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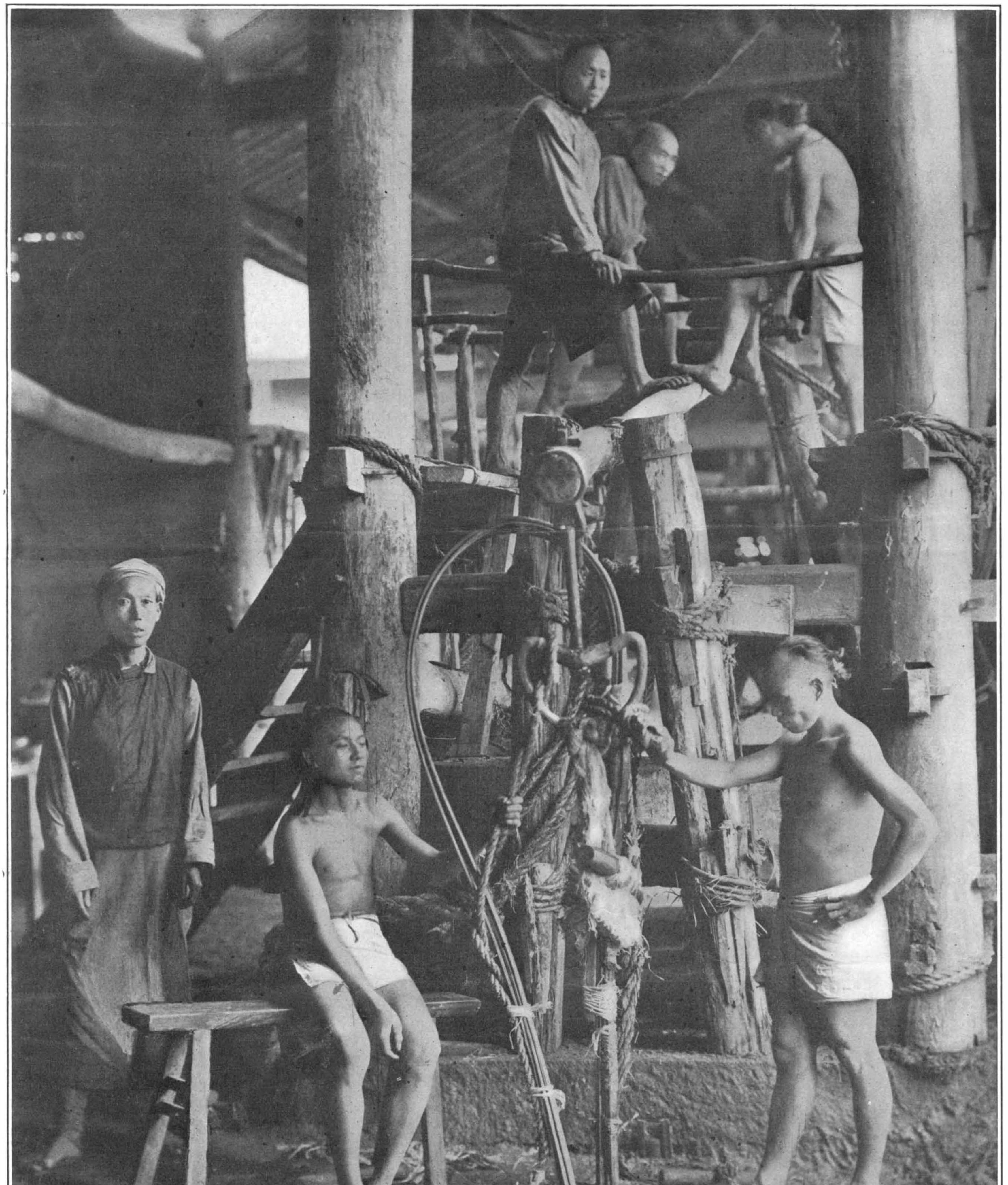


Drilling a salt well in China. By these primitive devices, the prototypes of modern machinery, wells over three thousand feet in depth are drilled. This method of drilling has been in use for over a thousand years.

THE SALT WELLS OF TZULIUTSING.—[See page 324.]

The Distribution of Gaseous Matter*

Throughout Interstellar or Cosmic Space

By Theodore William Schaeffer, M. D.

It has been supposed for a long time that the space that separates us from the sun is a desolate void not containing any air or other known substances of a gaseous like nature, except the mythical something or hypothetical medium called the ether, by means of which energy is transmitted in form of undulations through space. In a similar manner it has been supposed for a long time that this same immensity of space is at absolute zero temperature, having so been affirmed with an evident assurance of certainty and supported by a plausible display of mathematical calculations. The first supposition has just been successfully assailed by a few eminent scientists and there appears to be a gradual natural philosophical regression with respect to this conception which was firmly believed until recently. The second suppositioon, however, that of the assumed absolute zero temperature of space, has not been courageously attacked by men of science. It still flourishes in scientific works as a pet, traditional, scientific fiction.

ANCIENT AND MODERN VIEWS OF OUR ATMOSPHERE AND HEAVENLY SPACE.

In antiquity, when it was assumed that the earth stood still in the center of the world, the ancients concerned themselves but little about the limits of the terrestrial atmosphere. The region of the clouds, lightning and meteors was considered the upper boundary of the atmosphere.

Anaximenes of Milet and Diogenes of Apollonia, who lived in the 5th century B. C., placed the primordial matter of all things in the air. A distinction was made even in antiquity between the air and the ether (Aristoteles). During those times it was not perfectly clear whether the ether possessed the all-penetrating importance that is given to it to-day in our physical theories or whether the ether, unlike the air, was to be considered the essential material medium filling the heavenly space beyond the highest strata of the air. This uncertainty, however, of the limitations of the atmosphere vanished as soon as a rotary movement of the earth and subsequently a revolution around the sun became known.

According to the nebular hypothesis of Kant and Laplace the whole interstellar or cosmic space was originally filled with gaseous matter, including air.

THE HITHERTO PREVAILING IDEAS OF THE HEIGHT OF THE ATMOSPHERE OF THE EARTH AND THE MATERIAL CONDITIONS OF THE COSMIC SPACE.

The atmospheric envelope surrounds the solid body of the earth in the form of a hollow spheroid. Its height has been calculated from the instant that meteors flash and after the disappearance of the blue color of the sky when twilight is approaching and after other signs, to be approximately from 200 to 250 kilometers. Of course, these figures are only of relative value and for the time being. But beyond and further into space rarefied gases fill the space between the planets and the sun: gases which we have designated in anthithesis to the atmosphere of the earth as the atmosphere of the heavens and which are clearly to be differentiated from the ether, that assumed medium, which is supposed to fill all intermolecular space of ponderable matter and which transmits the electrical, heat and light phenomena. While the atmosphere of the earth still participates in the movements of the earth, there are other and more distant strata of the air that no longer or not so completely take part in the rotation of the earth, i. e., remaining relatively quiescent, but are, nevertheless, carried along in the moments of the earth around the sun and then further on as the earth, including the whole planetary system, wanders through the world of space.

A numerical limit between the heavenly atmosphere and the atmosphere of the earth has not been estimated, says Supan,[1] but from the observations of the "silvery clouds" (Jesse's night clouds) we know that already at a height of 82 kilometers the strata of air are no longer in full dependence on the rotation of the earth.

From certain perturbations or so-ocalled movements of resistance observed in cometary formations in the inner space which is in proximity to the sun, we infer the presence of ponderous cosmic matter, gaseous and ultra gaseous elements, besides the universal ether. If our cosmic space were filled exclusively with the universal ether we should not anticipate any perceptible resistance offered to the movements of the earth. Inhibitory effects, however, have been noticed in the movements of swarms of fine particles of cosmic matter out of which certain cometary forms are composed. This resistance has been clearly proven to be the case in a striking resistance with Encke's comet. There is a constant presence of material elements of a coarser kind existing in the space surrounding the sun between the planetary paths. In short, it can now be maintained with great certainty that the space of our planetary system is not only filled with the ideal medium called the ether, but also with small and very minute elementary masses of a solid or gaseous nature, and, furthermore, probably a part of these material elements describe a planetary movement around the sun, whereby the resisting action of this part that fills the space against the movements of the planets is naturally diminished. On the other hand, another part of the material elements, essentially under the influence of the power of the attraction of the sun, attracted by the latter from their cometary paths of the outer planetary space, wander through our system and at the same time cross the paths of different planets, and finally penetrate very often their very atmosphere as well as the atmosphere of our earth.

It is evident that in such a manner cosmic matter, of a solid nature, containing occluded gaseous matter, enters our atmosphere with great velocity and often in a state of incandescence. The whole problem of the conditions of the highest strata of the atmosphere becomes indeed important if we conceive of a space filled with cosmic dust gaseous and ultra gaseous matter. It is indeed conceivable that traces of counter actions occur in the highest strata of the air, where very complicated and peculiar movements must obtain We refer to the illuminated trail of meteors or shooting stars, luminous clouds, etc., that leave a lighted path along their passage. To all these phenomena we have first of all no other choice than the assumption of counter actions of a cosmically filled space through which the earth, in its path around the sun, is moving with the enormous velocity of 30,000 meters per second.[2]

Arrhenius[3] has calculated the amount of matter that falls upon the earth from cosmic space to be about 200 tons a year. The action of this dust is, nevertheless, considerable on account of its fine attenuation and it should constitute a far larger amount in the higher strata of the air than is furnished by the downfall of meteors or falling stars. These particles of matter carry off gases from the sun which are capable of condensing on their surface which existed originally in the chromosphere and corona of the sun. Particles of dust take up the rays of the sun and give their heat to the individual molecules with which they collide. Ionized gases possess the remarkable property of condensing vapors. Wilson has shown that the negative ions possess this property to a higher degree than the positive ions (by condensation of watery vapor). If, therefore, vapors in the vicinity of the sun, which become cooled, and condensed, the formed drops of water will be precipitated at first upon the negative ions. When the vapors are driven away by "radiation pressure" (Arrhenius) or fall down in consequence of gravity, like the rain-drops in the atmosphere of the earth, they therefore carry the charge of negative electricity, while the corresponding positive electricity remains in the gas (respectively the air). In this way the negative and positive charges are separated from one another and electrical charges may be the result if sufficiently large quantities of electricity are separated from one another. In consequence of these discharges which pass through the gases the latter become luminous, although their temperature may be apparently very low. It is probably worth mentioning that the strongest spectral line of the Northern Light (Aurora Borealis) has been found to belong to the noble gas krypton. As this gas occurs but in minute traces in the atmosphere, it is not improbable that it is carried with the solar dust (occluded) and that its spectrum, therefore, appears on its electrical discharge. Recent investigations make it probable that the noble gases discovered by Ramsay, which are similar to argon, neon and xenon, and which have not yet been separated from the nitrogen spectrum, likewise take part in the formation of the spectrum of the Northern Light. Krypton,[4] found in the infinitesimal proportion of 1 to 20 millions, glimmers in the Northern Light. Of special importance is neon's transmission for electrical light. Air requires 1,000 volts, neon requires but 13 volts. The blue color is absent in the spectrum of neon, its coloring being somewhat red. Indeed, some very interesting experimental researches of Birkeland, published in the Scientific American Supplement, July 5 and 12, 1913, on the Aurora Borealis, render it probable that the phenomena is due to corpuscular radiation proceeding from the sun to earth. Among other things, gases can be ionized by being charged with Röntgen rays, cathode rays or ultra violet light as well as being strongly heated. As the rays of the sun contain much ultra violet light, it is undoubted that the masses of gas in the vicinity of the sun (perchance in the case of comets that come near the sun) are partially ionized and contain positive as well as negative electricity.

GASES ARE CONTINUALLY LEAVING THE ATMOSPHERE OF THE EARTH AS WELL AS OTHER CELESTIAL BODIES AND ESCAPE INTO THE GREAT COSMIC SPACE.

The kinetic theory of gases gives a simple explanation for a number of highly interesting observations which concern the gaseous atmosphere of the heavenly bodies. The hypothesis evolved by the eminent Dublin scientist, Dr. Johnstone Stoney,[5] contains a considerable element of truth. It is simply this: Gases are continually leaving our atmosphere, owing to the intrinsic rate of motion of their molecules. For example, when a molecule of hydrogen arrives at the confines of our atmosphere it may escape, provided its rate of motion is sufficiently rapid. And it may be proven that some molecules of hydrogen possess sufficient velocity to carry them beyond the sphere of the earth's attraction. If given ample time, all molecules of hydrogen would ultimately fly off and would find a home when they reached a body of sufficient mass, and, therefore, of adequate attractive force to retain them permanently. The sun is such a body; and it has been abundantly proven that free hydrogen exists in quantity in the solar atmosphere.[6] The chief objections to Stoney's deductions have been logically removed. Among the gases hydrogen and after this helium and other noble gases, including those of an ultra gaseous nature, play the chief role. Some of these gases occur, though in small quantities, in the atmosphere of the earth, others occur in nebulous masses and larger celestial bodies. As far as hydrogen is concerned, Sieveking and Mitchell maintain that it is not generated in the atmosphere of the earth. From the kinetic theory of gases the inference is drawn that isolated molecules of gas must constantly leave the atmosphere of planets, as soon as their velocity should accidentally become so great that they overcome their attraction. Stoney has drawn attention to the fact that a body that is moving upward from the earth with a velocity of 11.2 kilometers per second would no longer be held back by the gravitational force of the earth, but would fly off into infinity, apart from the consideration of the attraction of the sun. According to the laws of probability there must be some also among the molecules of a gas that have attained the necessary velocity, and, conversely, there are some which are not sufficiently swift, to abandon even the smallest heavenly body. No planet can (in empty space) possess theoretically an absolute permanent atmosphere, and none can have lost it completely. When the number of molecules with sufficient momentum has become very small, then the atmosphere can be actually considered as nearly permanent. For those gases that have a low specific gravity and therefore a greater average velocity (the density of oxygen O is 16 to hydrogen H, the average distance of the path of the molecule H is therefore four times greater) the probability is greater, that single molecules attain accidentally the extraordinary speed that is essential for

*Popular Astronomy.

[1]*Grundzüge der Physischen Erdkunde* von Alexander Supan, 1908, p. 50.

[2]*Von der Erdatmosphäre zum Himmelsraum.* Von Professor Dr. Wilhelm Foerster. 1906, pp. 9-24.

[3]*Das Werden der Welten.* Von Svante Arrhenius, 1907, pp. 4-189.

[4]*Erdmagnetismus, Erdstrom und Polarlicht.* Von Dr. A. Nippoldt, Jr. 1903, p. 120.

[5]Johnstone Stoney, *Astrophysical Journal*, 7, 25 (1898); 9, 1 (1899); 11, 251-357 (1900); *Nature*, 61, 515 (1899).

[6]The Gases of the Atmosphere, the History of their Discovery, by Sir William Ramsay, K. C. B., F. R. S., 1905, pp. 265, 266.

abandoning the atmosphere. Of this kind of gases more escape than from the denser ones. This process will remove in the course of time all gases from the atmosphere of planets of definite mass and force of attraction, whose density is below a certain limit. The velocity that is essential to leave the earth must be 5 times greater than the one necessary to leave the moon, as the potential of the earth is 25 times greater than that of the moon. For this reason the moon can possess but a barely perceptible atmosphere, as even the lightest gases, like hydrogen and helium, have wholly or nearly wholly escaped from the atmosphere of the earth.[7] The often repeated contention, so ably advanced by Friedel, Foerster, Birkeland and others, that the interstellar space is supposed to be filled with fine cosmic dust, representing many elements, seems, therefore, to be of far reaching importance. Birkeland, however, believes that the interstellar space is airless. That originally corpuscular matter in the form of supposed electrons, possessing great penetrative and accumulative powers, should have for ages filled cosmic space, is, indeed, not a new idea. Theoretically, Foerster, Stoney, Friedel[8] and others have for a number of years advanced this supposition. Birkeland, starting with experimental analogues, has studied practically the action of electrical discharges in "vacuum chambers," which he compares with cosmic phenomena like the zodiacal light, etc., which seems to be of great importance in understanding solar phenomena and the evolution of all celestial bodies of the universe.

From these different points of departure of the reflection of the limitation of the atmosphere of the earth we logically come to the conclusion that there is actually no real limit of our atmosphere and that beyond the atmosphere cosmic space must be filled with gases which are exceedingly rarified.

The Position of the Abundant Elements in the Periodic System*

By John Waddell, B.Sc., (Lond)., D.Sc., (Edin).

If we consider the groups of the elements as they are given in the periodic classification there seems to be a relationship that can scarcely be accidental between the atomic weights of the elements and the quantity in the earth's crust.

Lithium, though widespread, is small in quantity, sodium is far more plentiful, the amount of potassium, too, is considerable, while there is little rubidium and still less cæsium. Similarly there is the gradation from little beryllium to much magnesium, less zinc, less cadmium, and again less mercury.

In the third group the same relationships hold between boron, aluminum, and gallium, while the higher members of the group are so rare that it is difficulty to determine their order. In the fourth group silicon far exceeds carbon, titanium is much less abundant, and zirconium is rare.

Though there is much nitrogen in the atmosphere it is overbalanced by the phosphorus in the lithosphere, while arsenic, antimony, and bismuth are found in lessening quantities. Chlorine is more abundant than flourine on the one hand and than bromide and iodine on the other, the last mentioned being least in quantity.

For the most part the elements in what is commonly called the typical series of the periodic table are most abundant, there being two exceptions, one unimportant, the other very conspicuous.

There are two members in the group of inert gases with lower atomic weight than argon, which is by far the most abundant of the group. Argon, however, might almost as logically be placed at the *end* of the typical series as at the *beginning* of the next. Oxygen, though in the series of less atomic weights than the typical series, is not only far more abundant than sulphur, which is in the same group of the typical elements, but nearly equals all other elements put together. Sulphur, selenium, and tellurium follow the general rule.

(*Note.*—After I had written the above I found that Prof. F. W. Clarke, in "The Data of Geochemistry," has given a number of the facts but in a somewhat different form, and contents himself with the statement of fact).

There are various lines of argument that point to the existence of an element with an atomic weight between hydrogen and helium. It has been suggested that it is analogous to the halogens, but I am not aware of any argument for placing it in that group rather than with oxygen. If it belongs to the oxygen group it may well be much more active, the difference between it and oxygen being greater than between flourine and chlorine. In this case its affinity may readily be conceived to be such that not only has it never been isolated but it has not even been suspected, and it is quite possible that compounds of this element with some other have been considered as elementary. This is not without precedent, for an oxide of vanadium was at first thought to be the element, and for a number of years the oxide UrO_2 was considered to be the metal, and what is ordinarily called uranium nitrate is really the nitrate of this oxide. Now, as uranium, which is in Group VI., combines with oxygen in such a manner as to form a compound which was mistaken for an element, may it not be that what is called tellurium is really a compound of an element with an unknown element that may be called suboxygen or hypoxygen? It is noticeable that the difference in atomic weight between antimony and tellurium is more than seven units, whereas the difference between arsenic and selenium is only about four units, and for the most part the difference in atomic weight between the members of the fifth and sixth groups is only one or two units.

We have, then, two facts to account for—first, the comparatively small quantity of elements of high atomic weight, and secondly, the small quantity of elements of the lowest atomic weight. With the exception of oxygen no element with an atomic weight less than sodium exists to the extent of 1 per cent, and if hydrogen is omitted all these elements put together do not reach 0.20 per cent, while sodium, magnesium, aluminum, and silicon combined amount to nearly 38 per cent.

It is almost impossible in this connection not to take into consideration the knowledge we have recently acquired regarding the three elements with the highest atomic weights—uranium, thorium, and radium. These are known to be disintegrating, uranium and thorium slowly, radium comparatively rapidly. Thorium and uranium were known for many years without there being the least suspicion that they were not perfectly stable, and the discovery of their disintegration may be considered almost accidental. We are able to detect their disintegration by its effect upon an electroscope for instance. Probably few of the elements except those only known by their radio-activity disintegrate in this way, but the disintegration may none the less exist. A number of elements were detected by the spectroscope which might otherwise have continued to elude us; our only test for the existence of a still greater number is their radio-activity, and it is quite possible that with other means at our disposal we might be able on the one hand to discover new elements, or on the other hand to show that elements now regarded as stable are in reality unstable. In this case there would be a gradual disappearance of elements of high atomic weight, while the elements of low atomic weight would increase in quantity.

Why, then, do we have only a small quantity of the elements of lowest atomic weight? The answer seems natural—that the disintegration has not gone on long enough or far enough. There has so far not been much accumulation of the elements of lowest atomic weight. In some of the heavenly bodies the disintegration may have gone farther than on the earth. In the sun even the spectroscope does not show the presence of uranium, or thorium, or radium, though helium, which is one product of disintegration of all these elements, is present. The gaseous stars give the spectrum of hydrogen and of helium, while few of the other elements are to be detected. It is generally considered that these are the hottest stars and that they are at an earlier stage of development than the sun. Some of the nebulæ give lines in the spectrum unknown in the sun, which are attributed to an element to which the name nebulium has been given. The atomic weight of this element may be even lower than that of hydrogen.

If the gaseous stars and the nebulæ are the result of disintegration of elements of high atomic weight they would belong to the late stages of development rather than to the early. Though this is different from the view usually held, is it not quite as reasonable that these hot gases are produced by the energy of disintegration as that matter on its first appearance should be at an exceedingly high temperature? So long as we know of no sources of heat except those dependent on masses or molecules coming together, it was natural to conceive of the radiated heat being compensated by contraction of the body or by chemical action, but now that we have discovered that radium by disintegration produces several million times as much heat as the same weight of oxygen and hydrogen by their combination, the high temperature may be accounted for without the assumption that the gases were originally excessively hot.

Why is it that oxygen is in such large quantity? Again we turn to the radio-active elements. These all seem to end with lead, so that there is lead derived from uranium and lead derived from thorium, as well as lead which appears to be without radio-active origin. All these different leads are alike in chemical properties and in spectrum, though there appears to be a difference in atomic weight. So it may be that oxygen is the end or the apparent end of the disintegration of a large number of elements, its change, if it does change, being very slow. The fact that, so far as we know, oxygen wherever obtained has the same atomic weight is a difficulty, but possibly not an insurmountable one. The process by which oxygen is produced from one element may be different from that by which it is produced from another, and the end product may be exactly the same instead of being, as in the case of radio-active elements, simply isotopic.

[7] *Lehrbuch der Meteorologie* von Dr. Julius Hann, 1906, pp. 2, 3.

[8] Johann Friedel, *Petermann's Mittheilungen*, 1905, p. 43.

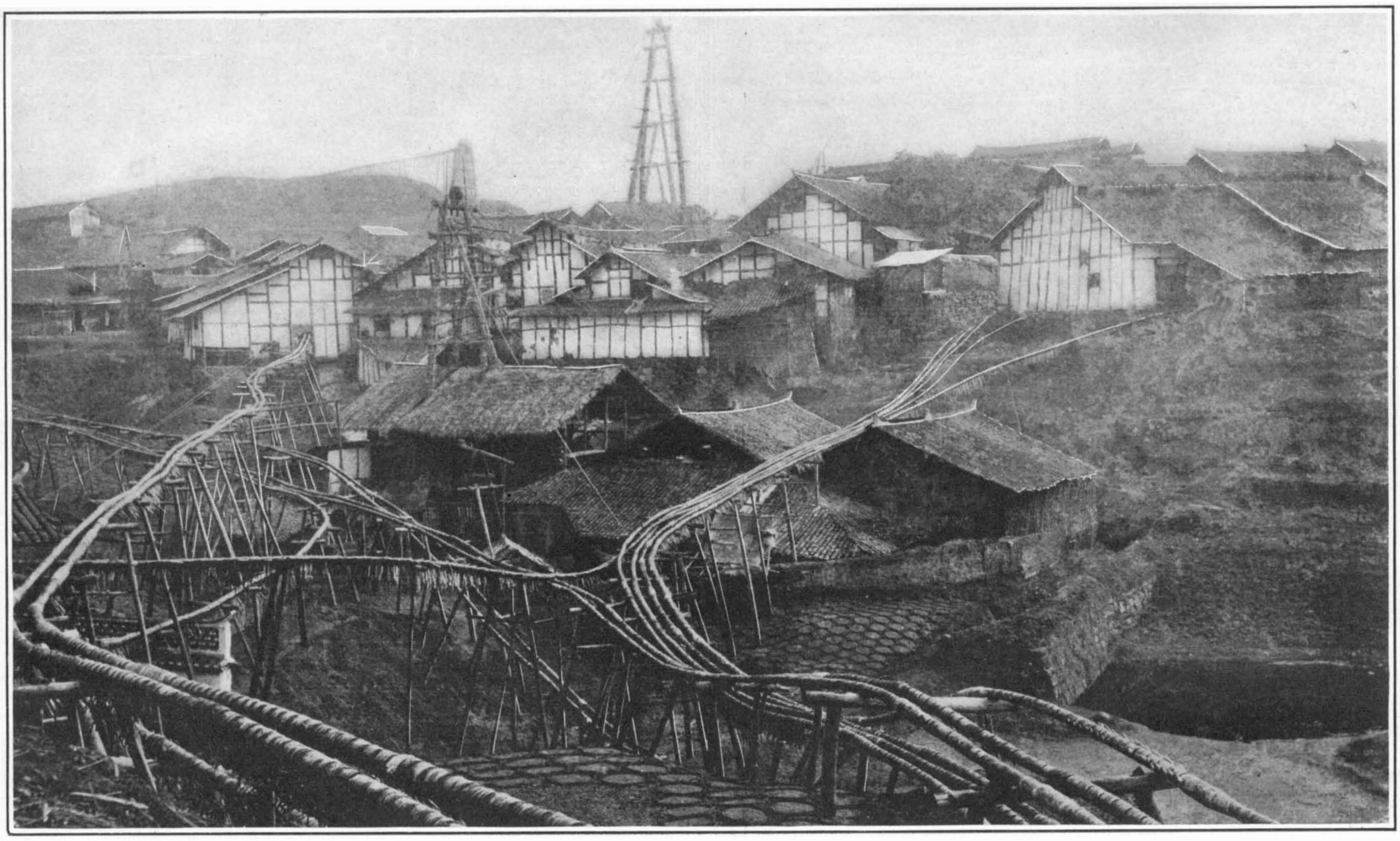
* *The Chemical News.*

French Academy Prizes

The French Academy of Science distributed the following annual prizes for this year. As concerns the Bonaparte Endowment, the amount to be awarded for the present year was 20,500 francs, and after examining thirteen demands, the committee awarded 8 subsidies: 4,000 francs to M. Ch. Alland for his work "Exploration Made by Jeannel and Allaud"; 2,000 francs to M. Boudroit, "The Ants of France"; 2,500 francs to M. P. Lesage, "Vegetation of the French Coast"; 3,000 francs to the Touring Club, "Botanic Garden of Lauteret," in the Alpine region; 3,000 francs to M. Sauvageau, "Fecundation and Development of Laminares"; 2,000 francs to M. Ed. Vigouroux, "Silicon and Metals"; 2,000 francs to Dr. Bayeaux, "Hypodermic Oxygenation"; 2,000 francs to Father Joseph Lais, of the Vatican, for "Map of the Heavens." It should be stated that since the commencement, this Endowment has awarded the sum of 400,000 francs for scientific work.

This year the Academy Prizes were as follows: Mathematics, Grand Prix. The Academy had proposed the following question: "Application of H. Poincaré's Methods to the Integration of Differential Equations," but no papers were received on this subject. A prize of 2,000 francs was awarded to Prof. Noerlund, of the University of Lund, for his work upon linear equations. Mechanics—The Montyon Prize of 700 francs was obtained by Prof. Merigeault of the Saint Etienne School of Mines, for his work, "Theory of Fans and Centrifugal Pumps," and "Theory of Gas and Oil Engines." M. L. Torres y Quevedo, member of the Madrid Academy of Science and an eminent theorician and inventor, received the De Parville Prize of 1500 francs for his calculating machine for solving algebraic equations and for other inventions, one of which, a most interesting electric Chess Player, we had occasion to describe in our columns.

Geography—The Gay Prize of 1,500 francs was awarded to M. Henri Vallot, of the Alpine Club topographic commission, for his topographic work in the French Alps in the Chamonix region. M. Eugene Prévot, a prominent engineer of the Levelling Service, received the Binoux Prize of 2,000 francs. Mineralogy and Geology—The Victor Raulin Prize of 1,500 francs was obtained by Prof. Lapparent for the ensemble of his researches. Botany—M. J. Cardot and the late F. Renault secured the Desmazières Prize of 1,600 francs for their work entitled "Mosses of Madagascar." Anatomy and Zoology—Savigny Prize, 1,500 francs, M. Ed. Lamy, for his malacologic researches. Cuvier Prize—1,500 francs, M. Ed. Chevreaux, for biologic explorations. Medicine and Surgery—Baron Larrey Prize, 750 francs, Dr. Lasnet of the Colonial Troops, "Organization and Working of the Medical Service," with honorable mention to Dr. Tournade, of the French army, "Verdun Field Hospital." History and Science Philosophy—Binoux Prize of 2,000 francs. One-half to J. Bensaude, a Portuguese scientist, "Nautical Astronomy in Portugal at the Time of the Great Discoveries." The remaining half of this prize fell to the late Prof. L. Couturat, of the College de France, for the ensemble of his work, including "Infinity in Mathematics,' 'Algebra of Logic," etc. M. Doublet, of the Bordeaux Observatory, received 500 francs for his researches. General Prizes—Gegner Prize of 4,000 francs. The sum of 2,000 francs fell to M. A. Claude, of the Bureau of Longitudes, and 2,000 francs to Mlle. I. Ioteyko, formerly at the head of the Brussels University Laboratory. Wilde Prize—2,000 francs, to M. Mansuy, an eminent palaeontologist of the Indo-China geologic service, and 2,000 francs to Dr. Garrigou, of Toulouse University. De Parville Prize—1,000 francs to M. A. Barbey, "Forest Entomology"; 500 francs to L. Raveneau, "Geographic Bibliography"; 500 francs to M. D. Bellet, "Man and the Sea"; 500 francs to M. Montoriol, "Telegraphy in France." Houllevigue Prize—5,000 francs, Prof. Bordage, of the Paris University, for the ensemble of his work. The Jean-Reynaud Prize of 10,000 francs was awarded to the late Henri Amagat, Member of the Academy, for his researches.



Bamboo pipe lines for carrying brine in the salt well districts of China. This mode of transportation has been employed there for over a thousand years.

The Salt-Wells of Tzuliutsing

An Ancient Industry of China With Many Unique Features

By H. K. Richardson

TUCKED away in the hills of Szechuen, over a hundred miles from the capital Chengtu, is a city which for its hustle and its energy would be mistaken for an American city, if we did not see the gray tile, one-story houses and the black hair and yellow faces of the inhabitants. This city of nearly a million inhabitants is Tzuliutsing, the location of the most productive and numerous salt wells of the province and of China. Coming upon this city along the road from the nearest treaty port, Chungking, we at first think that we are approaching an oil well district, for on every side we see tall derricks and hear the squeaking of the pulleys and the driving of the buffalo; the hustle is so unusual for China that we are tempted to investigate.

Entering the enclosure surrounding the Great Happiness well we come into full view of the cause of all the noise. We have arrived just as the bailer, a hundred-foot bamboo tube, emerges from the ground; this tube is seized by the attendant and pulled aside over a tub. He then plunges an iron like a meat hook up into the bottom of the tube and the contents of brine come rushing down into the tub. Sometimes the well has gas and oil in small quantities mixed in the brine, and the smell is overcoming to one not accustomed to it. After the brine has run out, the tube is placed over the hole in the ground and allowed to fall. For a few seconds it falls swiftly, but is suddenly checked and ends its minute and a half descent by a gradual stop. This is accomplished by a brake on the winding apparatus. We ask an attendant how deep the well is and he says that it is 2,500 feet Chinese or 2,275 feet English deep. We have a tendency to question this fact, but later we were able to count the rope strands on the winding drum and check the accuracy of the figures. There were wells in the district as deep as 3,600 feet Chinese or 3,996 feet English. After watching the ascent and descent of the bailer we were interested to know where the power came from, so we follow the stranded bamboo rope back to an old thatched roof shed. Here we saw an open wheel that looked like a discarded Ferris wheel, built of wood and bamboo lashed together and laid on its side. This wheel is 18 feet in diameter and will wind about 60 feet of rope on its 16-sided circumference. As we entered the shed the drum was winding up the rope to bring the bailer to the surface. Power is supplied by five water buffalo hitched to the circumference of the drum. With each buffalo is a driver who is continually hitting the big animal under the belly with a knotted rope to hurry him up. As the bailer nears the top the load lightens and the animals are whipped into a run. This, for a slow, plodding animal, is cruel treatment, so that the average use of these animals is not over four years, after which they are traded off to the farmers as part payment on a fresh animal. At last the blue rag on the bamboo rope comes in sight and the animals are slowed down just as the top of the bailer appears over the stone cap of the well, and the brake applied. The brake is a bamboo tube split up its length and opened out to its full width and one end is attached to a post and brought around the top of the drum. The other end is attached loosely but firmly by a rope to an adjacent post.

The buffalo are disconnected from the drum as soon as the bailer is fully out of the well and the brake is set, and when the bailer is empty it is allowed to drop. The big lumbering drum gains speed, revolving about fifty times a minute, creating a small sized cyclone that blows all loose material out of the shed, but before the bailer strikes bottom the rope mender catches the loose end of the brake rope and allows his whole weight to fall upon it, thus slowly bringing the drum to a stop just as it hits the brine at the bottom of the well. The buffalo are quickly attached again before the drum has hardly stopped and are again making the circle to bring up the bailer. One shift of buffalo are used twice, and then allowed to rest for eight hours. It takes from ten to twenty minutes to wind the drum up once, and about eighty trips can be made in a day. A good well will have eighty to one hundred buffalo in its stable. Some fifty men are required to run a well, including the cooks, the drivers and the feed men for the animals. The total expense of the whole well for a day is only $35. Most of the men get only $2.30 a month, including their food. The best wells will produce twenty-seven tons of brine or four tons of salt per day.

From the tub under the bailer the brine flows through bamboo tubes to the evaporator house, and these bamboo tubes form a pipe line that antedates the crude oil pipe lines of this country by over a thousand years. Gravity is made use of as much as possible to get the brine to the evaporator, which is located by the side of a natural gas well. In cases where gravity is insufficient, and the brine has to be raised higher than its source, the Chinese have several very ingenious means of accomplishing this. The simplest means is that of coolie carriage, with two buckets slung from a shoulder pole, carrying the brine up a long incline, and dumping it into a tank set high above the ground, so that from this tank the brine will flow over the hill beyond. Another method is the dragon bone lift, a wood chain pump worked on an incline by a treadmill. These are placed in cascades up the hill side, and the brine pumped up from one to the other. Sometimes a sweep, like the old oaken bucket, is used. A few of these have a continuous chain of buckets and are driven by mules or horses. The pipe line passes over the tops of houses, through the foundations, and, in fact, one can be found almost anywhere.

There is little tampering with the pipe lines, for to do so is a crime with a severe penalty. The bamboo pipe is protected by a cement of chalk and China wood or tung oil applied over a winding of shredded bamboo, and, although it is quite tight, there are a few leaks, and many of the beggars get their salt by catching the drippings or leaching the earth obtained around the pipe lines. The longest line is about seven miles long. In one section of the district the pipe line is not used and the brine is run into small scows, which are poled upstream to an unloading place, where a dragon lift pump is installed to raise the brine and start it across country again to the evaporator.

We next paid a visit to one of the largest evaporator houses where we saw over a hundred pans evaporating the brine to get salt. The pans are cast in the shape of a shallow segment of a sphere, about five feet across, and are four inches deep. These are made of native cast iron, three inches thick in the middle and one half inch thick at the edges. They cost about thirty dollars, and can be used for about seventy heats, when they are cracked so badly that they are traded in for a part

payment on a new pan. The first few cracks are repaired by drilling a hole down through the crack, driving a pin of wrought iron through the hole, putting washers over each end and heading the ends to make a rivet. Thus the cracked piece is held from falling out. This kind of repairing goes on until the pan is all rivets. In the casting of these pans the Chinese use permanent molds made of cement, ventilated all over. They are so expert at this work that even with their crude apparatus they will cast a four-foot pan eight inches deep and only one eighth inch thick.

As we watch, one of the workers dismantles a pan. The pan is set on stone legs like a tripod, over a hole in the ground. In the center of this hole the gas burner is seen; this is a three-inch bamboo tube covered with Chinese cement, made from lime, broken tile hammered fine, and mud or sand. This is applied to all the bamboo joints, and hammered in with a wooden mallet, and makes a very satisfactory protection to the bamboo. The pan is soon ready for another heat, so we watch the setting up operation. First the pan is cleaned off, then the salt crystals from the previous run are spread out over the pan evenly. Fifteen iron side pieces are placed around the edge to make an easily detachable rim, and are held together with mud, over which salt crystals are spread to form a glaze. The cracks between the plates and the pan are treated in the same way. The whole is then heated red hot for eight hours to harden the cement, while the salt over the mud glazes, so the joints are all tight. Into this pan the brine is allowed to trickle continuously. The evaporation is continued until a four to six-inch layer of salt is built up on the bottom of the iron pan. When the evaporation becomes too slow, after about four days, the brine and salt crystals are removed, the salt cake dried, the iron sides removed and the piece of salt, five feet in diameter and four to six inches thick, is set aside to cool. When cool, it is broken up for transit to distant points. It is hard as stone and stands long distance transportation better than the crystals. While the pan is in use thin clay bricks are laid up all around the outside so as to protect the burner from draft and conserve the heat; these are removed when the pan is dismantled, so the pan will cool enough to work on, for there are no valves in the pipe line, and the gas burns continuously once it is lighted. This plant works night and day every day in the year, except, perhaps, at Chinese New Year, when everything stops.

Nearby is the gas well that supplies some two hundred burners, using approximately 20,000 cubic feet of gas per hour. Here surrounded by a big picket fence, and all openings protected so no one could enter, we saw what looked like an ordinary brine well. In fact, there is no difference between a gas and a brine well. A well is driven for brine and if gas is struck it has to be taken care of, so it is burned. There is no smell of gas at the well, and it is not capped, but a cement box is built around the top, close under the ground, to serve as a gas collecting chamber. From the top of the collecting chamber bamboo gas pipes lead to the burners. The suction of the lighted burners is all that is necessary to keep the gas in motion. If gas should be smelled more burners would be lighted. If the pressure falls some burners are put out. If the pressure falls too low, the bailer is dropped down into the well and the brine that has cut off the gas is removed. The pressure then rises so high that there is a superabundance of gas, and some heroic measures must be made to get rid of it. For this purpose there are big auxiliary torches outside of the well, and these are lighted in this case. By intelligent regulation and modern apparatus probably half the gas could be saved. One cannot but admire the wonderful use made of the simple apparatus, so good in idea but so poor in execution, but, even at that, it is of the pattern of A. D. 400 or earlier. Nearby this well we heard a thud-thud-thud and were told that a well was being drilled, so we investigated. Attached to a framework beside the well is a long lever, along both sides of which is a bench. To the short end of the lever is hung the drilling rope; the drill is a twelve-foot iron bar with a four-inch drilling face, weighing two hundred pounds and fashioned like an American rock drill. Above this drill in a bamboo casing is a sinker bar to add weight to the drill and power to the blow. The drill is suspended by a rope made of three pieces of split bamboo, connected to the lever bar by a hemp rope and an iron eye. The lifting of the drill is accomplished by man-power. The drill rope is adjusted so that, with the lever horizontal, the drill rests easily on the bottom of the well. To raise the drill the long arm of the lever is depressed by the men, who place their right foot on the lever to depress it, at the same time stepping across to the opposite bench, thereby releasing the lever, which flies up, and the drill drops. The men about face, depressing the lever again, as they return to their starting place. Five or six men are used, who are divided into squads, which simultaneously cross the lever in opposite directions. They make an average of fifteen to twenty steps a minute, lifting and dropping the drill about a foot each time. Each time the drill rises, the man at the well gives it a half twist. The men work about ten minutes, when they rest while the drill rope is being lengthened. The drilling keeps up night and day, using three shifts of men. A well takes from six to twenty years to drill, although only about four years is used in the actual drilling of the rock; the rest is lost in breakages, litigation and lack of funds. To recover lost tools, etc., the Chinese have invented a number of ingenious tools, some of which are shown in one of the illustrations, and they greatly resemble those used in America at the present time. The average rate of drilling is about three feet in twenty-four hours, and the total cost of drilling a well is from $2,000 to $17,000, varying according to the depth. In case a leak is found in the well and the inflow of fresh water threatens to end it's usefulness, a bunch of coarse grass is rammed down the well below the leak and a mixture of lime, mud and China wood oil is poured on top of the grass. The mixture soon hardens to a cement, when the drill is again used to slowly bore a hole through the cement, when the leak is found to be effectually stopped. The use of this method by the Chinese antedates the use of a similar method in the Oklahoma oil fields by a thousand years.

To start a well a hole is quarried out of the rock to a depth of 200 feet. Into the center of this excavation a wooden pipe, made by hollowing out a tree. is placed. These tree lengths are placed accurately vertical and held firm by stone cribbing, and serve as the guide for starting the drilling aright. They are protected by a limestone cap with a ten-inch hole that prevents the wood from being split by the descending drill.

The production of the district cannot be far from 300,000 tons of salt per year, and this is carried away by pack animals to the north, coolies to the east, and by boat to the south and east. Probably most of the salt leaves by the small river in boats. As there is a scarcity of water the river is dammed at several points, and the boats enter the locks and stay until water enough collects to float them up or down. The coolies carry away about 120 pounds per person. Coming toward the city from the east we meet the string of salt coolies at the rate of one or more a minute all day for three days.

Before the salt leaves the district it has to be given the government salt office chop or stamp, which is an iron rust character placed on the salt. The present salt tax is about $1.25 per 100 catties Chinese, or 133⅓ pounds English. The cost of production of the salt cannot be far from half a cent per pound, and it retails at about two to three cents, according to how far away from the wells it is bought. Road transport costs on the average 1/10 cent per pound per twenty-five miles.

It is estimated by the Chinese that there are 10.000 wells in the district, including many that are abandoned or in process of drilling. The active number is less than half of this figure. The district is some fifteen miles long and over five miles wide.

The people of this town have a hustle and an energy that is more the characteristic of an American oil well district than a Chinese city, and this hustle goes through all their affairs, and the city is very progressive. While not of high rank politically and unwalled, it is the most important commercial town in the province. The wells are mostly owned by wealthy clans, and are the source of the few million dollar fortunes to be found in this part of China.

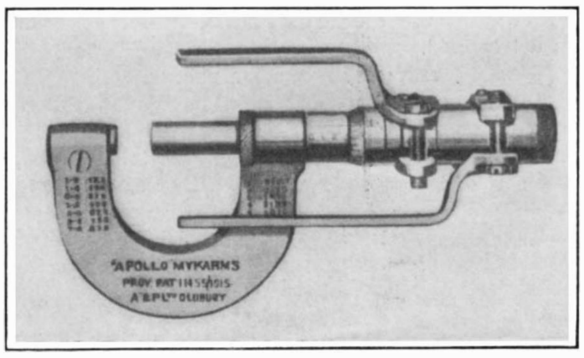
To one who believes that all scientific and technical progress is bound up with the Anglo-Saxon race a visit to this section is an eye-opener. The methods in use here are so evidently the prototypes of and in principle the same as those in use in the well drilling and oil fields of America and Europe that one has a great deal of admiration for the ingenuity of the Chinese, who have been using these methods for over a thousand years. We cannot help asking ourselves the question, if this development was reached so long ago, why did it stop there and remain stationary for this thousand of years and more? A satisfactory answer to this question would be welcomed by many workers in China.

The bailer used for taking out the brine is a bamboo bucket about 3½ inches in diameter and from 60 to 115 feet long, made of carefully joined lengths of bamboo that are strengthened by bands of lashings put on every few inches. The longest of these slender buckets will bring up about 676 pounds of brine at each lift. For operating this bailer a rope of bamboo is used, and this is an inch in diameter, made up of three strands, each composed of about thirty strips of split bamboo, three sixteenth inches wide and one sixty fourth inch thick. These ropes are made in lengths of from 24 to 28 feet long, at a cost of about ten cents. In a 2,600-foot well such a rope lasts about twenty days, and is replaced at the rate of five lengths a day.

All of the apparatus used in drilling wells and producing the salt are primitive, but labor is so cheap that the results attained are quite satisfactory.

A Micrometer Limit Gage Attachment

"Apollo Mykarms" is the name given to a small limit gageing device invented and patented by a British Government inspector for use on standard micrometers. The "Mykarms" attached to a Brown & Sharp micrometer is shown in the accompanying figure. It will be seen that the "Mykarms" consist of a pair of arms made of hardened steel that are constructed to clamp upon the thimble of the micrometer. They are arranged in such a manner as to allow the thimble to make a partial rotation in either direction before bringing one or other of the arms into contact with opposite sides of the horseshoe body of the micrometer. It will be seen that these arms may be adjusted upon the thimble of the micrometer to enable the amount of its rotation to be arranged as required. The ordinary micrometer may thus be converted into a limit gage, having a tolerance ranging from 0.001 inch to 0.022 inch. The value of the "Mykarms" will be readily appreciated by those



A micrometer limit gage attachment.

accustomed to gageing large quantities of repetition work, and the advantages of them seem so obvious that it is strange that they have not been developed before. It would seem that there is a great possibility that some device to give the same results may be incorporated in standard micrometers in the future. We understand that these "Mykarms" have been applied so that the resulting micrometer limit gage may be operated by foot pressure, leaving both hands free for manipulating the work. Under this system, the micrometer is held by the horseshoe portion in a suitable stand, a cord operating the thimble by a pedal. Foot pressure rotates the thimble in one direction, and a strip of elastic or a spring being used for the reverse movement. A feature of the attachment is, of course, that it can be readily removed when desired, as the ordinary functions of the micrometer are not interfered with.—*The Automobile Engineer.*

Wonderful If True

The *British Medical Journal* gives some remarkable particulars of an invention by a sergeant in the R.A.M.C., and working at a casualty clearing station in France. By birth a Scotsman, he received his late education in America, where he graduated M.D., Ch.M., at the University of Washington. In broad daylight, we are told, it is possible to see the blood-vessels in the brain, to observe a blood-clot in that organ, to detect abscesses in the liver and wounds or cuts in any organ. In one case a "concretion" in the appendix was seen clearly when the picture was complete. There is no darkening of rooms, no flashing of lights, and no crackling of spark-gaps. In fact, the whole proceeding is so brief and seemingly so simple that when the results are observed the first sensation is one of bewilderment. A patient is laid on a plain deal table (insulated by standing it on glass), a little clicking is heard in a cupboard hard by, and after sixty seconds or so the bearers are directed to remove him. Nothing has been felt by the patient, little or nothing has been seen by the bystanders beyond what has been noted, yet a visible record of the outline of a living organ has been conveyed to a wax sheet. "The inventor," says the *British Medical Journal*, "believes that the results are primarily due to the fact that the process interposes between two alternating electric fields of equal strength —and at the precise point where they meet—a third electric field, whose facultative potential force is thus released, and can be converted into dynamic power."

The Testing of Automobile Motors*

Methods Followed and Apparatus Required

By Ferdinand Jehle[1]

TESTS on prime movers may be divided into two classes:

First—Tests made for commercial purposes.

Second—Tests made for research.

COMMERCIAL TESTS.

In the commercial tests we are interested merely in the power developed and in the cost, that is, we are interested only in the results obtained without any explanations or reasons therefor. As an example we might take an acceptance test of a steam turbine in which we test for the output and the quantity of steam used to develop one horse-power. If tests show that the apparatus is not up to specifications, the machine is possibly not accepted, but no investigation is made as to the cause of the failure.

RESEARCH TEST.

This class of tests includes a study of the performance and a further investigation to discover the reasons for such performance. This involves a study of the theories involved as well as their application. As an example of this kind of test we may consider the study of any prime mover—gas engine or steam engine—in which all of the thermal and mechanical efficiencies are determined.

TEST OF AUTOMOBILE ENGINE.

In applying the above classification to automobile engines, the commercial test becomes what is ordinarily known as the factory test. Every motor is put through some sort of test to see roughly whether or not it gives the desired output. And sometimes, although not frequently, a test is also made to determine the amount of gasoline consumption per brake horse-power hour. At times tests are also made to determine the maximum speed, the idling speeds and the acceleration. In scientific or research tests additional data, to arrive at the cause or reason for the results obtained in the factory tests, must be obtained.

OUTLINE OF COMPLETE TEST OF AUTOMOBILE MOTORS.

In making a complete test of an automobile motor the following determinations are necessary:

1. Speed.
2. Torque at different speeds (from which is calculated the brake horse-power at different speeds).
3. Fuel consumption.
4. Frictional losses.
5. Ignition (spark advance).
6. Carburation (mixture ratio and the degree of vaporization).
7. Combustion (exhaust gas analysis).
8. Compression.
9. Volumetric efficiency.
10. Heat given to the cooling water.
11. Sensible heat given to the exhaust.
12. Other observations as might have a bearing on the particular kind of test made, such as temperature of the oil in crank case, temperature of the cylinder walls, etc.

APPARATUS REQUIRED AND METHODS OF TAKING OBSERVATIONS.

Power—The most important measurement, of course, is the measurement of power, which is the product of the torque and the speed.

1. *Speed*—The speed is rather easily determined by simply counting the number of revolutions of the engine shaft by means of a revolution counter and watch. A tachometer may be used to give a rough indication of the speed, but as a rule tachometers are not sufficiently accurate to be used for the purpose of the various calculations. Much time and care has been spent in the testing laboratory of The Automobile Club of America to perfect the revolution counting devices. These are constructed so that either one of two counters may be connected with the dynamometer or engine shaft at will. In making a long test it is especially necessary to have two separate counters. At the beginning of the test the zero reading of both is noted and at stated intervals during the test, say every 10 minutes, the one counter is released and the other connected to the shaft, thus giving a total count of revolutions and at the same time a breaking up of the total count into comparatively short intervals of time.

2. *Torque*—The problem of determining engine torque resolves itself into the problem of choosing a dynamometer that is suitable for the work. Before deciding what dynamometer is best suited for the testing of automobile motors, a careful study of the torque curves of such motors is necessary. Fig. 1 A shows a characteristic torque curve of an automobile motor. By studying this curve it will be seen that as a rule there are at least two different speeds at which the engine develops the same number of pounds feet of torque and the question has often been asked the writer: Why is it that the motor can be held at say 900 r. p. m. and does not speed up to 1,200 r. p. m., which has the same torque? The answer to this question, of course, is that the speed at which the motor will run is dependent upon the combined characteristics of the motor torque and the resistance of the dynamometer used to absorb power. To make this perfectly clear let us study the characteristics of the different dynamometers in general use and compare them with the characteristic torque curve of automobile motors.

Frictional Brakes—This type of brake includes all such dynamometers which use the friction of two surfaces for absorbing the power. Under this heading come the familiar prony brake, the rope brake and the Alden brake. The characteristic of this brake, that is, the resistance with a given setting, practically does not depend upon the speed; in other words, the resistance curve for different speeds is practically a straight line for brakes of this description. In Fig. 1, "B" represents the characteristic curve of a frictional brake. It will be noted that the torque at points "X" and "Y" are identical. "B" represents the characteristic resistance of a frictional dynamometer set so as to absorb the load at the point "X." It will be noted that at all speeds to the left of "X" the resistance is greater than the torque of the motor, consequently if the motor for any reason should slow up it would be stalled. At all speeds between points "X" and "Y" the resistance is less than the torque developed by the motor, consequently the engine is at liberty to speed up, until point "Y" is reached. A further increase in speed would therefore be impossible because the resistance is greater than the torque developed by the motor. By studying these curves it can be seen that the motor operation would be stable at point "Y," but not at point "X," and if it were desired to run at point "X" it would be necessary to station a man at the adjustment of the prony brake so that he could increase the load slightly every time the motor speeded up and release it every time it showed a tendency to slow down. This would be necessary in trying to operate the motor at any speed below the speed of the maximum torque, which in the illustration in Fig. 1 is point "Z." The operation at speeds above point "Z" would be stable. This class of dynamometers is therefore not adaptable to the testing of ungoverned automobile motors. The curve "B" in Fig. 1 must not be considered as representing absolutely the power-absorbing characteristics of a friction brake. This, of course, depends entirely upon the coefficient of friction, which does vary with the speed, but not a very great deal.

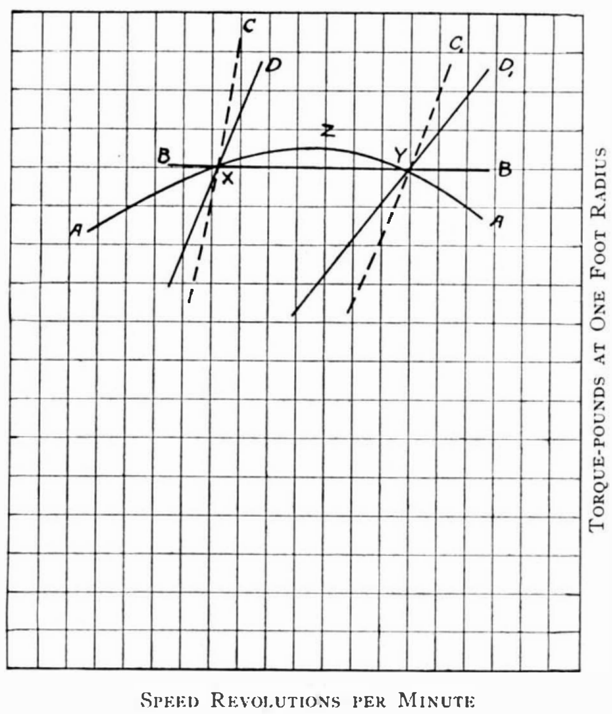


Fig. 1.—Curves showing characteristic automobile motor torque curves and load curves of different types of dynamometers.

Dynamometers Depending Upon the Resistance of a Fluid—This class includes water dynamometers and fan dynamometers. For a given setting of a water dynamometer and for a fan dynamometer with a certain set of blades at a given distance from the center, the resistance varies approximately as the square of the speed. In Fig. 1, curve "C" and "C_1" represents the characteristics of such a dynamometer. Curve "C" is for the dynamometer set to hold the motor at speed "X." The one at "C_1" is to hold it at speed "Y." By comparing the curves "C" and "A" it can at once be seen that the motor cannot increase its speed, due to the fact that the resistance increases much more rapidly with the speed than does the motor torque. If for any reason the speed is reduced the motor cannot be stalled because the resistance falls off more rapidly than the torque of the motor. A dynamometer of this description, therefore, has load characteristics which are ideal for testing automobile motors. Both water dynamometers and fan dynamometers, however, have other characteristics which make them undesirable for this purpose. In the fan dynamometer there is no way of measuring the power except by calibrating the fan and this is a very difficult thing to do, inasmuch as the power absorbed by the fan at a given speed depends upon the barometric pressure, the temperature, of the air, and above all, its surroundings. If a fan is operated in close proximity of a wall or some other object, the power taken to drive it at a certain speed is much less than if it is further removed from surroundings. Air currents also greatly affect it. Then, there is the inconvenience of having to change the size of blades or varying their distances from the center to change the load and speed of the motor. The water brake, on the other hand, can be mounted so that its torque reaction can be measured upon a balance and the load can be quite easily controlled. It has the disadvantage, however, that its maximum absorbing power varies roughly as the cube of its speed and consequently a brake that would absorb the power of an automobile engine at all speeds ranging from a few hundred r. p. m. to 3,000 or over r. p. m., would hardly be possible. If the brake were designed to meet the requirements at low speed, it would have to be of very large proportions, in fact, the rotor would have to be so large that the minimum load at high speed might be beyond the power developed by the engine under test. If, on the other hand, the dynamometer were designed to meet the requirements at high speed, the rotor would not be large enough to absorb the power at the lower speeds.

Electric Cradle Dynamometers—This type of dynamometer is most desirable for the testing of automobile motors and has been practically universally adopted for the purpose. In Fig. 1, curve "D" and "D_1" represents the characteristic resistance curve of a dynamometer of this description. At "D" the load has been set to hold the engine at speed "X," while "D_1" is set to keep the speed of the engine at "Y." The torque varies directly as the speed. It can be seen from the curve that the load therefor will increase more rapidly than the torque of the engine and also falls off more rapidly than the engine torque. For this reason the engine cannot hunt, but is held at a constant speed. Its characteristics in this respect are equally as good as those of the fan or water dynamometers. In other respects it is much more desirable, however, than either the fan or water dynamometer for the testing of automobile motors. These advantages are chiefly that it has practically during its entire speed range a constant torque. This refers, of course, to the maximum torque that can be obtained at the different speeds. This torque, or resistance, is dependent upon the current capacity of the machine. The power which the dynamometer can absorb varies directly as the speed up to the point where the maximum permissible voltage is reached and from that point on to the maximum speed the power absorbing ability is constant. Another great advantage is that the load is very easily controlled. This is accomplished either by varying the armature resistance or by varying the field strength. In making a

*The *Sibley Journal of Engineering.*

[1]Laboratory Engineering of the Automobile Club of America.

test of a motor on an electric dynamometer it is best to so adjust the armature resistance that the dynamometer will absorb the power at the lowest motor speed. At the other speeds the load can be adjusted by manipulating the field rheostat.

Another advantage of the electric cradle type of dynamometer is that it can be used to run the engine and thus the friction losses of the motor under test can be determined.

The high speed dynamometer in the testing laboratory of The Automobile Club of America is capable of handling somewhat over 100 horse-power continuously from 1,500 r. p. m. to its speed limit, which is above 3,000 r. p. m. A heavier duty machine in the same laboratory has a continuous capacity of approximately 120 horse-power at as low a speed as 1,000 r. p. m. Its maximum speed is 2,000 r. p. m. This testing equipment is especially arranged to accommodate aviation motors, inasmuch as the bed-plate upon which the motor is erected is enclosed in a sheet metal house and a current of air of approximately 40 to 50 miles per hour is blown past the motor under test. This imposes upon the motor practically operating conditions. For higher powered motors than 120 horse-power, both the dynamometers are coupled together. The continuous capacity is then about 200 horse-power

3. *Fuel Consumption*—The fuel consumption can best be determined by placing the tank which contains the fuel supply for the motor upon a scale and noticing the decrease in weight. In tests of very short duration in which very small quantities of fuel are consumed, it is preferable to determine the consumption volumetrically, that is, to measure in a pipette the quantity of fuel consumed.

4. *Frictional Losses*—It is not possible to obtain a reliable indicator diagram from automobile motors, chiefly due to the fact that there is no instrument made that will operate successfully at the high speed that motors are operated at. There are on the market several optical indicators which are designed to draw indicator diagrams at these high speeds, but as yet they have not been absolutely successful. For this reason it is not possible to determine the frictional losses by comparing the indicated horse-power with the brake horse-power. As noted above, however, with the electric cradle dynamometer it is perfectly possible to determine the friction losses at the different speeds. If it is desired to obtain the indicated horse-power for use in expressing the thermal efficiency, this friction horse-power at a given speed can be added to the brake horse-power developed at that same speed. It is quite true that the friction determined when the engine is not operating under its own power may be slightly different from the friction when the engine is operating under its own power. Nevertheless, the error introduced is less than would be introduced if an indicator diagram were to be used for this purpose.

5. *Ignition*—The spark advance, that is, the number of degrees of crank-shaft travel that the spark takes place in the cylinder before the piston arrives at top center, is of great importance. The apparatus in use for determining this in the testing laboratory of The Automobile Club of America consists of a pointer rotating in front of a protractor which is insulated from it. The gap between the pointer and protractor is connected in series with the high tension side of the ignition system, and when the spark occurs in the cylinder it will also jump the gap mentioned and the number of the degrees can be read on the protractor at which this takes place. Needless to say, the pointer is revolved at the same speed as the crank shaft of the engine and is set on zero when one of the pistons is on top-center.

6. *Carburetion*—It is of great importance to learn what the ratio is of the air supplied to the motor to the gasoline used. The method used in determining the quantity of gasoline consumed has already been described. It is now necessary to measure the air consumed. There are various ways of doing this, the most accurate of which, of course, would be to use a gasometer. It would, however, be very expensive to install a gasometer of such capacity to run a motor for any length of time and we must therefore look for more practical means to make this measurement. The best method for this purpose, in the writer's estimation, is to make use of a Venturi meter which has been calibrated by means of a gasometer, although it would be quite possible to use a standard orifice. Another investigation that is of importance is the amount of vaporization that takes place before the mixture enters the cylinders. Some idea of this can be obtained by comparing the temperature of the ingoing air with the temperature of the mixture in the manifold.

7. *Combustion*—It is as necessary to study the combustion which occurs in the cylinders of an automobile engine as it is to study the combustion under a steam boiler in making a boiler test. The only way of accomplishing this is to make an analysis of the exhaust gases. It is desirable that the CO content of these gases be kept at quite a low figure, although, strange to say, the maximum power is not obtained when there is no carbon monoxide present, but when there is approximately 4 per cent. Maximum economy, of course, does not occur at this same point. From the percentage of CO present the heat lost, due to incomplete combustion, can be determined.

8. *Compression*—The amount of compression in the cylinders is dependent upon several things. First, the size of the valves; second, the valve timing; third, leakage around the piston rings. The method which the writer has found to be most satisfactory for measuring this pressure is to use a steam gauge connected to an expansion chamber, which is in turn connected to the engine cylinder by means of a check valve. There is another instrument on the market, the O'Kill indicator, which gives fairly good results. This instrument, however, is quite difficult to calibrate.

9. *Volumetric Efficiency*—The volumetric efficiency is the ratio of the air taken into the motor in a given time to the effective piston displacement during the same time under existing atmospheric conditions. The air measurement to determine the mixture ratio described above can, of course, be used for this calculation.

10. *Heat Given to the Cooling Water*—To determine this loss it is necessary to measure the difference between the ingoing and outgoing cooling water and the quantity of water circulated per unit of time. The temperatures, of course, are easily measured with mercurial thermometers, while the quantity of cooling water circulated can either be weighed on a scale or measured with a calibrated meter. In the testing laboratory of The Automobile Club of America a calibrated Venturi meter is used for this purpose.

11. *Heat Lost in the Exhaust*—The heat lost in the exhaust can best be determined by cooling the exhaust to room temperature by means of water in a calorimeter and measuring the increase in the temperature of the water and the quantity of water used. The calorimeter in use in the testing laboratory of The Automobile Club of America for this purpose consists of a steel barrel enclosed in a wooden box. The space between the barrel and the box is filled with wood shavings which makes a very good insulator. The piping from the exhaust manifold to the calorimeter is insulated, as well as the exhaust manifold. The cooling water is injected into the exhaust pipe and follows the exhaust into the calorimeter. The exhaust gas can escape by bubbling through the water. The temperature of the exhaust gases as they leave the calorimeter is the same as the temperature of the air entering the carburetor.

12. Other measurements that are at times necessary are the temperature of the oil in the crank case, which can be determined by drilling thermometer wells into the crank case and reading the temperature on mercurial thermometers; the temperature of the exhaust, which can be determined by pyrometers; the temperature of cylinder walls, etc.

The design and construction of apparatus necessary to make determinations and measurements on tests, is one of the important duties of the testing engineer. Nevertheless, he must not lose track of the fact that this is merely a means toward an end and the complicating and increasing expense of apparatus is never justified unless it will help and make more valuable the data or the results obtained. Too often apparatus builders and engineers in charge of laboratories unnecessarily increase the expense and complications of apparatus. Automatic apparatus may be desirable for factory tests where the class of labor employed for making the tests is below that in the scientific laboratory. The best method to follow is to use absolutely the simplest apparatus which will meet the various requirements.

Cumin—A Crop Valuable for the Small Diversified Farm

The tendency of the American farmer to cultivate only such crops for which there is the readiest sale in this or other countries, is not one of the least evils. The consequence of this exclusive attention to one or two objects of cultivation with an almost total neglect of many articles in every day demand for home use, renders us dependent upon other countries and more especially upon Europe and the Far East. Among the farm products the want of an internal production of which has been felt especially since our source of supplies in Europe has partly been cut off, are cumin, caraway, fennel, anise, mustards, and many other important food and drug plants. Of these cumin is in greatest demand in this country. Practically all of the cumin used in the United States is being imported from the Mediterranean region, the annual importation increasing from less than 150,000 pounds in 1900 to over 530,000 pounds in 1914 and about 700,000 pounds in 1915. Since there is no domestic production, the price of cumin has constantly advanced from 4 cents to about 18 cents per pound. Its use is becoming more general and it is believed that the price, even with strict European competition, will never decrease to the figures that prevailed before the war.

Heretofore the growing of such crops as cumin, fennel, anise, etc.,—very different from the growing of wheat and oats,—could not be carried on profitably in the United States on account of the low price and high cost of labor. Cumin does not offer an exceptional opportunity to a great many farmers, because all the cumin used in this country annually can be grown on less than 1,000 acres of good land. It is a good crop, however, for a number of small farmers in the South to grow on odd corners of their farms and thereby encourage thrift, diversify crops and increase their profits. This would require almost no reduction in the acreage of the staple crops, but would tend to establish an industry sufficient to render us independent of European producers.

Cumin is but little known in most parts of the United States. In general appearance and manner of growth it resembles closely allied plants, such as fennel, anise, caraway, etc. It is a member of the large group of umbelliferous plants, which among the many natural families of plants contribute so largely to the wants and necessities of man. Botanists distinguish the plant by the name of *Cuminum cyminum*; kuminon is the ancient classical Greek name. The plant is slender, erect or partly procumbent, branched and grows about 12 inches in height; the leaves are numerous, narrow, pointed and grasslike; the flowers are purple and produce in numerous umbels small egg-shaped or oblong-striated fruits which are double and rarely over one fourth of an inch in length and less than one half as wide. These fruits, which are known in the trade as cumin seeds, constitute a valuable crop in many parts of southern Europe and northern Africa; large quantities are grown also in India, but Malta, Sicily and Morocco afford the chief supply. Cumin was cultivated in England as early as 1594, but its production has never been great. In fact, the production of cumin in Europe has been decreasing for some time, and at the present the supply in some countries is entirely cut off. It will probably be several years before the yield is as great as it was before the war. It appears, therefore, that the present offers an opportunity to establish the industry in the United States.

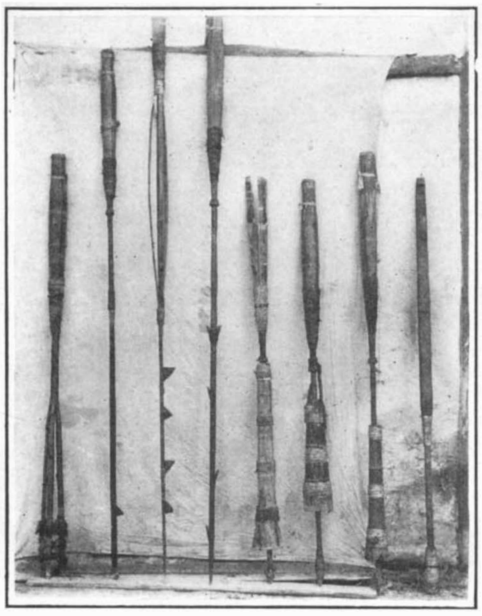
Cumin may be recommended to the farmers in the Southern States, particularly along the Gulf Coast and on the Pacific Coast. This plant will succeed, it is said, wherever the fig tree will grow well. For the best results with cumin, a growing period with no extremes of temperature is essential. The plant is not adapted to regions in which there are late, heavy frosts. In the United States it is believed that it will do best in the South Atlantic and Gulf States where the climate and the distribution of the rainfall are most suitable for this crop. The soil must be good. An undrained soil where water stands at any time during the year is not suitable. A rich sandy loam is considered the best for cumin.

The fruits of the cumin plant have a bitterish, warm taste with an aromatic flavor which to many is not agreeable. They yield a great part of the odor by infusion in water, but very little of the taste. In distilling them with water a pungent oil arises, which has a strong odor similar to that of the fruits. When the decoction is inspissated a peculiar rough and bitter extract is left. Alcohol dissolves all the volatile oil in cumin leaving the fruits uninjured, but odorless upon drying. The fruits contain about 2 per cent of volatile oil. This oil was and still is believed to possess carminative and stimulative properties. While cumin is an official drug in the United States only a very small part of the material imported into this country is used medicinally. It is employed more extensively as a condiment for flavoring foods. It is said to be used for seasoning certain grades of wholewheat bread; in connection with coriander it is employed in flavoring sausages and Dutch cheese. Large quantities are shipped to the Southwest for use in the Mexican dish known as hot tamale. It also forms one of the ingredients of curry. Many thousands of pounds of cumin are consumed annually in the preparation of condition powders for horses and cattle.

Since the use of cumin in this country is becoming more general, it seems advisable for farmers to undertake the cultivation of this valuable crop. The plant requires a warm, moist climate, and the South contains every element favorable to the success of this enterprise.

The Salt Wells of China

Original Pictures Showing How the Salt Brine Is Raised from the Well, Transported and Evaporated to Obtain Solid Crystals



Tools used for recovering drills.

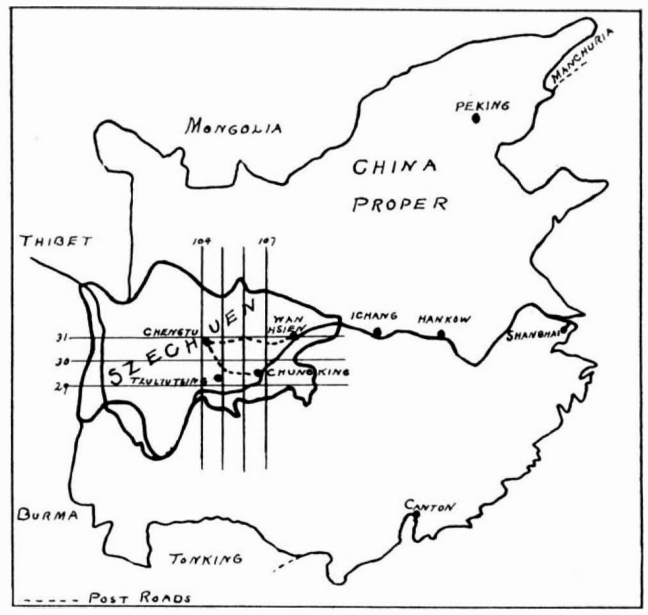
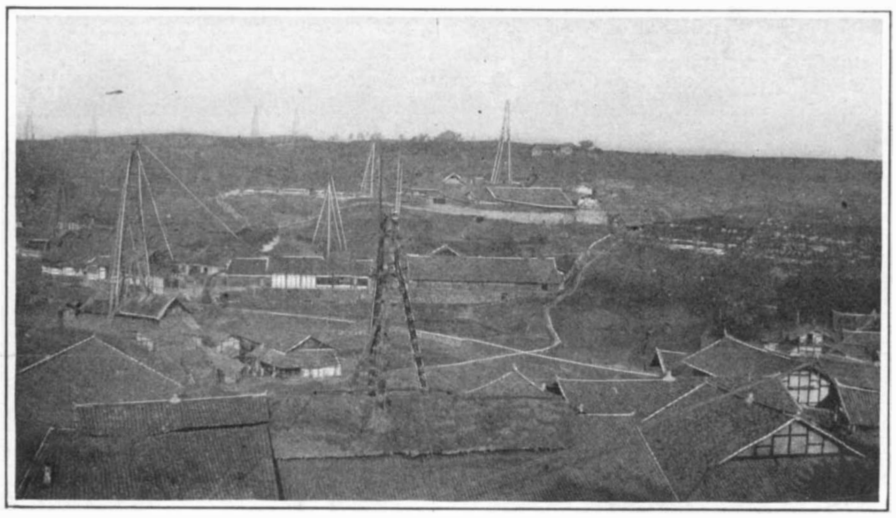
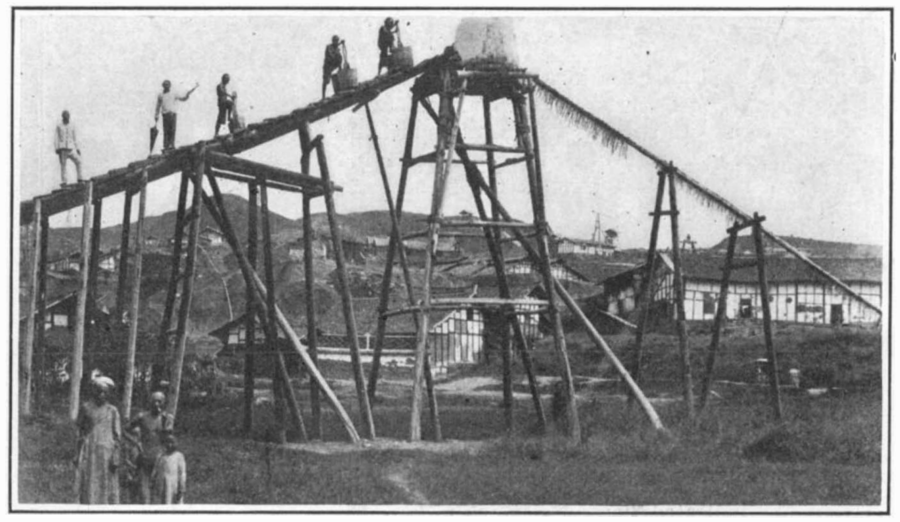


Chart of China, showing salt well district.



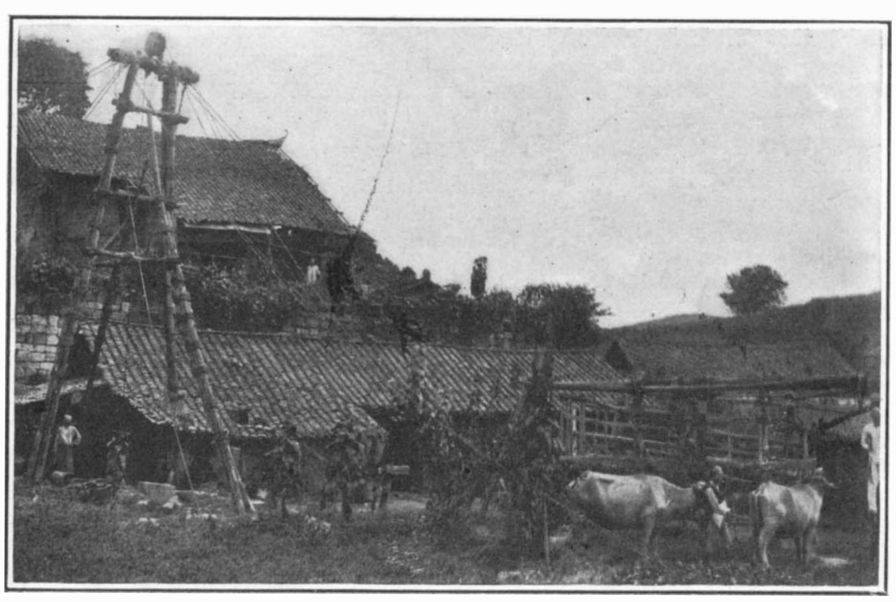
View in salt well district in Szechuen.



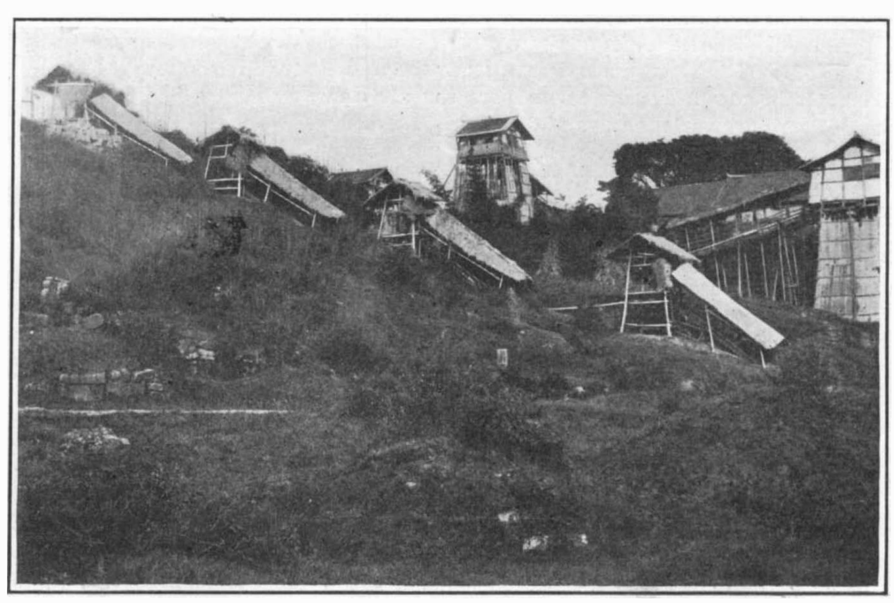
Coolies carrying brine to an elevated tank.

Emptying the long bamboo bailer bucket.

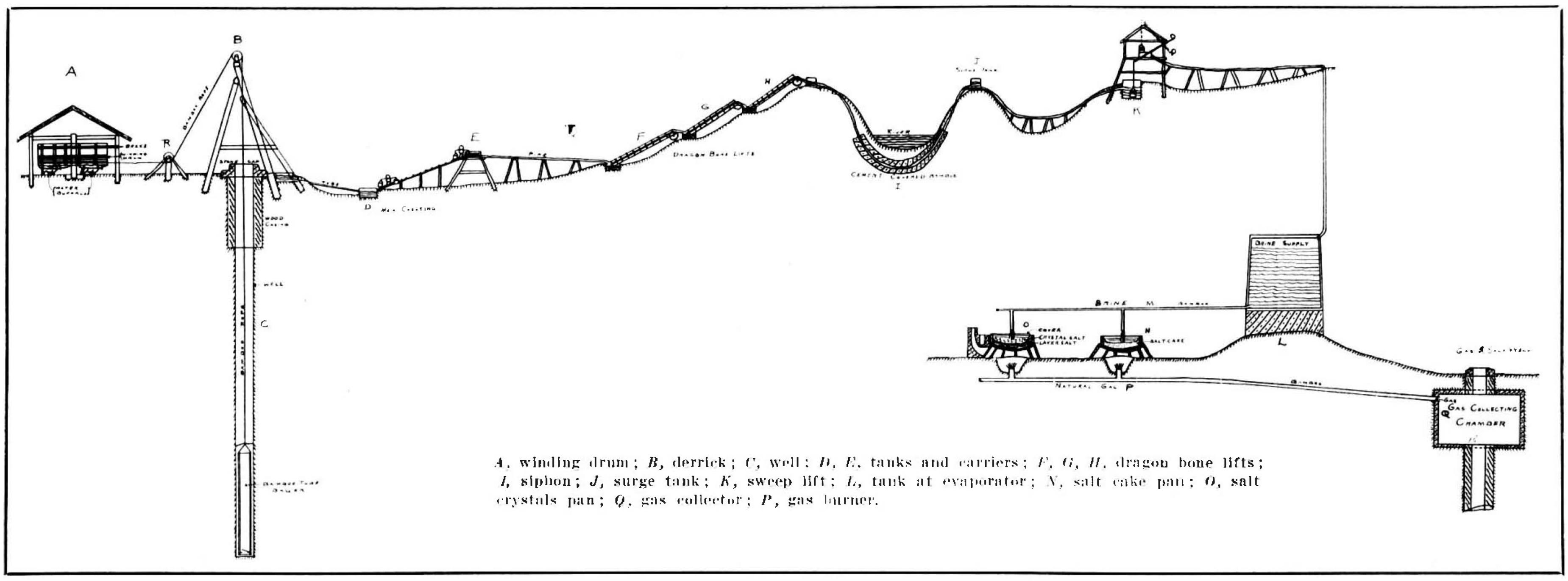
Pumping brine from a tank boat.



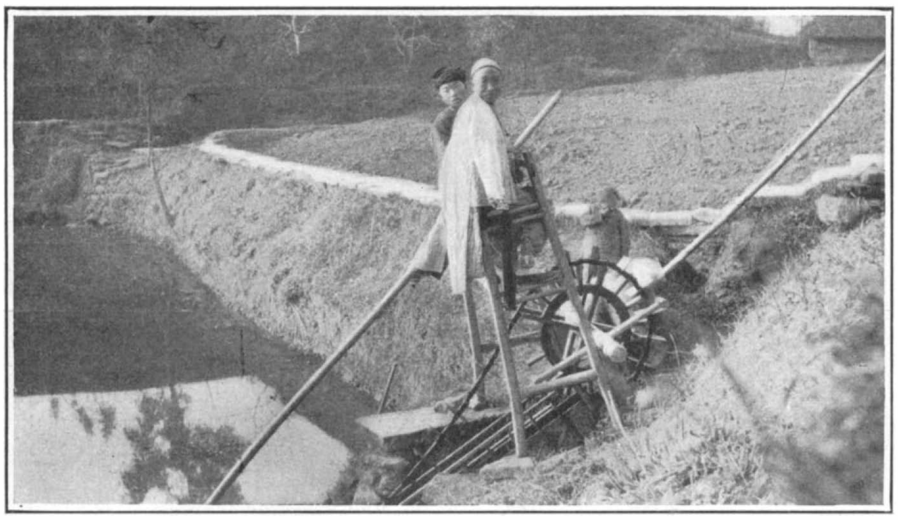
Derrick and winding drum at a well.



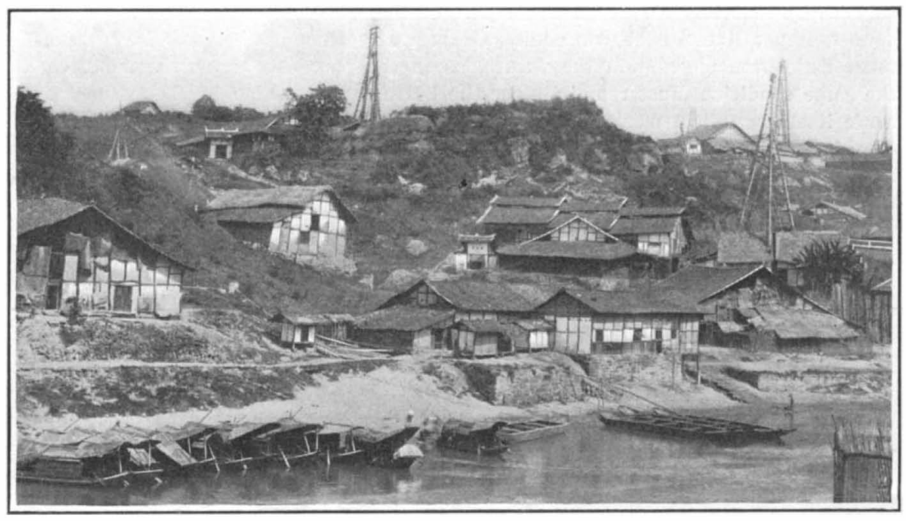
A flight of dragon bone lifts.



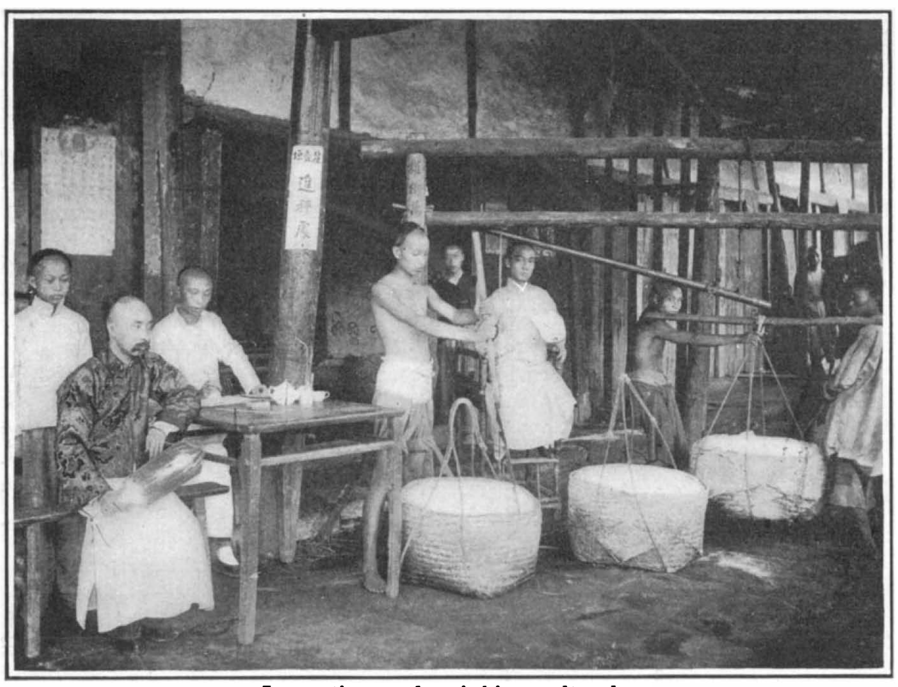
A, winding drum; *B*, derrick; *C*, well; *D*, *E*, tanks and carriers; *F*, *G*, *H*, dragon bone lifts; *I*, siphon; *J*, surge tank; *K*, sweep lift; *L*, tank at evaporator; *N*, salt cake pan; *O*, salt crystals pan; *Q*, gas collector; *P*, gas burner.



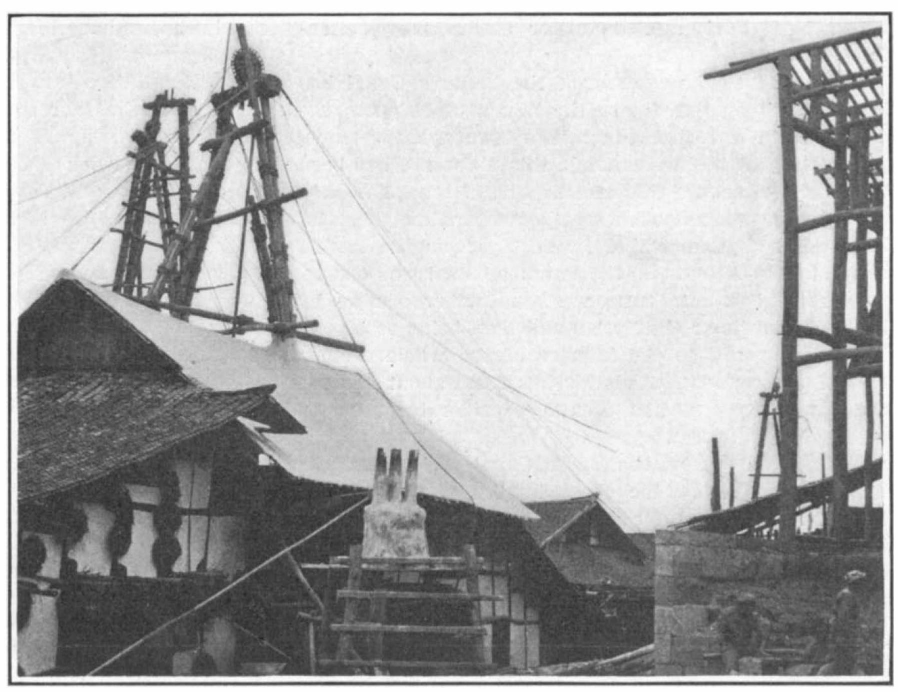
A dragon bone lift worked by two coolies.



Tank boats loading with brine.

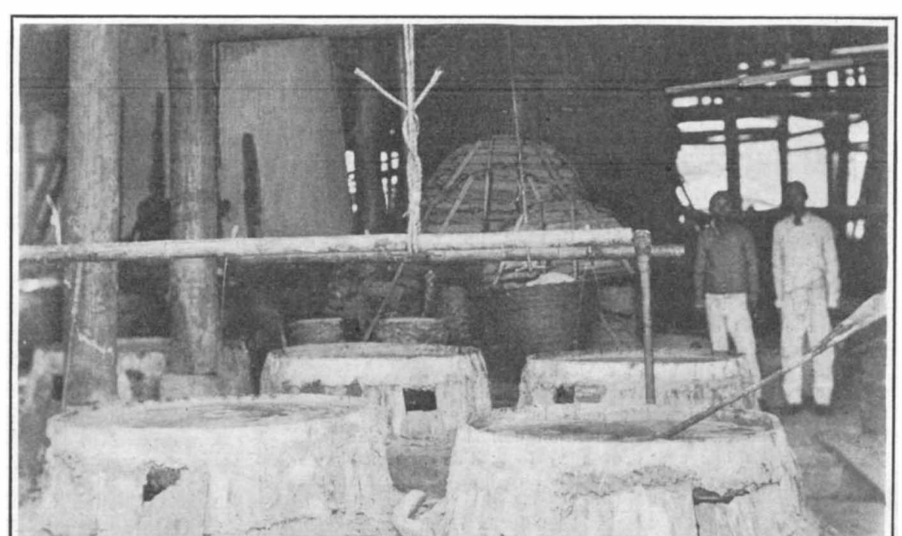


Inspecting and weighing salt cakes.



Surplus relief burners at a gas well.

Surge tanks on pipe lines.



Pans in which the brine is evaporated.

The New York Barge Canal*

Its Relation to Other Waterways and Outlying Territory

As the Barge Canal nears completion the important part it seems destined to play as a connecting link between other great waterway systems becomes very apparent. The agitation for these systems has grown insistent of late, stimulated in large measure by the example set by New York State, and the projects themselves depend for their success to a greater or less extent upon the existence of the Barge Canal. A study of the relationship the Barge Canal bears to this wide area of surrounding territory forms an interesting subject for consideration. It can be seen now, how the usefulness of the Barge Canal will be greatly augmented by such of these projects as are already under way and by others which may soon be undertaken.

During a hundred years of canal-building New York State has led the Union in this particular form of internal improvement. Single-handed and alone the State has undertaken and carried through its great task. That other states have been benefited by these waterways cannot be questioned and that the area of this beneficence has covered a large part of the whole country must likewise be conceded. Of necessity this must have been so, and in the future, as in the past, the same condition must remain, since the State cannot serve itself in fullest measure without including others in this service. Whether it was just that New York should be almost wholly denied assistance by the Federal Government in this work of a hundred years is a question appearing to have but one answer but which need not now take our attention. However, in view of the State's activity and generosity, it would seem that argument is superfluous to prove the imperative duty of the Government to meet the State's improvement with adequate improvements in adjacent waters which are under its control.

In making its latest improvement—the building of the Barge Canal—New York is also primarily doing something for its own benefit. But, as we have seen, this beneficial service must of necessity extend beyond its own borders. A few examples of the extent and nature of this beneficience, which becomes mutual between New York and its sister states, may be enlightening.

One result of the opening of the Panama Canal has been to bring pointedly to the minds of shippers the difference in rates between rail and water-borne transportation. In the lumber trade this difference has been seen very clearly. The forests of the East have become so nearly exhausted that for some time the East has had to draw much of its supply from the Pacific coast states. As soon as the Panama Canal was opened this traffic began to turn, western lumber coming by boat to Atlantic or Gulf ports and then being reshipped by water or rail to the interior of the whole eastern half of the country. And this has come about because the saving in cost has been a considerable sum on every thousand feet.

A study as to how the Barge Canal will extend the limits to which Pacific coast lumber may profitably be shipped by the water route brings out some interesting facts. If we consider that the lumber which has come by boat from the Pacific Coast to New York city continues to move by water, reversing its general course and going back west through the Barge Canal and on through the Great Lakes as far as they extend, and then, if we compare the cost of transportation by this route with the cost to ship the same lumber overland by rail to the same points at the western extremities of the Lakes, we find a balance in favor of the water route, although the distance traveled is several times that by land. Now, if we use this balance to move this water-borne cargo still farther to the west, using railroads, of course, we shall reach a point where the cost of transporting this cargo will exactly equal the cost of the cargo coming overland by rail. Drawing a line through several points obtained in like manner, we shall obtain a boundary which we may call the "line of equal costs." The interesting fact about this line is that it is away to the west of the Mississippi River, scores and in some cases hundreds of miles. The area thus benefitted by the Barge Canal includes most of the northeastern quarter of the United States, embracing the territory east of this line of equal costs and north of the Ohio River. This area would extend farther south were it not for the fact that the cargo approaches the country from the south, and so the Mississippi River and southern railroads from the coast become competing factors.

In the case of materials produced in the region of the Great Lakes and also somewhat to the west of them, as, for instance, the grain from the great belt covering the northern States and southern Canada, and also in the case of foreign goods reaching New York from the east, the area influenced by the Barge Canal is farther extended, including both that mentioned in connection with Pacific coast lumber and also considerably more. Perhaps the importance of the Barge Canal as an essential link in the water route for this vast east and west traffic can be shown most strikingly by considering what happens to a shipment starting from the head of Lake Superior and going to Europe by way of the Mississippi. After it has gone 2,000 miles and reached the mouth of this river, it is still 4,500 miles from Liverpool, no nearer its destination than at the beginning, in view of the possible 4,500-mile water route by the Lakes, the Barge Canal and the Atlantic Ocean.

As New York was the pioneer in the early days of canal-building, so now it has again taken the lead along the way which others seem about to follow. Numerous canal schemes have been agitated since the Barge Canal was begun and some of them have passed from the stage of agitation into that of preliminary surveys. Of these there are four in the region of the Great Lakes which are worthy of notice. If built, they will be in effect extensions of New York's Barge Canal and their efficiency will depend in large measure upon the Barge Canal, since it forms the outlet between them and the sea.

These four proposed canals are, first, the Lake Erie and Ohio River Canal, which would join the Ohio River at Pittsburg with Lake Erie, and for which complete surveys and estimates have been made by the States of Ohio and Pennsylvania; second, the Lake Erie and Lake Michigan Canal, surveyed by the United States engineers and joining the heads of Lakes Erie and Michigan by a line only one third the length of the present natural route, thus bringing Chicago, Milwaukee and Grand Rapids that much nearer to the eastern States and the ocean; third, the proposed improvement of existing canals in Illinois, which extend between Lake Michigan and the Mississippi River; fourth, a canal from the head of Lake Superior to the cities of Minneapolis and St. Paul.

The engineers who have made the plans for these canals either have been drawn from the Barge Canal corps or have studied New York's canal and adopted its ruling features and dimensions.

It seems scarcely necessary to call attention to the importance of these proposed canals—what it means, for example, to place Pittsburg with its steel industries and the great twin cities with their grain and flour interests on a vast Lakes-to-Atlantic waterway system—nor to point out the vital position and the extended influence of the Barge Canal in this mighty chain of improvements.

Nor would the canals just mentioned constitute the entire system of internal waterways contemplated for the Middle and Atlantic States. The projects advocated by the Atlantic Deeper Waterways Association form a part of the whole vast scheme. These canals would give an inside passage along a large portion of our Atlantic coast. Thus the Barge Canal would become the connecting link between two great systems —the intracoastal canals and the Great Lakes with their adjoining canals—and the supreme importance of this connecting link becomes very evident.

It is not generally known how important is the territory adjoining the Barge Canal as a region in which certain products originate and others are consumed. The original canals were responsible for the founding of a chain of cities and villages across the Empire State, the like of which does not exist elsewhere in the whole country. Directly upon New York's waterways of Barge Canal dimensions there are situated more than thirty cities, some ninety villages and many hamlets, while other populous communities are but a few miles away. A study of the State's population reveals the fact that nearly 75 per cent of the people live within two miles of the waterways. As New York's population is one tenth that of the whole country, we see that about seven per cent of the people of the United States are within a half hour's walk of the New York waterway system. From this we can see what it means to the State and to the country at large that the products of these seven million people and the supplies they need may have available a cheap means of transportation.

Moreover, the natural and manufactured products originating in close proximity to the Barge Canal are of no mean proportions. A study made by the Barge Canal Terminal Commission showed that by a very conservative estimate the region along the canal proper, not including anything on the Hudson River south of Albany, produced annually more than ten million tons of freight for transportation by canal.

Before a Congressional Committee on Transportation some years ago a man who was considered one of the best railroad authorities in the country made the statement that the Erie Canal regulated freight rates on all roads east of the Mississippi. The chairman of this committee went still further, declaring in one of his speeches that the canal exerted an influence over the whole country, "from the interior of the Gulf States to the St. Lawrence River, and from the great plains of the eastern foothills of the Rocky Mountains to the Atlantic Ocean."

In view of the benefits which New York is thus conceded to have conferred upon the nation, the proportion which the State has received of the Federal expenditures for rivers and harbors in comparison with the proportion of foreign commerce it contributes is so small that it appears ridiculous. Examining the statistics for one or two decades, we learn that New York's export and import trade has been practically equal to the sum total of all the combined export and import trade of the remaining 90 per cent (by population) of the United States; yet this State has received, as a return benefit with which to maintain its facilities for handling its immense contribution to the commerce of our country, only about five or six per cent of the total expenditures for river and harbor improvement. The proportion of New York's share is substantially the same if we consider all the Government appropriations for this kind of work since 1802.

New York State has set an example and in building its canals has incidentally provided the most important link in a great chain. If the chain is to be completed and the acme of mutual benefit to be attained, the States and Federal Government must do their part.

There are four principal termini of the Barge Canal system and the adjoining waters at each of these termini are under the control of the United States Government. At the western terminus of the Erie Canal the Niagara River has been improved under Federal authority to meet Barge Canal requirements. It was expected that work at the mouth of the Oswego River, the northern terminus of the Oswego Canal, would also be undertaken by the Government, but as this has not been done, it has been decided not to wait longer, and accordingly the State is about to let a contract for this section. In the upper end of Lake Champlain, the northern terminus of the Champlain Canal, considerable more work is very desirable, which it is anticipated the Government will undertake to perform. In the Hudson River at the eastern terminus of the Erie and the southern terminus of the Champlain Canal improvements of Barge Canal dimensions are under way, but an agitation for a larger improvement has been in progress for several years and has now gained great impetus. The arguments in favor of this project need not be repeated here, but it appears to be one of the most logical, well-advised and commercially-important enterprises ever brought before Congress.

The projects closely connected with the Barge Canal which have already been approved by the army engineers and which need Federal appropriations are, the improvement of Oswego, Rochester, Black Rock and Tonawanda harbors, the enlarging of the narrows

Barge Canal Bulletin.

NOTE.—There will be 446 miles of barge canals, the Erie being 339 miles long, the Champlain 61, the Oswego 23, and the Cayuga-Seneca 23 miles long. Of this total, 400 miles are completed and the most of it will be in operation during the present year, while the remainder is rapidly being finished. The dimensions of the Barge Canal vary according to the locality, but at all places it will be at least 12 feet deep. It is 125 feet wide in earth sections of the land line, 94 feet wide in rock cuts, and has a width of at least 200 feet in the beds of rivers and lakes through which it runs.

The Barge Canal locks are 328 feet long and 45 feet wide. The most wonderful of these locks are the five at Waterford, near Troy, which have a combined lift of 169 feet, the greatest series of high lift locks in the world. The locks cost about one quarter of a million dollars each. The lock at Little Falls has a lift of 40½ feet; this is remarkable because it has a greater lift than any lock on the Panama Canal. The siphon lock at Oswego has a lift of 25 feet, is the first lock of this type to be built in the United States and the largest of its type in the world.

This great inland canal will cost $150,000,000 and is being paid for by the people of New York State without any aid from the United States Government.

of Lake Champlain and the dredging of the Hudson.

The mileage of waterways connected and the extent of territory influenced by the building of the Barge Canal are already great. Even now the 1,500 miles in the Great Lakes and the 800 miles of New York waterways form a mighty system. If the canals and improvements adjacent to the Great Lakes and the Atlantic intracoastal chain with its continuous navigation of 1,800 miles are eventually built, the area coming under the influence of the Barge Canal will indeed be vast.

New York's expenditures for contributing the important connecting link between other waterway systems have been very large and without precedent. That the Federal Government should do its utmost to make the Barge Canal supremely effective by providing the most suitable outlets in the waters under its control and thus render the canal a national asset of far-reaching influence, seems so self-evident and reasonable as scarcely to need expression in formal words. In view of New York's commercial importance, its constant and enormous contributions to the nation's trade and revenue, its generous expenditures without aid and its almost total lack of assistance throughout the past, what more is needed to prove that the General Government should serve itself by performing the necessary work connected with the Barge Canal and should begin this work without delay.

The Flying Service, from a Medical Point of View*

By Staff-Surgeon Hardy V. Wells, R. N.

Great advances have been made, both in the skill of air pilots and in the actual machines, during the past twelve months. The speed of aeroplanes has greatly increased, chiefly on account of engine power, but partly also due to the design.

High-velocity Accidents—With an increased speed of aeroplanes the crushing effect on striking earth nose first will be very great, and will demolish a great part of the aeroplane even from a very little height. Cases occur where the pilot has not been crushed, but has been seriously injured, by apparently hitting a part of the machine due to the forward velocity of his body when the aeroplane strikes on its nose and suddenly stops. These incidents occur only in aeroplanes that have the engine in front and the pilot well behind. The engine takes the shock, and the portion of the aeroplane directly behind the engine (where the passenger seat usually is) crumples up, while the pilot's seat, etc., which is behind, may suffer comparatively little damage. It is usually the pilot's head that suffers. His body apparently comes to a sudden stop, owing either to a safety belt or a hand outstretched, while the head bends forcibly forward on the neck. The result is usually that the head strikes some portion of the machine, and is injured, or the neck is forcibly wrenched. No such injury has actually occurred at the Royal Naval Flying School, but an accident of this description did happen: the pilot at the moment of starting put his hand out in front of him against a wooden wind screen which broke, and his hand and arm went through it. His head went violently forward, just failing to hit the screen in front, and he suffered from some pain and stiffness in the neck for a day or two afterwards. He was wearing a belt.

The injuries sustained in such accidents seem to be chiefly injuries of the skull due to actually striking; but in one case the only injury found was a fracture or dislocation of the neck. In the case which happened at Brooklands, when an officer was killed in the accident to the Martinsyde monoplane, the pilot, although wearing a belt, was shot almost out of the belt, and sustained head injuries by striking some portion of the machine in front. This was the only injury. It has been suggested that in this accident the head injuries were due to the chin striking forcibly. Here is a possible solution of this and similar cases, but I venture to think that owing to the head being inclined forward the forehead or vertex sustains the striking blow. There seem two ways to avoid this; one is a safety belt having shoulder straps, to keep the body from being propelled upwards and forwards. This would be unpopular with pilots, and would give trouble in releasing before landing. A second and better solution would be to have some giving material in the position in front of the pilot, where the head would strike. This could not be a raised cushion or pad, as it would obstruct view and would increase head resistance, a thing the makers would not favor. The giving material would have to be on a level with the existing structure. I have examined a number of various types of tractor machines, and I think the scheme could be carried out in most machines. If, as it seems possible, serious injuries to the neck may occur through a forcible bending forward only of the head on the neck, shoulder straps appear to be the sole solution.

Safety Belts in Aeroplanes—The question of safety belts in aeroplanes has been much discussed. Most pilots are in favor of such, and do wear belts, but a few are averse to them. I have heard several well-known and experienced pilots, in discussing the use of belts, say that they object to them, because if the machine crashes to earth suddenly the pilot may be crushed in his seat when the machine turns over; whereas, if he has no belt, and the aeroplane turns over on the ground, the worst that can happen is that he is thrown out. Also, if strapped in he probably could not clear himself if the aeroplane caught fire after a smash, and quick-releasing devices do not always act. The question of belts I have considered carefully, and have come to the conclusion that a safety belt is a very necessary thing, for the following reasons:

At times, in flying, air conditions are met with which may unseat the pilot. Unseating may not throw him out, but it will cause him to lose hold of his controls for the time being, which in itself is a serious danger. This frequently happens while flying in strong gusty winds, and also occurs on calm days when an aeroplane comes suddenly from a calm to a disturbed local condition. The pilot is then caught unawares; his feet, which are resting against the steering bar, easily come off that, and thus rudder direction is lost. Moreover, he may be thrown forward on the elevator control, and pushing this forward suddenly may cause a dangerously steep dive. I have witnessed an accident by which a pilot was nearly thrown out. A naval officer pilot, while descending from about 500 feet in an ordinary volplane glide, got into a disturbed air "patch," and was thrown bodily forward. His foot coming off the rudder, he was thrown against the control, which was pushed forward, and so the machine was placed at a dangerous diving angle. Only by holding on to the wheel control was he saved from being thrown right out, and when the machine was about 70 feet up, it luckily recovered itself before the pilot had time to get back to his seat and regain control. I went to the aeroplane after it landed, and the pilot said he was not using a belt, but was only kept from being thrown out by holding tightly to the wheel control.

Now against the safety belt is the danger that, when the occupants of an aeroplane are strapped in, they will in all probability be crushed should the machine roll over on touching ground at a bad landing, or landing on bad ground. I know of several cases where, if the occupants had been strapped in, they most certainly would have been crushed owing to the capsizing of the machine. In the case of an accident at Queenborough, the aeroplane turned over and over, and was completely demolished. The occupants, although seriously hurt by being thrown out, were saved death.

There is a good deal to be said on both sides of this question, but the objection to belts can, I think, be easily overcome by devising a release which can be readily used just before a landing is made. The present type, where the release pin is on the belt and releases the belt from the body, is not reliable or easy to manipulate when the pilot is busy, his attention being taken up with working controls, engine, etc., for landing. A lever on the side of the machine by the pilot's side, which releases the belt from its attachment to the seat, is, I think, a more suitable, more convenient, and quicker arrangement. The belt must be fairly broad and comfortable, and have elastic or such other means for giving springiness. Its attachment to the aeroplane must be very carefully adjusted, so that all freeing devices can clear. A case happened recently when an aeroplane capsized on a forced landing just outside the flying ground; the pilot was found unhurt, but suspended face down, owing to the quick-release device failing, the buckles of which were not able to clear owing to being fitted faultily in the aeroplane.

Safety Helmets—Whether these should be worn or not is also a matter of discussion among aeroplane pilots. The objections put forward against helmets are that they are uncomfortable, and would not save the head from a fall except from the smallest of heights. If one falls on any other part of the helmet but the actual top of the crown, the additional height of the crown would force the head backward or forward, and so break the neck. Also, if wearing one in a tractor machine, the added propeller draught beating on a high-crowned helmet forces the head back in a most uncomfortable manner. In favor of helmets it can be stated that they are quite comfortable if a proper size is used; that in a ground smash they protect the head from a blow of broken spars; that, if the pilot is thrown out, and his head hits a wire, they save a scalp wound; and that the earflaps save damage to the ears. Moreover, if he is thrown on to the ground, the helemt would save injury to the scalp, and possibly a fracture of the vertex or the base of the skull. All the above would be, of course, in the case of an aeroplane smashed on actually landing. Everything seems to favor helmets being worn. They are light and can be quite comfortable, and in the modern engine-in-front machine the pilot is protected a good deal from the propeller draught. A favorite head-gear of pilots just now is a leather skull cap with ear protection pads, such as is worn by the racing motorist. The ideal helmet, no doubt, would be one that took its support from the shoulders, but it would be rather cumbersome, and would encase the wearer, and so be rather unpopular. What type of helmet is most suitable is now under consideration.

Clothing—As a protection from cold, lined leather jackets are generally worn, with, in cold weather, a "sweater" (woolen) underneath. The hands are shielded by lined leather gauntlet gloves. Aeroplaning, even in cold weather, seems to cause very few chills on the abdomen or chest, probably because pilots take the precaution of being adequately clothed. The only cases of chills can usually be traced to inadequate protection.

Physical Requirements of Candidates for the Flying Service—The candidate must be physically fit, and I would reject the anæmic type. Particular attention must be paid to eyesight. Full normal vision and color vision are required. Hearing must be good. The teeth ought to be in good condition. Weight does not matter.[1]

Age—It is not possible at present to lay down any hard-and-fast rule as to age. My opinion is that the age for selection is between twenty and thirty years. Over the age of thirty is, I think, too old to begin to learn flying with a view to being a Service pilot, e. g., to take up a flying career and fly under all conditions.

Type—This I have studied carefully, but have come to no conclusion. The active type, the man who is keen on such things as motoring, motor bicycling, riding, hunting, the exciting sports with an element of danger, seem to make the best pilots.

Sight—Full normal vision is important for all aeroplane pilots, and all candidates should be carefully examined for vision. This full vision is important for landing an aeroplane, because the machine, diving towards earth at an angle, is then turned up, or what is called "flattened out," at the right moment for landing. This right moment is at a certain distance from earth which the pilot must gage. The accidents on landing are, in the majority of instances, probably due to error of judgment on the part of the pilot; but that error, I think, in some cases is due to defective vision, although so far there is no proof of this. Two well-known private aeroplane pilots have defective vision corrected by glasses. This seems to serve them well, especially as they can have their glasses fitted as goggles instead of wearing the usual plain glass goggles; but there is always the possibility of the glasses or goggles getting shifted, or covered with oil (in the engine-in-front type of aeroplane). This does not affect the normal vision pilot, who pushes the goggles up or down out of the way. Good vision is needed in looking for a suitable landing, when a forced landing has to be made due to engine trouble or other defect.

Hearing—This must be good, as any engine defect in the air gives first indication by sound. Failure to instantly detect, by hearing, any engine defect may lead to serious accident while flying.

Effects of Aeroplane Flying on the Pilot—During the previous year an attempt was made to find out if the pulse-rate and blood-pressure were affected. This was continued during the early part of 1913, but the results were most unsatisfactory from a research point of view. In some cases the pulse-rate showed an increase after only a short flight in calm weather, while in others the rate remained normal. After a flight in bad weather conditions the pulse-rate was always increased. This was to be expected, because to keep the machine on a level means an expenditure of muscular energy. In the case of passengers the pulse-rate showed very little difference, except, of course, those passengers who were making their first flights, and suffered a little from nervous excitement. Nearly all the cigarette smokers seem to have an increase of pulse-rate, and as a great number of aviators are cigarette smokers, one can expect some increase in pulse-rate after flying. As regards blood-pressure, the only way to get any definite results seems to be to send the subject up in the air with a recording blood-pressure apparatus, but unfortunately the vibrations of the machine, due to the engine, affect all pressure-recording instruments; and the results are very doubtful. I think as machines improve it may be possible to carry out such experiments, and obtain some definite data.

*Abstract of an article written in 1913, and published in the *Journal of the Royal Naval Medical Service.*

[1]Weight, and especially size, most emphatically matter nowadays.

A Vortex Hypothesis of World Formation*

An Examination and Explanation of the Theories of Belot

By E. Briner, Dr.Sc., Privat Docent, University of Geneva

THE most popular and widely known cosmogonic theory has certainly been the nebular hypothesis of La Place. This has sometimes been attributed to the German philosopher Kant; but his hazy philosophical generalities have little in common with the admirable precision brought by the French mathematician to his immortal *Theorie du système du monde.*

La Place started from the fact that all the planets and planetary satellites known to him revolve in the same direction, in what is called the direct sense. This agreement gave him a figure of mathematical probability which seemed equivalent to certainty. But since his time, progress in the construction of apparatus, and more especially the strides made by astronomical photography, have brought about the discovery that certain satellites of Jupiter, Uranus and Neptune revolve, not in the direct, but in the retrograde sense. The theory of La Place, if it is still to be accepted as regards its general content, must therefore be modified in its details.

That this modification may be effected is shown by Arrhenius, of Stockholm, who in his *Hypothèse cosmogonique* has been able to explain away all anomalies by taking into account, in addition to the gravitational attraction alone considered by La Place, various other physical forces unknown to the latter, notably the pressure of light rays falling on small bodies. On the other hand, many scientists have felt the necessity of replacing the nebular hypothesis more completely by some form of vortex theory; and various attempts have been made, and are more or less familiar to the reading public, to account for the origin of the solar system in this way.

Among such efforts, the recent one of E. Belot, a prominent French savant, deserves particular attention, by reason of the fact that it explains not merely the origin of the solar system, together with the eccentricities presented by all its members, but actually accounts for the general character of land and sea distribution on the face of the earth. The underlying principle of this hypothesis consists in the careful consideration, not only of the force of gravitation, leading to the movements of revolution and rotation, but of all the forces which can operate upon cosmic matter; and most especially, the force which produces the very significant rectilinear translation of the stellar system through space. The combination of all these forces is seen to produce vortices; so this hypothesis becomes a vortex theory. The germ of the matter is to be found as far back as the writings of Descartes. That genius recognized the analogy between the whirlpools of our rivers, with their marginal eddies and smaller whirls, and the orbits of the planets, carrying with them those of the satellites; and he suggested that the ether, filling the voids between the various orbits, might in similar fashion form circular vortices about the planets.

Belot argues that in the solar system in its primitive form the Newtonian attraction must have been but feeble in comparison with the forces discovered by Clerk-Maxwell and other modern physicists—electrical forces, radiation pressure, and the like. On bodies of very small diameter, say a micron (1/25,000 inch), these forces act with such strength as completely to overcome the attraction of gravitation, and to repel the particles in question from the radiating body at velocities as high as 600 miles per second—greatly in excess of all ordinary planetary velocities. In an original nebula under the influence of a central radiation, the cold of interstellar space would condense the outer vapors and gases in globules, at first very small; and upon these the repulsive force described would act with such violence that the trajectories of the particles would not be sensibly affected by gravitation.

The consequences of this action may be observed in the nebulæ now existent. Belot remarks that:

(1) The amorphous nebulæ, as that of Orion and the American nebula, show no trace of the spherical form caused by attraction; as though they had been disrupted by an internal convulsion, their form seems often to evidence the predomination of repulsive forces. The velocity imparted to cosmic matter by such forces has been actually observed and measured in the tails of comets and in the phenomenon presented by the so-called *Novæ*, or new stars.

(2) The filament nebulæ, like that in Cygnus, the dark regions of the Milky Way adjoining the nebulous masses, and the nebular filaments which connect some of the stars of the Pleiades, all indicate clearly the existence of rectilinear forces of translation. Again we find an instance in which the strength and direction of these forces has been measured; the entire solar system is being carried toward the constellation Hercules at a rate of some 12 miles per second. This means that the energy behind such motion is two hundred times as great as that of the ordinary planetary rotations and revolutions.

(3) The spiral nebulæ, as those of Perseus and Andromeda, of which there are some 20,000, show conclusively the existence of cosmic vortices. It is easy to see how these could arise from combination of the various forces already mentioned. It is not easy to see how they could

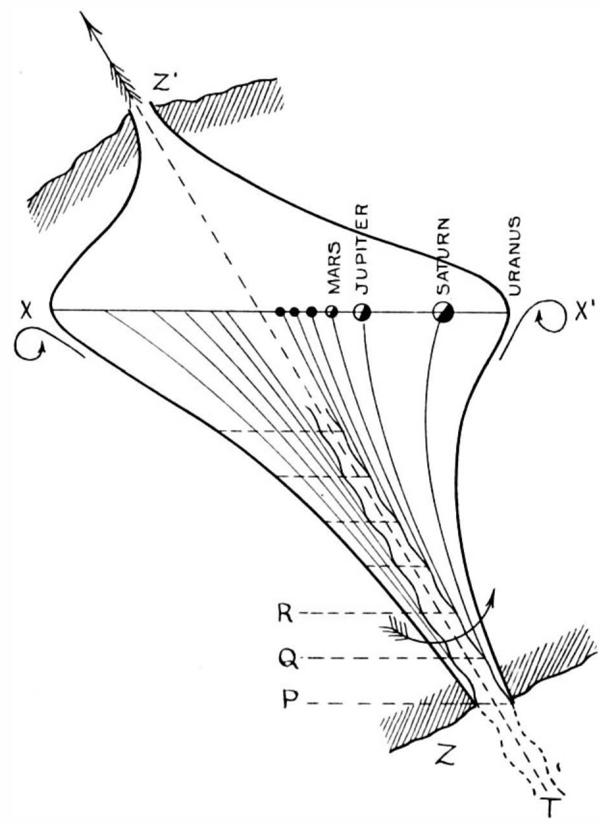


Fig. 1.

result in the formation of a solar system, except under collision.

Such collision ought to be similar to that observed in the *Novæ*. These arise from impact between two bodies; their light, when analyzed under the spectroscope, leaves no possible doubt as to its dual origin. The finest example of *Nova* in modern times was *Nova Persei*, appearing February 21st, 1901. Several months after its first outburst, photographs revealed the existence of four luminous rings about the central nucleus, whose diameters in-

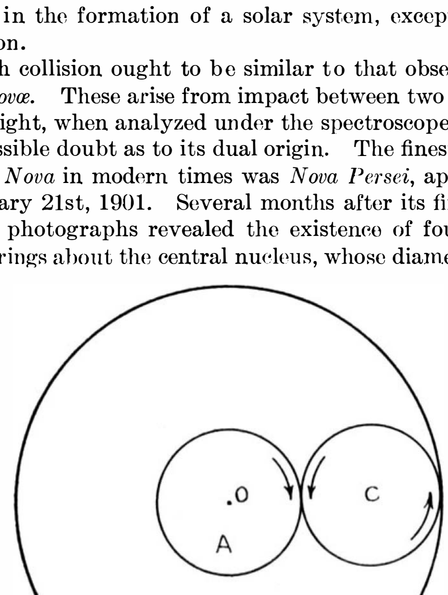


Fig. 2.

creased with a velocity comparable only to that of light.

To explain the *Novæ* Arrhenius suggested that two "dark bodies," i. e., suns of cold surface, meet in space with such impact that quantities of endothermic compounds are liberated from within. This hypothesis is ingenious and elegant, but on the ground of the infinitesimal size of the largest sun in comparison with all space, its probability is slight. Seliger and Halm have made the more likely suggestion that a sun encounters a nebula. At a velocity of 30 miles per second, however, a sun would traverse a nebula with as little commotion as was caused by the earth's passage through the tail of Halley's comet on the last visit of that body. To realize an actual shock in this manner, a sun would have to meet a nebula at a speed considerably in excess of 60 miles per second. And since the projectile must be supposed to have a motion that will lead to explanation alike of the rotations and revolutions existing in the solar system, and of the twisted and centrifugal portions of the spiral nebulæ, it is clear that such motion must be of the vortex type. Where shall we seek for its origin?

Modern physics teaches us that gaseous or ultra-gaseous particles are capable of great velocities. On the other hand, it tells us that gaseous jets in a rarefied medium possess a peculiar vibrant structure, showing a surface undulating in crests and troughs, rather like the waves seen in a vibrating cord or an organ tube. This is not untested theory; these crests and troughs have been photographed, so that their existence is completely established.

Then a gaseous surface moving ahead at high velocity, like a jet of gas, but at the same time actuated by an axial rotation, would correspond exactly to the cosmic entity sought; for through combination of this rotation with the surface waves caused by the motion in the path, its particles would take a whirling course which can perhaps be described by calling the entire body a tube-vortex.

This much established, the fundamental propositions of the vortex hypothesis are:

(1) At the beginning of the solar system there existed (see Fig. 1) a tube-vortex, *T*, of gaseous or ultra-gaseous matter, with high rectilinear speed in the direction, indicated by the straight arrow, of that point in the constellation Hercules toward which the solar system is now headed; and rotating, in the sense indicated by the curved arrow, in planes parallel to the ecliptic *XX'*.

(2) With an impact analogous to that of a *Nova*, this vortex struck an amorphous nebula *ZZ'*, having a comparatively slow rectilinear motion out from the page toward the eye. It may be remarked here that we know by direct experiment that a vortex is permanent, and cannot be destroyed by an impact; and that ordinarily impact widens its spires.

(3) Under the shock of this impact the original vortex, in penetrating the nebula, acquired a vibration throughout its length, in a system of equidistant crests and troughs *P*, *Q*, *R*. . . .

(4) At each crest of vibration there was a maximum of impact with the nebula, giving a maximum disruption, and hence a radial discharge of molecules by virtue of the repulsive forces. These molecules were thrown off in sheets, which expanded and flattened into approximately the form of tulips, concentric with the vortex, spreading out around the axis of the latter, and flattened down toward the ecliptic. We have here a reproduction in theory of the concentric rings of the *Nova* of Perseus, whose formation and projection are thus explained.

A simple experiment in the production of whirling smoke rings, such as those blown by a smoker, will show that such a ring, as it progresses through the air, expands more and more, and that the rotation of its particles from the inside, out, slackens. If a surface be constructed eveloping the successive positions of this expanding ring, it will have the section, speaking mathematically, of a logarithmic spiral; or, speaking in the language of the man who winces at mention of a derivative, it will be shaped precisely like a tulip. It is quite the same in the case of the several planetary rings that arise from the pulsations of the tube-vortex; and there are just as many of these as there are waves throughout the course of the vortex.

Knowing the profile of these rings, it is easy to find at what distances from the center they meet a plane parallel to the ecliptic. Belot has discussed this question by means of the calculus, and has formulated the law governing the distances of the planets from the sun, and of satellites from the controlling planet. This law, which is almost that of Bode, may be stated as follows:

The distance to the vortex from the *n*th planet, counting in order of their detachment from the main body, is the *n*th power of a number *C*, the characteristic of the systems, the different numbers *C* are proportional to the cube roots of the densities of the central bodies. This law, verified for every system of satellites, affords the first important proof of the validity of the Belot hypothesis; and it likewise disposes of the first serious difficulty—to know how a nebula can condense itself into a series of rings, spaced periodically, and separated from each other by very considerable voids.

But even more noteworthy is the fact that the hypothesis of Belot explains the inclination of the axes of

*Adapted from *Larousse Monthly*.

rotation of the planets to the plane of the ecliptic, together with the retrograde motion of certain of their satellites. For, on the side OX, the planetary rings would meet the ecliptic at angles, varying from one planet to the next, which are calculated to be precisely the angles which the axes of rotation of the several planets make with that plane. We say on the side OX, because with the tube vortex rotating from left to right and the nebula into which it has been hurled moving straight out from the page, it is only on that side that the paths of their respective particles are in opposite directions, only there that these two forces conflict for the formation of planetary vortices. Close calculation shows that the nebula falls into two regions; that up to the distance 17, in which only direct rotation can originate, and that beyond, where retrograde motions are produced.

In this way are met the very conditions that led Belot to the formation of his hypothesis, namely, the facts that certain satellites of the outer planets have retrograde orbits, while the axis of rotation of Uranus—and that of Neptune only in lesser degree —lies almost in the plane of the ecliptic.

This matter of retrograde orbits is made clear, according to the author of the hypothesis, by analogy with a certain type of differential gearing. If we have two concentric gears of different sizes, and a third whee', axially free, meshing internally with the one and externally with the other, as in Fig. 2, this third wheel will have two motions, a rotation about its own center, and a revolution about the center of the system. These will vary in speed as the speeds of the two driving gears vary. If the inner driving gear A is given a direct (counter clock-wise) rotation, and the outer one B a retrograde (clock-wise) rotation, the floating gear C will exhibit a retrograde rotation, at the circumference velocity of the slower of the two driving gears, and a revolution about O, direct or retrograde as the case may be, taking up the rest of the impulse afforded by the faster of the two. If we start the apparatus with a very high velocity of the inner gear, and gradually reduce that velocity, C will start with a rapid direct revolution, which will gradually decrease to zero, and then become retrograde. In other words, without changing anything except the relative velocities of the driving gears A and B, without even halting the retrograde rotation of C, we can change the revolution of C from direct to retrograde at pleasure. A similar situation exists in the planetary vortices of Fig. 1.

The explanation of the horizontal position of the axle of Uranus, as Belot says, is the touch-stone of a cosmogony. In this case, the explanation is evident from a glance at the figure. For the projection, at extreme velocity, of the sheet T into the relatively fixed nebula would lead to the formation, at its edge, of a ring vortex quite like the smoke rings given out by a factory chimney, and having the axis of rotation of each element in the plane of the ring. This, of course, would eventually lead to condensation into a planet with its axis in that same plane. A similar explanation would be appropriate in the case of Neptune's 35 degree axial inclination.

We may mention one more circumstance of importance; looking along the line ZZ', the trajectory of the individual molecule, which in each planetary ring is a flattened helix, appears as a spiral projected on a plane perpendicular to the line of sight; and thus is explained the appearance of the spiral nebulæ.

The exponential law governing the distances of planets and satellites, stated above, gives, on consideration of missing members in the various series obtained, five planetary zones and a score of satellite zones, in which no body is known to exist. In several of these intervals astronomers had already suspected the existence of planetary material, without having had any clear notion of its precise distance. Not only does a detailed working out of Belot's hypothesis resolve these difficulties, but it shows in a new and illuminating way the interdependence of orbital eccentricity and axial inclination.

So much for the general aspects of the matter. But there is a great divergence between this hypothesis and its fellows; for instead of contenting himself with an account of the origin of the earth as a planet, Belot follows it after its birth, and attempts to explain the more prominent aspects of the terrestrial surface.

Like all the bodies of the solar system, our planet is the result of a bipolar condensation of the vortex from which it has been formed, together with equatorial condensation of the surrounding matter. This leads to a symmetry in the plane of the original ring—a symmetry due to the motion of the amorphous nebula with which collision was had by the generating vortex of the solar system.

The surrounding matter, by its condensation, produced at the equator a velocity of rotation of some five miles per second, about sixteen times the present equatorial velocity. The earth, constituting a plastic projectile by virtue of the primitive pasty state of its imperfectly solidified surface matter, took, in its progress through the resisting medium of the nebula, the well-known form of the solid of least resistance—a form corresponding to that of a fish, and one adapted for our dirigible balloons.

Again, by reason of the same resistance of the medium, the earth became flattened before and bulged behind. This statement is verified geographically. Since Nansen's first voyage we have known that the Arctic region is occupied by an ocean whose depth is as great as two miles; while, on the other hand, the Antarctic expeditions of Charcot, Shackleton, Scott and Amundsen have established the existence in this quarter of a continent forming a projection whose mean altitude above sea-level is perhaps 4,000 yards. Moreover, in the pursuit of the fish-like form mentioned, a swelling was produced in the northern hemisphere; and we actually find that at the latitude of 23½ degrees north, where the tangent to the sphere is parallel to the ecliptic, this swelling, as seen in the continental extension of the earth, has its

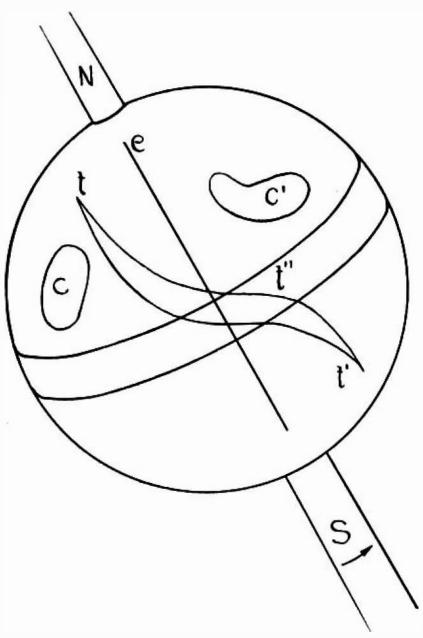


Fig. 3.

maximum. Then, too, the condensation of the vortex toward the north must have been effected in periodic waves, concentric at the pole; and here again the geologist tells us that the oldest foldings of the earth's crust do exhibit this disposition.

But even this is not all. Since it was the northern hemisphere which first met and penetrated the nebular resistant medium, rotation would there be diminished by friction to a much greater extent than in the southern half of the earth. The latter, in its rotation from west to east, would go ahead of the former. To this is attributed the general and uniform torsion which marks the line of our continental masses. South America referred to North America, Southern Africa referred to Northern Africa, the Australian continent and the island bridge of

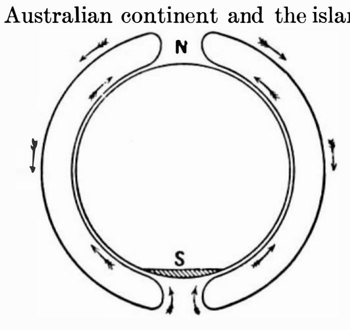


Fig. 4.

Malaysia referred to Asia, all display an unmistakable twist to the eastward.

The general conditions governing the formation of the terrestial shell can be reproduced in a simple experiment as follows: Arrange two tubes, N and S, so that they turn upon each other. In their equatorial plane fix a sphere of wax, properly centered over their common axis. Sow in the surface of this sphere a row of lead grains e, along the line of a meridian. If now the two tubes are rotated in the direct sense, the velocity of S being greater than that of N, or if N is held fixed and S is rotated alone, the meridian line marked by these grains is promptly distorted into a spherical helix $t\,t'$. And if we surround the equator of the miniature world with a metallic band, and give this band a direct rotation in imitation of the matter surrounding the primitive terrestrial body, this helix becomes still further displaced into the position $t\,t''t'$. It will be observed that this latter line takes its most nearly horizontal position somewhat north of the equator. This is in agreement with the continental line of the earth; the horizontal lines of Central America, the Greater Antilles, the Gulf of Guinea, and the Indian Ocean coast of Asia, all lie between 0 degrees and 20 degrees north latitude.

Again, if we hollow out on the surface of this waxen sphere a closed circular area C, and mark it well with grains of lead, we find that this depression, after rotation, takes the form C', with maximum depth at the west. This detail accords with the observed profile of the Atlantic and Pacific Ocean beds.

Not only does this hypothesis account for the main outlines of the earth's surface, but likewise for the formation and location of the primitive oceans. It is to be remarked that alike on the surface of the earth and on that of the planet Mars, the area of the oceans is far greater in the southern hemisphere than in the northern. This unipolar condensation of water is readily explained by consideration of the rectilinear projection of the planet into the nebula.

On the earth, in the beginning, all the water was in a purely gaseous state, by reason of the high temperature, and contributed thus to the formation of the primitive atmosphere. We can estimate at about two miles the thickness of the covering which the oceans would make if spread uniformly over the entire surface of the earth. As long as the terrestrial temperature remained higher than 364 degrees, the critical temperature of water, all this water remained in a completely vaporized state, exercising upon the globe a pressure of about three hundred atmospheres.

But the resistance offered by the nebular medium to the passage of the terrestrial projectile, in addition to producing the flattening of the north pole and the deviation toward the east of the continental masses, had still another effect. At the exterior of the primitive atmosphere of the earth, the friction against the surrounding nebula created a general circulation from north to south, and the circuit was completed upon the surface of the terrestrial core by a current running from south to north. The existence in liquids of a toroidal circulation of this sort has been demonstrated experimentally by Boussinesq. Now this circulation created a cool vertically descending current about the south pole (see Fig. 4), and, after reheating by contact with the incandescent core, a warm ascending current about the north pole. Consequently, it was in the Antarctic regions that the temperature first fell below the critical point of water, and here that abundant condensation first was possible.

The water, still under pressure, was then able to form, on the surface of the core, relatively fusible silicious scums. These scums were carried northward by the circulation of which we have spoken. Near the pole this current had a velocity too high to permit the deposit of this soild matter; but the rapid divergence toward the north of the earth's meridians, with the consequent broadening of the bed of the current and reduction of its depth, caused a decrease in speed which made possible, at about latitude 50 degrees south, the laying down of barrier reefs, which ultimately formed the southern extremities of future continents. It is to be remarked that the latitude of the southern point of New Zealand is 48 degrees, that of the attenuated point of Cape Horn is 55 degrees, and that of the comparatively blunt Cape of Good Hope is 35 degrees.

Such, in general outline, is the hypothesis of Belot, which accounts for the diametrical opposition of the land and water in the earth's surface and for the saltness of the latter. This hypothesis has inspired several notes presented to the Academy of Sciences by Henri Poincaré, and has been the subject of profound study by this distinguished mathematician, who has devoted to it a chapter of his work, *Les Hypothèses cosmogoniques*. It has been completely set forth by its author with all calculations given in detail, in a volume entitled *Cosmogonie tourbillonaire*.

Æolian Tones

In what has long been known as the Æolian harp, a stretched string, such as a pianoforte wire or a violin string, is caused to vibrate in one of its possible modes by the impact of wind; and it was usually supposed that the action was analogous to that of a violin bow, so that the vibrations were executed in the plane containing the direction of the wind. A closer examination showed, however, that this opinion was erroneous and that in fact the vibrations are transverse to the wind. Further, it is not essential to the production of sound that the string should take part in the vibration, and the general phenomenon, exemplified in the whistling of wind among trees, has been investigated by Strouhal (1878) under the name of *Reibungstöne*. In Strouhal's experiments a vertical wire or rod attached to a suitable frame was caused to revolve with uniform velocity about a parallel axis. The pitch of the Æolian tone generated by the relative motion of the wire and of the air was found to be independent of the length and of the tension of the wire, but to vary with the wire's diameter and with the speed of the motion.—*Rayleigh, in the Phil. Mag.*

Some Modern Conceptions of Spontaneous Generation*

The Nature of the Bridge That Spans the Gap from the Inorganic to the Living

By Guilford B. Reed

A DESIRE to know how life originates has been characteristic of the minds of all ages. According to Anaximander the first principle is "the boundless." It is neither water nor other substance yet recognized but some other natural body which is limitless and from it all the universe has arisen. Living things he, however, more concretely states to have sprung from the moist elements evaporated by the sun. This like Aristotle's remarkable paradox that dry bodies when they became wet and moist bodies when they became dry produced living forms is probably sounder philosophy than the fantastic ideas of spontaneous generation which undoubtedly developed from these in the sixteenth century.

The directions of the physicist Helmont for the generation of scorpions is illustrative of this period. "Scoop out a hole in a brick. Put into it some sweet basil, crushed. Lay a second brick on the first so that the hole may be perfectly covered. Expose the two bricks to the sun and at the end of a few days the smell of the sweet basil, acting as a ferment, will change the herb into real scorpions."

So firmly was his conception held that another investigator in the seventeenth century commenting on the ideas of an opponent considers that to question spontaneous generation is to question reason and experience. "If he doubts this let him go to Egypt, and there he will find the fields swarming with mice begot of the mud of Nylus, to the great calamity of the inhabitants."

Such grotesque conceptions were destroyed by the discovery of the Italian physician, Redi, that larvae are not engendered spontaneously in decomposing meat. This he demonstrated by the simple method of placing meat in a wide mouthed jar which was covered by gauze. Flies attracted by the odor of the meat deposited their eggs on the gauze where the larvae hatched. Thus the eggs were shown to be the source of the maggots. This and subsequent investigations along the same line utterly disproved the early theories of a spontaneous generation of life.

With the advent of the microscope, toward the end of the seventeenth century, the spontaneous generation theory was rehabilitated in new form. Every one fortunate enough to have the use of a microscope found new evidence for the theory. It was an easy matter to examine a sample of rain water, for example, leave it in a warm place for a few days and again examine it, when it would be found swarming with various organisms. Since such samples contained no organism at the start and neither organisms or spores were added it was naturally concluded that the living forms arose from the elements of the infusion. Voltaire's sarcasm describes an English investigator who studied generation in meat infusions as one who "engendered eels in the gravy of boiled mutton."

In spite of experimental evidences to the contrary, as well as satire, belief in the spontaneous generation of the various micro-organisms was held more or less firmly until the superb experiments of Pasteur fifty years ago completely banished the conception.

Pasteur proved that organisms which arose in infusions, developed from spores as Redi had shown fly larvae to develop from eggs. More conclusively he demonstrated that organisms which arose in preparations previously subjected to a boiling temperature and hermetically sealed possessed spores capable of resisting such a temperature; but after a series of boilings interspaced by periods of incubation which sufficed to effect the development of all spores to a non resistant condition and their final destruction by boiling, the solutions remained perfectly sterile.

Although Pasteur proved conclusively that life did not arise under a particular group of conditions this by no means disposes of the question of spontaneous generation. The effects of his discoveries have, however, been practically this, and for fifty years the problem has been almost banished from the research laboratory.

If life did not arise spontaneously on the earth it may be conceived according to the suggestions made at various times, as having reached our planet from some other. Arrhenius has dressed this theory in modern form by proceeding from the known facts of bacteriology particularly that the minutest germs of life, many of them ultra-microscopic in size, float about in the air. These spores floating to the upper strata of the atmosphere come under the influence of the pressure of light which he suggests may propel them through space. If an hour glass filled with metal particles, exceedingly fine spores and rarified air is exposed to a powerful beam of light as the particles run through, the metal of course falls perpendicularly but the spores fall in a pile slightly off from the perpendicular in the direction away from the source of light. Arrhenius calculates that if living germs were carried by such radiant forms of energy the time of transit from the earth to Mars would be twenty days, and from our solar system to the nearest stellar system about nine thousand years.

Prof. Schafet in his presidential address to the British Association in 1912 criticises not only the results of this suggestion but more particularly the attitude assumed toward the problem, a criticism which applies equally to the complacency which has followed a problem esteemed to have been settled. "But the acceptance of such theories of the arrival of life on the earth does not bring us any nearer to a conception of its mode of origin; on the contrary, it merely serves to banish the investigation of the question to some conveniently inaccessible corner of the universe, and leaves us in the unsatisfactory position of not only affirming that we have no knowledge as to the mode of origin of life —which is unfortunately true, but that we never can acquire such knowledge, which it is to be hoped is not true. Knowing what we know and believing what we believe, as to the part played by evolution in the development of terriestrial matter, we are, I think, (without denying the possibility of the existence of life in other parts of the universe), justified in regarding these cosmic theories as inherently improbable—at least in comparison with the solution of the problem which the evolutionary hypothesis offers."

With our present knowledge of molecular physics and the chemistry of protoplasm the only conceivable idea of spontaneous generation is a happy combination of matter and energy resulting in the formation of a compound sufficiently complex to carry out the varied activities of the living organism. It is a significant fact that all organisms, in the present stage of evolution, obtain their supply of complex organic compounds, both for their structural constituents and energy producing substances directly or indirectly from one source, namely, the synthetic mechanism of green plants.

The progress of this essential synthesis is dependent upon the presence of an energy transformer, the pigment substance chlorophyll which is a characteristic of green plant tissue. When these tissues are supplied with the simple substance carbon dioxide, a constant constituent of the atmosphere, and water, and illuminated, the elements of the two substances together with a portion of the energy of the light combine to form complex carbon compounds, while the chlorophyll although essential to the reaction is itself not used up but acts as an intermediary between the reacting substances. These parts of the plant which may have lost their chorophyll, for example through complete shading for some days, or those parts which are not green possess no power of building up energy from inorganic sources. Such colorless parts depend upon the green tissue for their supply of organic substances alike in growth and the production of energy. The bodies of green plants in turn are utilized by the colorless bacteria, moulds and mushrooms and, more conspicuously, by animals.

The distinctive feature of this synthetic reaction of green plants is the incorporation of energy in the new compound. Indeed our common-place that all energy comes from the sun might well include the further statement that this radiant energy becomes available through the photosynthesis of green plants. For, with the exception of certain sources such as winds, tides and waterfalls, the energy of life as well as of the industries comes from past or present sources of this nature.

In the non-living we usually look at the utilization of this stored energy as a simple process. When wood, coal or other product of green plants is raised to a sufficient temperature, in the presence of oxygen or subjected to the action of certain chemical agents it burns or oxidizes, in which process oxygen combines with the substance undergoing reaction so that the energy of the sun incorporated by photosynthesis is liberated as heat or light and the matter itself reduced to simple compounds.

Vital force, in the terminology of an older biology, results from a similar oxidation process; yet in the living organism various energy containing compounds are normally oxidized without the interaction of high temperature or strong chemical agents. This discrepancy between the oxidations in the living body and those which are carried on outside manifests itself also in other chemical reactions such as digestion processes, characteristic of both plants and animals, which were first found to occur outside the living body rapidly only under conditions incompatible with life. The discrepancy, however, was largely done away with by the discovery that the same acceleration of chemical reactions which is brought about by high temperature can also be accomplished at a low temperature by certain specific substances, the so-called catalyzers. The specific substances which accelerate the oxidations at body temperature, sufficient to allow the liberation of the stored energy for the propagation of the varied activities of the living organism, are the ferments of oxidation. Although recent research has shown that these ferments may be extracted from the living cell and made to accelerate oxidation processes under laboratory conditions, and that several purely inorganic substances are capable of effecting similar reactions, the fact remains that the bodies normally actuating these reactions are products if not parts of the protoplasm.

The protoplasm, like the energy of the organism, is developed directly or indirectly from the products of the photosynthesis of green plants. Although much of the structure of protoplasm is unknown to us at present we are at least familiar with the general course of its development. The chemical compounds resulting from photosynthesis, carbohydrates, as sugars, starches, celluloses and like compounds are compounds of carbon, hydrogen and oxygen. As a result of the wonderful property of carbon, molecules are produced far larger than occur with compounds of any other element. But more significant than the mere size of the molecule is the almost infinite possibility of variation and the likely formation of substitution products generally by the replacing of one or more atoms of the molecule by new elements.

The building up of the protoplasm is a series of such substitution reactions resulting in the formation of compounds of increasing complexity. A most important and probably primary stage is the addition of nitrogen. In the green plant the simple nitrogen compounds taken up by the roots are combined with the carbohydrates to form the most complex of chemical substances, the proteins, some of the simpler of which have been prepared under laboratory conditions so that we are familiar with them. These proteins like the carbohydrates are transferred to various parts of the plant or taken by animals, simplified by digestion and again complicated in assimilation.

In the construction of protoplasm due to the unstable affinity of the constituent proteins great aggregate molecules, as they are sometimes called, are produced. Many, perhaps hundreds of protein molecules associate, without any true atomic union, to form an organic colloid. The most noteworthy characteristic of this colloid is its instability. Its strength for the purpose of the vital reactions lies in its weakness as a chemical body, for its existence in a state of most delicate balance permits it to respond to every variation in the environment.

The development of these protein bodies as well as the subsequent colloid complexes, is due, like the production of energy in the organism, to the action of specific ferment bodies. Inorganic catalizers have been shown capable of effecting many of these reactions, yet in the normal reactions these bodies are colloidal and complex in their nature.

From this brief analysis it is apparent that the synthetic reactions of green plants is the one place where energy and inorganic bodies unite in the development of energy for the life activities and the first great step in the production of living structures. This seems then to be the fundamental reaction from the inorganic to the living upon which all organisms depend at present.

As already indicated, however, this reaction proceeds

*Queen's Quarterly.

only in the presence of the energy transformer chlorophyll upon which it is dependent. Although the chemical constitution of this chorophyll is now understood it is far too complex a body to be conceived of as arising in the first stage from inorganic matter in the absence of life, yet as the present intermediary in the building of life substances it affords at least a clue to the nature of the bridge which spans the gap from the inorganic to the living.

If, indeed, the first living substance had its origin in such a synthesis of energy the first transformer in a world which had no life must have been inorganic and it is at least of interest that more than one such transformer has been found. One investigator has found that carbon dioxide and water exposed to sun light in the presence of salts of the inorganic element uranium develops formaldehyde which is recognized as one of the first products of normal photosynthesis in green plants.

Avoidance of technicalities has prohibited anything approaching a full development of these ideas, yet this outline may serve to indicate the conception now held by many biologists, that through an infinitely long series of changes, first influenced by inorganic energy absorbers and catalytic agents and, subsequently, as more complicated bodies developed by colloidal and specific ferment substances, life may have arisen or still is arising from the inorganic.

It may be contended that such are speculations beyond the prerogative of the experimental scientist. It is indeed true that up to the present there is no direct evidence of such happenings; no process of transition from the inorganic has been directly observed. But on the other hand it is equally true that the kind of evidence which would be of any real value in determining this question has scarcely been looked for. We may be certain that if life is being produced from the non-living substance it would be life of a far simpler character than any which has yet been observed—in material which we should be uncertain whether to call animate or inanimate. The inorganic materials are of a certainty continually undergoing transition. New chemical combinations are constantly being formed and old ones broken down; new elements are making their appearance and old elements disappearing. Likewise among organisms from the simplest to the most complex variation is constant, examples of evolution and regression are obvious. We may well ask why the production of living matter alone should be subject to other laws than those which have produced and are producing various forms of non-living as well as living matter.

The Analysis of Living Matter*

Through Its Reactions to Poisons

By A. R. Cushny, M.A., M.D. Aberd., F.R.S., Prof. of Pharmacology, University College, London.

I AM told that the chair of Section I. has not been held by a pharmacologist for many years, and I wish to express the pleasure I feel in the honor that has been done me personally, and even more in the recognition vouchsafed to one of the youngest handmaidens of medicine. Pharmacology has too often shared the fate of the bat in the fable; when we appeal for support to the clinicians we are told that we represent an experimental science, while when we attempt to ally ourselves with the physiologists we are sometimes given the cold shoulder as smacking too much of the clinic. As a matter of fact, we should have a footing in each camp, or, rather, in each division of the allied forces. And the more recent successes in the application of pharmacology to diseased conditions are now beginning to gain it a rather grudging recognition from clinicians, while the alliance with the biological sciences is being knit ever more closely. The effect of chemical agents in the living tissues has assumed a new and sinister aspect since the enemy has resorted to the wholesale use of poisons against our troops, but I must leave this for the discussion to-morrow.

THE CHEMISTRY OF LIVING MATTER.

I wish to-day to discuss an aspect of pharmacological investigation which has not been adequately recognized even by the pharmacologists themselves, and which it is difficult to express in few words. In recent years great advances have been made in the chemical examination of the complex substances which make up the living organism, and still greater harvests are promised from these analytic methods in the future. But our progress so far shows that while general principles may be reached in this way, the chemistry of the living organ, like the rainbow's end, ever seems as distant as before. And, indeed, it is apparent that the chemistry of each cell, while possessing general resemblances, must differ in detail as long as the cell is alive. No chemistry dealing in grammes, nor even microchemistry dealing in milligrammes, will help us here. We must devise a technique dealing with millionths to advance towards the living organism. Here I like to think that our work in pharmacology may perhaps contribute its mite; perhaps the action of our drugs and poisons may be regarded as a sort of qualitative chemistry of living matter. For chemical investigation has very often started from the observation of some qualitative reaction, and not infrequently a good many properties of a new substance have been determined long before it has been possible to isolate it completly and to complete its analysis. For example, the substance known now as tryptophane was known to occur in certain substances and not in others long before Hopkins succeeded in presenting it in pure form. And in the same way it may be possible to determine the presence or absence of substances in living tissues, and even some of their properties, through their reaction to chemical reagents, that is, through the study of the pharmacology of these tissues. A simple example may render the point clearer. It is possible that if the toxicity of the saponins to different cells were accurately known, the relative importance of the lecithins in the life of these cells might be estimated, and this might give a hint to the chemist in approaching their analysis. I do not claim that pharmacological investigation can at present do much more than the qualitative testing of the tyro in the chemical laboratory, but even a small advance in the chemistry of living matter is worthy of more attention than this has received hitherto.

All forms of living matter to which they have free access are affected by certain poisons, and some of these have obvious chemical properties which suggest the method of their action; thus the effects of alkalies and acids and of protein precipitants hardly need discussion. Others such as quinine and prussic acid, which also affect most living tissues, have a more subtle action. Here it is believed that the common factor in living matter which is changed by these poisons is the ferments, and quinine and prussic acid may therefore be regarded as qualitative tests for the presence of some ferments, notably those of oxidation, and, in fact, have been used to determine whether a change is fermentative in character or not. Formaldehyde was stated by Loew to be poisonous to living matter through its great affinity for the NH_2 group in the proteins, a suggestion which has perhaps not received enough attention of late years, during which the importance of this group in proteins has been demonstrated. The toxicity of other general poisons, such as cocaine, is more obscure. But what has been gained already in this direction encourages further investigation of the action of the so-called general protoplasm poisons and further efforts to associate it with the special constituents of the cell.

BODIES ACTING ON THE NERVOUS SYSTEM.

In other poisons the action on the central nervous system is the dominating feature, and among these the most interesting group is that of the simple bodies used as anæsthetics and hypnotics, such as ether, chloroform and chloral. The important use of this group in practical medicine has perhaps obscured the fact that they act on other tissues besides the central nervous system, though we are reminded of it at too frequent intervals by accidents from anæsthesia. But while they possess this general action, that on the nervous tissues is elicited more readily. Not only the nerve cells, but also the nerve fiber reacts to these poisons, as has been shown by Waller and others. And even the terminations are more susceptible than the tissues in which they are embedded, according to the observations of Gros. The selective action on the nervous tissues of this group of substances has been ascribed by Overton and Meyer to the richness in lipoid substances in the neurons, which leads to the accumulation of these poisons in them, while cells containing a lower proportion of lipoid are less affected. In other words, Overton and Meyer regard these drugs as a means of measuring the proportion of lipoids in the living cell. This very interesting view has been the subject of much discussion in recent years, and, in spite of the support given it by several ingenious series of experiments by Meyer and his associates, no longer receives general acceptance. Too many exceptions to the rule have to be explained before the action of these bodies can be attributed wholly to their coefficients of partition between lipoids and water. At the same time the evidence is sufficient to justify the statement that the property of leaving water for lipoid is an important factor in the action of the bodies, although other unknown properties are also involved in it. And whatever the mechanism of the characteristic action, these substances in certain concentrations may be regarded as tests for the presence of nervous structures and have been employed for this purpose.

Other bodies acting on the nervous system have a much narrower sphere. Morphine and strychnine, for example, appear to be limited to the region of the nerve cells, but there is still doubt whether they affect the cell body alone or the synapses between certain of its processes. They have not been shown to act on peripheral nervous structures in vertebrates, nor on any but specific regions of the central nervous system. Nor has it been established that they affect invertebrates. The substance with which they react is obviously limited by very narrow boundaries around the nerve cell.

More interest has been displayed in recent years in the alkaloids which act on the extreme terminations of various groups of nerves. These are among the most specific reagents for certain forms of living matter which we possess. Thus, if an organ reacts to adrenalin we can infer that it contains the substance characteristic of the terminations of sympathetic fibers with almost as great certainty as we infer the presence of a phenol group from the reaction with iron. And this sympathetic substance can be further analyzed into two parts by means of ergotoxin, which reacts with the substance of the motor sympathetic ends, while leaving that of the inhibitory terminations unaffected. Similarly, the endings of the parasympathetic nerves are picked out with some exceptions by the groups represented by atropine and pilocarpine, and here again there must be some definite substance which can be detected by these reagents.

Further, some light has been thrown on, at any rate, one aspect of these nerve-end substances by the observation that they all react to only one optical isomer in each case. Thus, the dextro-rotary forms are ineffective in both atropine and adrenaline, and this suggests strongly that the reacting body in the nerve-ends affected by these is itself optically active, though whether it bears the same sign as the alkaloid is unknown. This very definite differentiation between two optical isomers is not characteristic of all forms of living matter. For example, the heart muscle seems to react equally to both lævo and dextro-camphor. The central nervous system contains substances which react somewhat differently to the isomers of camphor and also of atropine, but the contrast is not drawn so sharply as that in the peripheral nerve ends.

Another test alkaloid is curarine, the active principle of curare, which in certain concentrations selects the terminations of the motor nerves in striated muscle as definitely as any chemical test applied to determine the presence or absence of a metal.

RELATIONSHIPS IN REACTIONS OF DIFFERENT TISSUES.

The tyro in the chemical laboratory is not often fortunate enough to be able to determine his analysis with a single test. He finds, for example, that the addition of ammonium sulphide precipitates a considerable group of metals, which have then to be distinguished by a series of secondary reactions. The pharmacologist, as an explorer in the analysis of living matter, also finds that a single poison may affect a number of structures which appear to have no anatomical or physiological character in common. But as the chemist recognizes that the group of metals which react in the same way

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to his reagent have other points of resemblance, so perhaps we are justified in considering that the effects of our poison on apparently different organs indicate the presence of some substance or of related substances in them. A great number of instances of this kind could be given, and in many of these the similarity in reaction extends over a number of poisons, which strengthens the view that the different organs involved have some common reacting substance.

One of the most interesting of these is the common reaction of the ends of the motor nerves in striated muscle and of the peripheral ganglia of the autonomic system. It has long been known that curare and its allies act in small quantities on the terminations of the motor nerve in ordinary muscle, while larger amounts paralyze conduction through the autonomic ganglia. More recently it has been developed by the researches of Langley that nicotine and its allies, acting in small quantities on the ganglia, extend their activities to the motor ends in large doses. Some drugs occupy intermediate positions between nicotine and curare, so that it becomes difficult to assign them to either group. These observations appear to leave no question that there is some substance or aggregate common to the nerve ends in striated muscle and to the autonomic ganglia. As to the exact anatomical position of this substance, there is still some difference of opinion. Formerly it was localized in the terminations of the nervous fibers in the muscle and ganglia, but Langley has shown that in the latter the point of action lies in the ganglion cell itself, and his researches on the antagonism of nicotine and curare in muscle appear to show that the reacting substance lies more peripherally than was supposed, perhaps midway between the anatomical termination of the nerve and the actual contractile substance. Another analogy in reaction has been shown to exist between the ganglia and the terminations of the post-ganglionic fibers of the parasympathetic, for Marshall and Dale have pointed out that a series of substances, such as tetramethyl-ammonium, affect each of these in varying degrees of intensity. The specific character of the reaction is shown by the fact that while it is possessed by the tetramethyl-ammonium salts, the tetraethyl-ammonium homologues are entirely devoid of it.

Another close relationship is shown by the reaction of the glucosides of the digitalis series on the heart and vessels. These all act on the muscle of the heart, and in higher concentration on that of the vessel walls. There must, therefore, be a common base in these which is affected by the drugs. And the existence of this is perfectly intelligible in view of the fact that the heart is developed from the vessels. A more obscure relationship is shown by the reaction of this group to the inhibitory cardiac center in the medulla, which is thrown into abnormal activity by their presence in the blood, as has been shown alike by clinical and experimental observations. A similar relation is shown by the common reaction of the heart muscle and the vagus center to aconitine and some other related alkaloids. On the other hand, the saponin series, which shows a closer relationship to the digitalis bodies in the heart muscle, is devoid of its characteristic action on the medulla. The reacting substance in the heart is thus capable of responding to digitalis, sapronin and aconitine, while that in the vagus center can associate only the first and last and is not affected by the saponins; the common reactions indicate that the two are related, while the distinctive effect of saponin shows that they are not identical. A similar relationship may be drawn from the action of morphine and the other opium alkaloids on pain sensation, on respiration, and on the movements of the alimentary tract. Exact determinations of the relative power of these alkaloids in these regions are not at our disposal as yet, but sufficient is known to suggest that while morphine affects a common substance in the medullary center and the intestinal wall, the other members of the series act more strongly in one or other position.

It was long ago pointed out that caffeine affects both kidney and muscle cell, and Schmiedeberg has attempted to correlate the intensity of action of the purine bodies at these points and to measure the probable diuretic action by the actually observed effect on the contraction of muscle. Other reactions of the kidney suggest a relationship to the wall of the bowel. For example, many of the heavy metals and some other irritant bodies act strongly on the kidney and bowel, and again according to one view of renal function, many of the simple salts of the alkalies affect the kidney in exactly the same way as the bowel wall. This last may, however, be due to the physical properties of the salts, and the likeness in reaction to those of kidney and bowel, which is striking enough, may arise rather from a likeness in function of the epithelium rather than from any specific relationship to the salts which is not common to other forms of living matter.

INTERPRETATION OF REACTION IN COMMON.

Many other examples might be cited in which organs which are apparently not related, either morphologically or in function, react to poisons in quantities which are indifferent to the tissues in general. And this reaction in common can only be interpreted to mean that there is some substance or group of related substances common to these organs. The reaction may differ in character; thus a drug which excites one organ to greater activity may depress another, but the fact that it has any effect whatever on these organs in preference to the tissues in general indicates some special bond between them, some quality which is not shared by the unaffected parts of the body. I have, therefore, not differentiated between excitation and depression in discussing this relation. One is tempted to utilize the nomenclature introduced by Ehrlich here and to state that the common reaction is due to the presence of haptophore groups, while the nature of the reaction (excitation or depression) depends on the character of the toxophore groups. But while these terms may be convenient when applied to poisons whose chemical composition is altogether unknown, they merely lead to confusion when the question concerns substances of ascertained structure. Thus, as Dale has pointed out, it is impossible to suppose that such substances as tetramethyl-ammonium and tetraethyl-ammonium owe the difference in reactions to specific haptophore groups in the one which are absent in the other. It seems more probable that in this instance and in others the difference in the effect of these bodies in the tissues arises from difference in the behavior of the molecule as a whole than in differences in the affinities of its special parts; that is, that the action of these poisons is due to their physical properties rather than to their chemical structure, although this, of course, is the final determining cause.

In the same way the common reaction of tissues, which I have so far ascribed to their possessing some substance in common, may arise from community of physical relationship, and I wish to avoid the implication borne by the word "substance," which I have used in the widest sense, such as is justified perhaps only by its historical employment in theological or philosophical controversy. The reaction of living tissue to chemical agents may arise from a specific arrangement in its molecule, but may equally be attributed to the arrangement of the molecules themselves. And the curious relationships in the reactions of different tissues may indicate, not any common chemical factor, but a common arrangement of the aggregate molecules. We are far from being able to decide with even a show of probability which of these alternatives is the correct one, and my object to-day has been to draw attention to these relationships rather than to attempt their elucidation. Hitherto the speculative pharmacologist has been much engaged in comparing the chemical relationship of the drugs which he applies to living tissues; much useful knowledge has been incidentally acquired, and the law has been formulated that pharmacological action depends directly on, and can be deduced from chemical structure. This view, first elaborated in this country, has in recent years shared the fate of other English products in being advertised from the housetops and practically claimed as the discovery of more vociferous investigators. On examining the evidence, old and new, one cannot help feeling that attention has been too much directed to those instances which conform to the creed, while the far more numerous cases have been ignored in which this so-called rule fails. The difficulties are very great; for example, what chemical considerations can be adduced to explain why the central nervous tissues react differently to bromide and chloride, while to the other tissues these are almost equally indifferent; or how can the known chemical differences between potassium and sodium be brought into relation with the fact that they differ in their effects in almost every form of living tissue?

Less attention has been paid to the other factor in the reaction, the properties of the living tissue which lead one cell to react to a poison, while another fails to do so. I have pointed out some curious relations between different organs, but much needs to be done before any general view can be obtained. Further detailed examination of the exact point at which poisons act, and much greater knowledge of the physical characters of the drugs themselves and of the relation of colloid substances to these characters, are needed. We must attempt to classify living tissues in groups not determined by their morphological or even functional characters, but by their ability to react to chemical agents. Advance is slow, but it is continuous, and if no general attack on the problem is possible as yet, our pickets are at any rate beginning to give us information as to the position of the different groups to be attacked. And when a sufficient number of these qualitative reactions have been ascertained for any form of living matter, it may be possible for some Darwin to build a bridge from the structural chemistry of the protein molecule to the reactions of the living cell. We can only shape the bricks and mix the motar for him. And my purpose to-day has been to indicate how the study of the efforts of drugs on the living tissue may also contribute its mite toward the great end.

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