[4] estimations is 29 2. The results of estimations of carbonic acid in the air, made under the supervision of Munz and Aubin[5] in October, November, and December, 1882, at the stations where observations were made of the transit of Venus by astronomers sent out by the French government, yield the average, for all stations north of the equator to latitude 29 deg. 54' in Florida, 28.2 volumes carbonic acid in 100,000 volumes air, and for all stations south of the equator 27.1 volumes. The average of Claesson's[6] estimations is 27.9 volumes, his maximum number is 32.7, and his minimum is 23.7. It is apparent, from the results of estimations of carbonic acid of the air of various parts of the globe, by the employment of apparatus with which errors are avoided, that the quantity of carbonic acid is subject to slight variation, and not, as stated in nearly all text books of science, from 4 to 6 volumes in 10,000 volumes of air; and it is further apparent that the law of Schloesing[7] holds good. By this law the carbonic acid of an atmosphere in contact with water containing calcium or magnesium carbonate in solution is dissolved according to the tension of the carbonic acid; that is, by an increased quantity its tension increases, and more would pass in solution in the form of bicarbonates. On the

other hand, by diminishing the quantity of carbonic acid in the atmosphere, some of the bicarbonates would decompose and carbonic acid pass into the atmosphere.
[Footnote 2: Comptes Rendus, 88, 1007.] [Footnote 3: Comptes Rendus, 90, 1144.] [Footnote 4: Chem. Centralblatt, 1872 and 1875.] [Footnote 5: Comptes Rendus, 96, 1793.] [Footnote 6: Berichte der deutsch chem. Gesellschaft, 9, 174.] [Footnote 7: Comptes Rendus, 74, 1552, and 75, 70.]
Schloesing's law has been verified by R. Engel[8].

[Footnote 8: Comptes Rendus, 101, 949.]

The results of estimations of bases and carbonic acid in the water of the English Channel lead Schloesing[9] to conclude that the carbonic acid combined with normal carbonates, forming bicarbonates, dissolved in the water of the globe is ten times greater in quantity than that of the atmosphere, and on account of this available carbonic acid, if the atmosphere should be deprived of some of its carbonic acid, the loss would soon be supplied.

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[Footnote 9: Comptes Rendus, 90, 1410.]

As, in nearly all of the methods which were employed for estimating carbonic acid in the air, provision is not made for the exclusion of air not measured containing carbonic acid from the alkaline fluid before titrating or weighing, the results are generally too high and show a far greater variation than is found by more exact methods. For example, Gilm[10] found from 36 to 48 volumes; Levy's[11] average is 34 volumes; De Luna's[12] 50 volumes; and Fodor's,[13] 38.9 volumes. Admitting that the quantity of carbonic acid in the air is subject to variation, yet the results of Reiset's and Schultze's estimations go to prove that the variation is within narrow limits.

[Footnote 10: Sitzungsher. d. Wien. Akad. d. Wissenschaften, 34, 257.] [Footnote 11: Ann. d. l'Observ. d. Mountsouris, 1878 and 1879.] [Footnote 12: Estudios quimicos sobre el aire atmosferico, Madrid, 1860.] [Footnote 13: Hygien. Untersuch., 1, 10.]

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—*Amer. Chem. Journal.*

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ANALYSIS OF KOLA NUT.

Alkaloids or crystallizable principles:

	Per Cent.
Caffeine.	2.710
Theobromine.	0.084

Bitter principle.
0.018
Total
alkaloids. ----- 2.812
Fatty matters:
Saponifiable fat or oil.
0.734
Essential oil.
0.081
Total
oils. ----- 0.815
Resinoid matter (*sol. in abs. alcohol*)
1.012

Sugar:
Glucose (*reduces alkaline*
cuprammonium). 3.312
Sucrose? (*red. alk. cupram.*
after inversion)[1]. 0.602
Total
sugars. ----- 3.914

Starch, gum, *etc*.:
Gum (*soluble in H2O at 90 deg. F*.). 4.876
Starch. 28.990
Amidinous matter (*coloring with iodine*). 2.130
Total gum and fecula. ----- 35.999
Albuminoid matters. 8.642
Red and other coloring matters. 3.670
Kolatannic acids. 1.204

Mineral matter:
Potassa.
1.415
Chlorine.
0.702
Phosphoric acid.
0.371
Other salts, *etc*.
2.330
Total ash.
----- 4.818
Moisture.
9.722
Ligneous matter and loss.
27.395

100.000

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[Footnote 1: Inverted by boiling with a 2.5 per cent. solution of citric acid for ten minutes.]

Both the French and German governments are introducing it into their military dietaries, and in England several large contract orders cannot yet be filled, owing to insufficiency of supply, while a well-known cocoa manufacturing firm has taken up the preparation of kola chocolate upon a commercial scale.—*W. Lascelles-Scott, in Jour. Soc. Arts.*

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CHAPIN WROUGHT IRON.

By W.H. *Searles*, Chairman of the Committee, Civil Engineers' Club of Cleveland, O.

Notwithstanding the wonderful development of our steel industries in the last decade, the improvements in the modes of manufacture, and the undoubted strength of the metal under certain circumstances, nevertheless we find that steel has not altogether met the requirements of engineers as a structural material. Although its breaking strain and elastic limit are higher than those of wrought iron, the latter metal is frequently preferred and selected for tensile members, even when steel is used under compression in the same structure. The Niagara cantilever bridge is a notable instance of this practice. When steel is used in tension its working strains are not allowed to be over fifty per cent. above those adopted for wrought iron.

The reasons for the suspicion with which steel is regarded are well understood. Not only is there a lack of uniformity in the product, but apparently the same steel will manifest very different results under slight provocation. Steel is very sensitive, not only to slight changes in chemical composition, but also to mechanical treatment, such as straightening, bending, punching, planing, heating, *etc*. Initial strains may be developed by any of these processes that would seriously affect the efficiency of the metal in service.

Among the steels, those that are softer are more serviceable and reliable than the harder ones, especially whereever shocks and concussions or rapidly alternating strains are to be endured. In other words, the more nearly steel resembles good wrought iron, the more certain it is to render lasting service when used within appropriate limits of strain. Indeed, a wrought iron of fine quality is better calculated to endure fatigue than any steel. This is particularly noticeable in steam hammer pistons, propeller shafts, and railroad axles. A better quality of wrought iron, therefore, has long been a desideratum, and it appears now that it has at last been found.

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Several years since, a pneumatic process of manufacturing wrought iron was invented and patented by Dr. Chapin, and an experimental plant was erected near Chicago. Enough was done to demonstrate, first, that an iron of unprecedentedly good qualities was attainable from common pig; and second, that the cost of its manufacture would not exceed that of Bessemer steel. Nevertheless, owing to lack of funds properly to push the invention against the jealous opposition which it encountered, the enterprise came to a halt until quite recently, when its merits found a champion in Gustav Lindenthal, C.E., member of this club, who is now the general manager of the Chapin Pneumatic Iron Co., and under whose direction this new quality of iron will soon be put upon the market.

The process of manufacture is briefly as follows: The pig metal, after being melted in a cupola and tapped into a discharging ladle, is delivered into a Bessemer converter, in which the metal is largely relieved of its silicon, sulphur, carbon, *etc*., by the ordinary pneumatic process. At the end of the blow the converter is turned down and its contents discharged into a traveling ladle, and quickly delivered to machines called ballers, which are rotary reverberatory furnaces, each revolving on a horizontal axis. In the baller the iron is very soon made into a ball without manual aid. It is then lifted out by means of a suspended fork and carried to a Winslow squeezer, where the ball is reduced to a roll twelve inches in diameter. Thence it is taken to a furnace for a wash heat, and finally to the muck train.

No reagents are employed, as in steel making or ordinary iron puddling. The high heat of the metal is sufficient to preserve its fluidity during its transit from the converter to the baller; and the cinder from the blow is kept in the ladle.

The baller is a bulging cylinder having hollow trunnions through which the flame passes. The cylinder

is lined with fire brick, and this in turn is covered with a suitable refractory iron ore, from eight to ten inches thick, grouted with pulverized iron ore, forming a bottom, as in the common puddling furnace. The phosphorus of the iron, which cannot be eliminated in the intense heat of the converter, is, however, reduced to a minimum in the baller at a much lower temperature and on the basic lining. The process wastes the lining very slightly indeed. As many as sixty heats have been taken off in succession without giving the lining any attention. The absence of any reagent leaves the iron simply pure and homogeneous to a degree never realized in muck bars made by the old puddling process. Thus the expense of a reheating and rerolling to refine the iron is obviated.
It was such iron as here results that Bessemer, in his early experiments, was seeking to obtain when he was diverted from his purpose by his splendid discoveries in the art of making steel. So effective is the new process, that even from the poorest grades of pig may be obtained economically an iron equal in quality to the refined irons made from the best pig by the ordinary process of puddling.

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Numerous tests of the Chapin irons have been made by competent and disinterested parties, and the results published. The samples here noted were cut and piled only once from the muck bar.

Sample A was made from No. 3 mill cinder pig.

Sample B was made from No. 4 mill pig and No. 3 Bessemer pig, half and half.

Sample C was made from No. 3 Bessemer pig, with the following results:

Sample.	A	B	C
Tensile strength per sq. in.	56,000	60,772	64,377
Elastic limit.	34,000	....	36,000
Extension, per cent.	11.8	....	17.0
Reduction of area, per cent.	65.0	16.0	33.0

The tensile strength of these irons made by ordinary puddling would be about 38,000, 40,000, and 42,000 respectively, or the gain of the iron in tensile strength by the Chapin process is about fifty per cent. Not only so, but these irons made in this manner from inferior pig show a higher elastic limit and breaking strain than are commonly specified for refined iron of best quality. The usual specifications are for refined iron: Tensile strength, 50,000; elongation, 15 per cent.; elastic limit, 26,000; reduction, 25 cent.

Thus the limits of the Chapin iron are from 12 to 20 per cent. above those of refined iron, and not far below those of structural steel, while there is a saving of some four dollars per ton in the price of the pig iron from which it can be made. When made from the best pig metal its breaking and elastic limits will probably reach 70,000 and 40,000 pounds respectively. If so, it will be a safer material than steel under the same working strains, owing to its greater resilience.

Such results are very interesting in both a mechanical and economical point of view. Engineers will hail with delight the accession to the list of available building materials of a wrought iron at once fine, fibrous, homogeneous, ductile, easily weldable, not subject to injury by the ordinary processes of shaping, punching, *etc*., and having a tensile strength and elastic limit nearly equal to any steel that could safely be used in the same situation.

A plant for the manufacture of Chapin iron is now in course of erection at Bethlehem, Pa., and there is every reason to believe that the excellent results attained in Chicago will be more than reached in the new works.—*Proceed. Jour. Asso. of Eng. Societies*.

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CELLULOID.

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Professor Sadler, of the University of Pennsylvania, has lately given an account of the development and method of the manufacture of celluloid. Alexander Parkes, an Englishman, invented this remarkable substance in 1855, but after twelve years quit making it because of difficulties in manipulation, although he made a fine display at the Paris Exposition of 1867. Daniel Spill, also of England, began experiments two years after Parkes, but a patent of his for dissolving the nitrated wood fiber, or "pyroxyline," in alcohol and camphor was decided by Judge Blatchford in a suit brought against the Celluloid Manufacturing Company to be valueless. No further progress was made until the Hyatt Brothers, of Albany, N.Y., discovered that gum camphor, when finely divided, mixed with the nitrated fiber and then heated, is a perfect solvent, giving a homogeneous and plastic mass. American patents of 1870 and 1874 are substantially identical with those now in use in England. In France there is only one factory, and there is none elsewhere on the Continent, one in Hanover having been given up on account of the explosive nature of the stuff. In this country pure cellulose is commonly obtained from paper makers, in the form of tissue paper, in wide rolls; this, after being nitrated by a bath of mixed nitric and sulphuric acids, is thoroughly washed and partially dried. Camphor is then added, and the whole is ground together and thoroughly mixed. At this stage coloring matter may be put in. A little alcohol increases the plasticity of the mass, which is then treated for some time to powerful hydraulic pressure. Then comes breaking up the cakes and feeding the fragments between heated rolls, by which the amalgamation of the whole is completed. Its perfect plasticity allows it to be rolled into sheets, drawn into tubes, or moulded into any desired shape.—*Jewelers' Journal.*

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APPARATUS FOR TESTING CHAMPAGNE BOTTLES AND CORKS.

Mr. J. Salleron has devised several apparatus which are destined to render valuable service in the champagne industry. The apparently simple operation of confining the carbonic acid due to fermentation in a bottle in order to blow the cork from the latter with force at a given moment is not always successful, notwithstanding the skill and experience of the manipulator. How could it be otherwise?

Everything connected with the production of champagne wine was but recently unknown and unexplained. The proportioning of the sugar accurately dates, as it were, from but yesterday, and the measurement of the absorbing power of wine for carbonic acid has but just entered into practice, thanks to Mr. Salleron’s absorptiometer. The real strength of the bottles, and the laws of the elasticity of glass and its variation with the temperature, are but little known. Finally, the physical constitution of cork, its chemical composition, its resistance to compression and the dissolving action of the wine, must be taken into consideration. In fact, all the elements of the difficult problem of the manufacture of sparkling wine show that there is an urgent necessity of introducing scientific methods into this industry, as without them work can now no longer be done.

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No one has had a better opportunity to show how easy it is to convert the juice of the grape into sparkling wine through a series of simple operations whose details are known and accurately determined, so we believe it our duty to recommend those of our readers who are particularly interested in this subject to read Mr. Salleron's book on sparkling wine. We shall confine ourselves in this article to a description of two of the apparatus invented by the author for testing the resistance of bottles and cork stoppers.

It is well, in the first place, to say that one of the important elements in the treatment of sparkling wine is the normal pressure that it is to produce in the bottles. After judicious deductions and numerous experiments, Mr. Salleron has adopted for the normal pressure of highly sparkling wines five atmospheres at the temperature of the cellar, which does not exceed 10 degrees. But, in a defective cellar, the bottles may be exposed to frost in winter and to a temperature of 25 deg. in summer, corresponding to a tension of ten atmospheres. It may naturally be asked whether bottles will withstand such an ordeal. Mr. Salleron has determined their resistance through the process by which we estimate that of building materials, *viz*., by measuring the limit of their elasticity, or, in other words, the pressure under which they take on a new permanent volume. In fact, glass must be assimilated to a perfectly elastic body; and bottles expand under the internal pressure that they support. If their resistance is insufficient, they continue to increase in measure as the pressure is further prolonged, and at every increase in permanent capacity, their resistance diminishes.

[Illustration: Fig. 1.—MACHINE FOR TESTING BOTTLES.]

The apparatus shown in Fig. 1 is called an elasticimeter, and permits of a preliminary testing of bottles. The bottle to be tested is put into the receptacle, A B, which is kept full of water, and when it has become full, its neck is played between the jaws of the clamp, *p*. Upon turning the hand wheel, L, the bottle and the receptacle that holds it are lifted, and the mouth of the bottle presses against a rubber disk fixed under the support, C D. The pressure of the neck of the bottle against this disk is such that the closing is absolutely hermetical. The support, C D, contains an aperture which allows the interior of the bottle to communicate with a glass tube, *a b*, which thus forms a prolongation of the neck of the bottle. This tube is very narrow and is divided into fiftieths of a cubic centimeter. A microscope, *m*, fixed in front of the tube, magnifies the divisions, and allows the position of the level of the water to be ascertained to within about a millionth of a cubic centimeter.

A force and suction pump, P, sucks in air through the tube, *t*, and compresses it through the tube, *t'*, in the copper tube, T, which communicates with the glass tube, *a b*, after passing through the pressure gauge, M. This pump, then, compresses the air in the bottle, and the gauge accurately measures its pressure.

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To make a test, after the bottle full of water has been fastened under the support, C D, the cock, *s*, is opened and the liquid with which the small reservoir, R, has been filled flows through an aperture above the mouth of the bottle and rises in the tube, *a b*. When its level reaches the division, O, the cock, *s*, is closed. The bottle and its prolongation, *a b*, are now exactly full of water without any air bubbles.

The pump is actuated, and, in measure as the pressure rises, the level of the liquid in the tube, *a b*, is seen to descend. This descent measures the expansion or flexion of the bottle as well as the compression of the water itself. When the pressure is judged to be sufficient, the button, *n*, is turned, and the air compressed by the pump finding an exit, the needle of the pressure gauge will be seen to redescend and the level of the tube, *a b*, to rise.

If the glass of the bottle has undergone no permanent deformation, the level will rise exactly to the zero mark, and denote that the bottle has supported the test without any modification of its structure. But if, on the contrary, the level does not return to the zero mark, the limit of the glass's elasticity has been extended, its molecules have taken on a new state of equilibrium, and its resistance has diminished, and, even if it has not broken, it is absolutely certain that it has lost its former resistance and that it presents no particular guarantee of strength.

The vessel, A B, which must be always full of water, is designed to keep the bottle at a constant temperature during the course of the experiment. This is an essential condition, since the bottle thus filled with water constitutes a genuine thermometer, of which *a b* is the graduated tube. It is therefore necessary to avoid attributing a variation in level due to an expansion of the water produced by a change in temperature, to a deformation of the bottle.

The test, then, that can be made with bottles by means of the elasticimeter consists in compressing them to a pressure of ten atmospheres when filled with water at a temperature of 25 deg., and in finding out whether, under such a stress, they change their volume permanently. In order that the elasticimeter may not be complicated by a special heating apparatus, it suffices to determine once for all what the pressure is that, at a mean temperature of 15 deg., acts upon bottles with the same energy as that of ten atmospheres at 25 deg.. Experiment has demonstrated that such stress corresponds to twelve atmospheres in a space in which the temperature remains about 15 deg..

In addition, the elasticimeter is capable of giving other and no less useful data. It permits of comparing the resistance of bottles and of classifying them according to the degree of such resistance. After numerous experiments, it has been found that first class bottles easily support a pressure of twelve atmospheres without distortion, while in those of an inferior quality the resistance is very variable. The champagne wine industry should therefore use the former exclusively.

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Various precautions must be taken in the use of corks. The bottles that lose their wine in consequence of the bad quality of their corks are many in number, and it is not long since that they were the cause of genuine disaster to the champagne trade.

Mr. Salleron has largely contributed to the improving of the quality of corks found in the market. The physical and chemical composition of cork bark is peculiarly favorable to the special use to which it is applied; but the champagne wine industry requires of it an exaggerated degree of resistance, inalterability, and elasticity. A 11/4 inch cork must, under the action of a powerful machine, enter a 3/4 inch neck, support the dissolving action of a liquid containing 12 per cent. of alcohol compressed to at least five atmospheres, and, in a few years, shoot out of the bottle and assume its pristine form and color. Out of a hundred corks of good quality, not more than ten support such a test.

In order to explain wherein resides the quality of cork, it is necessary to refer to a chemical analysis of it. In cork bark there is 70 per cent. of suberine, which is soluble in alcohol and ether, and is plastic, ductile, and malleable under the action of humid heat. Mixed with suberine, cerine and resin give cork its insolubility and inalterability. These substances are soluble in alcohol and ether, but insoluble in water.

According to the origin of cork, the wax and resin exist in it in very variable proportion. The more resinous kinds resist the dissolving action of wine better than those that are but slightly resinous. The latter soon become corroded and spoiled by wine. An attempt has often been made, but without success, to improve poor corks by impregnating them with the resinous principle that they lack.

Various other processes have been tried without success, and so it finally became necessary simply to separate the good from the bad corks by a practical and rapid operation. A simple examination does not suffice. Mr. Bouche has found that corks immersed in water finally became covered with brown spots, and, by analogy, in order to test corks, he immersed them in water for a fortnight or a month. All those that came out spotted were rejected. Under the prolonged action of moisture, the suberine becomes soft, and, if it is not resinous enough, the cells of the external layer of the cork burst, the water enters, and the cork becomes spotted.

It was left to Mr. Salleron to render the method of testing practical. He compresses the cork in a very strong reservoir filled with water under a pressure of from four to five atmospheres. By this means, the but slightly resinous cork is quickly dissolved, so that, after a few hours' immersion, the bad corks come out spotted and channeled as if they had been in the neck of a bottle for six months. On the contrary, good corks resist the operation, and come out of the reservoir as white and firm as they were when they were put into it.

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[Illustration: Fig. 2.—SALLERON’S APPARATUS FOR TESTING CORKS.]

Fig. 2 gives a perspective view of Mr. Salleron’s apparatus for testing corks. A reservoir, A B, of tinned copper, capable of holding 100 corks, is provided with a cover firmly held in place by a clamp. Into the cover is screwed a pressure gauge, M, which measures the internal pressure of the apparatus.

A pump, P, sucks water from a vessel through the tubulure, *t’*, and forces it through the tubulure, *t*, into the reservoir full of corks. After being submitted to a pressure of five atmospheres in this apparatus for a few hours, the corks are verified and then sorted out. In addition to the apparatus here illustrated, there is one of larger dimensions for industrial applications. This differs from the other only in the arrangement of its details, and will hold as many as 10,000 corks.—*Revue Industrielle.*

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IMPROVED BISCUIT MACHINE.

The accompanying illustration represents a combined biscuit cutting, scrapping, and panning machine, specially designed for running at high speeds, and so arranged as to allow of the relative movements of the various parts being adjusted while in motion. The cutters or dies, mounted on a cross head working in a vertical guide frame, are operated from the main shaft by eccentrics and vertical connecting rods, as shown. These rods are connected to the lower strap of the eccentric by long guide bolts, on which intermediate spiral springs are mounted, and by this means, although the dies are brought quickly down to the dough, they are suffered to remain in contact therewith, under a gradually increasing pressure, for a sufficient length of time to insure the dough being effectually stamped and completely cut through.

[Illustration: IMPROVED BISCUIT MACHINE.]

Further, the springs tend to counteract any tendency to vibration that might be set up by the rapid reciprocation of the cross head, cutters, and their attendant parts. Mounted also on the main shaft is one of a pair of reversed cone drums. These, with their accompanying belt and its adjusting gear, worked by a hand wheel and traversing screw, as shown, serve to adjust the speed of the feed rollers, so as to suit the different lengths of the intermediate travel or “skip” of the dough-carrying web.

Provision is made for taking up the slack of this belt by mounting the spindle of the outer coned drum in bearings adjustable along a circular path struck from the axis of the lower feed roller as a center, thus insuring a uniform engagement between the teeth of the small pinion and those of the spur wheel with which the drum and roller are respectively provided.

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The webs for carrying forward the dough between the different operations pass round rollers, which are each operated by an adjustable silent clutch feed, in place of the usual ratchet and pawl mechanism. Movement is given to each feed by the connecting links shown, to each of which motion is in turn imparted by the bell crank lever placed beside the eccentric. This lever is actuated by a crank pin on the main shaft, working into a block sliding in a slot in the shorter or horizontal arm of the lever, while a similar but adjustable block, sliding in the vertical arm, serves to impart the motion of the lever to the system of connecting links, the adjustable block allowing of a longer or shorter stroke being given to the different feeds, as desired.

The scraps are carried over the roller in rear of the cutters, and so to a scrap pan, while the stamped biscuits pass by a lower web into the pans. These pans are carried by two endless chains, provided with pins, which take hold of the pans and carry them along in the proper position. The roller over which these chains pass is operated by a silent clutch, and in order to give an additional motion to the chains when a pan is full, and it is desired to bring the next pan into position, an additional clutch is caused to operate upon the roller. This clutch is kept out of gear with its pulley by means of a projection upon it bearing against a disk slightly greater in diameter than the pulley, and provided with two notches, into which the projection passes when the additional feed is required.

The makers, H. Edwards & Co., Liverpool, have run one of these machines easily and smoothly at a hundred revolutions per minute, at which speed, and when absorbing about 3.5 horse power, the output would equal 4,000 small biscuits per minute.—*Industries*.

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IMPROVED CREAM SEPARATOR.

A hand separator of this type was exhibited at the Royal Show at Newcastle by the Aylesbury Dairy Company, of 31 St. Petersburg Place, Bayswater, England.

[Illustration: IMPROVED CREAM SEPARATOR. Fig. 1.]

[Illustration: IMPROVED CREAM SEPARATOR. Fig. 2.]

Fig. 1 is a perspective view of the machine, Fig. 2 being a vertical section. The drums of these machines, which make 2,700 revolutions per minute for the large and 4,000 for the small one, have a diameter of 27 in. and 151/2 in. respectively, and are capable of extracting the cream from 220 and 115 gallons of milk per hour. These drums are formed by hydraulic pressure from one piece of sheet steel. To avoid the possibility of the machines being overdriven, which might happen through the negligence of the attendant or through the governing gear on the engine failing to act, an ingenious controlling apparatus is fixed to the intermediate motion of the separator as shown in Fig. 3. This apparatus consists of a pair

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of governor balls pivoted near the center of the arms and attached to the main shaft of the intermediate gear by means of a collar fixed on it. The main shaft is bored out sufficiently deep to admit a steel rod, against which bear the three ends of the governor arms. The steel rod presses against the counterbalance, which is made exactly the right weight to withstand the force tending to raise it, when the intermediate motion is running at its designed speed. The forks between which the belt runs are also provided with a balance weight. This brings them to the loose pulley, unless they are fixed by means of the ratchet. Should the number of revolutions of the intermediate increase beyond the correct amount, the extra centrifugal force imparted to the governor balls enables them to overcome the balance weight, and in raising this they raise the arm. This arm striking against the ratchet detent releases the balance weight, and the belt is at once brought on to the loose pulley.

[Illustration: IMPROVED CREAM SEPARATOR.
Fig. 3.]

The steel drum is fitted with an internal ring at the bottom (see Fig. 2), into which the milk flows, and from which it is delivered, by three apertures, to the periphery of the drum, thus preventing the milk from striking against the cone of the drum, and from mixing with the cream which has already been separated. The upper part of the drum is fitted with an annular flange, about 11/2 in. from the top, reaching to within one-sixteenth of an inch of the periphery. After the separation of the skim milk from the cream, the former passes behind and above this flange through the aperture, B, and is removed by means of the tube, D, furnished with a steel tip projecting from the cover of the machine into the space between the top of the drum and the annular flange, a similar tube, F, reaching below this flange, removing the cream which collects there. The skim milk tube is provided with a screw regulator, the function of which is to enable cream of any desired consistency to be obtained, varying with the distance between the skim milk and cream points from the center of the drum. Another point about these tubes is their use as elevating tubes for the skim, milk and cream, as, owing to the velocity at which the drum is rotating, the products can be delivered by these tubes at a height of 8 or 10 feet above the machine if required, thus enabling scalding and cooling of either to be carried on while the separator is at work, and saving hand labor.—*Iron*.

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GAS FROM OIL.

At the twenty-fourth annual meeting of the Gas Institute, which was recently held in Glasgow, Dr. Stevenson Macadam, F.R.S.E., lecturer on chemistry, Edinburgh, submitted the first paper, which was on “Gas from Oil.”

He said that during the last seventeen years he had devoted much attention to the photogenic or illuminating values of different qualities of paraffin oils in various lamps, and to the production of permanent illuminating gas from such oils. The earlier experiments were directed to the employment of paraffin oils as oils, and the results proved the great superiority of the paraffin oils as illuminating agents over vegetable and animal oils, alike for lighthouse and ordinary house service.

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The later trials were mainly concerned with the breaking up of the paraffin oils into permanent illuminating gas. Experiments were made at low heats, medium heats, and high heats, which proved that, according to the respective qualities of the paraffin oils employed in the trials, there was more or less tendency at the lower heats to distill oil instead of permanent gas, while at the high heats there was a liability to decarbonize the oil and gas, and to obtain a thin gas of comparatively small illuminating power. When, however, a good cherry red heat was maintained, the oils split up in large proportion into permanent gas of high illuminating quality, accompanied by little tarry matter, and with only a slight amount of separated carbon or deposited soot.

The best mode of splitting up the paraffin oils, and the special arrangements of the retort or distilling apparatus, also formed, he said, an extensive inquiry by itself. In one set of trials the oil was distilled into gaseous vapor, and then passed through the retort. In another set of experiments, the oil was run into or allowed to trickle into the retorts, while both modes of introducing the oil were tried in retorts charged with red hot coke and in retorts free from coke.

Ultimately, it was found that the best results were obtained by the more simple arrangement of employing iron retorts at a good cherry red heat, and running in the oil as a thin stream direct into the retort, so that it quickly impinged upon the red hot metal, and without the intervention of any coke or other matter in the retorts. The paraffin oils employed in the investigations were principally: (1) Crude paraffin oil, being the oil obtained direct from the destructive distillation of shale in retorts; (2) green paraffin oil, which is yielded by distilling or re-running the crude paraffin oil, and removing the lighter or more inflammable portion by fractional distillation; and (3) blue paraffin oil, which is obtained by rectifying the twice run oil with sulphuric acid and soda, and distilling off the paraffin spirit, burning oil, and intermediate oil, and freezing out the solid paraffin as paraffin scale. The best practical trials were obtained in Pintsch's apparatus and in Keith's apparatus.

After describing both of these, Dr. Macadam went on to give in great detail the results obtained in splitting up blue paraffin oil into gas in each apparatus.
He then said that these experimental results demonstrated that Pintsch's apparatus yielded from the gallon of oil in one case 90.70 cubic feet of gas of 62.50 candle power, and in the second case 103.36 cubic feet of 59.15 candle gas, or an average of 97.03 cubic feet of 60.82 candle power gas.

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In both cases, the firing of the retorts was moderate, though in the second trial greater care was taken to secure uniformity of heat, and the oil was run in more slowly, so that there was more thorough splitting up of the oil into permanent gas. The gas obtained in the two trials was of high quality, owing to its containing a large percentage of heavy hydrocarbons, of which there were, respectively, 39.25 and 37.15 per cent., or an average of 38.2 per cent., while the sulphureted hydrogen was nothing, and the carbonic acid a mere trace. Besides testing the gas on the occasion of the actual trials, he had also examined samples of the gas which he had taken from various cylinders in which the gas had been stored for several months under a pressure of ten atmospheres, and in all cases the gas was found to be practically equal to the quantity mentioned, and hence of a permanent character.

By using Keith's apparatus the results obtained were generally the same, with the exception that an average of 0.27 per cent. of carbonic acid gas and decided proportions of sulphureted hydrogen were found to be present in the gas. Dr. Macadam devoted some remarks to the consideration of the question as to how far the gas obtained from the paraffin oil represented the light power of the oil itself, and then he proceeded to say that, taking the crude paraffin oil at 2d. a gallon, and with a specific gravity of 850 (water = 1,000), or 81/2 lb. to the gallon, there were 264 gallons to the ton, at a cost of L2 4s. per ton. The sperm light from the ton of oil as gas being 3,443 lb., he reckoned that fully 6 lb. of sperm light were obtained from a pennyworth of the crude oil as gas.

Then, taking the blue paraffin oil at 4d. per gallon, and there being 255 gallons to the ton, it was found that the cost of one ton was L4 5s., and as the sperm light of a ton of that oil as gas was 5,150 lb., it was calculated that 5 lb. of sperm light were yielded

in the gas from a pennyworth of the blue oil.
The very rich character of the oil gas rendered it unsuitable for consumption at ordinary gas jets, though it burned readily and satisfactorily at small burners not larger than No. 1 jets.

In practical use it would be advisable to reduce the quality by admixture with thin and feeble gas, or to employ the oil gas simply for enriching inferior gases derived from the more common coals. On the question of dilution, he said that he preferred to use carbonic oxide and hydrogen, and most of the remainder of his paper was devoted to an explanation of the best mode of preparing those gases (water gases).

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He concluded by saying: The employment of paraffin oil for gas making has advantages in its favor, in the readiness of charging the retorts, as the oil can be run in continuously for days at a time, and may be discontinued and commenced again without opening, clearing out residual products, recharging and reclosing the retorts. There is necessarily, therefore, less labor and cost in working, and as the gas is cleaner or freer from impurities, purifying plant and material will be correspondingly less. Oil gas is now employed for lighthouse service in the illumination of the lanterns on Ailsa Craig and as motive power in the gas engines connected with the fog horns at Langness and Ailsa Craig lighthouse stations. It is also used largely in the lighting of railway carriages. Various populous places are now introducing oil gas for house service, and he felt sure that the system is one which ought to commend itself for its future development to the careful consideration and practical skill of the members of the Gas Institute.

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THE MANUFACTURE OF SALT NEAR MIDDLESBROUGH.[1]

[Footnote 1: Abstract of paper read before the Institution of Civil Engineers, May 17, 1887.]

By Sir LOWTHIAN BELL, Bart., F.R.S.

The geology of the Middlesbrough salt region was first referred to, and it was stated that the development of the salt industry in that district was the result of accident. In 1859, Messrs. Bolckow & Vaughan sank a deep well at Middlesbrough, in the hope of obtaining water for steam and other purposes in connection with their iron works in that town, although they had previously been informed of the probably unsuitable character of the water if found. The bore hole was put down to a depth of 1,200 feet, when a bed of salt rock was struck, which proved to have a thickness of about 100 feet. At that time one-eighth of the total salt production of Cheshire was being brought to the Tyne for the chemical works on that river, hence the discovery of salt instead of water was regarded by some as the reverse of a disappointment. The mode of reaching the salt rock by an ordinary shaft, however, failed, from the influx of water being too great, and nothing more was heard of Middlesbrough salt until a dozen years later, when Messrs. Bell Brothers, of Port Clarence, decided to try the practicability of raising the salt by a method detailed in the paper. A site was selected 1,314 yards distant from the well of Messrs. Bolckow & Vaughan, and the Diamond Rock Boring Company was intrusted with the work of putting down a hole in order to ascertain whether the bed of salt extended under their land. This occupied nearly two years, when the salt, 65 feet in thickness, was reached at a depth of 1,127 feet. Other reasons induced the owners of the Clarence iron works to continue the bore hole for 150 feet below the bed of salt; a depth of 1,342 feet from the surface was then reached. During the process of boring, considerable quantities of inflammable gas were met with, which, on the application of flame, took fire at the surface of the water in the bore hole. The origin of this gas, in connection with the coal measures underlying the magnesian limestone, will probably hereafter be investigated.

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For raising the salt, recourse was had to the method of solution, the principle being that a column of descending water should raise the brine nearly as far as the differences of specific gravity between the two liquids permitted—in the present case about 997 feet. In other words, a column of fresh water of 1,200 feet brought the brine to within 203 feet of the surface. For the practical application of this system a hole of say 12 inches in diameter at the surface was commenced, and a succession of wrought iron tubes put down as the boring proceeded, the pipes being of gradually decreasing diameter, until the bottom of the salt bed was reached. The portion of this outer or retaining tube, where it passed through the bed of salt, was pierced with two sets of apertures, the upper edge of the higher set coinciding with the top of the seam, and the other set occupying the lower portion of the tube. Within the tube so arranged, and secured at its lower extremity by means of a cavity sunk in the limestone, a second tube was lowered, having an outer diameter from two to four inches less than the interior diameter of the first tube. The latter served for pumping the brine. The pump used was of the ordinary bucket and clack type, but, in addition, at the surface, there was a plunger, which served to force the brine into an air vessel for the purposes of distribution. The bucket and clack were placed some feet below the point to which the brine was raised by the column of fresh water descending in the annulus formed between the two tubes. In commencing work, water was let down the annulus until the cavity formed in the salt became sufficiently large to admit of a few hours' pumping of concentrated brine. On the machinery being set in motion, the stronger brine was first drawn, which, from its greater specific gravity, occupied the lower portion of the cavity. As the brine was raised, fresh water flowed down. The solvent power of the newly admitted water was of course greater than that of water partially saturated, and being also lighter it occupied the upper portion of the excavated space. The combined effect was to give the cavity the form of an inverted cone. The mode of extraction thus possessed the disadvantage of removing the greatest quantity of the mineral where it was most wanted for supporting the roof, and had given rise to occasional accidents to the pipes underground. These were referred to in detail, and the question was started as to possible legal complications arising hereafter from new bore holes put down in close proximity to the dividing line of different properties, the pumping of brine formed under the conditions described presenting an altogether different aspect from the pumping of water or natural brine.

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The second part of the paper referred to the uses to which the brine was applied, the chief one being the manufacture of common salt. For this purpose the brine, as delivered from the wells, was run into a large reservoir, where any earthy matter held in suspension was allowed to settle. The clear solution was then run into pans sixty feet long by twenty feet wide by two feet deep. Heat was applied at one end by the combustion of small coal, beyond which longitudinal walls, serving to support the pan and to distribute the heat, conducted the products of combustion to the further extremity, where they escaped into the chimney at a temperature of from 500 deg. to 700 deg. Fahr. On the surface of the heated brine, kept at 196 deg. Fahr., minute cubical crystals speedily formed. On the upper surface of these, other small cubes of salt arranged themselves in such a way that, in course of time, a hollow inverted pyramid of crystallized salt was formed. This ultimately sank to the bottom, where other small crystals united with it, so that the shape became frequently completely cubical. Every second day the salt was “fished” out and laid on drainers to permit the adhering brine to run back into the pans. For the production of table salt the boiling was carried on much more rapidly, and at a higher temperature than for salt intended for soda manufacture. The crystals were very minute, and adhered together by the solidification of the brine, effected by exposure on heated flues. For fishery purposes the crystals were preferred very coarse in size. These were obtained by evaporating the brine more slowly and at a still lower temperature than when salt for soda makers was required. At the Clarence works experiments had been made in utilizing surplus gas from the adjacent blast furnaces, instead of fuel, under the evaporating pans, the furnaces supplying more gas than was needed for heating air and raising steam for iron making. By means of this waste heat, from 200 to 300 tons of salt per week were now obtained.

The paper concluded with some particulars of the soda industry. The well-known sulphuric acid process of Leblanc had stood its ground for three-quarters of a century in spite of several disadvantages, and various modes of utilizing the by-products having been from time to time introduced, it had until recent years seemed too firmly established to fear any rivals. About seven years ago, however, Mr. Solvay, of Brussels, revived in a practical form the ammonia process, patented forty years ago by Messrs. Hemming & Dyar, but using brine instead of salt, and thus avoiding the cost of evaporation. This process consisted of forcing into the brine currents of carbonic acid and ammoniacal gases in such proportions as to generate bicarbonate of ammonia, which, reacting on the salt of the brine, gave bicarbonate of soda and chloride of ammonium. The bicarbonate was placed in a reverberatory furnace, where the heat drove off the water and one equivalent

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of carbonic acid, leaving the alkali as monocarbonate. Near Middlesbrough, the only branch of industry established in connection with its salt trade was the manufacture of soda by an ammonia process, invented by Mr. Schloesing, of Paris. The works were carried on in connection with the Clarence salt works. It was believed that the total quantity of dry soda produced by the two ammonia processes, Solvay's and Schloesing's, in this country was something under 100,000 tons per annum, but this make was considerably exceeded on the Continent.

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COTTON INDUSTRIES OF JAPAN.

The cotton plant principally cultivated in Japan is of the species known as *Gossypium herbaceum*, resembling that of India, China, and Egypt. The plant is of short stature, seldom attaining a growth of over two feet; the flower is deciduous, with yellow petals and purple center, and the staple is short, but fine. It is very widely cultivated in Japan, and is produced in thirty-seven out of the forty-four prefectures forming the empire, but the best qualities and largest quantities are grown in the southern maritime provinces of the mainland and on the islands of Kiusiu and Shikoku. Vice consul Longford, in his last report, says that the plant is not indigenous to Japan, the seed having been first imported from China in the year 1558. There are now many varieties of the original species, and the cultivation of the plant varies in its details in different localities. The variations are, however, mostly in dates, and the general grinding principles of the several operations are nearly the same throughout the whole country.

The land best suited for cotton growing is one of a sandy soil, the admixture of earth and sand being in the proportion of two parts earth to one of sand. During the winter and spring months, crops of wheat or barley are raised on it, and it is when these crops have attained their full height during the month of May that the cotton is sown. About fifty days prior to the sowing a manure is prepared consisting of chopped straw, straw ashes, green grass, rice, bran, and earth from the bottom of the stagnant pools. These ingredients are all carefully mixed together in equal proportions, and the manure thus made is allowed to stand till required for use. Ten days before the time fixed for sowing, narrow trenches, about one inch in depth, are dug in the furrows, between the rows of standing wheat or barleys and the manure is liberally sprinkled along them by hand. For one night before sowing the seed is steeped in water. It is then taken out, slightly mixed with straw ashes, and sown in the trenches at intervals of a few inches. When sown, it is covered with earth to the depth of half an inch, and gently trampled down by foot. Four or five days after sowing, the buds begin to appear above the earth, and almost simultaneously the wheat or barley between which they grow is ripe for

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the sickle. While the latter is being harvested, the cotton may be left to itself, but not for very long. The buds appear in much larger numbers than the soil could support if they were allowed to grow. They have accordingly to be carefully thinned out, so that not more than five or six plants are left in each foot of length. The next process is the sprinkling of a manure composed of one part night soil and three parts water, and again, subsequent to this, there are two further manurings; one of a mixture of dried sardines, lees of oil, and lees of rice beer, which is applied about the middle of June, when the plant has attained a height of four inches; and again early in July, when the plant has grown to a height of six or seven inches, a further manuring of night soil, mixed with a larger proportion of water than before. At this stage the head of the plant is pinched off with the fingers, in order to check the excessive growth of the stem, and direct the strength into the branches, which usually number five or six. From these branches minor ones spring, but the latter are carefully pruned off as they appear. In the middle of August the flowers begin to appear gradually. They fall soon after their appearance, leaving in their place the pod or peach (*momo*), which, after ripening, opens in October by three or four valves and exposes the cotton to view. The cotton is gathered in baskets, in which it is allowed to remain till a bright, sunshiny day, when it is spread out on mats to dry and swell in the sun for two or three days. After drying, the cotton is packed in bags made of straw matting, and either sold or put aside until such time as the farmer’s leisure from other agricultural operations enables him to deal with it. The average yield of cotton in good districts in Japan is about 120 lb. to the acre, but as cotton is only a secondary crop, this does not therefore represent the whole profit gained by the farmer from his land. The prefectures in which the production is largest are Aichi on the east coast, Osaka, Hiogo, Hiroshima, and Yamaguchi on the inland sea, and Fukui and Ishikawa on the west coast. Vice-consul Longford says that the manufacture of cotton in Japan is still in all its stages largely a domestic one. Gin, spindle, and loom are all found in the house of the farmer on whose land the cotton is grown, and not only what is required for the wants of his own family is spun and woven by the female members thereof, but a surplus is also produced for sale.

Several spinning factories with important English machinery have been established during the last twenty years, but Consul Longford says that he has only known of one similar cotton-weaving factory, and that has not been a successful experiment. Other so called weaving factories throughout the country consist only of a collection of the ordinary hand looms, to the number of forty or fifty, scarcely ever reaching to one hundred, in one building or shed, wherein individual manufacturers have their own special piece goods made.

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The first operation in the manufacture is that of ginning, which is conducted by means of a small implement called the *rokuro*, or windlass. This consists of two wooden rollers revolving in opposite directions, fixed on a frame about 12 inches high and 6 inches in width, standing on a small platform, the dimensions of which slightly exceed that of the frame. The operator, usually a woman, kneels on one side of the frame, holding it firm by her weight, works the roller with one hand, and with the other presses the cotton, which she takes from a heap at her side, between the rollers. The cotton passes through, falling in small lumps on the other side of the frame, while the seeds fall on that nearest the woman. The utmost weight of unginned cotton that one woman working an entire day of ten hours can give is from 8 lb. to 10 lb., which gives, in the end, only a little over 3 lb. weight of ginned cotton, and her daily earnings amount to less than 2d. A few saw gins have been introduced into Japan during the last fifteen years, but no effort has been made to secure their distribution throughout the country districts. After ginning, a certain proportion of the seed is reserved for the agricultural requirements of the following year, and the remainder is sent to oil factories, where it is pressed, and yields about one-eighth of its capacity in measurement in oil, the refuse, after pressing, being used for manure. The ginning having been finished in the country districts, the cotton is either packed in bales and sent to the dealers in the cities, or else the next process, that of carding, is at once proceeded with on the spot.

This process is almost as primitive as that of the ginning. A long bamboo, sufficiently thin to be flexible, is fastened at its base to a pillar or the corner of a small room. It slopes upward into the center of the room, and from its upper end a hempen cord is suspended. To this is fastened the “bow,” an instrument made of oak, about five feet in length, two inches in circumference, and shaped like a ladle.

A string of coarse catgut is tightly stretched from end to end of the bow, and this is beaten with a small mallet made of willow, bound at the end with a ring of iron or brass. The raw cotton, in its coarse state, is piled on the floor just underneath the string of the bow. The string is then rapidly beaten with the mallet, and as it rises and falls it catches the rough cotton, cuts it to the required degree of fineness, removes impurities from it, and flings it to the side of the operator, where it falls on a hempen net stretched over a four-cornered wooden frame. The spaces of the net are about one-quarter of an inch square, and through these any particles of dust that may still have adhered to the cotton fall to the floor, leaving piled on top of the net the pure cotton wool in its finished state. This work is always performed by a man, and by assiduous toil throughout a long day, one man can card from ten to twenty pounds weight

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of raw cotton. Payment is made in proportion to the work done, and in the less remote country districts is at the rate of about one penny for each pound carded. As regards spinning and weaving, in the first of these branches of cotton manufacture the Japanese have largely had recourse to the aid of foreign machinery, but it is still to a much greater extent a domestic industry, or at best carried on like weaving in the establishments of cotton traders, in which a number of workers, varying from 20 to 100 or more, each with his own spinning wheel, are collected together. Consul Longford says the spinning wheel used in Japan differs in no respect from that used in the country 300 years ago or (except that bamboo forms an integral part of the materials of which it is made) from that used in England prior to the invention of the jenny. The cost of one of the wheels is about 9d., it will last for five or six years, and with it a woman of ordinary skill can spin about 1 lb. of yarn in a day of ten hours, earning thereby about 2d. There are at present in various parts of Japan, in all, 21 spinning factories worked by foreign machinery. Of four of these there is no information, but of the remainder, one has 120 spindles; eleven, 2,000 spindles; two, 3,000 spindles; two, 4,000 spindles; and one, 18,000 spindles.—*Journal Soc. of Arts.*

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[Continued from SUPPLEMENT, No. 612, page 9774.]

CENTRIFUGAL EXTRACTORS.

By ROBERT F. GIBSON.

SUGAR MACHINES.—Besides separating the crystalline sugar and the sirup, secondary objects are to wash the crystals and to pack them in cakes. The cleansing fluid or "white liquor" is introduced at the center of the basket and is hurled against and passes through the sugar wall left from draining. The basket may be divided into compartments and the liquor guided into each. The compartments are removable boxes and are shaped to give bars or cakes or any form desired of sugar in mass. These boxes being removable cannot fit tightly against the liquor guides, and the liquor is apt to escape. This difficulty is overcome by giving the guides radial movement or by having rubber packing around the edges.

Sugar machines proper are of two kinds—those which are loaded, drained and then unloaded and those which are continuous in their working. The various figures preceding are of the first kind, and what has been said of vibrations applies directly to these.

The general advantages claimed for continuous working over intermittent are—that saving is made of time and motive power incident to introducing charge and developing velocity, in retarding and stopping, and in discharging; that, as the power is brought into the machine continuously, no shifting of belts or ungearing is necessary; and that there are less of the dangers incident to variable motion, either in the machine itself or the belting or gearing. The magma (the mixture of crystalline sugar and sirup) is fed in gradually, by which means it is more likely to assume a position of equilibrium in the basket.

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There are two methods of discharging in continuous working—the sugar is thrown out periodically as the basket fills, or continuously. In neither case is the speed slackened. In the first either the upper half of the basket has an upward motion, on the lower half a downward motion (Pat. 252,483); and through the opening thus made the sugar is thrown. Fig. 22 (R.B. Palmer & Sons) is a machine of this kind. The bottom, B, with the cone distributor, *a*, have downward motion.

[Illustration: Fig. 22.]

Continuous discharge of the second kind may be brought about by having a scoop fixed to the curb (or casing), extending down into the basket and delivering the sugar over the side (Pat. 144,319). Another method will be described under “Beet Machines.”

BASKET.—The construction of the basket is exceedingly important. Hard experience has taught this. When centrifugals were first introduced, users were compelled by law to put them below ground; for they frequently exploded, owing to the speed being suddenly augmented by inequalities in the running of the engine or to the basket being too weak to resist the centrifugal force of the overcharge. Increasing the thickness merely adds to the centrifugal force, and hence to the danger, as even a perfectly balanced basket may sever.

One plan for a better basket was to have more than one wall. For example, there might be an inner wall of perforated copper, then one of wire gauze, and then another of copper with larger perforations. Another plan was to have an internal metallic cloth, bearing against the internally projecting ridges of the corrugations of the basket wall. A further complication is to give this internal gauze cylinder a rotation relative to the basket.

The basket wall has been variously constructed. In one case it consists of wire wound round and round and fastened to uprights, commonly known as the “wire basket;” in another case of a periphery without perforations, but spirally corrugated and having an opening at the bottom for the escape of the extracted liquid; in still another of a series of narrow bars or rings, placed edgewise, packed as close as desired. An advantage of this last style is that it is easily cleaned.

The best basket consists of sheet metal with bored perforations and having bands or flanges sprung on around the outside. The metal is brass, if it is apt to be corroded; if not, sheet iron. The perforations may be round, or horizontally much longer than wide vertically. One method for the manufacture of the basket wall (Pat. 149,553) is to roll down a plate, having round perforations, to the required thickness, causing narrowing and elongation of the holes and at the same time hardening the plate by compacting its texture. Long narrow slots are well adapted to catch sugar crystals, and this is not an unimportant point. Round perforations are usually countersunk. Instead of flanges, wire bands have been used, their lapping ends secured by solder.

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As to comparative wear, it maybe remarked that one perforated basket will outlast three wire ones.

As to size, sugar baskets vary from 80 inches in diameter by 14 in. depth to 54 by 24. They are made, however, in England as large as 6 feet in diameter—a size which can be run only at a comparatively slow speed.

A peculiar complication of basket deserves notice (Pat. 275 874). It had been noticed that when a charge of magma was put into a centrifugal in one mass, the sugar wall on the side of the basket was apt to form irregularly, too thick at base and of varied color. To remedy this it was suggested to have within and concentric with the basket a charger with flaring sides, into which the mixture was to be put. When this charger reached a certain rotary velocity, the magma would be hurled out over the edge by centrifugal force and evenly distributed on the wall of the main basket.

SPINDLE.—The spindle as now made is solid cast steel, and the considerations governing its size, form, material, *etc*., are identical with those for any spindle. In order that the basket might be replaced by another after draining, the shaft has been made telescopic, but at the expense of stability and rigidity. In Fig. 16 is shown a device to avoid crystallizations, which are apt to occur in large forgings, and would prove fatal should they creep into the upper part of the spindle proper in a hanging machine. It consists of the secondary spindle, *c*.

DISCHARGING.—The drained sugar may either be lifted over the top of the basket (in machines which stop to be emptied), or be cast through openings in the bottom provided with valves. A section of the best form of valve may be seen in Figs. 15 and 17. Fig. 23 is a plan of the openings.

The valve turns on the basket bearing. It may be constructed to open in the same direction in which the basket turns; so that when the brake is put on, the inertia of the valve operates to open it and while running to keep it closed. There are many other styles, but no other need be mentioned.

[Illustration: Fig. 23.]

CASING.—The different styles of casing may be seen by reference to the various drawings. In one machine (not described) the casing is rigidly fixed to the basket, space enough being left between the bottom of the basket and the bottom of the casing to hold all the molasses from a charge. This arrangement merely adds to the bulk of the revolving parts, and no real advantage is gained.

BEARINGS.—The various styles of bearings can be seen by reference to the figures. One which deserves special attention is shown in Fig. 16 and Fig. 19. In one case it consists of loose disks, in the other of loose washers, rotating on one another. They are alternately of steel and hard bronze (copper and tin).

“There is probably no machine so little understood or so imperfectly constructed by the common manufacturer of sugar supplies as the high speed separator or centrifugal.” Unless the product of experience and good workmanship, it is a dangerous thing at high velocities. Besides, its usual fate is to have an incompetent workman assigned to it, who does not use judgment in charging and running. So that designers and manufacturers have been forced not only to take into account the disturbing forces inherent in revolving bodies, but also to make allowance for poor management in running and neglect in cleaning.

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CANE AND BEET MACHINES.—The first step in the process of sugar making is the extraction of the juice from the beet or cane. This juice is obtained by pressure. The operation is not usually, but may be, performed in a special kind of centrifugal. One style (Pat. 239,222) consists of a conical basket with a spiral flange within on the shaft, and turning on the shaft, and having a slight rotary motion relative to the basket. The material is fed in and moves downward under increased pressure, the sirup released flying out through the perforations of the basket, the whole revolving at high velocity. The solid portion falls out at the bottom. Another plan suggested (Pat. 343,932) is to let a loose cover of an ordinary cylindrical basket screw itself down into the basket, by reason of its slower velocity (owing to inertia), causing pressure on the charge.

Various other applications of the different styles of sugar machines are the defibration of raw sugar juice, freeing beet crystals of objectionable salts, freeing various crystals of the mother liquor, drying saltpeter.

DRIERS.—Another important division of this first class of centrifugals is that of driers or, as they are variously styled, whizzers, wringers, hydro-extractors. The charge in these is never large in weight compared to a sugar charge, and its initial distribution can be made more symmetrical. The uses of driers are various, such as extracting water from clothes, cloth, silk, yarns, *etc*. Water may be introduced at the center of the basket from above or below to wash the material before draining. A typical form of drier is shown in Fig. 24. (Pat. Aug. 22, 1876—W.P. Uhlinger.) Baskets have been made removable for use in dyeing establishments, basket and load together going into dyeing vat. Yarn and similar material can be drained by a method analogous to that of hanging it upon sticks in a room and allowing the water to drip off. It is suspended from short sticks, which are held in horizontal layers around the shaft in the basket, and the action is such during the operation as to cause the yarn to stand out in radial lines.

[Illustration: Fig. 24.]

Driers are not materially different from sugar machines. Any of the devices before enumerated for meeting vibrations in the latter may be applied to the former. There is one curious invention which has been applied to driers only (Pat. 322,762—W.H. Tolhurst). See Fig. 25. A convex shaft-supporting step resting on a concave supporting base, with the center of its arc of concavity at the center of the upper universal joint, has been employed, and its movements controlled by springs, but the step was apt to be forced from its support. The drawing shows the improvement on this, which is to give the shaft-supporting step a less radius of curvature.

[Illustration: Fig. 25.]

An interesting form of drier has its own motor, a little steam engine, attached to the frame of the machine. See Fig 24. This of course demands fixed bearings. The engine is very small. One size used is 3"x4”. When a higher velocity of basket is required, we have the arrangement in Fig. 26.

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[Illustration: Fig. 26.]

MOTORS.—This naturally introduces the subject of motive power. We may have the engine direct acting as above, or the power may be brought on by belting. Fig. 27 shows a drier with pulley for belting. Fig. 28 (W.H. Tolhurst) shows a very common arrangement of belting and also the fast and loose pulleys. When the heaviest part of the engine is so far from the vertical shaft as to overhang the casing on one side, there is apt to be an objectionable tremor. To remedy this, it is suggested to put these heavy parts as near the shaft as possible. It has been suggested also to use the Westinghouse type of engine, although the type shown in Fig. 24 works faultlessly in practice.

[Illustration: Fig. 27.]

One plan (Pat. 346,030), designed to combine the advantages of a direct acting motor and an oscillating shaft, mounts the whole machine, motor and all, on a rocking frame. The spindle is of course in fixed bearings in the frame. However, the plan is not practical.

[Illustration: Fig. 28.]

In driers the direct acting engine has many advantages over the belt. The atmosphere is always very moist about a whizzer, and there are frequently injurious fumes. The belt will be alternately dry and wet, stretched and limp, and wears out rapidly and is liable to sever. In all machines in which the shaft oscillates, if the center of oscillation does not lie in the central plane of the belt, the tension of the latter is not uniform. This affects badly both the belt and the running. A reference to the various figures will show the best position for the pulley.

The greatest difficulty experienced with belting is in getting up speed and stopping. The basket must not be started with a sudden impulse. Its inertia will resist and something must give way. A gradual starting can be obtained by the slipping of the belt at first, but this is expensive. The best plan is to conduct the power through a species of friction clutch—an iron disk between two wooden ones. This has been found to work admirably.

BRAKES.—The first centrifugals had no brakes. They ran until the friction of the bearings was sufficient to stop them. This occasioned, however, rapid wearing and too great a loss of time. The best material for a brake consists of soft wood into which shoe pegs have been driven, and which is thoroughly saturated with oil. The wooden disks referred to just above are of the same construction. The center of oscillation ought to be in the central plane of the brake as well as that of the pulley, but the preference is given to the pulley.

Figs. 15 and 16 (I) give sectional views of a brake for hanging machines. Figs. 19, 20, and 21 give two sections and a view of a brake which can be used on both hanging and standing machines. A very simple form of brake is shown in Figs. 24, 26, and 27 (A), a mere block pressing on the rim of the basket.

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OIL AND FAT.—A machine in most respects like a whizzer is used for the "extraction of oil and fat and oily and fatty matters from woolen yarns and fabrics, and such other fibrous material or mixtures of materials as are from their nature affected in color or quality when hydrocarbons are used for the purpose of extracting such oily or fatty matters, and are subsequently removed from the material under treatment by the slow process of admitting steam, or using other means of raising the temperature to the respective boiling points of such hydrocarbons, and so driving them off by evaporation."
In the centrifugal method carbon-bisulphide, or some other volatile agent, is admitted and is driven through the material by centrifugal force, when the necessary reactions take place, and is allowed to escape in the form of hydrocarbons. A machine differing only in slight particulars from the above is used for cleansing wool.

LOOSE FIBER.—Another application is the drying of loose fiber. Two distinctive points deserve to be noticed in the centrifugal used for this purpose. An endless chain or belt provided with blades moves the material vertically in the basket, and discharges it over the edge. During its upward course the material is subjected to a shower of water to wash it.

OIL FROM METAL CHIPS.—Very material savings are made in many factories by collecting the metal chips and turnings, coated and mixed with oil, which fall from the various machines, and extracting the oil centrifugally. The separator consists of a chip holder, having an imperforate shell flaring upward and outward from the spindle (in fixed bearings) to which it is attached. When filled, a cover is placed upon it and keyed to the spindle. Between the cover and holder there is a small annular opening through which oil, but not chips, can escape.
Fig. 29 (Pat. 225,949—C.F. Roper) is

designed (like the greater part of the drawings inserted) to show relative position of parts merely, and not relative *size*. This style of machine can be used for sugar separating (Pat. 345,994—F.P. Sherman) and many other purposes, to which, however, there are other styles more especially adapted.

[Illustration: Fig. 29.]

FILTERERS.—There are two distinct kinds of centrifugal filterers, working on different principles. Petroleum separators (Pat. 217,063) are of the first kind. They are in form in all respects like a sugar machine. The flakes of paraffine, stearine, *etc*., which are to be extracted, when chilled are very brittle and would be disintegrated upon being hurled against a plain wire gauze and would escape. Even a woven fabric presents too harsh a surface. It is necessary to have a very elastic basket lining of wool, cotton, or other fibrous material. The basket itself may be either wire or perforated, but must have a perfectly smooth bottom.

As the pressure of the liquor upon the filtering medium per unit of surface depends entirely upon its radial depth, mere tubes, connecting a central inlet with an annular compartment, will serve the purpose quite as well as a whole basket. In this style of machine (Pat. 10,457) the filtering material constitutes a wall between two annular compartments. The outer one is connected with a vacuum apparatus.

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Filterers of the second kind work on the following principle: If a cylinder be rapidly revolved in a liquid in which solid particles are suspended, the liquid will be drawn into a like rotation and the heavy particles will be thrown to the outer part of the receptacle. If a perforated cylinder is used as stirrer, the purified liquid will escape into it through the perforations and may be conducted away. The impurities, likewise, after falling down the sides of the receptacle, are carried off. The advantages of this method are that no filtering material is needed and the filtering surface is never in contact with anything but pure liquor.

Very fine sawdust is, to a considerable extent, employed in sugar refineries as a filtering medium. By such use the sawdust becomes mixed with sand, fine particles of cane, *etc*. As sawdust of such fineness is expensive, it is desirable to purify it in order to reuse it. A centrifugal (Pat. 353,775—J.V.V. Booraem) built on the following principle is used for this purpose. It has been observed that by rotating rather *slowly* small particles of various substances in water, the finer particles will be thrown outward and deposit near the circumference of the vessel, while the heavier and coarser particles will deposit nearer to or at the center, their centrifugal force not being sufficient to carry them out. A mere rod, extending radially in both directions, serves by its rotation to set the water in motion.

Another form of filter of this second kind (Pat. 148,513) has a rotating imperforate basket into which the impure liquor is run. Within and concentric with it is another cylinder whose walls are of some filtering medium. The liquid already partly purified by centrifugal force passes through into the inner cylinder, thus becoming further purified. Centrifugal filters are used also to cleanse gums for varnishes.

HONEY.—The simplest form of honey extractor

(Pat. 61,216) consists of a square framework, symmetrical with respect to a vertical spindle. This framework is surrounded by a wire gauze. The combs, after having the heads of the cells cut off, are placed in comb-holders against the wire netting on the four sides, the cells pointing outward. The machine is turned by hand. The honey is hurled against the walls of a receiving case and caught below. But few improvements have been made on this. The latest machines are still hand-driven, as a sufficiently high velocity can be obtained in this manner. In one style the combs are placed upon a floor which rests upon springs. The rotating box is given a slight vertical and horizontal reciprocatory motion, by which the combs are made to grate on the wire gauze sides, breaking the cells and liberating the honey. Thus the labor of cutting the cells is saved. Every comb has two sides, and to present each side in succession to the outside without removing from the basket, several devices have been patented.

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In some the comb holders are hinged in the corners of the basket, and have an angular motion of ninety degrees. Decreasing the speed is sufficient to swing these. The other side is then emptied by revolving in the opposite direction. In one case each holder has a spindle of its own, connected with the main spindle by gearing and, to present opposite side, turns through 180 deg.. The usual number of sides and hence of comb holders is four, but eight have been used. There are minor differences in details of construction, looking to the most convenient removal and insertion of comb, the reception of the extracted honey in cups, buckets, *etc*., and the best method of giving rapid rotation, which cannot be touched upon. The product of the operation is white and opaque, but upon heating regains its golden color and transparency.

STARCH.—A centrifugal to separate starch from triturated grain, carried in suspension in water, is as follows. (Pat. 273,127—Mueller & Decastro.) The starch water is led to the bottom of a basket, and, as starch is heavier than the gluten with which it is mixed, the former will be immediately compacted against the periphery of the basket, lodging first in the lower corner, the starch and gluten forming two distinct strata. A tube with a cutting edge enters the compacted mass so deeply as to peel off the gluten and part of the starch, which is carried through the tube to another compartment of the basket, just above, where the same operation is performed, and so on. There may be only one compartment, the tube carrying the gluten directly out of the machine. These machines are continuous working, and hence some way must be devised to carry the water off. The inner surface of the water is, as we have seen, a cylinder. When the diameter of this cylinder becomes too small, overflow must be allowed. One plan is to have an overflow opening made in the bottom of the basket in such a way that as the starch wall thickens, the opening recedes toward the center.

The starch wall is either lifted out in cakes or put again in suspension by spraying water on it and conducting the mixture off.

A centrifugal (Pat. 74,021) to separate liquids from paints depends on building a wall of paint on the sides of the basket and carrying the liquids off at the center.

A centrifugal (Pat. 310,469) for assorting wood pulp, paper pulp, *etc*., works by massing the constituents in two or three cylindrical strata, and after action severing and removing these separately.

BREWING.—In brewing, centrifugals are quite useful. After the wort has been boiled with hops, albuminous matters are precipitated by the tannic acid, which must be extracted. Besides these the mixture frequently contains husk, fiber, and gluten. The machine (Pat. 315,876), although quite unique in construction, has the same principle of working as a sugar centrifugal, and need not be described. There is one point, however, which might be noticed—that air is introduced at about the same point as the material, and has an oxidizing and refrigerating effect.

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Class I. includes also centrifugals for the following purposes: The removal of must from the grape after crushing, making butter, extracting oils from solid fats, separating the liquid and solid parts of sewerage, drying hides, skins, spent tan and the like, drying coils of wire.

HORIZONTAL CENTRIFUGALS.—Only vertical machines have been and will be dealt with. Horizontal centrifugals, that is, those whose spindles are horizontal have been made, but the great inconvenience of charging and discharging connected with them has occasioned their disuse; though in other respects for liquids they are quite as good as vertical separators. Their underlying theory is practically the same as that hereinbefore discussed.

CLASS II., CREAMERS.—Centrifugals of the second class separate liquids from liquids. There are two main applications in this class—to separate cream from milk and fusel oil from alcoholic liquors. When a liquid is to be separated from a liquid, the receptacle must be imperforate. The components of different specific gravity become arranged in distinct concentric cylindrical strata in the basket, and must be conducted away separately. In creamers the particles of cream must not be broken or subjected to any concussion, as partial churning is caused and the cream will, in consequence, sour more rapidly.

The chief cause of oscillations in machines of this class, where the charge is liquid, is the waves which form on the inner surface. They may be met by allowing a slight overflow over the inner edge of the rim of the basket; or by having either horizontal partitions, or vertical, radial ones, special cases of which will be noticed. Oscillations may also be met in the same manner as in sugar machines, by allowing the revolving parts to revolve about an axis through their common center of gravity. (Pat. 360,342—J.

Evans.)

The crudest form of creamer contains a number of bottles, with their necks all directed toward the spindle, filled with milk. The necks, in which the cream collects, are graduated to tell when the operation is complete.

Many methods for introducing the milk into creamers have been devised. It may run in from the top at the center, or emerge from a pipe at the bottom of the basket; or the spindle may be hollow and the milk sucked up through it from a basin below. It is usual to let the milk enter under hydrostatic pressure (Pat. 239,900—D. M. Weston) and let the force of expulsion of the cream be dependent on this pressure. This renders the escape quiet, and prevents churning. Gravity, too, is made effective in carrying the constituents off.

The cream may escape through a passage in the bottom at the center, and the skim milk at the lower outer corner; or by ingeniously managed passages both may escape at or near center. The rate of discharge can be managed by regulating the size of opening of exit passages.

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A curious method consists in having discharge pipes provided with valves and floats at their lower ends, dipping into the liquid (Pat. 240,175). "The valves are opened and closed, or partially opened or closed, by the floats attached to them, these floats being so constructed and arranged with reference to their specific gravity and the specific gravity of the component parts of the liquids operated upon, that they will permit only a liquid of a determinate specific gravity to escape through the pipes to which they are respectively attached."

We may have tubes directed into the different strata with cutting edges. (Pat. 288,782.) A remarkable fact noticed in their use is that these edges wear as rapidly as if solids were cut instead of liquids.

The separated fluids may be received into recessed rings, having discharge pipes, the proportionate quantity discharged being regulated by the proximity of the discharge lips to the surface of the ring, and the centrifugal force being availed of to project the liquids through the discharge pipes.

There is a very simple device by which a very rapid circulation of the liquid is brought about. (Pat. 358,587—C.A. Backstrom.) The basket has radial vertical partitions, all but one having communicating holes, alternately in upper and lower corners. The milk is delivered into the basket on one side of this imperforate partition and must travel the whole circuit of the basket through these communicating holes, until it reaches the partition again, and then passes into a discharge pipe. Thus during this long course every particle of cream escapes to the center. As the holes are close to the walls of the basket, the cream has not the undulatory motion of the milk, which would injure it. The greater the number of partitions, the longer is the travel of the milk, and the more rapid the circulation. Blades have been devised similar to the above, having communicating passages extending the whole width of the blade, but we see that here the cream would circulate with the milk; which must not be allowed. Curved blades have been used, and paddles and stirrers, to set the milk in motion, but to them the same objection may be made.

[Illustration: Fig. 30]

Fig. 30 (Pat. 355,048—C.A. Backstrom) illustrates one of the latest and best styles of creamers. The milk enters at C. The skim milk passes into tube, T, and the cream goes to the center and passes out of the openings in the bottom, k^{l}, k^{2}, and k^{3}, out of the slit, k, and thence out through D^{5}. The skim milk moves through T, becoming more thoroughly separated all the while, and at each of the radial branch tubes, T^{1}, T^{2}, T^{3}, and T^{4}, some cream leaves it and goes to the center, while it passes down out of slit, t^{3}, and thence out of D^{6}.

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Fig. 31 (Pat. 355,050—C.A. Backstrom) shows another very late style of creamer. A pipe delivers the milk into P^{4}. Passing out of the tube separation takes place, and cream falls down the center to P^{2} and out of O^{3}. When the compartment under the first shelf becomes full of the skim milk, the latter passes up through the slot, S, strikes a radial partition, R, and its course is reversed. Here more cream separates and passes to center and falls directly, and so on through the whole series of annular compartments, until the top one, when the skim milk enters tube T^{2} and passes out of O^{2}. By this operation there are substantially repeated subjections of specified quantities of milk to the action of centrifugal force, bringing about a thorough separation. By changing the course of the milk in direction, its path is made longer. This machine can run at much lower speed than many other styles, and yet do the same work.

[Illustration: Fig. 31]

CLASS III., SOLIDS FROM SOLIDS.—As for grain machines, which are in this class, it may be said that in centrifugal flour bolters, bran cleaners, and middlings purifiers, though theoretically centrifugal force plays an important part in their action, yet practically the real separation is brought about by other agencies: in some by brushes which rub the finer particles through wire netting as they rotate against it.

The principle exhibited in a separator of grains and seeds is very neat. (Pat. 167,297.) See Fig. 32. That part of the machine with which we have to do consists essentially of a horizontal revolving disk. The mixed grains are cast on this disk, pass to the edge, and are hurled off at a tangent. Suppose at A. Each particle is immediately acted on by three forces. For all particles of the same size and having the same velocity the resistance of the air may be taken the same, that is, proportional to the area presented. The acceleration of gravity is the same; but the inertia of the heavier grain is greater. The resultant of the two conspiring forces R and $(Mv^{2})/2$ varies, and is greater for a heavier grain. Therefore, the paths described in the air will vary, especially in length; and how this is utilized the drawing illustrates.

[Illustration: Fig. 32.]

ORE.—In ore machines there is one for pulverizing and separating coal (Pat. 306,544), in which there is a breaker provided with helical blades or paddles, partaking of rapid rotary motion within a stationary cylinder of wire netting. The dust, constituting the valuable part of the product, is hurled out as fast as formed. In this style of machine, beaters are necessary not only for pulverizing, but to get up rotary motion for generating centrifugal force. In the classes preceding, the friction of the basket sufficed for this latter purpose; but here there is no rotating basket and no definite charge. As the material falls through the machine, separation takes place. Various kinds of ore may be treated in the same manner.

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An “ore concentrator” (Pat. 254,123), as it is called, consists of a pan having rotary and oscillatory motions. Crushed ore is delivered over the edge in water. The heavy particles of the metal are thrown by centrifugal force against the rim of the pan, overcoming the force of the water, which carries the sand and other impurities in toward the center and away.

AMALGAMATORS.—The best ore centrifugal or separator is what is called an “amalgamator.” The last invention (Pat. 355,958, White) consists essentially of a pan, a meridian section of which would give a curve whose normal at any point is in the direction of the resultant of the centrifugal force at that point and gravity. There is a cover to this pan whose convexity almost fits the concavity of the pan, leaving a space of about an inch between. Crushed ore with water is admitted at the center between the cover and the pan, and is driven by centrifugal force through a mass of mercury (which occupies part of this space between the two) and out over the edge of the pan. The particles of metal coming in contact with the mercury amalgamate, and as the speed is regulated so that it is never great enough to hurl the mercury out, nothing but sand, water, *etc*., escape. There have been many different constructions devised, but this general principle runs through all. By having annular flanges running down from the cover with openings placed alternately, the mixture is compelled to follow a tortuous course, thus giving time for all the gold or other metal to become amalgamated. There are ridges in the pan, too, against which the amalgam lodges. It is claimed for this machine that not a particle of the precious metal is lost, and experiments seem to uphold the claim.

A machine for separating fine from coarse clay for porcelain or for separating the finer quality of plumbago from the coarser for lead pencils uses an imperforate basket, against the wall of which the coarser part banks and catches under the rim. The finer part forms an inner cylindrical stratum, but is allowed to spill over the edge of the rim. The mixture is introduced at the bottom of the basket at the center.

CLASS IV., GASES AND SOLIDS.—There is a very simple contrivance illustrating machines of this class used to free air from dust or other heavy solid impurities which may be in suspension. See Fig. 33. The air enters the passage, B (if it has no considerable velocity of itself, it must be forced in), forms a whirlpool in the conically shaped receptable, A, and passes up out of the passage, D. The heavy particles are thrown on the sides and collect there and fall through opening, C, into some closed receiver.

[Illustration: Fig. 33]

CLASS V., GASES AND LIQUIDS.—The occluded gases in steel and other metal castings, if not separated, render the castings more or less porous. This separation is effected by subjecting the molten metal to the action of centrifugal force under exclusion of air, producing not only the most minute division of the particles, but also a vacuum, both favorable conditions for obtaining a dense metal casting.

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Most of the devices for drying steam come under this head. Such are those in which the steam with the water in suspension is forced to take a circular path, by which the water is hurled by centrifugal force against the concave side of the passage and passes back to the water in the boiler.

SPEED.—The centrifugal force of a revolving particle varies, as we have seen, as the square of the angular velocity, so that the effort has been to obtain as high a number of revolutions per minute as was consistent with safety and with the principle of the machine. For example, creamers which are small and light make 4,000 revolutions per minute, though the latest styles run much more slowly. Driers and sugar machines vary from 600 to 2,000, while on the other hand the necessity of keeping the mercury from hurling off in an amalgamator prevents its turning more rapidly than sixty or eighty times a minute.

However, speed in another sense, the speed with which the operation is performed, is what especially characterizes centrifugal extractors. In this particular a contrast between the old methods and the new is impressive. Under the action of gravity, cream rises to the milk's surface, but compare the hours necessary for this to the almost instantaneous separation in a centrifugal creamer. The sugar manufacturer trusted to gravity to drain the sirup from his crystals, but the operation was long and at best imperfect. An average sugar centrifugal will separate 600 pounds of magma perfectly in three minutes. Gold quartz which formerly could not pay for its mining is now making its owners' fortunes. It is boasted by a Southern company that whereas they were by old methods making twenty-five *cents* per ton of gold quartz, they now by the use of the latest amalgamator make twenty-five *dollars*. Centrifugal force, as applied in extractors, has opened up new industries and enlarged old ones, has lowered prices and added to our comforts, and centrifugal extractors may well command, as they do, the admiration of all as wonderful examples of the way in which this busy age economizes time.

* * * * *

A NEW TYPE OF RAILWAY CAR.

[Illustration: Fig. 1.—CAR WITH LATERAL PASSAGEWAYS.]

Figs. 1 and 2 give a perspective view and plan of a new style of car recently adopted by the Bone-Guelma Railroad Company, and which has isolated compartments opening upon a lateral passageway. In this arrangement, which is due to Mr. Desgranges, the lateral passageway does not extend all along one side of the car, but passes through the center of the latter and then runs along the opposite side so as to form a letter S. The car consists in reality of two boxes connected beneath the transverse passageway, but having a continuous roof and flooring. The two ends are provided with platforms that are reached by means of steps, and that permit one to enter the corresponding half

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of the car or to pass on to the next. The length from end to end is 33 feet in the mixed cars, comprising two first-class and four second-class compartments, and 32 feet in cars of the third class, with six compartments. The width of the compartments is 5.6 and 5 feet, according to the class. The passageway is 28 inches in width in the mixed cars, and 24 in those of the third class. The roof is so arranged as to afford a circulation of cool air in the interior.

[Illustration: Fig. 2.—PLAN.]

The application of the zigzag passageway has the inconvenience of slightly elongating the car, but it is advantageous to the passengers, who can thus enjoy a view of the landscape on both sides of the train.—*La Nature*.

* * * * *

FOUNDATIONS OF THE CENTRAL VIADUCT OF CLEVELAND, O.

The Central viaduct, now under construction in the city of Cleveland, is probably the longest structure of the kind devoted entirely to street traffic. The superstructure is in two distinct portions, separated by a point of high ground. The main portion, extending across the river valley from Hill street to Jennings avenue, is 2,840 feet long on the floor line, including the river bridge, a swing 233 feet in length; the other portion, crossing Walworth run from Davidson street to Abbey street, is 1,093 feet long. Add to these the earthwork and masonry approaches, 1,415 feet long, and we have a total length of 5,348 feet. The width of roadway is 40 feet, sidewalks 8 feet each. The elevation of the roadway above the water level at the river crossing is 102 feet. The superstructure is of wrought iron, mainly trapezoidal trusses, varying in length from 45 feet to 150 feet. The river piers are of first-class masonry, on pile and timber foundations. The other supports of the viaduct are wrought iron trestles on masonry piers, resting on broad concrete foundations. The pressure on the material beneath the concrete, which is plastic blue clay of varying degrees of stiffness mixed with fine sand, is about one ton per square foot.

The Cuyahoga valley, which the viaduct crosses from bluff to bluff, is composed mainly of blue clay to a depth of over 150 feet below the river level. No attempt is made to carry the foundation to the rock. White oak piles from 50 to 60 feet in length and 10 inches in diameter at small end are driven for the bridge piers either side of the river bed, and these are cut off with a circular saw 18 feet below the surface of the water. Excavation by dredging was made to a depth of 3 feet below where the piles are cut off to allow for the rising of the clay during the driving of the piles. The piles are spaced about 2 feet 5 inches each way, center to center. The grillage or platform covering the piles consists of 14 courses of white oak timber, 12 inches by 12 inches, having a few pine timbers interspersed so as

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to allow the mass to float during construction. The lower half of the platform was built on shore, care being taken to keep the lower surface of the mass of timber out of wind. The upper and lower surfaces of each timber were dressed in a Daniels planer, and all pieces in the same course were brought to a uniform thickness. The timbers in adjacent courses are at right angles to each other. The lower course is about 58 feet by 22 feet, the top course about 50 by 24 feet, thus allowing four steps of one foot each all around. The first course of masonry is 48 feet by 21 feet 8 inches; the first course of battered work is 41 feet 81/2 inches by 16 feet 3 inches. Thus the area of the platform on the piles is 1,856 square feet, and of the first batter course of masonry 777.6 square feet, or in the ratio of 2.4 to 1. The height of the masonry is 78 feet above the timber, or 731/2 feet above the water. The number of piles in each foundation is 312. The average load per pile is about 11 tons, and the estimated pressure per square inch of the timber on the heads of the piles is about 200 pounds.

To prevent the submersion of the lower courses of masonry during construction, temporary sides of timber were drift-bolted to the margin of the upper course of the timber platform, and carried high enough to be above the surface of the water when the platform was sunk to the head of the piles by the increasing weight of masonry.

The center pier is octagonal, and is built in the same general manner as to foundations as the shore piers, but the piles are cut off 22 feet below water, and there are eighteen courses of timber in the grillage. The diameter of the platform between parallel sides is 53 feet, while that of the lower course of battered masonry is but 37 feet. The areas are as 2,332 to 1,147, or as 2 to 1 nearly. The pressure per square inch of timber on the heads of the piles is about the same as stated above for the shore piers.

The number of piles under the center pier is 483.

The risks and delays by this method of constructing the foundations were much less, and the cost also, than if an ordinary coffer dam had been used. Also the total weight of the piers is much less, as that portion below a point about two feet below the water adds nothing to their weight.

The piles were driven with a Cram steam hammer weighing two tons, in a frame weighing also two tons. The iron frame rests directly upon the head of the pile and goes down with it. The fall of the hammer is about 40 inches before striking the pile. The total penetration of the piles into the clay averaged 27 feet. The settlement of the pile during the final strokes of the hammer varied from one quarter to three quarters of an inch per blow.

There are 122 masonry pedestals, of which eight are large and heavy, carrying spans of considerable length. They will all be built upon concrete beds, except a few near the river on the north side, where piles are required.

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The four abutments with their retaining walls are of first-class rock-faced masonry. The footing courses are stepped out liberally, so as to present an unusually large bottom surface. They rest on beds of concrete 4 feet thick. The foundation pits are about 50 feet below the top of the bluffs, and are in a material common to the Cleveland plateau, a mixture of blue sand and clay, with some water. The estimated load of masonry on the earth at the bottom of the concrete is one and seven tenths tons to the square foot. Two of the large abutments were completed last season. They show an average settlement of three eighths of an inch since the lower footing courses were laid.

The facts and figures here given regarding the viaduct were kindly furnished by the city civil engineer, C.G. Force, who has the work in charge.—*Jour. Asso. of Eng. Societies.*

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For sticking paper to zinc, use starch paste with which a little Venice turpentine has been incorporated, or else use a dilute solution of white gelatine or isinglass.

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CENTRIFUGAL PUMPS AT MARE ISLAND NAVY YARD, CALIFORNIA.[1]

[Footnote 1: Built by the Southwark Foundry and Machine Company, of Philadelphia.]

By H.R. CORNELIUS.

In December, 1883, bids were asked for by the United States government on pumping machinery, to remove the water from a dry dock for vessels of large size.

The dimensions of the dock, which is situated on San Pablo Bay, directly opposite the city of Vallejo, are as follows:

Five hundred and twenty-nine feet wide at its widest part, 36 feet deep, with a capacity at mean tide of 9,000,000 gallons.

After receiving the contract, several different sizes of pumps were considered, but the following dimensions were finally chosen: Two 42 inch centrifugal pumps, with runner 66 inches in diameter and discharge pipes 42 inches, each driven direct by a vertical engine with 28 inch diameter cylinder and 24 inch stroke.

These were completed and shipped in June, 1885, on nine cars, constituting a special train, which arrived safely at its destination in the short space of two weeks, and the pumps were there erected on foundations prepared by the government.

From the “Report of the Chief of Bureau of Yards and Docks” I quote the following account of the official tests:

“The board appointed to make the test resolved to fill the dock to about the level that would attain in actual service with a naval ship of second rate in the dock, and the tide at a stage which would give the minimum pumping necessary to free the dock. The level of the 20th altar was considered as the proper point, and the water was admitted through two of the gates of the caisson until this level was reached; they were then closed. The contents of the dock at this point is 5,963,921 gallons.

“The trial was commenced and continued to completion without any interruption in a very satisfactory manner.

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“In the separate trials had of each pump, the average discharge per minute was taken of the whole process, and there was a singular uniformity throughout with equal piston speed of the engine.“It was to be expected, and in a measure realized, that during the first moments of the operations, when the level of the water in the dock was above the center of the runner of the pumps, that the discharge would be proportioned to the work done, where no effort was necessary to maintain a free and full flow through the suction pipes; but as the level passed lower and farther away from the center there was no apparent diminution of the flow, and no noticeable addition to the load imposed on the engine. The variation in piston speed, noted during the trial, was probably due to the variation of the boiler pressure, as it was difficult to preserve an equal pressure, as it rose in spite of great care, owing to the powerful draught and easy steaming qualities of the boilers.“After the trial of the second pump had been completed the dock was again filled through the caisson, and as both pumps were to be tried, the water was admitted to a level with the 23d altar, containing 7,317,779 gallons, which was seven feet above the center of the pumps; this was in favor of the pumps for the reasons before stated. In this case all the boilers were used.“Everything moved most admirably, and the performance of these immense machines was almost startling. By watching the water in the dock it could be seen to lower bodily, and so rapidly that it could be detected by the eye without reference to any fixed point.“The well which communicates with the suction tunnel was open, and the water would rise and fall, full of rapid swirls and eddies, though far above the entrance of these tunnels. Through the man hole in the discharge culvert the issuance from the pipes could be seen, and its volume was beyond conception. It flowed rapidly through the culvert, and its outfall was a solid prism of water, the full size of the tunnel, projecting far into the river.“During a pumping period of 55 minutes, the dock had been emptied from the twenty-third to two inches above the sixth altar, containing 6,210,698 gallons, an average throughout of 112,922 gallons per minute. At one time, when the revolutions were increased to 160 per minute, the discharge was 137,797 gallons per minute. This is almost a river, and is hardly conceivable. After the pumps were stopped, on this occasion, tests were made with each in succession as to the power of the ejectors with which each is fitted to recharge the pumps.“The valves in the discharge pipe were closed and steam admitted to the ejector, the pump being still and no water in the gauge glass on the pump casing, which must be full before the pumps will work. The suction pipe of

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the ejector is only two and a half inches in diameter, the steam pipe one inch in diameter. To fully charge the pumps at this point required filling the pump casing and the suction pipe containing about 2,000 gallons; this was accomplished in four minutes, and when the gauge glass was full the pump operated instantly and with certainty, discharging its full volume of water.“I went on several occasions down in the valve pits on the ladder of the casing, and to all accessible parts while in motion at its highest speed, and there was no undue vibration, only a uniform murmur of well-balanced parts, and the peculiar clash of water against the sides of the casing as its velocity was checked by the blank spaces in the runner.“The pumps are noisy while at work, due to the clashing of the water just mentioned, but it affords a means of detecting any faulty arrangements of the runner or unequal discharge from any of its openings. While moving at a uniform speed, this clashing has a tone whose pitch corresponds with that velocity of discharge, and if this tone is lacking in quality, or at all confused, there is want of equality of discharge through the various openings of the runner. To this part I gave close attention, and there was nothing that the ear could detect to indicate aught but the nicest adjustment. The bearings of the runners worked with great smoothness, and did not become at all heated. Through a simple, novel arrangement, these bearings are lubricated and kept cool. There is a constant circulation of water from the pumps by means of a small pipe, which completes a circuit to an annular in the bearings back to the discharge pipe while the pump is in motion, requiring no oil and making it seemingly impossible to heat these bearings.“The large cast steel valves placed in the embouchement of the casing, it was thought, might act to check the free discharge, and arrangements were provided for raising and keeping them open by a long lever key attached to their axes of revolution, but, to our great surprise, at the first gush from the pumps these valves, weighing nearly 1,500 pounds, were lifted into their recessed chambers, giving an unobstructed opening to the flow, and they floated on its surface unsupported, save by the swiftly flowing water, without a movement, while the pump was in operation.

“The steam-actuated valves in the suction and discharge pipes worked very well, and the water cushion gave a slow, uniform motion, and without shock, either in opening or closing them.

“The engines worked noiselessly, without shock or labor. At no time during the trial was the throttle valve open more than three-eighths of an inch.

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“The indicator cards taken at various intervals gave 796 horse power, and the revolutions did not exceed 160 at any time, though it was estimated that 900 horse power and 210 revolutions would be necessary to attain the requisite delivery. So that there is a large reserve of power available at any time.“The erection of this massive machinery has been admirably done. The parts, as sent from the shops of the contractor, have matched in all cases without interference here; and, when lowered into place, its final adjustment was then made without the use of chisel or file, and has never been touched since.“The joints of the steam and water connections were perfect, and the method of concentrating all valves, waste pipes, and important movements at the post of the engineer in charge gives him complete control of the whole system of each engine and pump without leaving his place, and reduces to a minimum the necessary attendance. All the parts are strong and of excellent design and workmanship; simple, and without ornamentation.

“Looking down upon them from a level of the pump house gallery, they are impressive and massive in their simplicity.

“The government is well worth of congratulation in possessing the largest pumping machinery of this type and of the greatest capacity in the world, and the contractors have reason to be proud of their work.”—*Proc. Eng. Club.*

* * * * *

THE PART THAT ELECTRICITY PLAYS IN CRYSTALLIZATION.

Since the discovery of the multiplying galvanometer, we know for an absolute certainty that in every chemical action there is a production of electricity in a more or less notable quantity, according to the nature of the bodies in presence. Though, in the play of *affinity*, there is a manifestation of electricity, is it the same with *cohesion*, which also is a chemical force?

We know, on another hand, that, on causing electricity to intervene, we bring about the crystallization of a large number of substances. But is the converse true? Is spontaneous crystallization accompanied with an appreciable manifestation of electricity? If we consult the annals of science and works treating on electricity in regard to this subject, we find very few examples and experiments proper to elucidate the question.

Mr. Mascart is content to say: “Some experiments seem to indicate that the solidification of a body produces electricity.” Mr. Becquerel does more than doubt—he denies: “As regards the disengagement of electricity in the changing of the state of bodies, we find none.” This assertion is too sweeping, for further along we shall cite facts that prove, on the contrary, that in the phenomena of crystallization (to speak of this change of state only) there is an unequivocal production of electricity. Let us remark, in the first place, that when a number of phenomena of physical and chemical order incontestably testify to the very intimate correlation that exists between the molecular motions of bodies and their electrical state, it would not be very logical to grant that electricity is absent in crystallization.

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Thus, to select an example from among physical effects, the vibratory phenomena that occur in telephone transmissions, under the influence of a very feeble electric current, show us that the molecular constitution of a solid body is extremely variable, although within slight limits. The feeblest modification in the electric current may be shown by molecular motions capable of propagating themselves to considerable distances in the conducting wire. Conversely, it is logical to suppose that a modification in the molecular state of a body must bring electricity into play. If, in the phenomena of solidification, and particularly of crystallization, we collect but small quantities of electricity, that may be due to the fact that, under the experimental conditions involved, the electricity is more or less completely absorbed by the work of crystal building.

On another hand, the behavior of electricity shows in advance the multiple role that this agent may play in the various physical, chemical, and mechanical phenomena.

There is no doubt that electricity exists immovable or in circulation everywhere, latent or imperceptible, around us, and within ourselves, and that it enters as a cause into the majority of the chemical, physical, and mechanical phenomena that are constantly taking place before our eyes. A body cannot change state, nature, temperature, form, or place, even, without electricity being brought into play, and without its accompanying such modifications, if it presides therein. Like heat, it is *the* natural agent *par excellence*; it is the invisible and ever present force which, in the ultimate particles of matter, causes those motions, vibrations, and rotations that have the effect of changing the properties of bodies. Upon entering their intimate structure, it orients or groups their atoms, and separates their molecules or brings them together. From this, would it not be surprising if it did not intervene in the wonderful phenomenon of crystallization? Crystallization, in fact, depends upon *cohesion*, and, in the thermic theory, this force is not distinct from affinity, just as solution and dissociation are not distinct from combination.

On this occasion, it is necessary to say that, between affinity, heat, and electricity there is such a correlation, such a dependency, that physicists have endeavored to reduce to one single principle all the causes that are now distinct. The mechanical theory of heat has made a great stride in this direction.

The equivalence of the thermic, mechanical and chemical forces has been demonstrated; the only question hereafter will be to select from among such forces the one that must be adopted as the sole principle, in order to account for all the phenomena that depend upon these causes of various orders. But in the present state of science, it is not yet possible to explain completely by heat or electricity, taken isolatedly, all the effects dependent upon the causes just mentioned. We must confine ourselves for the present to a study of the relations that exist between the principal natural forces—affinity, molecular forces, heat, electricity, and light. But from the mutual dependence of such forces, it is admitted that, in every natural phenomenon, there is a more or less apparent simultaneous concurrence of these causes.

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In order to explain electric or magnetic phenomena, and also those of crystallization, it is admitted that the atoms of which bodies are composed are surrounded, each of them, with a sort of atmosphere formed of electric currents, owing to which these atoms are attracted or repelled on certain sides, and produce those varied effects that we observe under different circumstances. According to this theory, then, atoms would be small electro-magnets behaving like genuine magnets. Entirely free in gases, but less so in liquids and still less so in solids, they are nevertheless capable of arranging themselves and of becoming polarized in a regular order, special to each kind of atom, in order to produce crystals of geometrical form characteristic of each species. Thus, as Mr. Saigey remarks in “Physique Moderne” (p. 181): “So long as the atmospheres of the molecules do not touch each other, no trace of cohesion manifests itself; but as soon as they come together force is born. We understand why the temperatures of fusion and solidification are fixed for the same body. Such effects occur at the precise moment at which these atmospheres, which are variable with the temperature, have reached the desired diameter.”

[Illustration: Figs. 1., 2., and 3.]

Although the phenomenon of crystallization does not essentially depend upon temperature, but rather upon the relative quantity of liquid that holds the substance in solution, it will be conceived that a moment will arrive when, the liquid having evaporated, the atmospheres will be close enough to each other to attract each other and become polarized and symmetrically juxtaposed, and, in a word, to crystallize.

Before giving examples of the production of electricity in the phenomenon of crystallization, it will be well to examine, beforehand, the different circumstances under which electricity acts as the determining cause of crystallization or intervenes among the causes that bring about the phenomenon. In the first place, two words concerning crystallization itself: We know that crystallization is the passage, or rather the result of the passage, of a body from a liquid or gaseous state to a solid one. It occurs when the substance has lost its cohesion through any cause whatever, and when, such cause ceasing to act, the body slowly returns to a solid state.

Under such circumstances, it may take on regular, geometrical forms called crystalline. Such conditions are brought about by different processes—fusion, volatilization, solution, the dry way, wet way, and electric way. Further along, we shall give some examples of the last named means.

Let us add that crystallization may be regarded as a general property of bodies, for the majority of substances are capable of crystallizing. Although certain bodies seem to be amorphous at first sight, it is only necessary to examine their fracture with a lens or microscope to see that they are formed of a large number of small juxtaposed crystals. Many amorphous precipitates become crystalline in the long run.

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In the examination of the various crystallizations that occupy us, we shall distinguish the following: (1) Those that are produced through the direct intervention of the electric current; (2) those in which electricity is manifestly produced by small voltaic couples resulting from the presence of two different metals in the solution experimented with; (3) those in which there are no voltaic couples, but in which it is proved that electricity is one of the causes that concur in the production of the phenomenon; (4) finally, those in which it is rational, through analogy with the preceding, to infer that electricity is not absent from the phenomenon.

I. We know that, by means of voltaic electricity or induction, we can crystallize a large number of substances.

Despretz tried this means for months at a time upon carbon, either by using the electricity from a Ruhmkorff coil or the current from a weak Daniell's battery. In both cases, he obtained on the platinum wires a black powder, in which were found very small octohedral crystals, having the property of polishing rubies rapidly and perfectly—a property characteristic of diamonds.

The use of voltaic apparatus of high tension has allowed Mr. Cross to form a large number of mineral substances artificially, and among these we may mention carbonate of lime, arragonite, quartz, arseniate of copper, crystalline sulphur, *etc*.

As regards products formed with the concurrence of electricity (oxides, sulphides, chlorides, iodides, *etc*.), see "Des Forces Physico-Chimiques," by Becquerel (p. 231).

There is no doubt as to the part played by electricity in the chemical effects of electro-metallurgy, but it will not prove useless for our subject to remark that when, in this operation, the current has become too weak, the deposit of metal, instead of forming in a thin, adherent, and uniform layer, sometimes occurs under the form of protuberances and crystalline, brittle nodules. When, on the contrary, the current is very strong, the deposit is pulverulent, that is, in a confused crystallization or in an amorphous state.

Further along, we shall find an application of this remark. We obtain, moreover, all the intermediate effects of cohesion, form, and color of galvanic deposits.

When, into a solution of acetate of lead, we pass a current through two platinum electrodes, we observe the formation, at the negative pole, of numerous arborizations of metallic lead that grow under the observer's eye (Fig. 1). The phenomenon is of a most interesting character when, by means of solar or electric light, we project these brilliant vegetations on a screen. One might believe that he was witness of the rapid growth of a plant (Fig. 2). The same phenomenon occurs none the less brilliantly with a solution of nitrate of silver. A large number of saline solutions are adapted to these decompositions, in which the metal is laid bare under a crystalline form. Further along we shall see another means of producing analogous ramifications, without the direct use of the electric current.—*C. Decharme, in La Lumiere Electrique.*

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ELECTRIC TIME.

By M. LIPPMANN.

The unit of time universally adopted, the second, undergoes only very slow secular variations, and can be determined with a precision and an ease which compel its employment. Still it is true that the second is an arbitrary and a variable unit—arbitrary, in as far as it has no relation with the properties of matter, with physical constants; variable, since the duration of the diurnal movement undergoes causes of secular perturbation, some of which, such as the friction of the tides, are not as yet calculable.

We may ask if it is possible to define an absolutely invariable unit of time; it would be desirable to determine with sufficient precision, if only once in a century, the relation of the second to such a unit, so that we might verify the variations of the second indirectly and independently of any astronomical hypothesis.

Now, the study of certain electrical phenomena furnishes a unit of time which is absolutely invariable, as this magnitude is a specific constant. Let us consider a conductive substance which may always be found identical with itself, and to fix our ideas let us choose mercury, taken at the temperature of 0 deg. C., which completely fulfills this condition.
We may determine by several methods the specific electric resistance, [rho], of mercury in absolute electrostatic units; [rho] is a specific property of mercury, and is consequently a magnitude absolutely invariable. Moreover, [rho] is *an interval of time*.

We might, therefore, take [rho] as a unit of time, unless we prefer to consider this value as an imperishable standard of time.

In fact, [rho] is not simply a quantity the measure of which is found to be in relation with the measure of time. It is a concrete interval of time, disregarding every convention established with reference to measures and every selection of unit. It may at first sight, appear singular that an interval of time is found in a manner hidden under the designation *electric resistance*. But we need merely call to mind that in the electrostatic system the intensities of the current are speeds of efflux and that the resistances are times, *i.e.*, the times necessary for the efflux of the electricity under given conditions. We must, in particular, remember what is meant by the specific resistance, [rho] of mercury in the electrostatic system. If we consider a circuit having a resistance equal to that of a cube of mercury, the side of which = the unit of length, the circuit being submitted to an electromotive force equal to unity, this circuit will take a given time to be traversed by the unit quantity of electricity, and this time is precisely [rho]. It must be remarked that the selection of the unit of length, like that of the unit of mass, is indifferent, for the different units brought here into play depend on it in such a manner that [rho] is not affected.

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It is now required to bring this definition experimentally into action, *i.e.*, to realize an interval of time which may be a known multiple of [rho]. This problem may be solved in various ways,[1] and especially by means of the following apparatus.

[Footnote 1: In this system the measurement of time is not effected, as ordinarily, by observing the movements of a material system, but by experiments of equilibrium. All the parts of the apparatus remain immovable, the electricity alone being in motion. Such appliances are in a manner clepsydrae. This analogy with the clepsydrae will be perceived if we consider the form of the following experiment: Two immovable metallic plates constitute the armatures of a charged condenser, and attract each other with a force, F. If the plates are insulated, these charges remain constant, as well as the force, F. If, on the contrary, we connect the armatures of resistance, R, their charges diminish and the force, F, becomes a function of the time, *t*; the time, *t*, inversely becomes a function of P. We find *t* by the following formula:

t = [rho] x (lS / S[pi]es) x log hyp(F0/F)

F0 and F being the values of the force at the beginning and at the end of the time, *t*. The above formula is independent of the choice of units. If we wish *t* to be expressed in seconds, we must give [rho] the corresponding value ([rho] = 1.058 X 10^-16). If we take [rho] as a unit we make [rho] = 1, and we find the absolute value of the time by the expression:

(lS)
/ (8[pi]es) log hyp(F0/F)

We remark that this expression of time contains only abstract numbers, being independent of the choice of the units of length and force. S and *e* denote surface and the thickness of the condenser; *s* and *l* the section and the length of a column of mercury of the resistance, R. This form of apparatus enables us practically to measure the notable values of *t* only if the value of the resistance, R, is enormous, the arrangement described in the text has not the same inconvenience.]

A battery of an arbitrary electromotive force, E, actuates at the same time the two antagonistic circuits of a differential galvanometer. In the first circuit, which has a resistance, R, the battery sends a continuous current of the intensity, I; in the second circuit the battery sends a discontinuous series of discharges, obtained by charging periodically by means of the battery a condenser of the capacity, C, which is then discharged through this second circuit. The needle of the galvanometer remains in equilibrium if the two currents yield equal quantities of electricity during one and the same time, [tau].

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Let us suppose this condition of equilibrium
realized and the needle remaining motionless at zero;
it is easy to write the conditions of equilibrium.
During the time, [tau], the continuous current yields
a
E
quantity of electricity = — [tau]; on the
other hand, each charge of
R
the condenser = CE, and during the time, [tau], the
number of
[tau]
discharges = -----, t being the fixed time between
two discharges;
t
[tau] and t are here supposed to be expressed by the
aid of an arbitrary unit of time; the second circuit
yields, therefore, a
[tau]
quantity of electricity equal to CE x -----.
The condition of
t
E [tau]
equilibrium is then ---[tau] = CE x ----- ; or, more
simply, t = CR.
R t
C and R are known in absolute values, *i.e.*, we
know that C is equal to *p* times the capacity
of a sphere of the radius, *l*; we have, therefore,
C = *pl*; in the same manner we know that R is
equal to *q* times the resistance of a cube of
mercury having l for its side. We
l [rho]
have, therefore, R = q[rho] --- = q ----- ; and consequently
t = pq[rho].
l squared l

Such is the value of *t* obtained on leaving
all the units undetermined. If we express [rho]
as a function of the second, we have *t* in seconds.
If we take [rho] = 1, we have the absolute value [Theta]

of the same interval of time as a function of this unit; we have simply [Theta] = *pq*.

If we suppose that the commutator which produces the successive charges and discharges of the condenser consists of a vibrating tuning fork, we see that the duration of a vibration is equal to the product of the two abstract numbers, *pq*.

It remains for us to ascertain to what degree of approximation we can determine *p* and *q*. To find *q* we must first construct a column of mercury of known dimensions; this problem was solved by the International Bureau of Weights and Measures for the construction of the legal ohm. The legal ohm is supposed to have a resistance equal to 106.00 times that of a cube of mercury of 0.01 meter, side measurement. The approximation obtained is comprised between 1/50000 and 1/200000. To obtain *p*, we must be able to construct a plane condenser of known capacity. The difficulty here consists in knowing with a sufficient approximation the thickness of the stratum of air. We may employ as armatures two surfaces of glass, ground optically, silvered to render them conductive, but so slightly as to obtain by transparence Fizeau's interference rings. Fizeau's method will then permit us to arrive at a close approximation. In fine, then, we may, *a priori*, hope to reach an approximation of one hundred-thousandth of the value of *pq*.

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Independently of the use which may be made of it for measuring time in absolute value, the apparatus described possesses peculiar properties. It constitutes a kind of clock which indicates, registers, and, if needful, corrects automatically its own variations of speed. The apparatus being regulated so that the magnetic needle may be at zero, if the speed of the commutator is slightly increased, the equilibrium is disturbed and the magnetic needle deviates in the corresponding direction; if on the contrary the speed diminishes, the action of the antagonistic circuit predominates, and the needle deviates in the contrary direction. These deviations, when small, are proportional to the variations of speed. They may be, in the first place, observed. They may, further, be registered, either photographically or by employing a Redier apparatus, like that which M. Mascart has adapted to his quadrant electrometer; finally, we may arrange the Redier to react upon the speed so as to reduce its variations to zero. If these variations are not completely annulled, they will still be registered and can be taken into account.

As an indicator of variations this apparatus can be of remarkable sensitiveness, which may be increased indefinitely by enlarging its dimensions.

With a battery of 10 volts, a condenser of a microfarad, 10 discharges per second, and a Thomson’s differential galvanometer sensitive to 10^{-10} amperes, we obtain already a sensitiveness of 1/1000000, *i.e.*, a variation of 1/1000000 in the speed is shown after some seconds of a deviation of one millimeter. Even the stroboscopic method does not admit of such sensitiveness.

We may therefore find, with a very close approximation, a speed always the same on condition that the solid parts of the apparatus (the condenser and the resistance) are protected from causes of variation and used always at the same temperature. Doubtless, a well-constructed astronomical clock maintains a very uniform movement; but the electric clock is placed in better conditions for invariability, for all the parts are massive and immovable; they are merely required to remain unchanged, and there is no question of the wear and tear of wheel-work, the oxidation of oils, or the variations of weight. In other words, the system formed by a condenser and a resistance constitutes a standard of time easy of preservation.

* * * * *

NEW METHOD OF MAINTAINING THE VIBRATION OF A PENDULUM.

A recent number of the *Comptes Rendus* contains a note by M.J. Carpentier describing a method of maintaining the vibrations of a pendulum by means of electricity, which differs from previous devices of the same character in that the impulse given to the pendulum at each vibration is independent of the strength of the current employed, and that the pendulum itself is entirely free, save at the point of suspension. The vibrations are maintained, not by direct impulsion, but by a slight horizontal displacement of the point of suspension in alternate directions.

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This, as M. Carpentier observes, is the method which we naturally adopt in order to maintain the amplitude of swing of a heavy body suspended from a cord held in the hand. The required movement of the point of suspension is effected by means of a polarized relay, through the coils of which the current is periodically reversed by the action of the pendulum, in a manner which will presently be explained. The armature of the relay oscillates between two stops whose distance apart is capable of fine adjustment.

It is clear, therefore, that the impulse is independent of the strength of the current in the relay, provided that the armature is brought up to the stop on either side. The reversal of the current is effected by means of a small magnet carried by the bob of the pendulum, and which as it passes underneath the point of suspension is brought close to a soft iron armature, which has the form of an arc of a circle described about the point of suspension. This armature is pivoted at its center, and thus executes vibrations synchronously with those of the pendulum. These vibrations are adjusted to a very narrow range, but are sufficient to close the contacts of a commutator which reverses the current at each semi-vibration of the pendulum.

The beauty and ingenuity of this device will readily be appreciated.

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DR. MORELL MACKENZIE.

The name of the great English laryngologist, which has long been honored by scientists of England and the Continent, has lately become familar to everyone, even in unprofessional circles, in Germany because of his operations on the Crown Prince's throat. If his wide experience and great skill enable him to permanently remove the growth from the throat of his royal patient, if his diagnosis and prognosis are confirmed, so that no fear need be entertained for the life and health of the Crown Prince, the English specialist will certainly deserve the most sincere thanks of the German nation. Every phase of this treatment, every new development, is watched with suspense and hope.

Many have been unable to suppress the expression of regret that this important case was not under the care of a German, and part of the press look upon it as unjust treatment of the German specialists. But science is international, it knows no political boundaries, and the choice of Dr. Mackenzie by the family of the Crown Prince, whose sympathy with England is natural, cannot be considered a slight to German physicians when it is taken into consideration that the German authorities pronounced the growth suspicious and advised a difficult and doubtful operation, and that Prof. v. Bergman recommended that a foreign authority be consulted. As Dr. Mackenzie removed the obstruction, which had already become threatening and, in fact, dangerous, causing a loss of voice, and promised to remove any new growth from the inside

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without danger to the patient, the Crown Prince naturally trusted him. Since Virchow has made a microscopic examination of the part which was cut away, and has declared the new growth to be benign, all Germans should watch the results of Dr. Mackenzie's operations with sympathy, trusting that all further growth will be prevented, and that the Crown Prince will be restored to the German people in his former state of health.

[Illustration: DR. MORELL MACKENZIE.]

Dr. Morell Mackenzie has lately reached his fiftieth year, and has attained the height of his fame as an author and practitioner. He was born at Leytonston in 1837, and studied first in London. At the age of twenty-two he passed his examination, then practiced as physician in the London Hospital, and obtained his degree in 1862. A year later he received the Jackson prize from the Royal Society of Surgeons for his treatment of a laryngeal case.

He completed his studies in Paris, Vienna (with Siegmund), and Budapest. In the latter place he worked with Czermak, making a special study of the laryngoscope. Later he published an excellent work on "Diseases of the Throat and Nose," which was the fruit of twelve years' work. The evening before the day on which this work was to have been issued, the whole edition was destroyed by a fire which occurred in the printing establishment, and had to be reprinted from the proof sheets, which were saved. In 1870 his work "On Growths in the Throat" appeared, and he has also published many articles in the *British Medical Journal*, the *Lancet*, *Medical Times and Gazette*, *etc*., which have been translated into different languages, making his name renowned all over Europe.

Since he founded the first English hospital for diseases of the throat and chest, in London in 1863, and held the position of lecturer on diseases of the throat in the London Medical College, his career has been watched with interest by the public, and his practice in England is remarkable. Therefore it is no wonder that his lately published work "On the Hygiene of the Vocal Organs" has reached its fourth edition already. This work is read not only by physicians, but also by singers and lecturers.

As a learned man in his profession, as an experienced diagnostician, and as a skillful and fortunate practitioner, he is surpassed by none; and his ability will be well known far beyond the borders of Great Britain if fortune favors him and he restores the future Emperor of Germany to his former strength and vigor, without which we cannot imagine this knightly form. The certainty with which Dr. Mackenzie speaks of permanent cures which he has effected in similar cases, together with the clear and satisfactory report of the great pathologist Virchow, lead us to look to the future with confidence.—*Illustrirte Zeitung*.

* * * * *

HYPNOTISM IN FRANCE.[1]

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[Footnote 1: Translated for *Science* from *Der Spinx*.]

The voluntary production of those abnormal conditions of the nerves which to-day are denoted by the term "hypnotic researches" has manifested itself in all ages and among most of the nations that are known to us. Within modern times these phenomena were first reduced to a system by Mesmer, and, on this account, for the future deserve the attention of the scientific world. The historical description of this department, if one intends to give a connected account of its development, and not a series of isolated facts, must begin with a notice of Mesmer's personality, and we must not confound the more recent development of our subject with its past history.

The period of mesmerism is sufficiently understood from the numerous writings on the subject, but it would be a mistake to suppose that in Braid's "Exposition of Hypnotism" the end of this subject had been reached. In a later work I hope to show that the fundamental ideas of biomagnetism have not only had in all periods of this century capable and enthusiastic advocates, but that even in our day they have been subjected to tests by French and English investigators from which they have issued triumphant.

The second division of this historical development is carried on by Braid, whose most important service was emphasizing the subjectivity of the phenomena. Without any connection with him, and yet by following out almost exactly the same experiments, Professor Heidenhain reached his physiological explanations. A third division is based upon the discovery of the hypnotic condition in animals, and connects itself to the *experimentum mirabile*. In 1872 the first writings on this subject appear from the pen of the physiologist Czermak; and since then the investigations have been continued, particularly by Professor Preyer.

While England and Germany were led quite independently to the study of the same phenomena, France experienced a strange development, which shows, as nothing else could, how truth everywhere comes to the surface, and from small beginnings swells to a flood which carries irresistibly all opposition with it. This fourth division of the history of hypnotism is the more important, because it forms the foundation of a transcendental psychology, and will exert a great influence upon our future culture; and it is this division to which we wish to turn our attention. We have intentionally limited ourselves to a chronological arrangement, since a systematic account would necessarily fall into the study of single phenomena, and would far exceed the space offered to us.

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James Braid's writings, although they were discussed in detail in Littre and Robin's "Lexicon," were not at all the cause of Dr. Philips' first books, who therefore came more independently to the study of the same phenomena. Braid's theories became known to him later by the observations made upon them in Beraud's "Elements of Physiology" and in Littre's notes in the translation of Mueller's "Handbook of Physiology;" and he then wrote a second brochure, in which he gave in his allegiance to braidism. His principal effort was directed to withdrawing the veil of mystery from the occurrences, and by a natural explanation relegating them to the realm of the known. The trance caused by regarding fixedly a gleaming point produces in the brain, in his opinion, an accumulation of a peculiar nervous power, which he calls "electrodynamism." If this is directed in a skillful manner by the operator upon certain points, it manifests itself in certain situations and actions that we call hypnotic. Beyond this somewhat questionable theory, both books contained a detailed description of some of the most important phenomena; but with the practical meaning of the phenomena, and especially with their therapeutic value, the author concerned himself but slightly. Just on account of this pathological side, however, a certain attention has been paid to hypnotism up to the present time.

In the year 1847 two surgeons in Poictiers, Drs. Ribaut and Kiaros, employed hypnotism with great success in order to make an operation painless. "This long and horrible work," says a journal of the day, "was much more like a demonstration in a dissecting room than an operation performed upon a living being." Although this operation produced such an excitement, yet it was twelve years later before decisive and positive official intelligence was given of these facts by Broca, Follin, Velpeau, and Guerinau. But these accounts, as well as the excellent little book by Dr. Azam, shared the fate of their predecessors. They were looked upon by students with distrust, and by the disciples of Mesmer with scornful contempt.

The work of Demarquay and Giraud Teulon showed considerable advance in this direction. The authors, indeed, fell back upon the theory of James Braid, which they called stillborn, and of which they said, "*Elle est restee accrochee en route*;" but they did not satisfy themselves with a simple statement of facts, as did Gigot Suard in his work that appeared about the same time. Through systematic experiments they tried to find out where the line of hypnotic phenomena intersected the line of the realm of the known. They justly recognized that hypnotism and hysteria have many points of likeness, and in this way were the precursors of the present Parisian school. They say that from magnetic sleep to the hypnotic condition an iron chain can be easily formed from the very same organic elements that we find in historical conditions.

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At the same time, as if to bring an experimental proof of this assertion, Lasigue published a report on catalepsy in persons of hysterical tendencies, which be afterward incorporated into his larger work. Among his patients, those who were of a quiet and lethargic temperament, by simply pressing down the eyelids, were made to enter into a peculiar state of languor, in which cataleptic contractions were easily produced, and which forcibly recalled hypnotic phenomena. "One can scarcely imagine," says the author, "a more remarkable spectacle than that of a sick person sunk in deep sleep, and insensible to all efforts to arouse him, who retains every position in which he is placed, and in it preserves the immobility and rigidity of a statue." But this impulse also was in vain, and in only a few cases were the practical tests followed up with theoretical explanations.

Unbounded enthusiasm and unjust blame alike subsided into a silence that was not broken for ten years. Then Charles Richet, a renowned scientist, came forward in 1875, impelled by the duty he felt he owed as a priest of truth, and made some announcements concerning the phenomena of somnambulism; and in countless books, all of which are worthy of attention, he has since then considered the problem from its various sides.

He separates somnambulism into three periods. The word here is used for this whole class of subjects as Richet himself uses it, *viz.*, *torpeur*, *excitation*, and *stupeur*. In the first, which is produced by the so-called magnetic passes and the fixing of the eyes, silence and languor come over the subject. The second period, usually produced by constant repetition of the experiment, is characterized chiefly by sensibility to hallucination and suggestion. The third period has as its principal characteristics supersensibility of the muscles and lack of sensation. Yet let it be noticed that these divisions were not expressed in their present clearness until 1880; while in the years between 1872 and 1880, from an entirely different quarter, a similar hypothesis was made out for hypnotic phenomena.

Jean Martin Charcot, the renowned neurologist of the Parisian Salpetriere, without exactly desiring it, was led into the study of artificial somnambulism by his careful experiments in reference to hysteria, and especially by the question of *metallotherapie*, and in the year 1879 had prepared suitable demonstrations, which were given in public lectures at the Salpetriere. In the following years he devoted himself to closer investigation of this subject, and was happily and skillfully assisted by Dr. Paul Richer, with whom were associated many other physicians, such as Bourneville, Regnard, Fere, and Binet. The investigations of these men present the peculiarity that they observe hypnotism from its clinical and nosographical side, which side had until now been entirely neglected, and that they observe patients of the strongest hysterical temperaments. “If we can reasonably assert that the hypnotic phenomena which depend upon the disturbance of a regular function of the organism demand for their development a peculiar temperament, then we shall find the most marked phenomena when we turn to an hysterical person.”

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The inferences of the Parisian school up to this time are somewhat the following, but their results, belonging almost entirely to the medical side of the question, can have no place in this discussion. They divide the phenomena of hystero-hypnotism, which they also call *grande hysterie*, into three plainly separable classes, which Charcot designates catalepsy, lethargy, and somnambulism.

Catalepsy is produced by a sudden sharp noise, or by the sight of a brightly gleaming object. It also produces itself in a person who is in a state of lethargy, and whose eyes are opened. The most striking characteristic of the cataleptic condition is immobility. The subject retains every position in which he is placed, even if it is an unnatural one, and is only aroused by the action of suggestion from the rigor of a statue to the half life of an automaton. The face is expressionless and the eyes wide open. If they are closed, the patient falls into a lethargy.

In this second condition, behind the tightly closed lids, the pupils of the eyes are convulsively turned upward. The body is almost entirely without sensation or power of thought. Especially characteristic of lethargy is the hyper-excitability of the nerves and muscles (*hyperexcitabilite neuromusculaire*), which manifests itself at the slightest touch of any object. For instance, if the extensor muscles of the arm are lightly touched, the arm stiffens immediately, and is only made flexible again by a hard rubbing of the same muscles. The nerves also react in a similar manner. The irritation of a nerve trunk not only contracts all the small nerves into which it branches, but also all those muscles through which it runs.

Finally, the somnambulistic condition proceeds from catalepsy or from lethargy by means of a slight pressure upon the *vertex*, and is particularly sensitive to every psychical influence. In some subjects the eyes are open, in others closed. Here, also, a slight irritation produces a certain amount of rigor in the muscle that has been touched, but it does not weaken the antagonistic muscle, as in lethargy, nor does it vanish under the influence of the same excitement that has produced it. In order to put an end to the somnambulistic condition, one must press softly upon the pupil of the eye, upon which the subject becomes lethargic, and is easily roused by breathing upon him. In this early stage, somnambulism appears very infrequently.

Charcot's school also recognize the existence of compound conditions, the history of whose symptoms we must not follow here. These slightly sketched results, as well as a number of other facts, were only obtained in the course of several years; yet in 1882 the fundamental investigations of this school were considered virtually concluded. Then Dumont-Pallier, the head of the Parisian Hospital Pitie, came forward with a number of observations, drawn also exclusively from the study of hystero-hypnotism, and yet differing widely from those reached by the physicians of the Salpetriere. In a long series of communications, he has given his views, which have in their turn been violently attacked, especially by Magnin and Berillon. I give only the most important points.

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According to these men, the hyper-excitability of the nerves and muscles is present not only in the lethargic condition, but in all three periods; and in order to prove this, we need only apply the suitable remedy, which must be changed for each period and every subject. Slight irritations of the skin prove this most powerfully. A drop of warm water or a ray of sunshine produces contractions of a muscle whose skin covering they touch.

Dumont-Pallier and Magnin accede to the theory of intermediate stages, and have tried to lay down rules for them with as great exactness as Charcot's school. They also are very decided about the three periods, whose succession does not appear to them as fixed; but they discovered a new fundamental law which regulates the production as well as the cessation of the condition—*La cause qui fait, defait*; that is, the stimulus which produces one of the three periods needs only to be repeated in order to do away with that condition. From this the following diagram of hypnotic conditions is evolved:

[Illustration]

And, furthermore, Dumont-Pallier should be considered as the founder of a series of experiments, for he was the first one to show in a decisive manner that the duality of the cerebral system was proved by these hypnotic phenomena; and his works, as well as those of Messrs. Berillon and Descourtis, have brought to light the following facts: Under hypnotic conditions, the psychical activity of a brain hemisphere may be suppressed without nullifying the intellectual activity or consciousness. Both hemispheres may be started at the same time in different degrees of activity; and also, when the grade is the same, they may be independently the seat of psychical manifestations which are in their natures entirely different.
In close connection with this and with the whole doctrine of hemi-hypnotism, which is founded upon these facts,

stand the phenomena of thought transference, which we must consider later.

As an addition to the investigations of Charcot and Dumont-Pallier, Bremaud, in 1884, made the discovery that there was a fourth hypnotic state, “fascination,” which preceded the three others, and manifested itself by a tendency to muscular contractions, as well as through sensitiveness to hallucination and suggestion, but at the same time left to the subject a full consciousness of his surroundings and remembrance of what had taken place. Descourtis, in addition, perceived a similar condition in the transition from hypnotic sleep to waking, which he called *delire posthypnotique*, and, instead of using the word “fascination” to express the opening stage, he substituted “captation.” According to him, the diagram would be the following:

[Illustration]

This whole movement, which I have tried to sketch, and whose chief peculiarity is that it considers hypnotism a nervous malady, and one that must be treated clinically and nosographically, was opposed in 1880 in two directions—one source of opposition producing great results, while the other fell to the ground. The latter joined itself to the theory of the mesmerists, and tried, by means of exact experiments, to measure the fluid emanating from the human body—an undertaking which gave slight promise of any satisfactory result.

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Baillif in his thesis (1878) and Chevillard in his (for spiritualists) very interesting books, tried, by means of various arguments, to uphold the fluidic explanation. Despine also thought that by its help he had been able to explain the phenomena; but it was Barety who, in the year 1881, first turned general attention in this direction. According to him, mankind possesses a nerve force which emanates from him in different kinds of streams. Those coming from the eyes and fingers produce insensibility to pain, while those generated by the breath cause hypnotic conditions. This nerve force goes out into the ether, and there obeys the laws that govern light, being broken into spectra, *etc*.

Claude Perronnet has more lately advanced similar views, and his greatest work is now in press. Frederick W.H. Myers and Edmund Gurney sympathize with these views, and try to unite them with the mesmerist doctrine of personal influence and their theory of telepathy. The third champion in England of hypnotism, Prof. Hack Tuke, on the contrary, sympathizes entirely with the Parisian school, only differing from them in that he has experimented with satisfactory results upon healthy subjects. In France this view has lately been accepted by Dr. Bottey, who recognizes the three hypnotic stages in healthy persons, but has observed other phenomena in them, and vehemently opposes the conception of hypnotism as a malady. His excellently written book is particularly commended to those who wish to experiment in the same manner as the French investigator, without using hysterical subjects.

The second counter current that opposed itself to the French neuropathologists, and produced the most lasting impression, is expressed by the magic word "suggestion." A generation ago, Dr. Liebault, the patient investigator and skillful physician, had endeavored to make a remedial use of suggestion in his clinic at Nancy. Charles Richet and others have since referred to it, but Professor Bernheim was the first one to demonstrate its full significance in the realm of hypnotism. According to him, suggestion—that is, the influence of any idea, whether received through the senses or in a hypersensible manner (*suggestion mentale*)—is the key to all hypnotic phenomena. He has not been able in a single case to verify the bodily phenomena of *grandehypnotisme* without finding suggestion the primary cause, and on this account denies the truth of the asserted physical causes. Bernheim says that when the intense expectance of the subject has produced a compliant condition, a peculiar capacity is developed to change the idea that has been received into an action as well as a great acuteness of acceptation, which together will produce all those phenomena that we should call by the name of "pathological sleep," since they are only separable in a gradual way from the ordinary sleep and dream conditions. Bernheim is particularly strenuous that psychology should appear in the foreground of hypnotism, and on this point has been strongly upheld by men like Professors Beaunis and Richet.

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The possibility of suggestion in waking conditions, and also a long time after the sleep has passed off (*suggestions posthypnotiques ou suggestions a (longue) echeance*), as well as the remarkable capacity of subjects to change their personality (*changement de la personnalite objectivation des types*), have been made the subject of careful investigation. The voluntary production of bleeding and stigmata through spiritual influence has been asserted, particularly by Messrs. Tocachon, Bourru, and Burot. The judicial significance of suggestion has been discussed by Professor Liegeois and Dr. Ladame. Professor Pitres in Bordeaux is one of the suggestionists, though differing in many points from the Nancy school.

This whole tendency brings into prominence the psychical influence, while it denies the production of these results from purely physical phenomena, endeavoring to explain them in a different manner. These explanations carry us into two realms, the first of which has been lately opened, and at present seems to abound more in enigmas than in solutions.

Metallotherapie, which was called into existence by Dr. Burg, and further extended by Dr. Gelle, contains a special point of interest—the so-called transference in the case of hysterically or hypnotically affected persons. Transference is caused by electro-magnetism, which has this peculiarity—that in the case of specially sensitive persons it can transfer the bodily affection from left to right, and *vice versa*. The transference of paralysis, the cures attempted on this plan, and the so-called “psychical transference,” which contains special interest for graphologists, are at the present time still open questions, as well as the closely connected theory of human polarity; and the odic experiments of Dr. Chazarain are yet waiting for their confirmation. At present the problem of the connection between magnetism and hypnotism is under investigation, and in such a manner that we may hope for a speedy solution.

Still stranger than these reports are the accounts of the distant operation of certain bodies; at least, they seem strange to those unacquainted with psychometry and the literature of the past century relating to this subject. Two physicians in Rochefort, Professors Bourru and Burot, in treating a hystero-epileptic person, found that gold, even when at a distance of fifteen centimeters, produced in him a feeling of unbearable heat. They continued these experiments with great care, and, after a number of trials, came to this conclusion—that in some persons certain substances, even when carefully separated from them by long distance, exercise exactly the same physiological influence as if introduced into their organism. In order to explain these phenomena, they refer to the radiating force of Barety, an explanation neither satisfactory to themselves nor to others. Lately the distinguished Parisian physician, Dr. Luys, has confirmed by his experiments the existence of these phenomena, but he thinks the explanation referable to hyper-sensitiveness of the “*regions emotives et intellectuelles de l’encephale*” yet even he has not reached the kernel of the difficulty.

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In close connection with action at a distance is the question of distant production of hypnotic sleep. For an answer to this problem, they are experimenting in both France and England; and Frederick W.H. Myers has thrown an entirely new light upon the subject by the investigations he is making upon a purely experimental basis. In Italy they have limited themselves to the study of isolated cases of hystero-hypnotism, except as the phenomena of magnetic fascination investigated by Donato have given rise to further research; but all the books I have seen upon this subject, as well as many by French authors, suffer from ignorance of the latest English discoveries.

With this I think that I have given a slight outline of the history of hypnotic investigation to the end of the year 1886. I shall attempt a criticism of this whole movement at some other time, as space is not afforded to me here; but I should like to make this statement now, that two of the characteristic indications of this period are of the gravest import—first the method ("Our work," says Richet, "is that of strictly scientific *testing*, *observation*, and *arrangement*"); and, secondly, the result. Hypnotism has been received into the realm of scientific investigation, and with this the foundation of a true experimental psychology has been laid.

MAX DESSOIR.

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THE DUODENUM: A SIPHON TRAP.

By MAYO COLLIER, M.S. Lond., F.R.C.S. Eng.;
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We may take it for granted that all gases generated in the jejunum, ileum, and large intestines pass onward toward the anus, and there sooner or later escape. Fetid gases—except those generated in the stomach and duodenum—never pass upward, not even during vomiting due to hernia, obstruction, and other causes. Physiologists, it would appear, have never busied themselves to find an explanation for this apparent breach of the laws of gravity. The intestinal canal is a tube with various dilatations and constrictions, but at no spot except the pylorus does the constriction completely obliterate the lumen of the tube, and here only periodically. It is perfectly evident, then, that, unless some system of trap exists in the canal, gases are free to travel from below upward in obedience to the laws of gravity, and would, as a matter of fact, sooner or later do so. From the straight, course and vertical position of the oesophagus, a very slight pressure of gas in the stomach easily overcomes the closure of its cardiac sphincter and allows of escape. When the stomach has digested its contents and the pylorus is relaxed, gases generated in the duodenum can and do ascend into the stomach and so escape. Normally, no fetid gases are generated in the stomach or duodenum. If we follow the course of the intestines down, we find that the duodenum presents a remarkable curve.

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Now, there are some points of great interest in connection with this remarkable, almost circular, curve of the duodenum. In the first place, this curve is a constant feature in all mammalians. Mr. Treves says it is one of the most constant features in the anatomy of the intestines in man, and, speaking of mammalians in general, that the curve of the duodenum varies in shape, but is never absent, becoming more complex in some of the higher primates, but seldom less distinct than in man. In birds the duodenum always forms a long loop embracing the pancreas.

A second point of great interest is the absolute constancy and fixation of its terminal portion at the point of junction with the jejunum, more correctly termed second ascending or fourth portion. Mr. Treves says that this fourth portion is never less than an inch, and is practically constant. It extends along the side of the left crus of the diaphragm opposite the second lumbar vertebra, and is there firmly fixed to the front of the aorta and crus of the diaphragm by a strong fibro-muscular band, slinging it up and absolutely retaining it in position. This band has been termed the "musculus suspensorius duodeni," but is chiefly composed of white fibrous tissue, and is more of the native of a ligament than a muscle. This ligament is always present, and its position is never altered. The curve of the duodenum may descend as far as the iliac fossa, but the terminal portion is always maintained by this band in its normal position.

Another point of great constancy is the position of the pancreas and its relation to the curve of the duodenum. The duodenum always curves round the head of the pancreas and is, as it were, moulded on it and retained in position by it. In birds the duodenum always forms a long loop embracing the pancreas. Further, the ducts of the liver and pancreas always open into the center Of the duodenum, either separately or by a common opening.

[Illustration]

Now, the absolute constancy of the curve of the duodenum, the complete fixation of its fourth portion, the position of the pancreas, and the place of entry of the ducts of the pancreas and liver, are all component parts of a siphon trap, whereby gases generated below the duodenum are prevented from passing upward. A reference to the accompanying diagrams will make this quite clear. A is a diagram of a siphon trap copied from Parkes' hygiene. B is a very diagrammatic outline of the stomach and duodenum, *a* is intended to mark the position of the fibrous band, or musculus suspensorius duodeni; and *b* the position of entry of the ducts of the liver and pancreas. The duodenum, then, is a siphon trap, and a most efficient one. Now, the efficiency of a siphon trap depends not only on its shape, but what is absolutely essential is that the curve must be kept constantly full of fluid, without which it ceases to be a trap, and would allow gases to ascend freely. The position of the place of entry of the ducts of the pancreas and liver assures that this *sine qua non* shall be present. The discharge of the secretions of the pancreas and liver, although more active during and after feeding, is practically constant, and so insures in an admirable manner that the curve on which the efficiency of the trap depends shall be constantly kept full not only with fluid, but, as I would suggest, antiseptic fluid. There is no other trap in the intestinal canal, but the peculiar position of the colon would no doubt have more or less effect in preventing gases ascending through the ileo-caecal valve.—*Lancet*.

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WISCONSIN CRANBERRY CULTURE.

Among the many thousands of well informed persons with whom the cranberry is a staple article of food throughout the autumn and winter, and who especially derive from its pungent flavor sharp relish for their Thanksgiving and Christmas turkey, not one in ten has any definite idea as to where the delicious fruit comes from, or of the method of growing and harvesting it. Most people are, however, aware that it is raised on little “truck patches” somewhere down in New Jersey or about Cape Cod, and some have heard that it is gleaned from the swamps in the Far West by Indians and shipped to market by white traders. But to the great majority its real history is unknown.

Yet the cranberry culture is an industry in which millions of dollars are invested in this country, and it gives employment, for at least a portion of each year, to many thousands of people. In the East, where the value of an acre of even swamp land may run up into the thousands of dollars, a cranberry marsh of five or ten acres is considered a large one, and, cultivated in the careful, frugal style in vogue there, may yield its owner a handsome yearly income. But in the great, boundless West, where land, and more especially swamp land, may be had for from $1 to $5 an acre, we do these things differently, if not better.

The State of Wisconsin produces nearly one-half of the cranberries annually grown in the United States. There are marshes there covering thousands of acres, whereon this fruit grows wild, having done so even as far back as the oldest tradition of the native red man extends. In many cases the land on which the berries grow has been bought from the government by individuals or firms, in vast tracts, and the growth of the fruit promoted and encouraged by a system of dikes and dams whereby the effects of droughts, frost, and heavy rainfalls are counteracted to almost any extent desired. Some of these holdings aggregate many thousands of acres under a single ownership; and after a marsh of this vast extent has been thoroughly ditched and good buildings, water works, *etc*., are erected on it, its value may reach many thousands of dollars, while the original cost of the land may have been merely nominal.

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Large portions of Jackson, Wood, Monroe, Marinette, Juneau, and Green counties are natural cranberry marshes. The Wisconsin Valley division of the Chicago, Milwaukee & St. Paul Railway runs through a closely continuous marsh, forty miles long and nearly as wide, as level as a floor, which is an almost unbroken series of cranberry farms. The Indians, who inhabited this country before the white man came, used to congregate here every fall, many of them traveling several hundred miles, to lay in their winter supply of berries. Many thousands of barrels are now annually shipped from this region; and thus this vast area, which to the stranger looking upon it would appear utterly worthless, is as valuable as the richest farming lands in the State.

In a few instances, however, this fruit is cultivated in Wisconsin in a style similar to that practiced in the East; that is, by paring the natural sod from the bog, covering the earth to a depth of two or three inches with sand, and then transplanting the vines into soil thus prepared. The weeds are then kept down for a year or two, when the vines take full possession of the soil, and further attention is unnecessary. The natural "stand" of the vines in the sod is so productive, however, and the extent of country over which bountiful nature has distributed them so vast, that few operators have thought it necessary to incur the expense of special culture.

One of the best and most perfectly equipped marshes in Wisconsin is owned by Mr. G.B. Sackett, of Berlin. It is situated four miles north of that village, and comprises 1,600 acres, nearly all of which is a veritable bog, and is covered with a natural and luxuriant growth of cranberry vines. A canal has been cut from the Fox River to the southern limit of the marsh, a distance of 4,400 ft. It is 45 ft. wide, and the water stands in it to a depth of nine feet, sufficient to float fair sized steamboats. At the intersection of the canal with the marsh steam water works have been erected, with flood gates and dams by means of which the entire marsh may be flooded to a depth of a foot or more when desired. There are two engines of 150 horse power each, and two pumps that are capable of raising 80,000 gallons per minute.

When, in early autumn, the meteorological conditions indicate the approach of frost, the pumps may he put to work in the afternoon and the berries be effectually covered by water and thus protected before nightfall. At sunrise the gates are opened and the water allowed to run off again, so that the pickers may proceed with their work. The marsh is flooded to a depth of about two feet at the beginning of each winter and allowed to remain so until spring, the heavy body of ice that forms preventing the upheaval that would result from freezing and thawing—a natural process which, if permitted, works injury to the vines.

There is a three-story warehouse on the marsh, with a capacity of 20,000 barrels of berries, and four large two-story houses capable of furnishing shelter for 1,500 pickers. The superintendent's residence is a comfortable cottage house, surrounded by giant oaks and elms, and stands near the warehouse on an "island," or small tract of high, dry land near the center of the great marsh. The pickers' quarters stand on another island about 200 yards away.

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A plank roadway, built on piles, about two feet above the level of the ground, leads from the mainland to the warehouse and other buildings, a distance of more than half a mile. Several wooden railways diverge from the warehouse to all parts of the marsh, and on them flat cars, propelled by hand, are sent out at intervals during the picking season to bring in the berries from the hands of the pickers. Each picker is provided with a crate, holding just a bushel, which is kept close at hand. The berries are first picked into tin pans and pails, and from these emptied into the crates, in which they are carried to the warehouse, where an empty crate is given the picker in exchange for a full one. Thus equipped and improved, the Sackett marsh is valued at $150,000. Thirteen thousand barrels have been harvested from this great farm in a single season. The selling price in the Chicago market varies, in different seasons, from $8 to $16 per barrel. There are several other marshes of various sizes in the vicinity.

The picking season usually begins about Sept. 1, and from that time until Oct. 1 the marshes swarm with men, women, and children, ranging in age from six to eight years, made up from almost every nationality under the sun. Bohemians and Poles furnish the majority of the working force, while Germans, Irish, Swedes, Norwegians, Danes, negroes, Indians, and Americans contribute to the motley contingent. They come from every direction and from various distances, some of them traveling a hundred miles or more to secure a few days' or weeks' work. Almost every farmer or woodsman living anywhere in the region of the marshes turns out with his entire family; and the families of all the laboring men and mechanics of the surrounding towns and cities join in the general hegira to the bogs, and help to harvest the fruit. Those living within a few miles go out in the morning and return home at night, taking their noon-day meal with them, while those from a distance take provisions and bedding with them and camp in the buildings provided for that purpose by the marsh owners, doing their own cooking on the stoves and with the fuel furnished them.

The wages vary from fifty cents to a dollar a bushel, owing to the abundance or scarcity of the fruit. A good picker will gather from three to four bushels a day where the yield is light, and five to six bushels where it is good. The most money is made by families numbering from half a dozen to a dozen members. Every chick and child in such families over six years old is required to turn out and help swell the revenue of the little household, and the frugal father often pockets ten to twenty dollars a day as the fruits of the combined labors. The pickers wade into the grass, weeds, and vines, however wet with dew or rain, or however deeply flooded underneath, making not the slightest effort to keep even their feet dry, and after an hour’s work in the morning are almost as wet as if they had swum a river. Many

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of them wade in barefooted, others wearing low cowhide shoes, and their feet, at least, are necessarily wet all day long. In many cases their bodies are thinly clad, and they must inevitably suffer in frosty mornings and evenings and on the raw, cold, rainy days that are frequent in the autumn months in this latitude; yet they go about their work singing, shouting, and jabbering as merrily as a party of comfortably clad school children at play. How any of them avoid colds, rheumatism, and a dozen other diseases is a mystery; and yet it is rarely that one of them is ill from the effects of this exposure. As many as 3000 or 4000 pickers are sometimes employed on a single marsh when there is a heavy crop, and an army of such ragamuffins as get together for this purpose, scattered over a bog in confusion and disorder, presents a strange and picturesque appearance.

Indians are not usually as good pickers as white people, but in the sparsely settled districts, where many of the berry farms are situated, it is impossible to get white help enough to take care of the crop in the short time available for the work, and owners are compelled to employ the aborigines. A rake, with the prongs shaped like the letter V, is used for picking in some cases, but owing to the large amount of grass and weeds that grow among the vines on these wild marshes, this instrument is rarely available. After being picked the berries are stored in warehouses for a period varying from one to three weeks. They are washed and dried by being passed through a fanning mill made for the purpose, and are then allowed to cure and ripen thoroughly before they are shipped to market.

From statistics gathered by the American Cranberry Growers' Association it is learned that in 1883 Wisconsin produced 135,507 bushels, in 1884 24,738 bushels, in 1885 264,432 bushels, and in 1886 70,686 bushels of this fruit. By these figures it will be seen that the yield is very irregular. This is owing, principally, to the fact that many of the marshes are not yet provided with the means of flooding, and of course suffer from worms, droughts, late spring or early autumn frosts, and extensive fires started by sparks from the engines on railroads running through the marshes. These and various other evils are averted on the more improved farms. So that, while handsome fortunes have in many cases been made in cranberry growing, many thousands of dollars have, on the other hand, been sunk in the same industry. Only the wealthier owners, who have expended vast sums of money in improving and equipping their property, can calculate with any degree of certainty on a paying crop of fruit every year.

Chicago is the great distributing point for the berries produced in Wisconsin, shipments being made thence to nearly every State and Territory in the Union, to Canada, to Mexico, and to several European countries. Berries sent to the Southern markets are put up in watertight packages, and the casks are then filled with water, this being the only means by which they can be kept in hot weather. Even in this condition they can only be kept a few days after reaching hot climates.—*American Magazine*.

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SOUDAN COFFEE.

(*Parkia biglobosa*.)

There are valuable plants on every continent. Civilized Europe no longer counts them. Mysterious Africa is no less largely and spontaneously favored with them than young America and the ancient territory of Asia.

The latter has given us the majority of the best fruits of our gardens. We have already shown how useful the butter tree (*Butyrospermum Parkii*) is in tropical Africa, and we also know how the *gourou* (*Sterculia acuminata*) is cultivated in the same regions. But that is not all, for the great family of Leguminosae, whose numerous representatives encumber this continent, likewise furnishes the negro natives a food that is nearly as indispensable to them as the *gourou* or the products of the baobab—another valuable tree and certainly the most widely distributed one in torrid Africa. This leguminous tree, which is as yet but little known in the civilized world, has been named scientifically *Parkia biglobosa* by Bentham. The negroes give it various names, according to the tribe; among the Ouloffs, it is the *houlle*; among the Mandigues, *naytay*; in Cazamance (Nalon language), it is *nayray*; in Bornou, *rounuo*; in Haoussa, *doroa*; in Hant-fleure (Senegal), *nayraytou*. On the old mysterious continent it plays the same role that the algarobas do in young America. However, it is quite a common rule to find in the order Leguminosae, and especially in the section Mimosae, plants whose pods are edible. Examples of this fact are numerous.

As regards the Mediterranean region, it suffices to cite the classic carob tree (*Ceratonia siliqua*), which also is of African nationality, but which is wanting in the warm region of this continent.

Throughout the tropical region of Africa, the aborigines love to consume the saccharine pulp and the seed contained in the pod of the *houlle*. Prepared in different ways, according to tribe and latitude, these two products constitute a valuable aliment. The pulp is consumed either just as it is or as a fermented beverage. As for the seeds, they serve, raw or roasted, for the production of a tea-like infusion (whence the name “Soudan coffee"), or, after fermentation in water, for making a national condiment, which in certain places is called *kinda*, and which is mixed with boiled rice or prepared meats. This preparation has in most cases a pasty form or the consistency of cohesive flour; but in order to render its carriage easier in certain of the African centers where the trade in it is brisk, it is compressed into tablets similar to those of our chocolate. As these two products are very little known in Europe, it has seemed to us that it would be of interest to give a description and chemical analysis of them. We shall say but little of the plant, which has sufficiently occupied botanists.

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[Illustration: Figs. 1 TO 6.—PODS
OF THE HOULLE AND MICROSCOPIC DETAILS.]

The houlle (*Parkia biglobosa*) is a large tree from 35 to 50 feet in height, with a gray bark, many branches, and large, elegant leaves. The latter are compound, bipinnate (Fig. 7), and have fifty pairs of leaflets, which are linear and obtuse and of a grayish green. The inflorescence is very pleasing to the eye. The flowers, say the authors of the *Florae Senegambiae Tentamen*, form balls of a dazzling red, contracted at the base, and resembling the pompons of our grenadiers (Fig. 8). The support of this latter consists only of male flowers. The fruit that succeeds these flowers is supported by a club-shaped receptacle. It consists of a large pod, which at maturity is 13 inches in length by 10 in width (Fig. 1). This pod is chocolate brown, quite smooth or slightly tubercular, and is swollen at the points where the seeds are situated. The pods are straight or slightly curved. The aborigines of Rio Nunez use the pods for poisoning the fishes that abound in the watercourses. We do not know what the nature of the toxic principle is that is contained in these hard pods, but we well know the nature of the yellowish pulp and of the seeds that entirely fill the pods.

[Illustration: Fig. 7.—PARKIA BIGLOBOSA.]

Although the pulp forms a continuous whole, each seed easily separates from the following and carries with it a part of the pulp that surrounds it and that constitutes an independent mass (Fig. 2). This pulpy substance, formed entirely of oval cells filled with aleurone, consists of two distinct layers. The first, an external one of a beautiful yellow, is from 10 to 15 times bulkier than the internal one, which likewise is of a beautiful yellow.

[Illustration: Fig. 8—FLOWERS OF PARKIA.]

It detaches itself easily from the seed, while the internal layer, which adheres firmly to the exterior of the seed, can be detached only by maceration in water. This fresh pulp has a sweet and agreeable although slightly insipid taste. Upon growing old and becoming dry, it takes on a still more agreeable taste, for it preserves its sweetness and gets a perfume like that of the violet.

As for the seed, which is of a brown color and provided with a hard, shining skin, that is 0.4 inch long, 0.3 inch wide, and 0.2 inch thick. It is oval in form, with quite a prominent beak at the hilum (Fig. 4). The margin is blunt and the two convex sides are provided in the center with a gibbosity limited by a line parallel with the margin, and this has given the plant its specific name of *biglobosa*. The mean weight of each seed is 41/2 grains. The skin, though thick, is not very strong. It consists, anatomically, of four layers (Fig. 5) of a thick cuticle, *c*; of a zone of palissade cells, *z p*; of a zone of cells with thick tangential walls arranged in a single row; and of a zone tougher than the others, formed of numerous cells with thick walls, without definite form, and filled with a blackish red coloring matter, *cs*. This perisperm covers an exalbuminous embryo formed almost entirely of two thick, greenish yellow cotyledons having a strong taste of legumine.

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When examined under the microscope, these cotyledons, the alimentary part of the seed, have the appearance represented in Fig. 6, where *ep* is the epidermic layer and *cp* constitutes the uniform parenchyma of the cotyledonary leaf. This parenchymatous mass consists of oval cells filled with fatty matter and granules of aleurone.

According to some chemical researches made by Professor Schlagdenhauffen, the pulp has the following composition per 100 parts:

Fatty matter	2.407
Glucose	33.92
Inverted sugar	7.825
Coloring matter and free acids	1.300
Albuminous matter	5.240
Gummy matter	19.109
Cellulose	8.921
Lignose	17.195
Salts	4.080

Total	100.000

The salient point of these analytical results is the enormous quantity of matter (nearly 60 per cent.) formed almost exclusively by sugar. It is not surprising, from this that this product constitutes a food both agreeable and useful.

An analysis of the entire seed, made by the same chemist, has given the following results:

Solid fatty matter	21.145
Unreduced sugar	6.183
Undetermined matters	5.510
Gummy "	10.272
Albuminoid "	24.626
Cellulosic "	5.752
Lignose and losses	20.978
Salts	5.534

Total	100.000

The presence in these seeds of a large quantity of fatty matters and sugar, and especially of albuminoid matters (very nutritive), largely justifies the use made of them as a food. The innate instinct of the savage peoples of Africa has thus anticipated the data of science.—*La Nature*.

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THE HEIGHT OF SUMMER CLOUDS.

A knowledge of the heights and movements of the clouds is of much interest to science, and of especial importance in the prediction of weather. The subject has therefore received much attention during recent years from meteorologists, chiefly in this country and in Sweden. In the last published report of the Meteorological Council for 1885-86 will be found an account of the steps taken by that body to obtain cloud photographs; and in the *Meteorologische Zeitschrift* for March last, M.M. Ekholm and Hagstrom have published an interesting summary of the results of observations made at Upsala during the summers of 1884-85. They determined the parallax of the clouds by angular measurements made from two stations at the extremities

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of a base of convenient length and having telephonic connection. The instruments used were altazimuths, constructed under the direction of Prof. Mohn, specially for measuring the parallax of the aurora borealis. A full description of these instruments and of the calculations will be found in the *Acta Reg Soc. Sc. Ups.*, 1884. The results now in question are based upon nearly 1,500 measurements of *heights*; the *motions* will form the subject of a future paper. It was found that clouds are formed at all levels, but that they occur most frequently at certain elevations or stages. The following are, approximately, the mean heights, in feet, of the principal forms: Stratus, 2,000; nimbus, 5,000; cumulus (base) 4,500, (summit) 6,000; cumulo-stratus (base), 4,600; “false-cirrus” (a form which often accompanies the cumulo-stratus), 12,800; cirro cumulus, 21,000; cirrus, 29,000 (the highest being 41,000). The maximum of cloud frequency was found to be at levels of 2,300 and 5,500 feet.

Generally speaking, all the forms of cloud have a tendency to rise during the course of the day; the change, excepting for the cumulus form, amounting to nearly 6,500 feet. In the morning, when the cirrus clouds are at their lowest level, the frequency of their lowest forms—the cirro-cumulus—is greatest; and in the evening, when the height of the cirrus is greatest, the frequency of its highest forms—the cirro-stratus—is also greatest. With regard to the connection between the character of the weather and the height of the clouds, the heights of the bases of the cumulus are nearly constant in all conditions. The summits, however, are lowest in the vicinity of a barometric maximum. They increase in the region of a depression, and attain their greatest height in thunderstorms, the thickness of the cumulo stratus stretching sometimes for several miles. The highest forms of clouds appear to float at their lowest levels in the region of a depression. The forms of clouds are identical in all parts of the world, as has been shown in papers lately read by the Hon. R. Abercromby before the English and Scottish Meteorological Societies.—*Nature*.

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ON THE CAUSE OF IRIDESCENCE IN CLOUDS.

By G. JOHNSTONE STONEY.

When the sky is occupied by light cirro-cumulus cloud, an optical phenomenon of the most delicate beauty sometimes presents itself, in which the borders of the clouds and their lighter portions are suffused with soft shades of color like those of mother-of-pearl, among which lovely pinks and greens are the most conspicuous. Usually these colors are distributed in irregular patches, just as in mother-of-pearl; but occasionally they are seen to form round the denser patches of cloud a regular colored fringe, in which the several tints are arranged in stripes following the sinuosities of the outline of the cloud.

I cannot find in any of the books an explanation of this beautiful spectacle, all the more pleasing because it generally presents itself in delightful summer weather. It is not mentioned in the part of Moigno's great *Repertoire d'Optique* which treats of meteorological optics, nor in any other work which I have consulted. It seems desirable, therefore, to make an attempt to search out what appears to be its explanation.

At the elevation in our atmosphere at which these delicate clouds are formed the temperature is too low, even in midsummer, for water to exist in the liquid state; and accordingly, the attenuated vapor from which they were condensed passed at once into a solid form. They consist, in fact, of tiny crystals of ice, not of little drops of water. If the precipitation has been hasty, the crystals will, though all small, be of many sizes jumbled together, and in that case the beautiful optical phenomenon with which we are now dealing will not occur. But if the opposite conditions prevail (which they do on rare occasions), if the vapor had been evenly distributed, and if the precipitation took place slowly, then will the crystals in any one neighborhood be little ice crystals of nearly the same form and size, and from one neighborhood to another they will differ chiefly in number and size, owing to the process having gone on longer or taken place somewhat faster, or through a greater depth, in some neighborhoods than others. This will give rise to the patched appearance of the clouds which prevails when this phenomenon presents itself. It also causes the tiny crystals, of which the cloud consists, to grow larger in some places than others.

Captain Scoresby, in his "Account of the Arctic Regions," gives the best description of snow crystals formed at low temperatures with which I am acquainted. From his observations it appears—(a) that when formed at temperatures several degrees below the freezing point, the crystals, whether simple or compound, are nearly all of symmetrical forms; (b) that thin tabular crystals are extremely numerous, consisting either of simple transverse slices of the fundamental hexagon or, more frequently, of aggregations of these attached edgewise and lying in one plane; and (c) that, according as atmospheric conditions vary, one form of crystal or another largely preponderates. A fuller account of these most significant observations is given in the appendix to this paper.

Let us then consider the crystals in any one neighborhood in the sky, where the conditions that prevail are such as to produce lamellar crystals of nearly the same thickness. The tabular plates are subsiding through the atmosphere—in fact, falling toward the earth. And although their descent is very slow, owing to their minute size, the resistance of the air will act upon them as it does upon a falling feather. It will cause them, if disturbed, to oscillate before they settle into that horizontal

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position which flat plates finally assume when falling through quiescent air. We shall presently consider what the conditions must be, in order that the crystals may be liable to be now and then disturbed from the horizontal position. If this occasionally happens, the crystals will keep fluttering, and at any one moment some of them will be turned so as to reflect a ray from the sun to the eye of the observer from the flat surface of the crystal which is next him. Now, if the conditions are such as to produce crystals which are plates with parallel faces, and as they are also transparent, part only of the sun's ray that reaches the front face of the crystal will be reflected from it; the rest will enter the crystal, and, falling on the parallel surface behind, a portion will be there reflected, and passing out through the front face, will also reach the eye of the observer.

These two portions of the ray—that reflected from the front face and that reflected from the back—are precisely in the condition in which they can interfere with one another, so as to produce the splendid colors with which we are familiar in soap bubbles. If the crystals are of diverse thicknesses, the colors from the individual crystals will be different, and the mixture of them all will produce merely white light; but if all are nearly of the same thickness, they will transmit the same color toward the observer, who will accordingly see this color in the part of the cloud occupied by these crystals. The color will, of course, not be undiluted; for other crystals will send forward white light, and this, blended with the colored light, will produce delicate shades in cases where the corresponding colors of a soap bubble would be vivid.

We have now only to explain how it happens that on very rare occasions the colors, instead of lying in irregular patches, form definite fringes round the borders of the cloudlets. The circumstances that give rise to this special form of the phenomenon appear to be the following: While the cloud is in the process of growth (that is, so long as the precipitation of vapor into the crystalline state continues to take place), so long will the crystals keep augmenting. If, then, a cloudlet is in the process of formation, not only by the springing up of fresh crystals around, but also by the continued growth of the crystals within it, then will that patch of cloud consist of crystals which are largest in its central part, and gradually smaller as their situation approaches the outside. Here, then, are conditions which will produce one color round the margin of the cloud, and that color mixed with others, and so giving rise to other tints, farther in. In this way there comes into existence that iris-like border which is now and then seen.

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The occasional upsetting of the crystals, which is required to keep them fluttering, may be produced in any of three ways. The cloudlets may have been formed from the blending together of two layers of air saturated at different temperatures, and moving with different velocities or in different directions. Where these currents intermix, a certain amount of disturbance will prevail, which, if sufficiently slight, would not much interfere with the regularity of the crystals, and might yet be sufficient to occasion little draughts, which would blow them about when formed. Or, if the cold layer is above, and if it is in a sufficient degree colder, there need not be any previous relative motion of the two layers; the inevitable convection currents will suffice. Another, and probably the most frequent, cause for little breezes in the neighborhood of the cloudlets is that when the cloudlets are formed they immediately absorb the heat of the sun in a way that the previously clear air had not done. If they absorb enough, they will rise like feeble balloons, and slight return currents will travel downward round their margins, throwing all crystals in that situation into disorder.

I do not include among the causes which may agitate the crystals another cause which must produce excessively slight currents of air, namely, that arising from the subsidence of the cloudlets owing to their weight. The crystals will fall faster wherein cloud masses than in the intervening portions where the cloud is thinner. But the subsidence itself is so slow that any relative motions to which differences in the rate of subsidence can give rise are probably too feeble to produce an appreciable effect. Of course, in general, more than one of the above causes will concur; and it is the resultant of the effects which they would have separately produced that will be felt by the crystals.

If the precipitation had taken place so very evenly over the sky that there were no cloudlets formed, but only one uniform veil of haze, then the currents which would flutter the crystals may be so entirely absent that the little plates of crystals can fixedly assume the horizontal position which is natural to them. In this event the cloud will exhibit no iridescence, but, instead of it, a vertical circle through the sun will present itself. This, on some rare occasions, is a feature of the phenomenon of parhelia.

It thus appears that the occasional iridescence of cirrus clouds is satisfactorily accounted for by the concurrence of conditions, each of which is known to have a real existence in nature....—*Phil. Mag., July 1887.*

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