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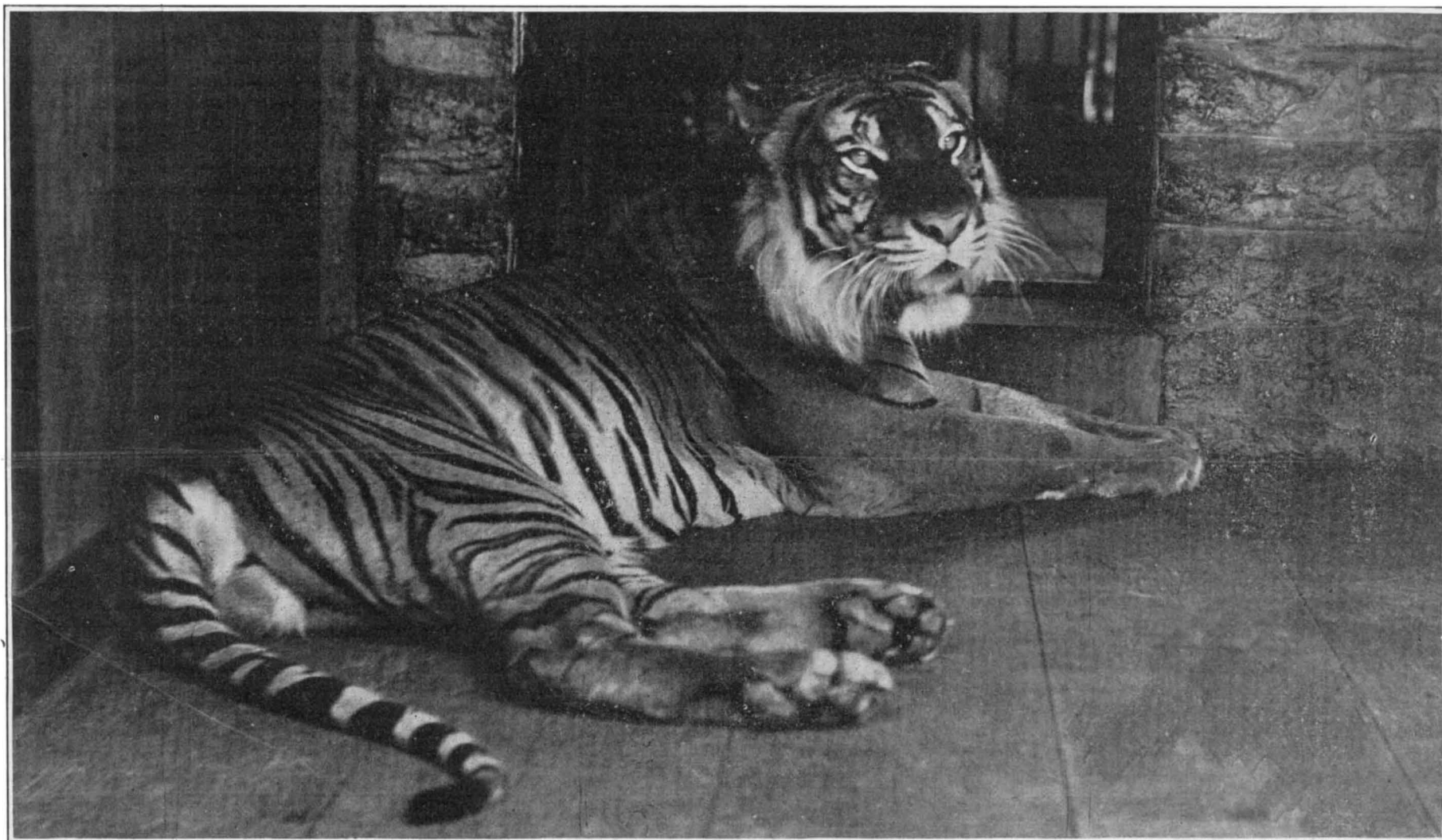
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"Brutus," a male African lion, one of the finest in captivity.



A magnificent male tiger in the Cincinnati zoo.

THE ZOOLOGICAL GARDENS OF CINCINNATI.—[See page 56.]

Modern Views of the Sun—I*

An Important Star Whose Real Nature Is Only Beginning to Be Understood

By J. S. Plaskett

THIS to us all important star, the sun, has in all times and all ages excited the keenest interest and wonder in mankind. It was in several races invoked as one of the deities who rule over mankind, and, indeed, though perhaps not realized to the full by its followers, sun worship had a better basis for its existence, so far as man's material welfare is concerned, than any of the pagan religions.

In modern times we are only at the beginning in obtaining some idea of the real nature, constitution and influence of the sun. Indeed, we need go no farther back than to the first Herschel to find that the sun was then considered a solid body essentially like the earth, surrounded by luminous, light-giving clouds, and that the sun-spots were mountains on this huge globe sticking up their heads through the clouds. It was probably not until the discovery of spectrum analysis, little more than half a century ago, that the true nature of the sun began to be dimly realized. Just as in the study of the stars, the last decade or so has seen more real advances in the study of the constitution, structure and motions of the sidereal universe than all preceding time, so the last twenty years of solar research have been more fruitful in teaching us the nature of this dominant orb of our system than all the labors and speculations of earlier periods.

And yet, just as in sidereal astronomy the advances of the present would have been impossible without the patient and painstaking observations of past generations, so in solar research we owe more than is generally realized to those who have carefully observed and faithfully recorded the visible phenomena of the sun, who have attempted to correlate them with terrestrial phenomena and who have advanced hypotheses, no matter if mistaken, to account for the observed facts.

The importance of the problem of the constitution of the sun is being more and more realized, not only by astronomers and scientists, but by representative governing bodies and the intelligent public as well. This is indicated by the formation, within the last ten years or so, of the International Union for Co-operation in Solar Research, an association of the prominent astronomers, physicists and other scientific men of the world, interested in solar research, with the purpose of intelligently co-ordinating and combining the energies of all institutions into the most profitable channels of attack, and of preventing useless duplication of work.

This organization has already been of immense advantage in standardizing and systematizing the methods of research and arranging for co-operative work in the various problems. It forms an authoritative international body whose decisions on systems of units, nomenclature, etc., shall be final. The adoption of standard methods in the determination of wave lengths and of a number of standards of wave-length for universal use, correct probably within one thousandth of an Angström unit, or one part in five million, is one example of a decision which more than justifies its formation; and a second is the adoption of the Harvard system of classification of stellar spectra for universal use.

The other instance of the dawning realization of the importance of the study of the sun has been the organization, under the auspices of the Carnegie Institution, of the Mt. Wilson Solar Observatory, also established just over ten years ago. This is probably the best equipped observatory in existence, with nearly every appliance that man can devise to assist in its special work on the sun, with the allied physical and astronomical problems. Under the able direction of Mr. George E. Hale, our knowledge of the structure and movements of the sun's upper atmosphere has already been wonderfully extended and I shall have occasion frequently to refer to the discoveries made there.

In view of the limited time at my disposal it has seemed best to give you a brief account of present day views of the nature of the sun without attempting other than incidental reference to the historical development of the subject. To make the subject as comprehensible as possible to the layman, let us open it, even at the risk of some lack of sequence later, at the very beginning. If we look at the sun through smoked glass we see an intensely bright disk with a sharp circular boundary which is called the limb, and, sometimes, with dark spots on its surface. If we use a telescope

of higher and higher power, of course with the intensity suitably diminished by shade glasses or other means, we find that the outer boundary still appears perfectly sharp and circular, that we see many more spots, that the surface of the sun, generally called the photosphere, is not uniformly bright but is mottled in a way that has led to its being called the rice grain structure, and that some parts near the limb and also often near spots are much brighter than the general surface, such parts being called faculae. If these observations are continued we would find, as was discovered about eighty years ago, that the numbers and sizes of the spots and faculae varied, that they passed through a complete cycle of change, through maximum and minimum spottedness, in a little over eleven years. Another evident, and even obtrusive, fact of observation is that in addition to sending us a great deal of light we also receive a considerable amount of heat.

In addition to these observational facts let us recount a few well-known dimensions. The sun, whose diameter is 865,000 miles, is situated nearly 93,000,000 miles from us. Its volume will evidently be $(865/8)^3$ or 1,306,000 times that of the earth. A simple dynamical calculation, based on the known times of revolution of the moon around the earth and of the earth-moon system around the sun, shows that the sun has 332,800 times the mass of the earth. The density of the earth, which has been very accurately determined by the physicists, is 5.52 times that of water, and hence the sun is 1.41 times as heavy as an equal volume of water. If expressed in pounds the mass of the earth is 1,317 followed by 22 ciphers and of the sun 438 followed by 28 ciphers. It readily follows that the attraction of the sun at its surface is 27.6 times that of the earth at its surface, and a man weighing 150 pounds would weigh over two tons on the sun and would be crushed to death under his own weight if he had not been already turned into vapor long before he reached the surface.

The sun being 93,000,000 miles from the earth, it is evident, even to the least observing and thoughtful, that it must be exceedingly bright and hot to give such striking evidence of these effects at that enormous distance. No doubt most of us have been present at a fire and have noticed how rapidly the heat diminished as we moved away, that, even if unpleasantly hot at a hundred yards, it was quite comfortable at two hundred. It seems quite reasonable to say that, if the sun radiates so much heat at 93,000,000 miles, it must be hotter than any temperature attainable on the earth.

It is evident that no direct method of determining the temperature of the sun can be used, but there are several indirect methods, fortunately, by which we can obtain the temperature of the visible radiating surface, the photosphere. These are mostly too technical for a lecture of this kind, but one of them, perhaps, may be made to come within its range. Theory and experiment have shown that the radiation, the emission of heat and other energy, from a perfect radiator (the sun is probably not quite a perfect radiator), varies as the fourth power of the temperature. This is known as Stefan's law, and it is evident that if we can find the radiation sent out by the sun, we can determine its temperature by extracting the fourth root of the radiation. The radiation or amount of energy emitted by the sun at the distance of the earth has been very carefully and accurately determined (of this I shall have something to say later on), and has been found to amount to 1.95 calories per square centimeter per minute. This is the value outside our own atmosphere, but, owing to the absorption of the latter, less than two thirds of this reaches the earth's surface; 1.95 calories means in plain language that if you have a little cube of water each side being a centimeter, two fifths of an inch long (less than a thimbleful of water altogether) and if the sun is allowed to shine directly on one of these sides for one minute, and no heat is lost by reflection or otherwise, the temperature of the water would be raised 1.95 deg. C., or 3.5 deg. F. Put in another way, the amount of heat reaching us from the sun is sufficient to raise the temperature of a layer of water two fifths of an inch thick 3.5 deg. F. in one minute. Knowing the amount per square centimeter, 93,000,000 miles from the sun, we get the total emission by multiplying 1.95 by the superficial area in square centimeters of a sphere 186,000,000 miles in diameter. Dividing this enormous amount by the superficial area of the sun, we get the amount radiated per unit area, and, applying the proper constants and extracting the fourth root, we obtain the tempera-

ture of 5,860 deg. C. absolute. As the sun is probably not a perfect radiator, its temperature would be higher than this figure, and the other methods indicate a temperature not less than 6,200 deg. C., probably approaching 7,000 degrees. On the ordinary Fahrenheit scale these are 10,700 and 12,100 degrees. Ordinary cast iron melts at 2,000 and platinum at 3,200 degrees, so you will realize that the photosphere must be composed of gases and vapors only.

Our ordinary methods of observation and analysis have shown us that the visible surface of the sun has a mottled appearance, is cyclically invaded by sun-spots and faculae and is at such an excessively high temperature—nearly 12,000 deg. F.—that it is unlikely to be composed of anything but gases and vapors.

To learn more of the structure of the photosphere and the upper solar atmosphere other methods of attack are necessary, and let us now see what we can learn from the spectrograph and spectroheliograph and various auxiliary attachments of them.

Every one, surely, in these days knows what a marvelous increase in our knowledge of the constitution and physical condition of the heavenly bodies has come to us by means of the spectroscope or spectrograph, the latter being the modern form designed to photograph the spectrum. We all know, for example, that by comparing the positions of lines crossing the spectrum of any body with the positions of the lines in the spectra of the various elements, we can surely identify the elements present in the body. And, further, we know that if the lines crossing the spectrum are separate bright lines, the body is composed of incandescent gases and vapors. If the lines are dark, then between the spectrograph and the bright body there is a layer of cooler gases, not necessarily cold, but a lower temperature than the bright body. If the spectrum is one continuous band of color without lines the body is an incandescent solid or liquid, or possibly a gas under great pressure. Furthermore, any shift from the normal positions of any of these lines shows that the gas or vapor producing these lines is in motion toward or from us or is under pressure, motion and pressure shifts of lines being usually easily differentiated. The accuracy of modern spectrographs is so great that we can easily determine, on the sun at any rate, where there is plenty of light, a motion of the gases equal to the speed of a man running.

A little reflection will show how much these unique properties and possibilities of the spectrograph enable us to determine of the constitution, physical condition and motions in the photosphere and upper atmosphere of the sun usually called the chromosphere. The solar spectrum is apparently a continuous spectrum crossed by thousands of dark lines. The continuous part shows that the light-emitting part, the photosphere, is either incandescent, solid or liquid matter or else gaseous material under great pressure. The dark lines show that above the photosphere is a layer of gases and vapors at a lower temperature, sometimes called the reversing layer. A comparison of the positions of these lines with those of the terrestrial elements testifies absolutely to the presence of the vapors of some forty elements in this reversing layer, and possibly to a dozen more. Nevertheless, every scientific man believes that all the terrestrial elements are present in the sun and the lines of some of them do not show in the spectrum only because they give relatively weak spectra which are overpowered by the stronger spectra of those whose lines are visible.

When the exceedingly bright photosphere of the sun is covered by the moon at total solar eclipses, the spectrograph shows that the cooler gases in the reversing layer are really incandescent and at a high temperature. At the instant the photosphere is obscured the spectrum changes or flashes from a dark-line to a bright-line spectrum, every dark line practically being replaced in the same position, though not always of the same intensity, by a bright line. This of course is indubitable proof of the presence of this layer of incandescent gases, while the length of the curved lines for the different elements enables a close estimate of the heights to which the vapors of these elements extend above the photosphere. The depth of this reversing layer or chromosphere is not uniform and the height to which the various gases ascend is different, depending in general upon the density, the heavier gases remaining at the lower levels and not often exceeding a height of 700 kilometers, about 450 miles. Hydrogen, calcium, helium, sodium and a few

*Address of the retiring president of the Royal Astronomical Society of Canada at its annual meeting, 1916. Republished from the *Journal* of the Society.

others rise to much greater heights up to 10,000 or 15,000 kilometers—6,000 to 9,000 miles. Rising higher still above the photosphere are the prominences which are apparently eruptions or outbursts of luminous gas which the spectrograph has shown are generally hydrogen and calcium. These were first seen at eclipses but can now be observed and photographed at any time. The prominences pass through a similar cycle to the spots and are apparently related in some way, although even when there are no spots the sun is never free from prominences. These prominences sometimes shoot up to the enormous height of two or three hundred thousand miles, occasionally reaching a velocity of two hundred miles, a second. They are, to my mind, striking confirmation of the disturbed condition of the interior of the sun.

But, besides these tremendous eruptions, the spectroscope shows that the chromosphere, and probably also the photosphere, is rarely quiescent. Over and near sun-spots, for instance, the work of Evershed first showed by the displacement of the spectral lines that the vapors were in motion and this work has been further extended and rendered beautifully complete by the work of Hale and St. John, at Mount Wilson. Before treating more particularly of the motions and structure of sun-spots, I wish to speak of an instrument by which the chromosphere can be photographed at different levels and in the light of different gases.

The principle of this instrument was independently brought out by Hale and Deslandres, about 1890, but the first spectroheliograph, as it is called, was constructed and used by Hale in 1891. This instrument, by which the distribution of the various gases and vapors at various levels in the sun's atmosphere can be photographed, is an ingenious application of the principle of the spectroscope. Many of the elements, especially calcium and hydrogen, give very strong and broad absorption lines in the sun's spectrum. It occurred to Hale that by isolating the light from one of these lines in a spectrograph it might be possible that by suitably moving the sun and spectrograph relatively, to obtain a photograph of the sun in the light of this gas. Various forms of spectroheliographs for accomplishing this aim have been devised, but I need only describe the simplest.

If we have a large spectrograph with a slit as long as the diameter of the solar image, this will form a spectrum as wide as the sun crossed by lines as long as the solar diameter. If in the place of the photographic plate we place a metal plate with a slit in it, adjustable to any position, it will be possible for us to place this slit on any desired line in the solar spectrum. Evidently, under such circumstances, only the light from the gas or vapor producing this line can get through the second slit. A plate placed immediately behind this second slit will record the distribution of this particular luminous vapor over the particular narrow segment of the sun which is on the first slit. If then the plate and image of the sun are kept stationary and the spectrograph as a whole moved transversely across them, we will record successively on the plate successive segments of the solar disk in the light of the particular vapor whose line is on the second slit, or in other words, we will obtain a photograph of the sun in the light of this particular vapor. This photograph will evidently record the distribution of this vapor, and this vapor only, over the sun's disk.

The spectroheliograph has been used almost continuously since its invention to obtain photographs of the sun in the light of calcium vapor, and the records of calcium flocculi, as the cloud-like formations covering the sun's surface are called, has been a valuable supplement to the direct photographs in ordinary light and clearly show the turbulent and ever changing state of the chromosphere. At Mount Wilson the sun's surface has also frequently been photographed in the green, blue and violet lines of hydrogen and occasionally in iron lines. These photographs show an entirely different characteristic appearance and structure from each other and from the calcium spectroheliograms.

But probably the most striking spectroheliograms are those made in the light of the red line of hydrogen, *H α* , as it is called. These have been obtained at Mount Wilson comparatively recently, after the introduction of specially stained plates highly sensitive to red light. It is the red light of hydrogen which ascends to the highest levels in the chromosphere and which is the most prominent in eruptions and prominences. The spectroheliograms in this light have a characteristic appearance entirely different from those made in the blue or violet lines of hydrogen or in any other vapors. The most striking features about them are the curious whirls or twisted appearance of the gaseous matter around sun-spots, and the strong resemblance of these whirls to the lines of force around magnets led Hale to suspect that there might be a magnetic field around sun-spots.

This supposition was very natural, as the relation between the spottedness of the sun and the activity of the earth's magnetism had long been recognized, the curves

of sun-spot numbers and those representing the daily range in the declination and horizontal force corresponding in the most remarkable manner. Further, it has been noticed that terrestrial magnetic storms are often nearly coincident with the central passage of a large sun-spot over the sun's disk.

To suspect that whirls in the *H α* spectroheliograms were indications of magnetic fields, and to prove it, were two entirely different matters. Even if such a field were possible of detection by magnetic methods on the earth, it would be impossible to definitely correlate such magnetic effects with any sun-spot showing whirls.

But here again the wonder-working powers of the spectroscope were brought into requisition by Hale in a most ingenious manner. About 1896, Zeeman discovered that most lines of the spectrum are separated into two components when the incandescent vapor producing these lines is in a strong magnetic field, and is observed by the spectroscope along the lines of force. With less powerful fields the lines are only widened. In addition to this doubling or widening the light is changed in character, it has become polarized, a curious one-sided form of light, and this polarization can be detected by suitable optical apparatus, such as a Nicol prism. When such a test was applied by Hale to some of the lines in the spectrum of a sun-spot it was found that they behaved in exactly the same way under the analysis of the Nicol prism, as their terrestrial counterparts did when the vapor producing them was in a magnetic field.

Here then was incontestable proof that the curious whirls around sun-spots in the *H α* spectroheliograms were of a magnetic character and that there was a magnetic field around sun-spots. By comparing the widening and the behavior of the sun-spot lines with their terrestrial counterparts under fields of varying strength, it was found at Mount Wilson that the fields around sun-spots varied up to a maximum of 4,500 gauss, which is about 7,000 or 8,000 times the strength of the earth's field, but not as strong as the average electromagnet. The polarity of the spots was found to vary in a somewhat irregular manner, large spots in northern and southern hemispheres being usually of opposite polarity and the same thing being true of the two main members of a spot group.

The strength of these fields is not sufficiently great to account for the magnetic storms on the earth which occasionally derange magnetic and telegraphic apparatus and which must be due to some more powerful and as yet unknown influence. But it seems evident that the striking similarity between the curves of spot numbers and the daily range of the terrestrial magnetic elements can be simply explained by the influence of the magnetic fields around sun-spots.

More recently Hale has shown, in a somewhat similar way, that in addition to the fields surrounding spots, the sun has a general magnetic field similar to the earth, only about 80 times as strong. The magnetic poles of the sun coincide approximately with its axis of revolution, the north magnetic pole being toward the north, as in the earth. The Zeeman displacements by so weak a field as this are exceedingly minute and require the greatest care and precision in measuring. These discoveries and measurements of the magnetic fields in the sun are striking examples of the wonderful experimental work carried on at Mount Wilson and are of the utmost importance.

But they have been supplemented by much additional evidence as to the physical conditions in and around spots. Considerably earlier than the discovery of the magnetic effects it was shown that the spot vapors were at considerably lower temperatures than those over the surrounding photosphere. This was done by a mass of cumulative evidence gathered by means of the spectrograph. It has long been known that the spot spectrum is different from the ordinary solar spectrum. Some of the lines are widened and strengthened, some are weakened, some are doubled as noted above, and many fine lines not present in the photospheric spectrum are present in spots. In the case of the widened and weakened lines it was found that these lines behaved in general in a similar way in terrestrial spectra as in sun-spots when the temperature of the vapors producing them was reduced, thus showing that the spot vapors are at a lower temperature. It was further found that the numerous fine lines in the spot spectra were due to the formation of such compounds as magnesium and calcium hydride and titanium oxide, which can only exist at considerably lower temperatures than the photosphere. These facts formed convincing evidence that the vapors over sun-spots were at lower temperatures than over the surrounding photosphere.

As stated earlier, the radical motions of the vapors over sun-spots were first observed by Evershed, but his work has quite recently been much extended by St. John, at Mount Wilson. These motions have, of course, been

measured by the spectrograph from the displacements of the lines from their normal positions, and they vary for different elements and for different levels in the chromosphere. The hydrogen and calcium at the upper levels move inward at about two kilometers a second, this velocity diminishing as we go down and come to the heavier elements, finally turning into an outward motion, of the order of one-half a kilometer per second, for many of the lines of iron and other metals which lie at low levels. There seems to be a circulation of the vapors from above in and downward, and from below up and outward.

Based on these results, on the lower temperatures in the spot-vapors and on the whirling motion and magnetic field around sun-spots, Hale has advanced a working hypothesis on sun-spots which includes all the data so far obtained and offers a reasonable explanation of the observed facts. According to this hypothesis a sun-spot is the result of an eruption, or some other deep-seated cause of which nothing is definitely known, which tends to produce rapid local upward movement of a column of gas from within the sun toward the surface of the photosphere. This column is given a whirling motion by differences in velocities or irregularities of some kind, producing a vertical motion much like a tornado or waterspout, the circulation in the spot being vertically upward and then outward along the photosphere. Expansion produces cooling at the center of the whirl or vortex and a comparatively dark cloud, the umbra of the sun-spot, results. A rapid flow of negative ions sets in toward the cooler gases at the center and these ions whirled in vortex produce a magnetic field. Higher up in the solar atmosphere the descending gases, hydrogen and calcium, are drawn in toward the center, producing the whirls shown on the *H α* spectroheliograms and giving the spectroscopic evidence of inward motion previously adduced.

(To be continued.)

Nitrogen: Its Virtues and Its Vices

PERSONS who talk of the importance of chemistry in this war are usually talking of one thing only though they may not know it—and that thing is nitrogen. The chief chemistry of the war is practically centered on nitrogen. Recognizing this fact, it is strange to think that we live by breathing an atmosphere containing 80 per cent of this element which in certain combinations is dealing out death on an appalling scale in all the fields of action. There are practically no useful explosives employed in which the action of nitrogen is not concerned. Without its aid the great ships at sea could not be sunk, or innocent victims on land killed, or property destroyed by the aeroplane and dirigible; while it serves to mow down whole columns of men in the field, for rifles, howitzers, machine-guns, and grenades are all dependent upon, and made terribly deadly by, the offices of nitrogen. We every day pass on to our lungs something like 450 gallons of nitrogen per 24 hours, which would be enough to make 30 pounds of tri-nitro-toluol, or 40 pounds of gun-cotton. In our early training in the elements of chemistry we were wont to regard nitrogen as a singularly uninteresting gas on account of its negative behavior. It did not burn like hydrogen, it did not support combustion like oxygen, and, in short, its presence was generally assumed because of its inactivity and because it did not directly respond to any test. And yet this element is the greatest of all as a munition power; it is hardly an exaggeration to say that applied nitrogen is going to be a factor in deciding the issue of the war. It is remarkable, also, that this element forms the central figure in the protein group or tissue-repairing material of our foods. To say that without protein we die, practically means that without nitrogen we die. The gas without positive tests is as necessary in one form for our support as in other forms it is ready to destroy us. Nitrogen's power depends in the first place on the fact that it carries in oxygen to compounds which are thus rendered explosive, turning all the elements into a huge volume of gas, itself being set free. The very inertness of nitrogen, or its objection to affinity, means that on the least provocation it will easily release its partner oxygen, handing this over to the combustion of other elements present, with the formation of volumes of gases, the nitrogen returning to what is apparently its congenial condition, the free state. As a fertilizer in the soil nitrogen acts as a stimulant and supplies the necessary nitrogen to the plant. In other words, it is a plant food. Thus the remarkable thing about nitrogen above all other elements is its power to destroy life or to sustain it according to the associates with which it is in company. With certain accomplices it forms death-dealing explosives, with others it becomes a nutritive material. It is the essentially romantic element, devil or god, according to its associations.—*The Lancet*.

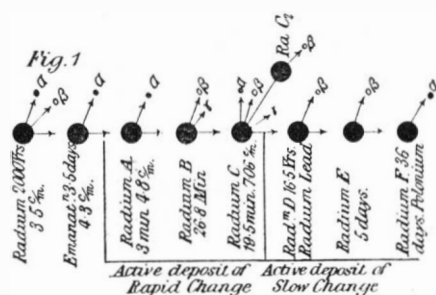
Radiations from Exploding Atoms*

Phenomena Which Spontaneously Arise in the Breaking Up of Radioactive Atoms.

By Sir Ernest Rutherford, F.R.S.

IN choosing this title the speaker said that he had not foreseen that the object of his discourse might be misinterpreted, but the explosion which he proposed to discuss had no connection with the common explosives used in military operations, but were the enormously more powerful phenomena which spontaneously arose in the break-up of radioactive atoms. It was most fortunate that the quantities available of these substances were too small to be of military value; and, indeed, it was a happy chance that the radiations from these atomic explosions, instead of serving as agents of destruction, found their sole practical utility in the beneficent treatment of disease. Everyone now knew that it was believed that the radiations in question were associated with the spontaneous transformation of one atom into another, the successive transformation of radium being represented in Fig. 1. Associated with this process three characteristic types of radiations had been recognized, and were known, respectively, as the α rays, the β rays, and the γ rays. The explosion of an atom was an event of extraordinary violence, being at least 10 million times as powerful as ordinary chemical explosions when referred to equal quantities of matter.

In most of these atomic explosions an α particle was expelled. The α particle was an atom of matter, and the speed with which it was projected attained 10,000 miles per second, so that it carried away with it a very large amount of energy. There was, however, an explosion of a different kind, such as that of radium E, represented in Fig. 1. In this no α particle was ex-



pelled, but a β particle merely. These β particles were identical with the cathode rays of a vacuum-tube, and were now commonly called electrons. In other cases the explosion was accompanied by the appearance of the γ rays, which, in fact, were an almost invariable accompaniment of the expulsion of a β particle.

An idea as to the enormous amount of energy accompanying each type of radiation could be obtained as follows: One of the simplest ways known of giving a very large amount of energy to a particle was to employ a vacuum-tube with a potential of, say, 20,000 volts between its terminals. In these conditions the atoms of the residual gases were dissociated or ionized, and these charged particles moving in the electric field attained very great speeds. There was thus a great deal of energy in the moving particles, which were, in fact, cathode rays, equivalent to the β radiation; but there were also, as Sir J. J. Thomson had shown, positively charged particles also moving very rapidly. Now the α ray was known to be a positively charged atom of helium, but to get it moving in a vacuum tube with a velocity equal to that with which it was expelled from radioactive elements would require an electromotive force between the terminals of not 30,000 volts, or even 100,000 volts, but one of 4,000,000 volts. The energy of expulsion of the β particle was also very large. In the case of radium C, this particle was shot out with a speed corresponding to a fall through at least 2,000,000 volts, in some cases through nearly 4,000,000 volts. Hence the β rays were far more penetrating than the cathode rays produced in any vacuum-tube. Thus, quite apart from the interest attaching to the atomic transformation, the radiations had another interest, providing as they did examples of individual concentrations of energy of far greater intensity than any we could produce, or even hope to produce, in our laboratories.

The α particle was an atom of helium carrying two positive charges, and it was important to measure the speed with which it moved. This could be accomplished by Sir J. J. Thomson's method of measuring the deflection the particles underwent in passing through a magnetic and through an electrostatic field. The apparatus used was represented diagrammatically in Fig.

2. At S there was a fine source of the rays, such as a wire coated with a radioactive film. The rays shot out passed between the parallel plates shown, and thence through a fine slit on to a photographic plate at P. If there were no field between the parallel plates,

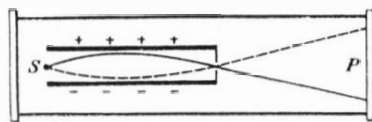


Fig. 2.

the rays struck the photographic plate centrally, but on establishing a field they were deflected up or down according to the direction of the field. Hence by reversing the field two sets of lines were obtained on the same plate, the distance between the two constituting the measure of the deflection undergone. The result obtained when the rays were passed through a magnetic field was illustrated in Fig. 3. The electrostatic deflection was much more difficult to measure, but it could be done, and Fig. 4 showed the result ob-

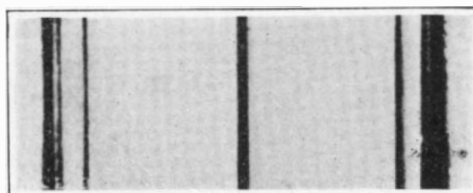


Fig. 3.



Fig. 4.

tained. It would be seen that in each photograph there were three lines, two of which were nearly coincident in the case of the magnetic deflection. These were due to the three sets of α particles emitted by the thin emanation-tube due to the emanation, radium A and radium C (see Fig. 1). The three sets of particles were much more widely separated by the electrostatic deflection than by the magnetic, because while the magnetic deflection was proportional to the velocity of the particle, the electrostatic was proportional to the square of this velocity. These experiments were started in Montreal in 1902, but it was not till last year that Mr. Robinson and himself had succeeded in obtaining the photographs shown. By the aid of these photographs the speed of the α particles had been determined within a limit of error not exceeding a quarter of 1 per cent. In addition the ratio e/m of charge to mass could also be determined from the plates, and the value obtained confirmed the view (previously arrived at) that the atomic weight of helium was 4, and that as an α particle it carried two charges of electricity.

The α particle being expelled from the radioactive atom at a very high speed, the residue left recoiled as a gun did when fired. By similar means to those already explained, it was possible to find the velocity of this recoil, which was sufficient to carry the atom back through some centimeters of air at 1 millimeter pressure. If the ordinary laws of mechanics held for these atomic explosions, the momentum of the recoiling mass should be equal to that of the α particle expelled, and this was found by Makower to be the case.

It appeared, however, that the recoil atom carried one charge only. Since the momentum of the recoil atom was the same as that of the α particle expelled, it appeared that the ordinary principles of mechanics still held, even for these exceedingly violent atomic explosions.

As already stated, the β rays corresponded to the ordinary cathode rays, and, like them, could be deviated in a magnetic field. Using the arrangement shown diagrammatically in Fig. 5, the rays issuing from the source at S were bent round by the field and impinged on the photographic plate PP. On development this plate showed that in certain cases the β rays after being curled round by the field were not uniformly distributed over the whole distance PP, but

were concentrated into bands or lines, as indicated, giving a veritable β -ray spectrum which was characteristic of the particular element under investigation. Very accurate measurements had been made in this way by Rutherford and Robinson with radium B and with radium C. Each band was due to β particles ejected at the same speed, which could be measured from the photographs. In the case of radium B, the highest speed observed was 0.823 that of light, or 150,000 miles a second. Radium C gave far more lines, and of these over fifty had been measured. The highest velocity attained was 0.985 that of light; and the velocity of light

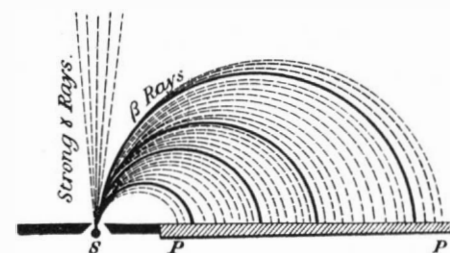


Fig. 5.

was believed to be the limiting value to which a β particle could attain.

How was the production of these β -ray spectra to be explained? It was known, for example, that an atom of radium C on an average emitted only one β particle, yet these single particles produced, say, 50 distinct lines. The individual atom could not be responsible for these, and it was thus to be assumed that the β -ray spectrum was a statistical result due to the conjoint action of a very large number of atoms. Hence it would appear that two atoms of an element did not necessarily break up in exactly the same way.

Coming next to the γ rays, these were equivalent to X rays, but very much more penetrating. They could also be analyzed in great detail, and the results obtained were of very great interest. Some years ago Barkla had shown that when X rays fell upon copper, for example, the copper, under certain conditions, gave out X rays which were as characteristic of copper as the D line was of sodium. These characteristic radiations varied in penetrating power with the atomic weight of the radiator. It thus appeared that the X rays excited definite modes of vibration in the interior of the atom, and it was thus probable that the γ rays ejected from radioactive bodies corresponded to fundamental modes of vibration in these atoms. They were thus not due to fortuitous collisions, but were as characteristic of the atom from which they came as was the fundamental note of a violin string. To test this view, the speaker and Mr. H. Richardson had analyzed the penetrating powers of the radiation from radium B, and found several fundamental types. In some cases there were as many as five types, of which two might correspond to the characteristic radiations of Barkla, while the others were new types, which it would be very difficult to observe by the use of X rays. It thus appeared that there was nothing of an accidental character in the behavior of a radioactive atom, but that,

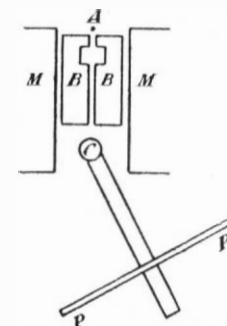


Fig. 6.

in studying them, we were dealing with the modes of vibration characteristic of it, and a consideration of these should throw light on the atomic structure.

Laue, Bragg, and others had actually determined the spectrum of X rays, but it was more difficult to accomplish the same feat in the case of γ rays. A very long exposure, extending over a day or more, was required, and the accompanying β radiation had to be got rid of. At Fanchester, however, Dr. Andrade and the speaker had succeeded by using the apparatus represented in Fig. 6. The source A was a tube containing

* From *Engineering*.

a relatively large amount of radium emanation. The radiation after passing between the two lead blocks *BB* through a fine slit fell on, and was reflected from a face of a thin crystal of rock salt placed at *C*. A rotating arm centered on *C* carried a photograph plate *PP*, on which the radiation fell after reflection from the crystal. The crystal and lead plates were placed between the poles of a powerful electro-magnet, which deviated the β radiation away from the plate. Without this precaution the β rays would blacken the plate in five minutes and completely mask the γ ray spectrum. A diagram of the γ spectra thus obtained was shown in Fig. 7. In this case there were two lines both fairly strong, and these were found to coincide in position (within 1 part in 300) with the characteristic radi-

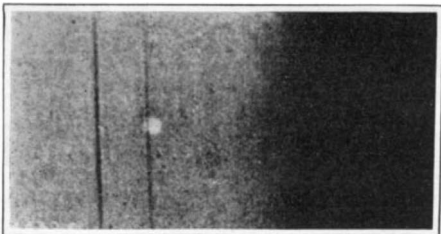


Fig. 7.

tions of lead. The plate therefore gave evidence that *Ra B* had really the same general chemical properties as lead, although its atomic weight was 7 units more. It had proved very difficult to determine the spectra of the very penetrating γ rays, yet success was finally attained, the wave-length found being half that of the hardest X rays known, having the value of less than 1/10 of an Angström unit, or 1/50,000 that of ordinary light. The next point that arose was a difficult one, viz.: the connection between the γ -ray spectrum and that of the β rays. The one was produced by waves, the other by flying particles. In the latter case the spectrum showed that these particles were shot out with perfectly definite speeds, while the γ ray spectrum showed that the γ rays had equally definite frequencies. It was known that the characteristic radiation of an element could be excited either by using X rays or cathode particles, and also that the frequency of the characteristic radiation increased with the energy of the individual cathode particles. Another result of great importance was that when X rays were passed through matter β particles were ejected, the energy of the X ray being converted into that of the ejected particle. This transfer was well shown by Fig. 8, which was a repro-

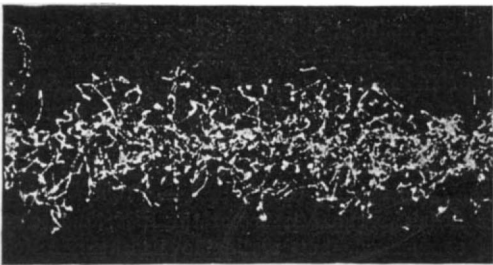


Fig. 8.

duction of a photograph by Mr. C. T. R. Wilson, obtained on passing X rays through moist air. The electrons set loose ionized the gas molecules, which then served as centers of condensation, thus showing the track of the β particles through the air. In this case the energy of the X rays passed into the energy of the electrons, which in its turn was absorbed by the air. The energy of the electrons shot out was nearly proportional to the frequency of the X rays responsible for their ejection. The energy of the X rays was, moreover, given out in definite quanta depending on the frequency of the wave. This quantum of energy was collected in the electron, and caused it to shoot out with great speed. The equality of the energy causing the emission and that of the ejected particle held approximately, but it could not yet be said that it was exact. Marked differences in the character of the radiations were observed in different substances. Thus with radium *B* or *C*, the γ radiation given out was very strong, and the β -ray spectrum was banded, as already explained (see Fig. 5). With radium *E*, however, the γ radiation was very weak, and in that case the β -ray spectrum had no bands, but was continuous. There was evidently, therefore, a connection between the γ and the β rays. This had been shown more directly by an apparatus on similar lines to that indicated in Fig. 5. Using an α -ray tube, the β -ray spectrum was obtained in the ordinary way. The source of radiation was then covered with a sheet of lead, and another exposure made. This lead stopped all the β rays, and

only the γ rays got through it. Nevertheless, the plate on development showed exactly the same β radiation as before, the lines or bands occupying exactly the same place as when the lead was removed. The γ rays, in fact, which got through the lead produced new β rays, which gave exactly the same spectrum as before. The β rays, in these lines, therefore, would appear to be produced by the conversion of the γ rays into β radiation. The velocity of the β particle produced by a wave of a given frequency was thus always the same. The energy of the β rays was connected with the frequency of the γ rays, and increased by definite increments, as shown in the following table:

Velocity of β Particle Expressed as Fraction of the Velocity of Light.	Observed Energy $\div 10^{13} e.$	Energy $\div 1.285 \times 10^{13} e.$	Nearest Integral Number.
0.750	2.59	2.015	2
0.868	5.16	4.010	4
0.917	7.68	5.98	6
0.946	10.31	8.02	8
0.962	11.49	8.94	9
0.969	12.82	9.97	10
0.964	14.09	10.96	11
0.969	15.42	12.00	12
0.972	16.71	13.01	13
0.978	17.96	13.97	14

strong line reflected from rock salt at 1. degree was $1.285 \times 10^{13} e.$, and referring to the table it would be seen that the energy in the ejected particle was for a number of lines practically an integral multiple of this constant. For three strong groups of low-velocity rays from radium *B*, the energies corresponded very closely with three lines in the γ -ray spectrum in Planck's law. But in the case of the swifter rays, the frequency of the γ radiation producing them was much too low, and should, in fact, if Planck's law held, in some cases be twenty times its actual value. Such a radiation would be exceedingly penetrating compared with the γ rays. He believed, however, that these very swift β radiations were really produced by γ radiations of not excessively high frequency, in, perhaps, somewhat the following way.

Taking a model atom of the Bohr type, such as represented in Fig. 9, suppose an electron knocked out

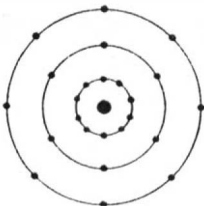


Fig. 9.

of the inner ring; then there would be a tendency for an electron to fall from the outer into the inner ring, thus setting the latter in vibration, and giving rise to a γ radiation. In certain cases two or three electrons might be knocked out simultaneously, and then two or three waves of the same frequency would issue together, and when these rays met another atom, the energy of the whole lot might be transferred to a single β particle, which would accordingly be ejected at a correspondingly high speed. As the table showed, there was a close connection between the energy of the β particle liberated by γ rays and the energy of these rays, and it was of interest to determine whether there was a similar connection between the energy of the X rays liberated when a target was bombarded by cathode rays falling through different voltages. Using a Coolidge tube, and working in conjunction with Barnes and Richardson, the

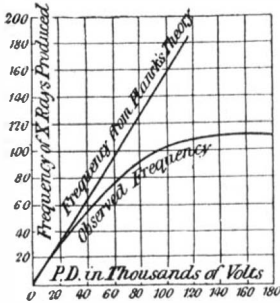


Fig. 10.

speaker had obtained the results shown in Fig. 10. The straight line showed what the connection between the frequency and the voltage should have been did Planck's law hold in this case, while the curved line showed the actual results observed. Up to a fall of 40,000 volts the two lines agreed fairly, though the discrepancy was 15 per cent; but with higher gradients the two curves diverged rapidly. The frequency reached its maximum at 145,000 volts, and underwent

no further increase when the voltage was raised to 175,000 volts. It was clear that Planck's relation did not hold for excitation of X rays by electrons, except possibly at very low speeds. It was of interest to note that the β particles from radium *C*, which had an energy due to a fall through two million volts, did not yield γ rays of more than twice the frequency of the X rays obtainable from a Coolidge tube. A problem which remained to be solved was the maximum frequency of the γ rays liberated from a radioactive body. In the foregoing he had assumed that the rays came entirely from one of the inner rings of electrons, but if the nucleus itself became involved, γ rays of very much greater frequency should be produced. In fact, from theoretical considerations, he thought that γ rays capable of passing through a mile of matter should exist, but, so far, no evidence had yet been found of this very penetrating radiation.

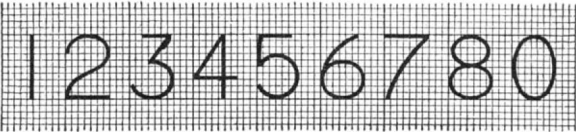
Comets

I HAVE lately had an interesting Fijian tradition of a bright comet, seen in Fiji at the end of the eighteenth century, brought to my notice by Mr. E. im Thurn. "When dawn was near they saw a three-tailed star rise above the horizon. The appearance was presaged by a brightness in the sky, the comet itself soon appearing. The middle tail was the largest, and in brightness resembled the hues of a rainbow. The other tails, one on each side, were equal to each other and white. The comet was seen for thirty-seven nights, after which our forefathers saw it no more. They took it as an omen of the death of their chief" (which, in fact, followed soon). Another account adds that a wasting sickness decimated the people at the same time. From the approximate date given by Mr. im Thurn I conclude that the comet was probably 1799 II, in perihelion on Christmas Day, 1799, which was seen for ten days in Europe with a tail 1 degrees to 3 degrees long. I have calculated an ephemeris, and find that it approached the Earth during January, 1800, but went into high south declination, so as to be invisible in Europe, but conspicuous to the Fijians. If my identification is right—and I have since found that the same problem was put to Mr. H. P. Hollis in 1894, and that he adopted the same comet—we are indebted to the Fijians for the knowledge that this was really a much grander comet than we should have suspected from the European accounts. We may compare the mediocre aspect of Halley's Comet in the British Isles with the grand spectacle that southern observers witnessed. The identification helps to fix the date of early European intercourse with Fiji and the beginning of the sandalwood trade. Mr. im Thurn tells me that the ship "Argo" was wrecked in Fiji about the time of the comet.

Neujmin's Comet (*a* 1916) is another member of Jupiter's family, with a period of about 6.3 years. It was nearest to the sun on March 10th. The plane of its orbit and direction of perihelion are nearly the same as those of Encke's Comet; but this is a mere coincidence, as the perihelion distance of Encke is inside Mercury's orbit, that of Neujmin outside the Earth's orbit; also its period is double that of Encke. It will be too faint for easy observation by the time this appears.—A. C. D. Crommelin, F. R. A. S., in *Knowledge*.

Standard Figures for Measuring Instruments

INSTRUMENT-MAKERS will find some useful suggestions in a short paper by Mr. A. P. Trotter in the *Journal of the Institution of Electrical Engineers* for February 1st. In 1908 Mr. Trotter prepared some notes on the most suitable numerals for the scales of measur-



Numerals designed by Mr. A. P. Trotter, minimum thickness.

ing instruments; these were recently placed at the disposal of the Metal Panel of the Engineering Standards Committee, and have now been published at their suggestion. Most of the figures which Mr. Trotter proposes as "standard" combine the maximum of legibility and convenience with a considerable degree of elegance; his 2, 3, and 7 are admirable. A more open 5, with the vertical and horizontal lines further to the right, may, however, be preferred; and this would enable the tails of the 6 and 9 (which it is proposed should simply be an inverted 6) to be set at a less violent and unconventional angle without danger of confusion between the 5 and 6; the extension of the horizontal bar of the 5 to the right, beyond the rest of the figure, would preserve its distinction from the 3. A slightly wider 4 would also be an improvement.—*Nature*.

The Evolution of Malleable Iron*

Early Practice and the Lesson from Scientific Investigation and the Microscope

By J. P. Pero and J. C. Nulsen

THE process of making malleable iron was slow in entering into a transitory stage, but once started it gained headway and we doubt if any other industry has taken so large a stride in the right direction in the past few years. Very few really know how much more ductile and strong the malleable iron of to-day is than that made twenty-five years ago.

Within a quarter of a century pig iron was bought by fracture almost entirely. The blast-furnace man paid little attention to manganese, sulphur and phosphorus. We know that he was not always right as to silicon, for an iron higher in carbon than another will show more mottles even with the same silicon content; he was dealing with two variables, where he figured on but one.

HOW THE MALLEABLE MIXTURE WAS MADE.

The white iron mixture from which malleable iron was made was arrived at in a very crude way. The method was rule-of-thumb. The initial charge averaged 3.5 on the basis of pig-iron grading. The charge for a ten-ton heat was as follows:

"The sprue and scrap might be considered as equivalent to No. 6 grading pig iron. Then if 10,000 pounds of sprue and scrap were used, 9,000 pounds of No. 1 pig iron and 1,000 pounds of No. 4 pig iron, the average grade of the heat would be 3.65, which for this case might have been deemed near enough to be satisfactory."

Some manufacturers did not even use an empirical formula. Some of the iron made at this time stood up as well. But plenty of bad heats were made even when the initial charge was as desired (around 3.5). The iron of this period varied greatly and was not reliable. Chemical analysis was suggested as a means of improvement.

The second period dates back about twenty-five or thirty years, chemical laboratories having been introduced into a number of plants from 1885 to 1890. Pig iron then could be bought by analysis as well as by grade. The empirical method of figuring charges was eliminated and the practice of obtaining the percentage of silicon in the initial charge was adopted.

IMPORTANCE OF PHOSPHORUS AND SULPHUR.

But even with chemical laboratories, bad malleable iron continued to make itself manifest. The principal difficulty was that the chemist did not know just what elements caused the trouble and those that he did analyze for he considered in the wrong light. Many chemists thought that silicon was the main factor, while carbon was seldom considered. We know now that the silicon content has an important bearing, but that the determination of silicon without knowing the carbon content gives almost useless information.

Chemists knew that phosphorus and sulphur were important in determining the quality of steel, so they proceeded to restrict it in malleable. Here again the sulphur content is uninteresting unless we know the manganese, and we are just recently beginning to believe that phosphorus has needlessly alarmed us in malleable iron.

The success of the chemical laboratory, as then constituted, was doomed to failure. Poor iron persisted and people concluded chemical analysis was no help; in many plants it was abandoned. But the need for improvement began to be felt more and more, and after several years malleable iron manufacturers began to take up chemical analysis again.

From 1895 to 1900 many malleable plants again equipped chemical laboratories, doing their best to solve some of the problems which confronted them, but they continued to look at the analysis in the same light as that of steel, and this more than any other fact prevented the discovery of the main difficulties. The different elements were considered independently as to the effects produced and the possibility of one element modifying or changing the effect of another was not considered.

STEELY IRON.

One of the most perplexing difficulties encountered was the occasional appearance of "steely iron." It showed a white, steely fracture after being annealed and remained so even after having been re-annealed. Such iron usually shows a high tensile strength, but is inferior when tested transversely. Its ductility is almost nil. This iron was obviously unsuited for railroad castings or any subjected to shock. It was a "Sword of Damocles" over the head of the malleable

iron trade. On analysis it was found to be low in silicon and for a time steely iron was supposed to be the result of allowing the silicon to get below a certain limit.

Just about the time malleable manufacturers were congratulating themselves on the fact that the cause of steely iron had been found, some one submitted a sample with silicon 0.94 per cent. All hopes of arriving at the correct solution were shattered. This was not the only trouble. The general practice then was to analyze for carbon, silicon, manganese, sulphur and phosphorus. It was considered that all carbon present in the iron after annealing was in the temper graphite form and, therefore, a great many chemists analyzed the iron on the basis of total carbon. This was wrong, but it resulted in many perplexing problems.

Malleable iron of inferior quality sometimes was obtained, but when analyzed it showed nearly the same chemical contents as that of excellent quality. This was puzzling and the determination of the cause seemed hopeless.

ASSOCIATED EFFORT AMONG PRODUCERS.

This is representative of conditions up to less than ten years ago, when some of the leading manufacturers of malleable met to talk over the situation. They feared that the poor malleable would slowly but surely hurt the industry and prejudice the users, especially railroad men and implement manufacturers, against it. It was decided that, as no scientific research had ever been attempted, some eminent metallurgist should undertake this work and see if he could not help them. Such a man was finally found and wonderful results have been obtained.

We have learned that steely iron can be made with the silicon high as well as low, because carbon also was a factor. If the carbon is below certain limits it will stay in the carbided state as pearlite, and cause steely iron, no matter what the silicon. Our former assumption that too low silicon caused steely iron also was correct. Iron too low in silicon cannot be forced to give up the combined carbon, no matter what the carbon may be.

In like manner we have learned that sulphur and manganese are just as closely related. Formerly it was believed that if the sulphur was below 0.05 per cent it could not harm malleable, because it did not harm steel. We used to think that an iron with 0.02 per cent sulphur was better than one with 0.06 per cent. But if the manganese in these two irons is 0.24 per cent, the one containing 0.06 per cent sulphur is the better iron.

PHOSPHORUS LIMITATION.

There has been some doubt as to whether the limitation of phosphorus to 0.225 per cent was not a needless precaution. The malleable iron specifications used in the past did not accomplish their purpose; they did not protect the buyer from poor malleable or assure a good quality.

Nearly all the old specifications contain a clause that malleable iron shall not contain over 0.05 per cent sulphur or over 0.225 per cent phosphorus. Nothing is said about the manganese content and, therefore, limiting the sulphur to 0.05 per cent is in some cases the means of securing bad iron rather than good. For instance, iron with a manganese of 0.34 per cent would be of inferior quality with a sulphur content of 0.05 per cent, but it would be satisfactory if the sulphur was 0.085 per cent. If a limit is placed on sulphur, the manganese content also should be limited, but it might preferably be stated that the sulphur content shall be from one third to one fourth the manganese content, as there is no temptation to unreasonably raise either of these elements.

The same is true as to silicon and carbon. It is meaningless to limit the percentage of the one without assigning the proper corresponding value of the other.

Perhaps the greatest improvement from this scientific work has been the introduction of microscopic investigation as well as chemical and physical analyses. Much depends on the state in which the elements exist, whether the carbon is combined with the iron to form pearlite and cementite or whether it is in the free state, as temper carbon, all of which is clearly brought out by means of the microscope.

WHAT THE MICROSCOPE HAS DONE.

The microscope reveals whether a piece of malleable has been annealed too short a time or at too low a temperature; whether the annealing temperature was

too high, or if the cooling was too fast, questions of doubt before this research.

The practice in many malleable plants to-day is to cast three types of test bars from each heat, one set $\frac{3}{4}$ inch square and 14 inches long for transverse test; another set of $\frac{5}{8}$ -inch round test bars for tensile strength and elongation, and one set of wedge-shaped bars for a dynamic test. The latter bars are 6 inches long and 1 inch wide. They are $\frac{1}{2}$ inch thick at the base and taper to 1/16 inch thick at the point. This wedge is held upright under a drop hammer delivering a 70-foot pound blow and is gradually curled up with each blow. This last test is also a direct result of the research work undertaken and is one of the most severe and exacting to which malleable cast iron has ever been subjected. All of these tests have values assigned to them, to which the iron must conform before it is passed as 100 per cent in quality.

A few years ago, when we first began to understand the relations of the elements in malleable iron and to change the white iron mixture to conform with this knowledge, we thought wedges that stood seven 70-foot-pound blows represented good iron. In a short time the quality of the iron had so far improved that we decided on ten blows, and about a year ago we had to change this so that twenty blows represented 100 per cent quality; but still we are not high enough, as we are making iron that will easily average thirty-five blows.

How far this improvement may go is not known, as we have tested bars that stood 108 blows.

In like manner the tensile strength of the iron has improved. The average tensile strength of malleable made fifteen to twenty years ago was from 38,000 to 40,000 pounds per square inch. To-day at some plants it will average 50,000 pounds per square inch, and we have broken one bar that tested 71,500 pounds per square inch.

A LESSON FROM STEEL CASTING MANUFACTURERS.

We may profitably take a lesson from the steel casting manufacturers who have been perfecting their product while we have been almost at a standstill. As a result, they are supplying castings which, from the nature of the service required of them, would be far more satisfactory if made from a high-grade malleable iron. Unfortunately, however, too many of our malleable manufacturers are still satisfied with the production of inferior iron and are not taking advantage of the knowledge and results obtained in securing uniformity and high quality. This attitude is detrimental to the entire industry and makes it possible for the steel casting to replace the malleable. When malleable castings fail in service, it is not the individual casting that is condemned, but malleable iron generally. A large part of the steel castings used, especially in railroad work, could be replaced by good malleable, both from the standpoint of economy and adaptability.

This may be a strong statement, but it is an incontrovertible fact that for certain classes of work malleable iron is indisputably superior to steel. Castings subjected to shock or to dynamic stresses, if made of a good quality of malleable iron, will outlast steel or any other ferrous metal, for malleable iron is not as susceptible to fatigue failure as cast steel, owing to the difference in structure of the two materials.

STEEL AND MALLEABLE IRON COMPARED.

Steel is of a crystalline nature, practically uninterrupted throughout its section. The basic structure of malleable iron is also crystalline, but this structure is not continuous, but is interrupted by particles of temper carbon. Ductile materials such as cast steel and malleable iron are weaker under shear than under tension and will fail in shear whether the force applied is tension or compression.

When the applied load exceeds the elastic limit the crystals begin to slide over each other, the amount of such slipping or sliding corresponding to the permanent deformation received. As these crystals slide the infinitesimal irregularities on their surfaces interlock, which increases the friction between these two particular crystals, bringing them to rest and starting the slipping between adjoining crystals. This motion continues across the section of the metal in question until the force applied has become so great that the weaker crystals part, intensifying the stress on those remaining, when the next weaker crystals part, and so on until complete failure occurs.

The surfaces over which these crystals slide are sometimes called slip planes and since the crystalline

*From a paper presented at the convention of the American Foundrymen's Association at Atlantic City, N. J., 1915, reported in the *Iron Age*.

nature of steel is practically uniform and uninterrupted, it is an easy matter for these slip planes to extend themselves across the section of steel in a continuous, though irregular line, causing cracks and failure.

Malleable iron starts to fail in the same manner, but before more than one or two adjacent crystals have failed, the incipient fracture will have run into a temper carbon spot. These spots usually are located at the conjunction of three or four crystals, so that there are three or four paths along which the fracture may continue and the probability is that the one serious crack will break up, taking three or four of these paths. These new paths, in turn, run into carbon spots, regardless of whether the smaller fractures are still further broken up. In this way the advance of one large serious fracture is prevented from working straight across the section of metal.

FAILURE DUE TO FATIGUE.

It is hoped that we soon may learn more about fatigue failure and establish why malleable iron is less susceptible to this than steel. Malleable iron has a

further and very important advantage over steel in the soundness and solidity of its sections, provided care is taken to eliminate shrinkage spots. It is cast at a lower temperature than steel and hence is free from occluded gases which cause blowholes and unsoundness.

Soundness of section, coupled with the fact that the ratio of ultimate strength to the so-called elastic limit of malleable is much higher than the same ratio in steel, should justify a much lower factor of safety in design than would be permissible in cast steel, as the allowable working stress of malleable iron is about 10 per cent higher than that of steel.

As an illustration we will assume that the ultimate strength of cast steel is 65,000 pounds per square inch and the elastic limit is quoted at 35,000 pounds per square inch. Many malleable plants to-day are producing iron with an average ultimate strength of 50,000 pounds per square inch, which, while lower than the ultimate strength of steel at 65,000 pounds, still has an elastic limit of approximately 38,000 pounds per square inch or about 8 per cent higher than that of

steel. Since in the design of castings it is the elastic limit and not the ultimate strength which is considered, it would seem that the facts, in connection with the superior soundness and freedom from blowholes of malleable castings, should be ample justification for using a lower factor of safety in arriving at the working stress to be used.

Malleable iron has greater rust-resisting properties than any of the other ferrous metals. Therefore, for use in railroad, implement and other work subjected to corrosion, it is to be preferred to case steel or gray iron.

Our desire is to see a much-abused metal (chiefly so through the ignorance, or carelessness bordering upon dishonesty of too many of the producers of malleable iron) given its rightful position in the engineering world. An earnest hope is expressed that this paper may awaken an interest in producers of malleable iron castings which will tend to secure the highest possible quality in one of the most useful of the ferrous metals.

Isotopy*

The radioactive elements are elements that are undergoing transformation, accompanied by the emission of rays. There are three great series of radioactive elements, the uranium-radium, the thorium, and the actinium series.

URANIUM RADIUM SERIES.		
Uranium I	α	5,000,000,000 years
↓		
Uranium X ₁	β	24.6 days
↓		
Uranium X ₂	β, γ	?
↓		
Uranium II	β	1,000,000 years
↓		
Ionium	α	100,000 years
↓		
Radium	α, β	2,000 years
↓		
Radium emanation	α	3.86 days
↓		
Radium A	α	3 minutes
↓		
Radium B	β, γ	26.7 minutes
↓		
Radium C ₁	α, β, γ	19.5 minutes
↓		
Radium C ₂	β	1.38 minutes
Radium D	β, γ	16 years
↓		
Radium E	β	5.10 days
↓		
Radium F (Polonium)	α	140 days
↓		
?		
THORIUM SERIES.		
Thorium ₁	α	30,000,000,000 years
↓		
Mesothorium I	—	5.5 years
↓		
Mesothorium II	β, γ	6.2 hours
↓		
Radiothorium	α	2 years
↓		
Thorium X	α, β, γ	3.65 days
↓		
Thorium emanation	α	54 seconds
↓		
Thorium A	α	0.14 seconds
↓		
Thorium B	β, γ	10.6 hours
↓		
Thorium C ₁	α, β	60 minutes
↓		
Thorium C ₂	α	very brief
↓		
Thorium D	β, γ	3.1 minutes
↓		
?		
ACTINIUM SERIES.		
Actinium	—	?
↓		
Radioactinium	α, β, γ	19.5 days
↓		
Actinium X	α	10.2 days
↑		
Actinium emanation	α	3.9 seconds
↓		
Actinium A	α	0.002 seconds
↓		
Actinium B	β, γ	36 minutes
↓		
Actinium C	α	2.1 minutes
↓		
Actinium D	β, γ	4.71 minutes
↓		
?		

*Abstract of an article by Harry Schmidt in Die Umschau.

Each element produces by its spontaneous disintegration the element that follows in the series, at the same time emitting rays of the character indicated in the second column of the table. The α (alpha) rays are streams of positively electrified helium atoms, the β (beta) rays are streams of negative electrons, and the γ (gamma) rays are trains of ether waves quite analogous to Roentgen rays. The third column of the table gives the "half period" of each element, i.e. the time in which any quantity of that element is diminished one half by disintegration.

A few years ago Soddy attempted to determine the chemical character of mesothorium by the following method. Five kilogrammes of thorianite, a mineral containing many radioactive ingredients, were dissolved in nitric acid. The solution was mixed with barium nitrate solution, and dilute sulphuric acid was added, which precipitated the mixed sulphates of barium, radium and mesothorium. After this precipitate had been removed, a second precipitate was formed by adding more barium nitrate and sulphuric acid to the solution. The operation was repeated a third time, each precipitate being collected and weighed separately. The aggregate weight of the three precipitates was about 200 grammes. Their radioactivity, as tested with electroscope, differed greatly, the first precipitate being strongest, and the third the weakest. The precipitates were separately converted into chlorides, which were dissolved in water. By fractional crystallization of these solutions the radium and mesothorium were separated from the barium. Examination of the radioactivity of the various fractions by a special method revealed the remarkable fact that the proportion of mesothorium to radium was the same in all. This proved that, in fractional crystallization, mesothorium and radium act like a single element. In other words, they are chemically identical. Thorium X, also, is inseparable from them, so that we have a group of these three elements which possess the same properties despite the difference in their atomic weights (mesothorium 228.4, radium 226.4, thorium X 224.4). A second group of identical elements includes thorium, ionium and radiothorium; a third group comprises the three emanations, radium D (radio-lead) and lead. Fleck subsequently discovered the following groups: uranium X, radioactinium and thorium; mesothorium and actinium; thorium B and lead; radium B, actinium B and lead; thorium C, radium C, actinium C and bismuth; radium E and bismuth. Soddy has given the name isotopes to such elements.

There are reasons for believing that the final products of radioactive disintegration (indicated by ? in the tables) are identical with lead, although the theory gives them atomic weights different from that of ordinary lead. Now Lambert has determined the atomic weight of lead obtained from uranium minerals, and found it to be 206.6, while the atomic weight of common lead is 207.1 This proves that two chemically identical elements may differ in atomic weight, and presents the new problem of studying the atomic weights of elements in relation to their origin.

How far does the chemical identity of isotopic elements extend? According to the modern electro-chemical theory, a solution of copper sulphate (Cu SO₄) contains positive copper ions and negative SO₄ ions. A copper rod partly immersed in the solution shows an electric potential differing from that of the solution by an amount which depends on the concentration of copper ions in the solution, according to a law which Nernst has expressed in simple formula, applicable to any metal in contact with a solution of its own ions. Von Hevesy and Paneth have found that the addition of lead ions to a solution of radium D nitrate produces the same change in the potential difference between the solution and metallic radium D in contact with it that a corresponding addition of radium D ions would produce.

The existence of isotopic elements accords with Rutherford's conception of the atom as a number of negative

electrons revolving about a nucleus, which contains an equal number of positive charges and the whole mass of the atom. Most physical and chemical properties of an atom depend chiefly on the number of electrons and of positive nuclear charges. Two isotopic atoms, therefore, may be assumed to possess nuclei which differ in mass, but have equal positive charges and are surrounded by the same number of electrons. Hence their spectra should be identical. This identity has been demonstrated in the case of ionium and thorium, the only case yet investigated.

Treating Stomach Trouble by Electro-Magnet

A NEW process of diagnosing certain affections of the digestive organs has been attracting attention recently in various German scientific journals. As described by Prof. E. Page, it consists in first filling the stomach and intestine with a compound of iron, ferrous-ferric oxide, i. e., *ferrum reductum*, and then suspending a powerful electro-magnet above the abdomen so that its attractive power is exerted through the abdominal wall upon the iron compound within the body. The ferrum reductum gathers at the point nearest the pole and thus permits an alteration of position in the different portions of the intestine to be made.

This ferrous solution is opaque to Röntgen rays, so it is easy to control the alterations of position by means of Röntgenograms. The magnet is suspended in an iron frame by means of a universal joint so as to turn freely, and it can be guided by means of a double handle. Suitably formed pole-pieces are arranged so as to be interchangeable. The portions of the alimentary canal filled with the iron oxide are attracted by the magnet and they can thus be readily manipulated.

Thus a motion of the muscular fibers of the intestine can be excited, and a sort of intestinal massage produced.

The magnet is described as follows by Prof. H. du Bois: It consists of an iron core, 0.5 meter long and about 12 centimeters thick, with a concave-shaped pole at an enlarged end, and with an opposite flanged pole at the other end.

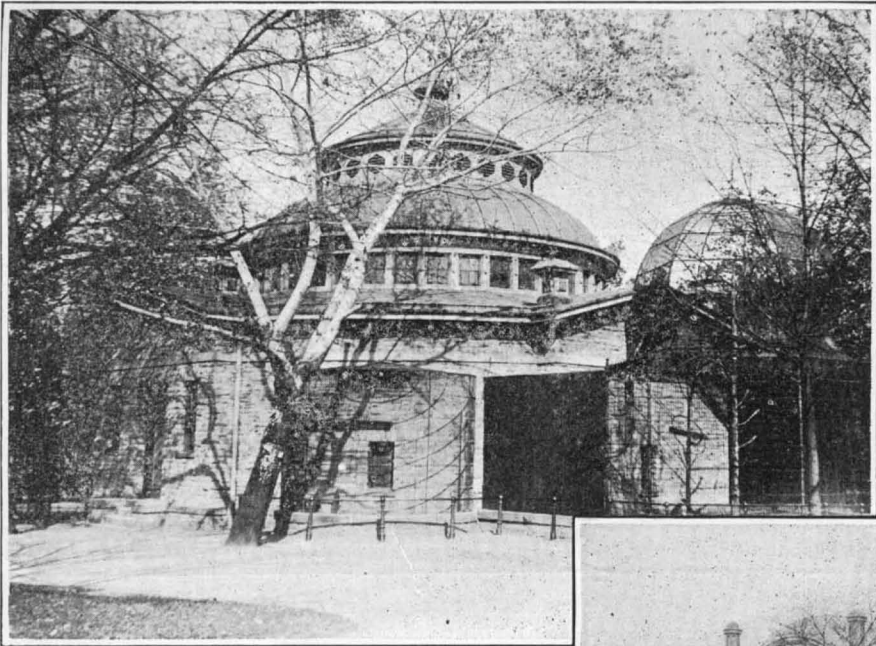
With this form of pole the magnetic field attains its highest value when at a certain distance from the iron. The coils are wound of enameled wire, and are graduated in strength from the working pole to the opposite pole. If the magnet be short-circuited at regular intervals of time by means of an interrupter or current breaker operated electro-magnetically, then a pulsating traction is exerted, which serves to increase the intestinal motion.

The minimum weight is obtained, i. e. about 160 kilogrammes, by a ratio of about one to four between the length and diameter of the magnet. This also makes the watts employed small, i. e. about 3 kilowatts. The Röntgen tube must be so arranged that the cathode rays are turned aside to only a small extent; an iron-enclosed tube, Zelinder tube, can be used, or a compensation coil can be arranged around the tube. The attractive power can be tested by test balls made out of a mixture of ferro ferrite (Fe₃ O₄) with an unmagnetic powder and some adhesive material; these are made in pill shape and are about 1 centimeter in diameter. The attractive power is measured with a spiral spring.

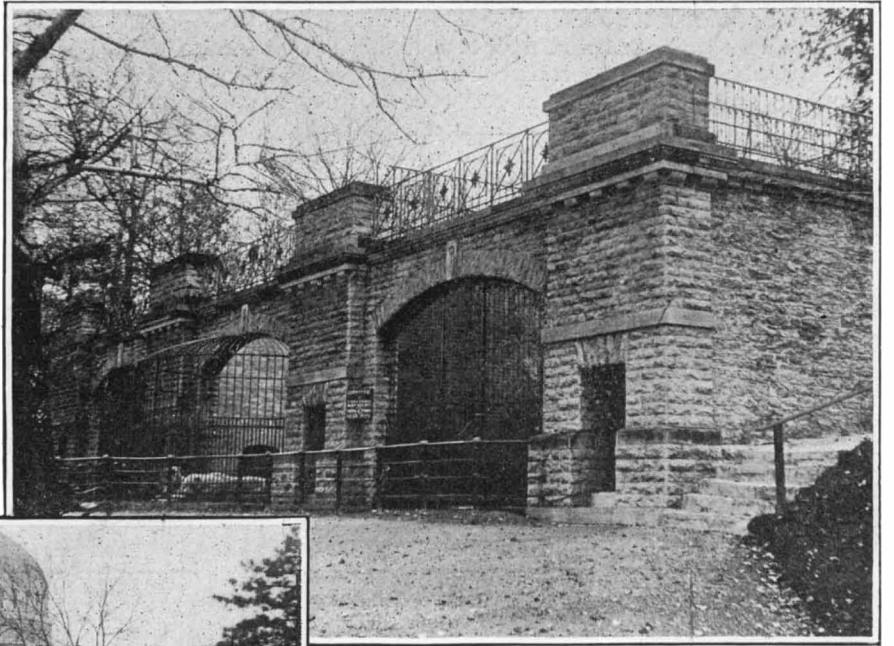
This magnet can also be employed for the removal of fragments of iron from the body.

Saving Daylight

It is regretted that in the article on "Saving Daylight," which appeared in the issue of the SUPPLEMENT of July 8th, there was a typographical error in spelling the name of the author, Dr. George F. Kunz. It is trusted, however, that this gentleman is so well known to our readers by reputation that there has been no misunderstanding as to his identity.



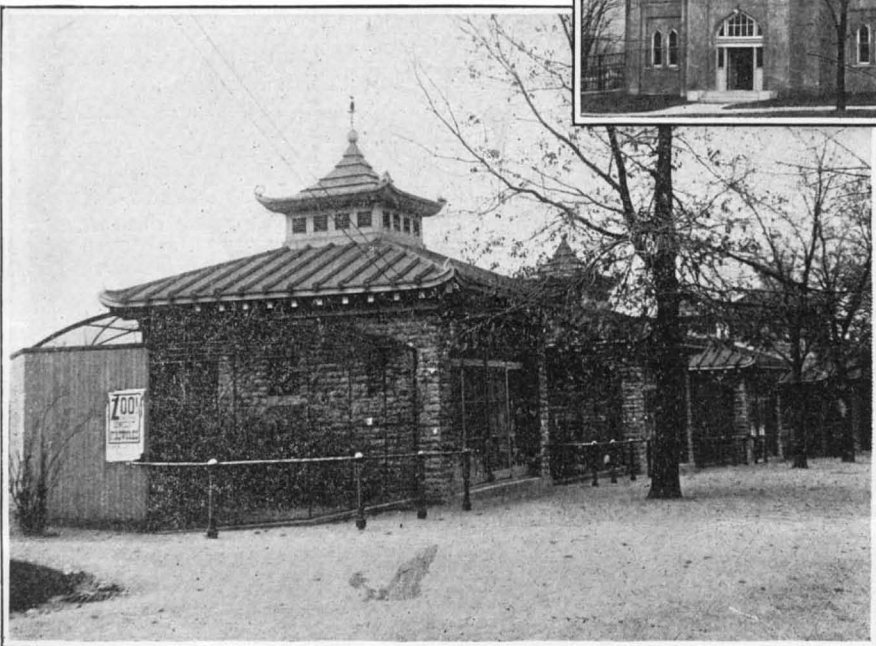
The monkey house.



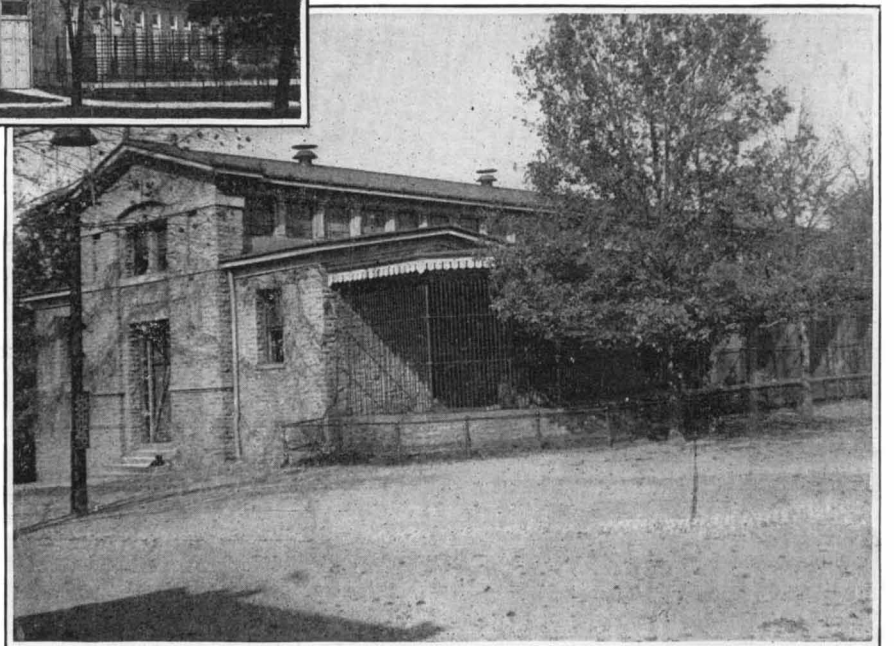
Massive bear pits.



Herbivora building.



The aviaries.



Carnivora house.

The Zoological Garden of Cincinnati

A Model Institution, Both in Its Collections and Management

By Dr. R. W. Shufeldt

IN the order of importance in this country, perhaps the Zoological Gardens of Cincinnati stand next to the one in New York city, which latter is the last institution of the kind described by me in the present series of articles on the subject.¹ At this time, no zoological park of its size is better stocked, better kept up and conducted, or contains more interesting animals than the one founded by Mr. Andrew Erkenbrecher in Cincinnati, which was opened to the public on the 18th of September, 1875. In the State of Ohio, no one was better fitted to make a success of this enterprise than Mr. Erkenbrecher; for, from the time he was a boy, he had studied and collected many living specimens of birds, mammals, and other forms. These he had kept as pets on his farm; and, indeed, at this writing there is a big bird cage at the "Zoo" which is the very one he used for his feathered favorites on that farm.

Before the Zoological Society was organized in Cincinnati there was in existence in that city a Society of Acclimatization, and it was at a meeting of this body, on June 30th, 1873, that the matter of instituting a zoological park was first agitated. The eminent zoologist, Doctor Brehm, of Berlin, wrote a letter on the question to the society, and this letter had much to do with the initial enthusiasm which characterized the progress of the organization of the scheme. Such prominent commercialists of the time as Mr. Florence Marmett, Mr. Albert Fischer, and others, promptly backed the project financially; the formation of a fine stock company put the concern squarely on its feet, and, after some of

the early vicissitudes were safely met and overcome, the enterprise became an assured success, both from a financial and educational point of view.

Originally this park included in its area sixty-seven acres of ground, but some of this was subsequently sold in order to liquidate certain outstanding indebtedness. At present the institution owns the entire tract, and all parts of it are in a very flourishing condition. Indeed, Cincinnati may well be proud of this wonderful place of resort, which not only adds to the long list of the city's attractions, but forms another most deserving center where the zoology and zoography of the United States may be studied under the most advantageous circumstances. So evident is the truth of this that, in a recent letter, the eminent zoological authority of Hamburg, Mr. Hagenbeck, was led to say, after having made a careful personal inspection of the entire establishment, that within the last fifteen months he had visited all the principal zoological gardens in the world, and that, as to the condition of the collection, buildings, grounds, the care displayed and success achieved with the animals and birds, the Cincinnati Zoological Garden was second to none, without exception, and superior to any other in many respects.

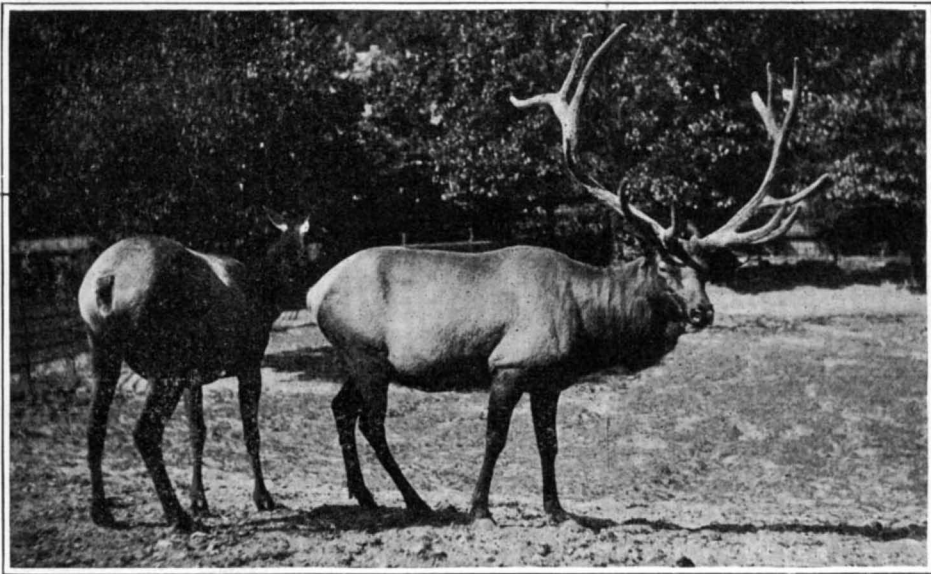
The sixty acres now embraced by these gardens are located about three miles from Fountain Square, in Cincinnati, in that well-known group of picturesque hills in the city's most charming suburb. Topographically, the grounds are greatly varied for so limited an area, there being valleys as well as undulating plains, covered with verdure and diversified plant and tree growth.

As in the case of the New York Zoological Park, the general care of the grounds is under the supervision of a special department, which will account for the exceptional beauty and taste displayed in the landscape gardening to be noted on every hand. That the general arrangement of the grounds is all that is to be desired will be appreciated through a study of the map illustrating the present article. Particular attention is directed to the broad gravel-walks passing through these gardens in sweeping and attractive curves, many of them leading over rustic bridges of unique design, spanning ravines too deep to be otherwise crossed. The visitor soon discovers, in addition to the pretty vistas arising from this skillful plan of the original designer, that convenience has been closely studied; for these roadways and paths take in the cages, buildings, and all else found in this admirably arranged park—all this in a most delightful succession, one feature after another presenting itself for inspection and study as the paths are traversed.

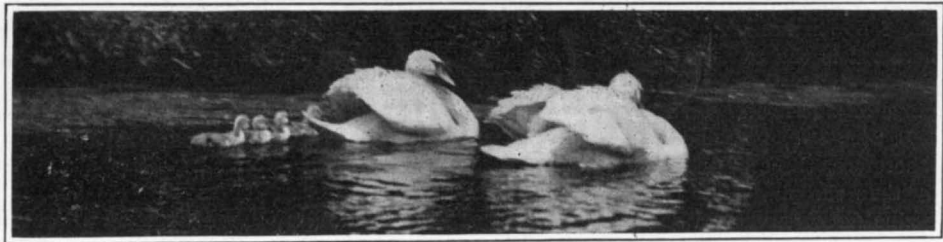
Most of the buildings are fine structures, erected in iron and stone and of pleasing designs; some of the most attractive ones are to be found among my illustrations, as well as a few of the garden's interesting denizens.

Mr. Stephan, the gardens' able and veteran director, will be pleased to show you their superb Club House, with its broad and homelike verandas, later conducting you to the immense building erected for the Carnivora, as well as to the circular Monkey House, the long row of aviaries, and the grand home for the eagles and vultures. Then there is a fine music stand and pavilion.

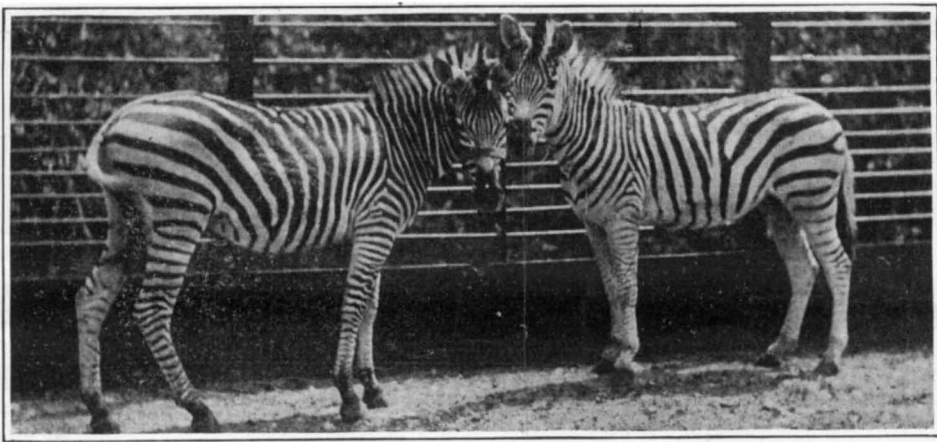
¹"The New York Zoological Park." SUPPLEMENT TO THE SCIENTIFIC AMERICAN, June 3rd, 1916. No. 2109.



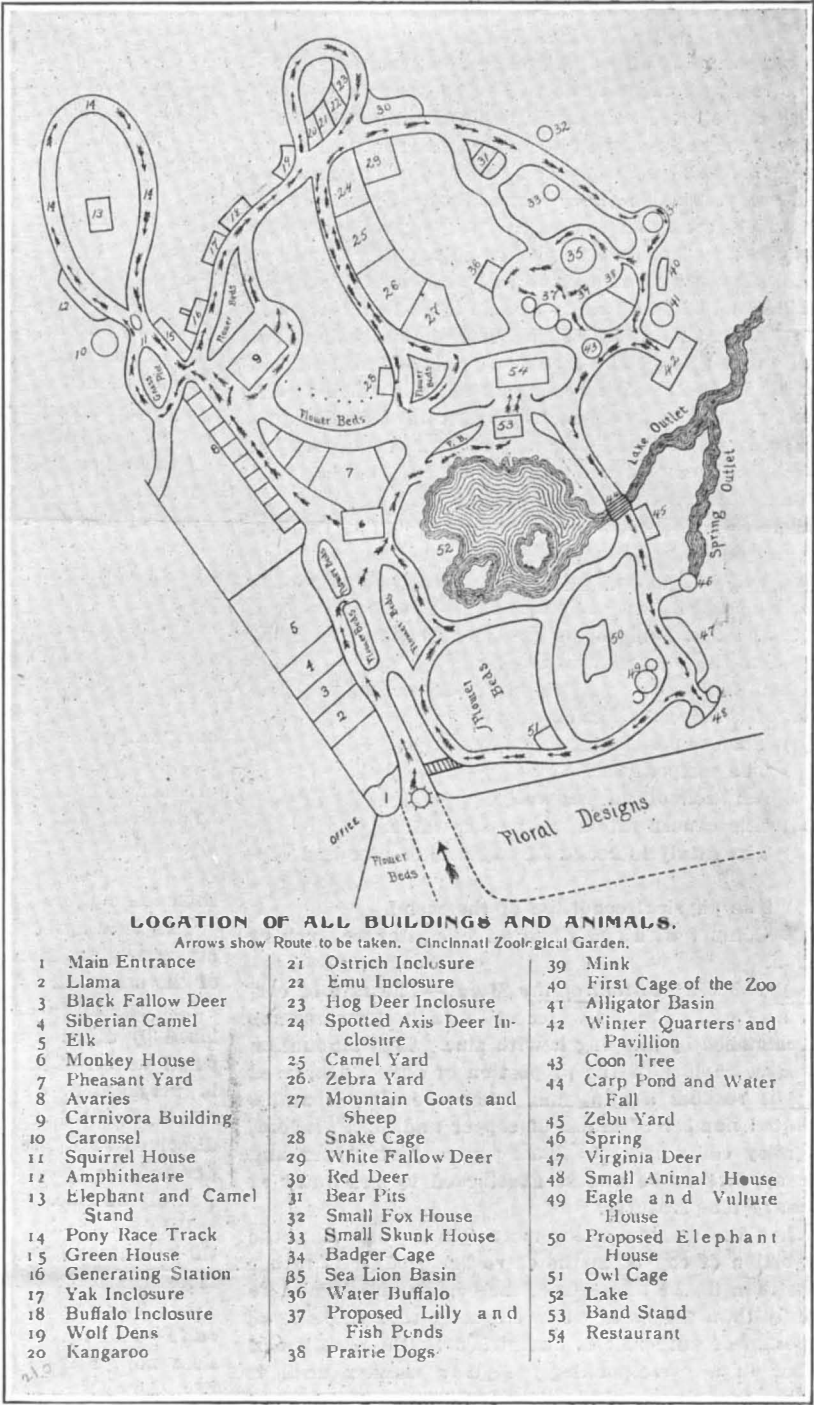
A pair of fine wapiti, or American elk.



A pair of swans, with cygnets, on the lake.



Chapman's zebra [E. b. Chapmani].



Plan of the Cincinnati Zoological Gardens.

ion not far from the sumptuous quarters that have been so generously built for the elephants, ostriches, seals and sea-lions, and many other animals. These structures have cost a great many thousands of dollars; but even so, the stock is now paying the company well for the investment, and they have the satisfaction of knowing that the institution is an endless source of pleasure to hundreds of visitors annually, to say not a word as to the educational value of what is so bounteously placed on exhibition there.

At different times the collection has contained a large number of the best known forms occurring in this country, as well as many from abroad, while all the specimens usually found in large "zoös" are always to be seen and in fine condition.

A few years ago the bird collection contained the last living wild pigeon (*Ectopistes migratorius*) in existence, and when this unique and valuable specimen died, it was turned over to me for anatomical description. This piece of work I promptly accomplished and published, thus making a complete account of the skeleton and general anatomy of the species accessible to future students of avian anatomy. I also photographed the specimen, and reproductions of those photographs have been published in many places—some in natural colors—while hundreds of public schools throughout the country have had those pictures framed for the class-rooms as a warning to all school children against the wanton destruction of the wild forms of this country. It is a well-known fact that this beautiful bird, once existing in our midst in untold millions, was practically exterminated by man; and, being extinct, it will never be seen or known in life on this globe again.

The Cincinnati Zoölogical Gardens publishes, from time to time, a number of very useful and instructive "Guide-Books," as well as descriptions of many of the animals to be found in its collection. Among these we find "Zig-Zags at the Zoo"; "Studies in Zoölogy"; "A Little Hand-Book of the Cincinnati Zoölogical Gardens," and similar publications. These are all beautifully and tastefully illustrated, and brimful of general informa-

tion on animals. Several of them, too, are very essential for casual visitors to the city, who have the time and desire to spend a forenoon profitably by a visit to these instructive grounds; moreover, the sale of these publications adds considerably to the company's revenue, as do similar properly prepared, edited and illustrated publications in the case of other institutions of this kind.

Among other attractions there are some pretty, well mounted specimens of mammals and birds on exhibition at the Carnivora Building. There we see what the taxidermist has done for old "Chief," a notoriously vicious elephant, which the authorities were obliged to slay a few years ago on account of its infamous temper and the danger it was to any that came near him. There is also a group of mounted lions, and one of a young giraffe, the last being the only specimen born in this country at the time of its death. When it died it was but five or six days old. In the same building we find a mounted specimen of the same species, the latter being one of a pair bought in 1877, and this particular animal flourished at the "Zoo" for sixteen years. In life it was eighteen feet in height, and with head and neck extended could reach twenty feet above the ground. It was a male, and the Barnum and Bailey Company purchased the female about eighteen years after the death of the male. These are all good examples of the gardens' museum, and the collection will doubtless be added to and extended from time to time, as the rarer animals succumb to age or die from other causes.

Three years ago there were 520 mammals living in these gardens; 1,200 birds, and 125 reptiles—the entire collection being valued at forty-three thousand dollars. At that time (1913) this garden owned the finest male lion in the United States; the largest herd of buffaloes; the biggest polar bear; the finest pair of giraffes; the smallest zebu or sacred cow of the Orient; the longest python and alligator, and the tamest elephant. With respect to this list I would say, that the three only giraffes born in this country were born in these gardens; and the superintendent informs me

that, growing within the preserves, there is at least one of every species of tree indigenous to the State of Ohio.

Every day in the year visitors may resort to this park, the admission for adults being twenty-five cents and for children ten cents. There is also an Associate Membership arrangement, members being allowed to purchase "coupon books" of twenty-five tickets for five dollars, reducing the admission fee for adults to twenty cents. There is also a special rate-system for casuals, and other arrangements, such as the one for special parties outside of the city, which can secure railroad zoo tickets at a low rate; these are intended particularly for "excursion parties."

Within the grounds there are plenty of wheeled chairs and go-carts for hire; there are good cafés, and a magnificent band-stand, upon which a military band gives regular entertainments. Certain parts of the ground are set aside for picnics or other social gatherings, and these are kept in control by special regulations which protect the animals, prevent acts of vandalism, and so on.

A contract has been made with Mr. Enno Meyer, of Cincinnati, to photograph all new animals acquired by the gardens, also new buildings and special features, and he is usually very successful in certain lines of his work. Most of the reproductions of the photographs illustrating the present article are by Mr. Meyer.

Among the lessons which the Cincinnati Zoölogical Gardens has for us is, that an institution of this kind, under good management, may be self-sustaining as well as an excellent paying proposition, and all this without any detriment to its educational advantages. Under such a management, too, it can be of the greatest service to the city in which it is established, to the country, and to visitors from foreign lands. Finally, in due time everything can be carried out upon a grander scale, as more and better buildings; a very much larger, more varied and healthier collection of animals, and the establishment of special lines of research work in the structure and natural history of animals, with the ability to publish such studies.

The Corrosion of a Solid Solution 70/30 Brass*

By William E. Gibbs

WHEN an alloy of copper and zinc is immersed in sea-water it may corrode uniformly in three ways:

(a) It may lose both constituents simultaneously and at the same rate. Both copper and zinc are then found in the corrosion product and in the proportions in which they are present in the original alloy. This is called "complete" corrosion.

(b) It may lose one constituent only, either copper or zinc. The corrosion product will then contain copper or zinc—not both. This is called "selective" corrosion.

(c) It may lose both constituents simultaneously but at different rates. The corrosion product will then contain both copper and zinc, but in a ratio which is different from that in which they occur in the alloy.

In addition to these three types of uniform corrosion localized action may occur at various points of the metal surface. This localized action may be "complete" or "selective." If the first, it produces a pit; if the second, it produces spongy copper or an alloy richer in zinc. Very frequently in practice these products of a selective local attack are worn away mechanically, and the final result is as in the case of "complete" localized corrosion, the formation of a pit.

Some of the many factors which determine the character of a corrosive attack are:

- (a) The composition of the alloy.
- (b) The temperature.
- (c) Aeration of the sea-water.
- (d) The concentration of the sea-water.
- (e) The catalytic action of oxysalts of zinc and copper.

(f) The physical condition of the metal.

(g) Contact with electro-negative substances, such as carbon.

(a) *The Composition of the Metal.*—The rate of corrosion of copper in sea-water at ordinary temperatures is diminished by alloying it with zinc. This diminution increases rapidly as the proportion of zinc is increased until it reaches a minimum, when the alloy contains an equal number of atoms of copper and zinc. Indeed, the alloy containing 50 atoms per cent of copper and zinc appears to be almost unattacked by sea-water at ordinary temperatures.

When the alloy contains more copper than zinc, the proportion of copper in the corrosion product is rather more than in the alloy—i. e., the copper dissolves more rapidly than the zinc. It would seem that the rate of corrosion of pure zinc is diminished by the addition of copper in a correspondingly regular manner until it reaches a minimum of the alloy containing 50 atoms per cent of zinc. In alloys containing more than this amount of zinc the zinc dissolves rather more rapidly than the copper.

The curve showing the relation between the rate of corrosion and the composition of the alloy exhibits during the first few weeks a second minimum point in the neighborhood of the 70/30 alloy. This, however, speedily disappears, and after ten weeks the curve exhibits the familiar deep U shape, characteristic of the properties of a series of solid solutions. This curve is being re-determined by Mr. F. G. Martin and the author. It is proposed also to extend the investigation to higher temperatures. Loss of weight measurements are being supplemented by a careful analysis of the corrosion products.

(b) *The Temperature.*—The initial rate of corrosion of 70/30 brass increases as the temperature rises from 15 deg. Cent. to 50 deg. Cent. Between 50 deg. Cent. and 60 deg. Cent. the initial rate of corrosion appears to fall off very quickly, for at 60 deg. Cent. it is less than at 15 deg. Cent.

In every case the rate of corrosion falls off with time, and more rapidly at higher temperatures than at low. Consequently, although the initial rate of corrosion is greater at higher temperatures, the actual rate of corrosion after a given time will be smaller.

Analysis of the corrosion product at 15 deg. Cent. and 50 deg. Cent. indicates that at these temperatures the attack takes place in three successive stages. First there is a selective attack upon the copper; this is succeeded by a period of complete corrosion (after nine days at 15 deg. Cent. and twenty days at 50 deg. Cent.); the third stage is a selective attack upon the zinc. In other words, at the beginning of corrosion the rate of solution of the copper is much greater than that of the zinc. This gradually falls off; at the same time the rate of solution of zinc gradually increases. For a short time they are approximately equal; after that the rate of solution of the zinc is much greater than that of the copper.

In stagnant sea water this third stage occurs more quickly at 15 deg. Cent. than at 50 deg. Cent. It is probably dependent upon the amount of O and CO₂ pres-

ent in solution in the sea-water. It is hastened by aeration. It appears to be associated with the formation of a film of copper oxide which protects the copper but permits solution of the zinc.

(c) *Aeration of the Sea-Water.*—At temperatures up to 50 deg. Cent. aeration of the sea-water increases the initial rate of corrosion. At 50 deg. Cent. its effect is very slight, while at 60 deg. Cent. it diminishes the rate of corrosion. The effect of aeration appears to be greatest at low temperatures. This is no doubt associated with the well-known fact that rapid localized corrosion occurs just inside the inlet end of the tubes in the coldest part of the condenser. In every case it increases the proportion of zinc in the corrosion product.

The corrosion of pure copper in sea-water is checked by aeration owing to the formation of an oxide film. On the other hand, the corrosion of pure zinc in sea-water is considerably accelerated by aeration.

(d) *Dilution of the Sea-Water.*—Diluted sea-water attacks 70/30 brass more slowly than ordinary sea-water. At the same time the proportion of zinc in the corrosion product increases rapidly as the sea-water is made more dilute.

Thus after thirty-four days at 50 deg. Cent. in aerated solutions of sea-water at the following concentrations, $s/1$, $s/2$, $s/4$, $s/8$, $s/16$ (where $s/1$ is the concentration of ordinary sea-water, $s/2$ being half that concentration, and so on), the percentage of zinc in the corrosion products was respectively 18.0, 24.2, 33.9, 44.1, and 58.5. In $s/1$ and $s/2$ sea-water, therefore, the copper in the brass dissolves more rapidly than the zinc, but in $s/4$, $s/8$ and $s/16$, sea-water the zinc dissolves more rapidly than the copper.

This is in agreement with the general belief that estuary waters are more selectively corrosive than the water of the open sea.

The solubility of pure copper in sea-water is diminished by dilution of the sea-water and is least in distilled water. The solubility of pure zinc in sea-water is increased by dilution of the sea-water, and is greatest in distilled water. It appears from this that the dissolved salts are responsible for the solution of copper and the water and the dissolved gases for the solution of the zinc.

Dilution of the sea-water, therefore, while retarding the actual rate of corrosion of 70/30 brass, actually promotes dezincification.

(e) *The Catalytic Action of Zinc and Copper Oxysalts.*—Moist zinc chloride at ordinary temperatures does not produce dezincification. When heated to 70 deg. Cent., however, rapid dezincification is set up, owing to the formation of zinc oxychloride. When zinc chloride is added to sea-water at 40 deg. Cent., in which a piece of 70/30 brass is suspended, it produces a finely divided white salt, zinc oxychloride, which gives rise to rapid dezincification of the brass similarly at 50 deg. Cent.

Aerated sea-water at 60 deg. Cent. produces white spots on the surface of the 70/30 brass. These white spots are found to cover areas of copper, showing that they have produced dezincification.

Sea-water when allowed to dry on a piece of 70/30 brass at ordinary temperatures forms a greenish blue crystalline salt which covers a pit. It does not appear to give rise to dezincification, but promotes rather the solution of copper.

Sea-water when allowed to dry on 70/30 brass at 100 deg. Cent. forms a white salt which does promote dezincification.

At ordinary temperatures, therefore, the attack is greater upon the copper, and the copper oxychloride is formed. This salt catalytically facilitates the solution of copper. At high temperatures (between 80 deg. Cent. and 100 deg. Cent. at any rate) the attack is almost completely upon the zinc, and oxychloride is formed. This salt catalytically facilitates the solution of zinc.

In connection with this fact it is interesting to note the following experiment: A tube of 70/30 brass was heated internally by steam. Cold sea-water flowed continuously round the outer surface. At various points of the surface air-bubbles were formed. Where these air-bubbles appeared upon the surface of the hot tube rings of zinc oxychloride were formed, presumably by the evaporation of the thin film of sea-water in the presence of the air of the bubble. In some cases a succession of air-bubbles had followed one another at the same point of the surface, each producing a ring of white salt, and so gradually increasing the deposit of white salt. This might be a frequent cause of localized dezincification in condenser tubes.

(f) *The Physical Condition of the Metal.*—When 70/30 brass is hard drawn it corrodes less rapidly than when it is annealed. At the same time, however, there is a greater proportion of zinc in the corrosion product. Dezincification, therefore, occurs more readily in a hard-drawn 70/30 tube than in an annealed 70/30 tube.

(g) *Contact with Electro-negative Substances.*—Carbon or coke resting upon a clean brass surface is generally in good electrical contact with the brass. When good contact exists between the two the rate of solution of the brass is increased fivefold, and the proportion of zinc in the corrosion product rises to 60 per cent. At the same time the surface of the metal becomes covered with a loosely adherent red film of copper oxide, which can be removed by a mere touch of the finger. The effect produced by contact with coke is much greater at 50 deg. Cent. than at 15 deg. Cent. The e.m.f. between coke and 70/30 is about 0.19 volt. Between coke and zinc there is an e.m.f. of about 1 volt.

Other substances, electrically neutral, such as string or brick, act as loci for the accumulation of oxysalts of Zn and copper, and so lead to accelerated local corrosion.

A piece of coke fixed in a condenser tube might accelerate selective corrosion in three ways:

(a) If contact were good it would exert an electrochemical action.

(b) By obstructing the free passage of the water in the tube it would lead to a greatly increased temperature along that part of the tube between the coke and the inlet end. This would facilitate general dezincification of that portion of the tube.

(c) The water on the outlet side of the coke would only be able to trickle along the tube, and the continuous film evaporation to which it would be subjected would, if the tube were hot enough, produce deposits of zinc oxychloride. This also would facilitate dezincification of the tube.

Other cases in which corrosion, particularly selective corrosion, is localized at certain points along a condenser tube appear to be due to a lack of homogeneity in the metal itself. Perhaps local e.m.f.'s are set up between areas containing dissolved copper oxide and the remaining portion of the tube. The presence of strained metal in the hard-drawn alloy may be a contributory factor in the early stages of corrosion. It is generally noticed that the white spots of zinc salt, which indicate the occurrence of dezincification, always occur first along the drawlines and upon the filed edges of the test-pieces.

A general consideration of the foregoing facts conveys the impression that a solid solution of zinc and copper is intermediate in character between a physical mixture and a chemical compound. The copper and the zinc retain to a very large extent their own characteristic individuality, but in each case it is modified by the presence of the other constituent. It is as though there were some kind of weak chemical combination (or rather physical combination, since the chemical character of the constituents is not changed entirely but only modified) between the two, whereby the available energy of each is diminished.

In 70/30 brass the diminution of the available energy of the zinc is of course greater than in the case of the copper, for the influence which is exerted by a dissolved metal upon the character of the solvent metal is a function of the atomic volume. In the case of zinc and copper the atomic volumes are practically equal and the influence of each constituent upon the other becomes a function of the concentration. When, however, the proportions of zinc and copper are equimolecular the available energy of both is reduced to a minimum, and the rate of corrosion at ordinary temperatures becomes practically zero.

In the alloys containing more than 50 atoms per cent of copper it is the copper which dissolves at first, although zinc is more rapidly soluble in sea-water. This suggests that the chemical activity of the zinc is neutralized in the solid solution.

The electrode potential of zinc in sea-water at 16 deg. Cent. is -0.5100 volt and of copper $+0.3896$ volt. That of 70/30 brass is $+0.3460$ volt, and therefore resembles copper rather than zinc. Similarly, the chemical activity of the copper is reduced considerably by the presence of the zinc in solid solution, and appears to reach a minimum when the atomic concentration of the zinc exceeds 50 per cent.

The strength of any combination between copper and zinc and the influence exerted by it upon the properties of the constituents would depend upon:

(a) The composition of the alloy. By which is meant the concentration of zinc and copper in the alloy and the presence of other metals, such as iron and tin, and of non-metals, such as oxygen.

(b) The physical state of the alloy, i. e., whether it is solid or liquid, amorphous or crystalline.

(c) The physical environment of the alloy, its temperature and pressure.

(d) The chemical environment of the alloy, which in this case refers to the nature and composition of the corroding solution.

Is it possible that a compound or compounds of copper and zinc exist stable only at low temperatures—say below 50 deg. Cent.? These may dissociate into

* A Contribution to a General Discussion on "The Corrosion of Metals," held before the Faraday Society.

a system of solid solutions as the temperature rises and the composition is altered.

Such a concentration appears to afford a reasonable explanation of the corrosion of 70/30 brass. Its application to other fields of investigation does not come within the scope of this paper.

Hydrogenated Oils in the Soap Industry*

By Carleton Ellis

THE developments in oil hydrogenation have brought to the soap industry an innovation of fundamental importance in the domain of raw materials. The soap manufacturer, no longer well able to purchase the best grade of fats in face of the high prices paid by the margarine and other fat edible industries, has now at his disposal the means for utilizing lower grade materials in substitution for more costly stock.

By hydrogenation, oils which formerly made soaps only of soft consistency, now yield the more valuable hard soaps. This has led to a very rapid development of the art with respect to the production of soap making fats. In particular, fish and whale oils have been made use of, because these oils may be completely deodorized by the addition of hydrogen.

According to a Japanese chemist, Tsujimoto, the odor of fish oil is due almost entirely to a fatty constituent and not to so-called impurities. This fatty constituent is clupanodonic acid having the formula $C_{18}H_{28}O_2$, which, therefore, by the addition of 8 hydrogen atoms, becomes stearic acid. When hydrogenated down to an iodine number of about 50, fish oil has the consistency of hard tallow and the odor of fish oil is wholly absent. Even the fishy taste is scarcely in evidence.

For soap making, this product is satisfactory, as it complies with the test for a deodorized fish oil suitable for soap making in that the odor of the original oil is not apparent when ironing laundered goods on which such soaps are used. If, however, at least with the poorer grades of oil, the hydrogenation is not carried on to a point where the iodine number is approximately 50 or less, there is some danger that the fishy odor will become apparent during the ironing operation.

It appears not improbable that unstable odor-forming nitrogenous impurities in fish oil add hydrogen during the hardening process and are transformed into bodies of a stable character.

A German-Norwegian company, capitalized at about \$833,500 organized to work a new German method for hydrogenating whale oil has commenced operations at Fredrikstad, Norway. The Hafslund Falls are being utilized to generate the electric power required by the work and also to manufacture by electrolysis the hydrogen required for the hardening process to which the purified whale oil is submitted and converted into a solid neutral fat. The daily consumption of oil is about 300 barrels.¹ (*Jour. Ind. and Eng. Chem.*, 1913, 608.)

Samples of Norwegian hydrogenated whale oil which have come to the writer's attention are of exceptionally high quality.

Whale oil of the grades known as 0 and 1 hydrogenate readily with nickel as a catalyzer. No. 2 is somewhat more difficult, and No. 3 is decidedly troublesome of treatment without special refining.

Auerbach (*Chem. Ztg.*, 37, 297) considers the hydrogenation process responsible for an advance in the price of fish oils so that they will be of doubtful benefit to the soap industry. Also he states that the so-called burned odor which was noticeable in soap made from hardened fats is said to have been overcome. Besides fish and whale oils, he notes that castor oil is used for insulation purposes in the electrical field.

The commercial side of fat hardening is discussed to some extent by Schicht (*Seifen. Ztg.*, 1913, 287) and the value of fish and whale oils in this field is considered.

As Dr. Holde states (*Seifen. Ztg.*, 1912, 918), oleic acid, the most important constituent of all semi-drying liquid oils, requires only 2 parts of hydrogen to 282 parts of oil in order to get stearic acid, while linoleic and linolenic acid require 4 and 6 parts, respectively, to 280 and 278 parts. Ricinolic acid, which contains one atom of oxygen more than oleic acid, forms an oxystearic acid which has a very high melting point, but which also only contains 2 atoms more of hydrogen than the original acid. The glycerides of stearic or palmitic acid naturally remain unchanged throughout the operation.

In this country very little has as yet appeared in the literature regarding the application of hydrogenated oils in soap making, but in Germany considerable space has been given by the trade journals to discussions of the subject. Some of the statements are of a very

contradictory character, as is, of course, to be expected in the early stages of development of this important subject, especially in view of the very considerable degree of empiricism which prevails in some branches of the soap making industry.²

It is to be regretted that so much of the published matter relates to the products of one concern, the talgol, candelite and similar hydrogenated fish and whale oils, etc., of the Germania Oelwerke at Emmerich, but while soap making as practiced in Germany differs considerably from the practice in this country, it is believed the work abroad will prove at least suggestive if not instructive.

In the following an attempt has been made to briefly review the more important contributions in this connection.

Garth (*Seifen. Ztg.*, 1912, 1278) states that fish and whale oils are the raw materials for a considerable proportion of the hydrogenated products which up to the present time have found application in soap making. Being relatively low priced raw material many attempts have been made to make cheap soaps from fish oil. These attempts in the past have been unproductive because the objectionable odor reappears after goods are laundered. Hence, there are many proposals directed toward the production of odorless fish oil. As is known, fish oil contains nitrogenous compounds and certain of the lower fatty acids arising from decomposition of the fish before the oils are expressed. Most of the proposals are based upon the assumption that these sources of the evil odor can be removed by the action of energetically reacting bodies, such as sulphuric acid and the like. However, neither treatment with strong acids nor distillation with superheated steam produce unobjectionable products. By hydrogenation the disagreeable odor disappears; nevertheless, there always remains an odor similar to that of distilled olein which, however, is completely concealed if the product is worked up with a goodly proportion of other fats.

Garth (*Seifen. Ztg.*, 1912, 1279) observes that the hydrogenated fats which have been used in the soap manufacture appear in the trade as talgol, talgol extra, candelite, candelite extra, crotolein talgin, etc. Talgol has a melting point of 35-37 deg. Cent. and an iodine number of 65-70. Talgol extra melts at 42-44 deg. Cent., and the iodine number 45-55. The candelite products are harder, candelite melting at 48-50 deg. Cent. and having an iodine number of 15-20, while candelite extra melts at 50-52 deg. Cent. and exhibits an iodine number of 5-10.

Heller (*Seifenfabrikant*, 1912, No. 31) furnishes the following data on these products:

	Acid No.	Saponification No.	Unsaponifiable.	Iodine No.
Talgol	3.5	190.7	0.33	63.9
Talgol extra	3.8	190.5	0.31	36.1
Candelite	3.8	190.4	0.41	18.1
Candelite extra	4.4	188.4	0.52	10.4

	Melting Point.	Fatty Acids Titer.	Acid No.
Talgol	38.5	34.6	199.7
Talgol extra	45.5	43.5	199.9
Candelite	48.5	47.4	198.9
Candelite extra	51.8	50.5	199.9

Schaal has reported³ the results of his observations on the two products "talgol" and "candelite" derived by hydrogenation of train or fish oil, and has called attention to the adaptability of these hardened fats in the production of soap base or milled soap. Both talgol and candelite have a tallowy appearance with this difference that one is softer and one is harder than tallow. At first glance one is likely to regard these fats as similar to high grade soap tallow, but the odor of the product immediately shows this is not the case. The odor is not disagreeable and, in fact, resembles some grades of tallow. It is suggestive of the cheesy odor given off by tallow which has been stored for a considerable time in warm weather. Of the two products, talgol and candelite, the odor in the latter is less noticeable.

In his first investigations Schaal simply replaced a part of the softer fats, as he thought talgol would lose its firm consistency during the boiling operation, and would return to a consistency approaching that of the original oil. This assumption proved to be unwarranted, as tests with small samples showed that the talgol fatty

¹In England one large concern is offering several grades of hardened fat ranging as follows:

	Iodine.	M. P.	Titer.
A1	50	40-42	36
A2	85	28-30	32
C1	60	44-46	45
C2	75	35-37	36

²The result of protracted investigations by Schaal on the utilization of hardened oils in soap manufacture are published in the *Seifensieder Zeitung*, 1912; 821, 846, 954 and 979; 1913, 173, and in a book entitled "Die Moderne Toiletseifen-Fabrikation," Augsburg, 1913.

acids were as hard as the talgol itself. The first fat mixture used for preparing a soap consisted of the following: Forty parts tallow, 15 parts talgol, 30 parts bone fat, 15 parts coconut oil.

No rosin was used as it was desired to determine the influence of the talgol odor. During the boiling the odor of talgol was plainly in evidence, much more noticeable, in fact, than could be observed afterwards in the finished soap. The dried curd exhibited a wholly agreeable odor in which the characteristic odor of talgol could not be detected, and no odor was in evidence of a nature calculated to affect the perfume. The soap was not perfumed, but was wrapped in paper and laid aside a few weeks for further observation. In another trial the tallow was reduced and the talgol increased in amount, the formula being: Twenty-five parts tallow, 35 parts talgol, 30 parts bone fat, 10 parts coconut oil.

The saponification progressed satisfactorily, indicating that talgol readily united with alkali. As the bone fat employed was of exceptionally dark color, the soap was bleached in the kettle with 0.2 per cent blankit. The dried product had a fine ivory white appearance, but the odor of talgol was apparent, although not so pronounced as to render the soap unusable. This soap base milled very smoothly and easily, giving an excellent finish. In another trial 5 per cent of rosin was introduced with improvement in the odor of the soap base.

The milled and perfumed soap was kept under observation, and it was noted that some perfumes were affected by the talgol odor. A person with a keen sense of smell would immediately detect the presence of talgol. Tests were conducted with a number of perfumes, including hyacinth, lilac, rose, patchouly and violet, each cake being separately wrapped in parchment paper.⁴ It was found that the two first mentioned perfumes were more sensitive to the presence of talgol smell and gave a momentary impression that the soap had become rancid; the rose was slightly affected, while the other samples were not noticeably changed. Schaal reaches the conclusion that the highest grade of toilet soap perfumed with delicate essential oils is affected by the use of talgol or candelite and that these hardened oils will not find an application here. Such soaps are, however, sold only to very fastidious trade and require in any case perfumes of the very highest grade. On the other hand, in manufacturing ordinary grades of toilet soap which are, of course, made in enormous quantities, up to about 35 per cent of talgol or candelite may be employed advantageously in the fat stock. As regards solubility in water and free lathering properties, Schaal found talgol or candelite to afford satisfactory results, the soaps which he prepared forming a lather immediately which was thick and voluminous, acting, in fact, like any standard soap. It is reported that the Olwerke Germania has been successful in producing a completely odorless product at a somewhat higher cost. If such a deodorized product can be put out at reasonable price, it will be possible to make toilet soaps of the highest grade with hardened fats derived from relatively cheap oils.

Of talgol Schaal notes that the fat is readily deprived of its glycerine and especially well by the Kriebitz process, and soaps made from this stock are prime products.

Schaal states that so long as these hardened fats are not entirely odorless, they cannot be advanced for the manufacture of soap stock of the first class. For these, the best beef tallow, etc., must remain the raw material, for this class demands the best that the soap industry can produce. Talgol is, therefore, considered suitable only for working up into soap stock of second and third grade. In these soaps the price of raw material plays a considerable role, and thus talgol proves an advantageous substitute for tallow.

Power Installations in the United States

WHILE 80 per cent of the total installed power from all sources in 1912 was steam power, and while nearly three fourths of the total primary power installed in commercial and municipal central stations (or establishments for the sale of power) and in street and electric railway plants was steam power, the preponderance of steam power is found, according to the figures given, in the Eastern States; and the per cent of increase in water power development for public service use in the three years since 1912 has been three times as great as in steam power. Primary power installation from all sources and for all uses increased in the eleven Western States 240 per cent from 1902 to 1912, or more than two and one half times as rapidly as in the remainder of the United States. This includes primary power used directly in manufactures, 94 per cent of which is found in the Central and Eastern States.—*Report of the United States Department of Agriculture.*

⁴Schaal gives a number of perfume formulae for hydrogenated oil soaps in *Seifen. Ztg.* 1912. 979.

*From *The American Perfumer*.
¹The Knowles Oxygen Company, of Wolverhampton, England, has contracted with the Sunlight Soap Factory in Port Arthur, to erect an annex to the plant for the production of the hydrogen necessary for hardening palm oil; the oxygen is to be collected and sold.

A New Electrolytic Interrupter

A Simple and Valuable Apparatus for the Wireless Experimenter

By C. A. Oldroyd

THE interrupter described here is a modification of the well-known Caldwell-Swinton type. The latter consists of an outer glass vessel containing diluted sulphuric acid and a lead plate electrode, and an inner vessel, which often takes the form of a glass or porcelain tube. This inner vessel also contains a lead plate as an electrode and has a small hole at the bottom, so that both vessels are filled with diluted acid to the same level. In operation, however, the liquid rises in the inner vessel and issues from a relief branch near the top of the inner container, returning in this manner to the outer vessel.

This returning stream of liquid has often caused short-circuits and current leakages, which are rather

This interrupter requires a voltage of at least 65 volts and can be used on voltages of 200 and above. It works equally well with either alternating or direct current.

The interrupter can be easily made by the average experimenter and the construction will be described in detail.

Procure, first, the glass jar *A*, which should be about 10 inches high by 6 inches diameter. This will be sufficient for coils up to 20-inch spark length and the interrupter can be worked for long stretches at a time without undue heating.

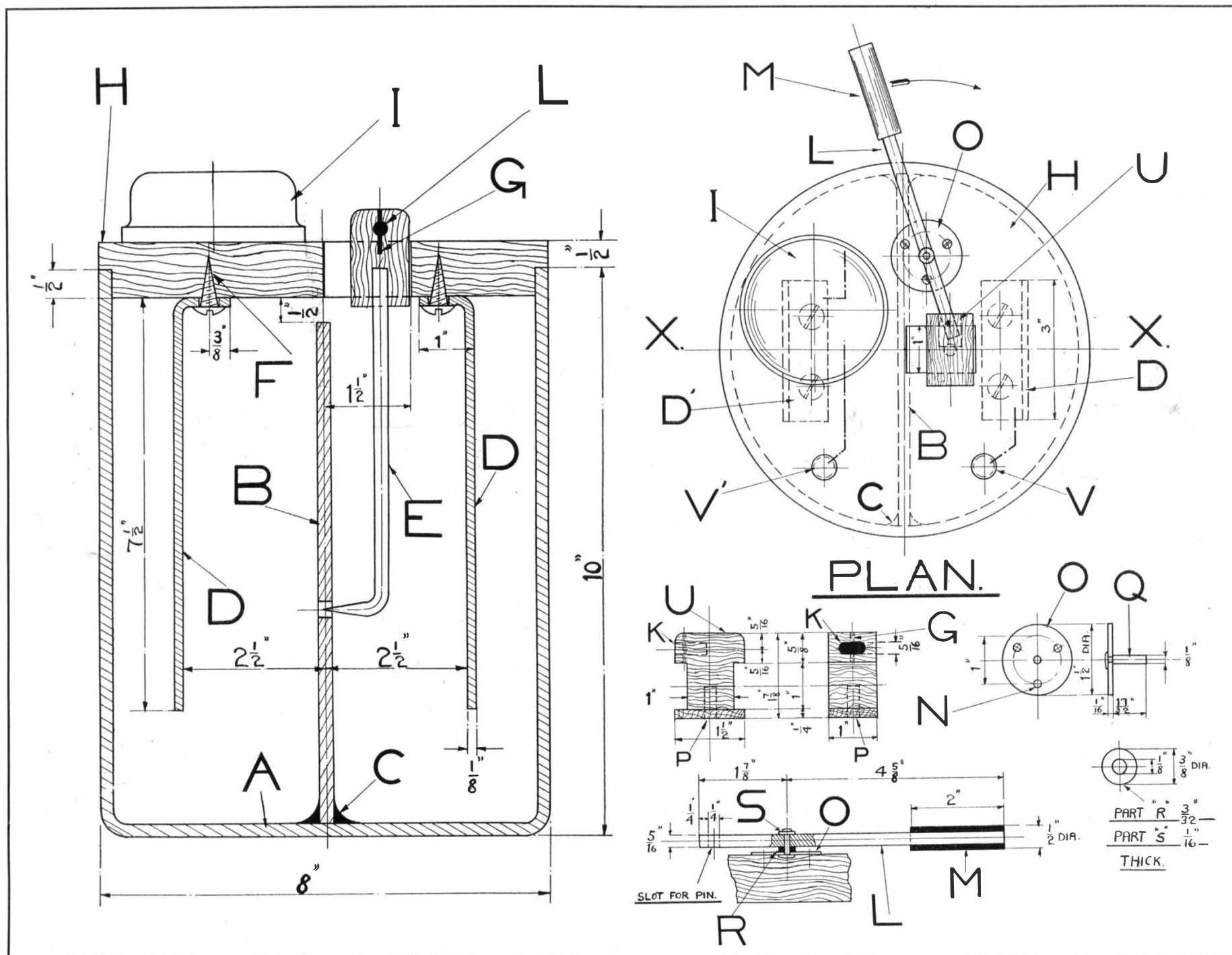
Cut a glass plate so that it will fit nicely into the jar *A*, and drill a hole one-quarter inch diameter,

bottom of the jar and also at the other side, and the glass plate *B* will be held firmly by the black wax on each side.

The vessel itself is now completed, and we turn next to the lead plates *D D*. These are $8\frac{1}{2}$ inches long by 3 inches wide, and cut from lead plate about $\frac{1}{8}$ inch thick. Two holes are punched through each plate about $\frac{3}{8}$ inch from one end, big enough to take the round-headed screws *F*.

The lug at the top is then formed by bending the plate over one inch from the end.

We turn now to the cover *H*. It is made from oak and turned so that the bigger diameter is the same as the outer diameter of the jar, while the smaller diam-



A new electrolytic interrupter.

serious, as this interrupter is often used with voltages exceeding 200.

The rising of the liquid in the inner vessel is due to the different cubic capacity of the two containers, and disappears immediately if we give both containers the same capacity. This has been achieved in the interrupter described here in the following manner.

The glass vessel *A* is divided by a glass plate *B* into two containers of equal capacity. A small hole is drilled through the center of the glass plate *B*, the opening of which can be varied by sliding the pointed end of a glass tube *E* backward or forward. This enables us to vary the rate of interruptions within wide limits.

D are two lead plates which serve as electrodes, and are suspended from the cover *H*.

The glass jar is filled with diluted sulphuric acid, and the interrupter is connected in series with the primary of the spark coil.

through the center of the plate. To do this take a triangular file and, using oil of turpentine as a lubricant, drill the hole by twisting the file. The plate must be carefully supported in the center or the glass will crack. As soon as the point of the file penetrates the glass, start from the other side and continue till you get a smooth round hole of one-quarter inch diameter. If you do not care to do this drilling yourself, and risk the plate, the glazier will do it for you for a nominal sum.

Now we have to fix the glass plate *B* in the vessel *A*.

To do this, clean and dry the glass jar and plate carefully and warm both near a fire till they are about as warm as your hand can bear. Melt some black wax (such as used for sealing accumulators), and inclining the glass jar *A*, pour the wax in a fine stream into the corner between jar and plate. The wax will run down and glue the glass vessel to the plate, as shown at *C*, in the drawing. Repeat this operation at the

eter should fit easily into the jar itself. Those who have no lathe can make the cover by cutting two disks to the diameters required and screwing them together, taking care that both disks are concentric. A slot $1\frac{1}{2}$ inches long by 1 inch wide is now cut through the cover for the adjusting piece *U*. Finish the sides of the slot well off so that *U* can slide easily when in place.

The cover is then immersed in molten paraffin-wax and left to soak for about an hour to make it acid-proof.

Next make the adjusting piece *U*. This is made from oak to the dimensions given, and consists of two parts, denoted by shading. The bottom part is $\frac{1}{4}$ inch thick, and screwed to the main part when in place. This adjusting piece receives a slot *K*, for the adjusting lever *L*, and a pin *G*, $\frac{1}{16}$ inch diameter, is driven through *U* and the slot in *L*, when in place. A hole *P* is drilled into the bottom of *U* to take the glass tube *E*. The adjusting lever *L* is made from brass rod $\frac{5}{16}$

inch diameter, and has a slot at one end to let the pin *G* pass through. At a distance of $1\frac{1}{8}$ inches from this end a hole $\frac{1}{8}$ inch diameter is drilled for the pin *Q*. A short piece of vulcanite tube *M* is slipped over the adjusting lever and glued to it, so as to form a handle. Next we make the bearing *O* and *Q*. *O* is a disk $1\frac{1}{2}$ inches diameter and $1/16$ inch thick, and cut from brass sheet. A hole $3/32$ inch diameter is drilled through the center and three small holes to suit wood-screws *N*, as shown. *Q* is made from brass rod $\frac{1}{8}$ inch diameter to the dimensions given, and one end is filed down to $3/32$ inch diameter, slipped through the hole in *O* and the projecting end riveted over.

We can now assemble the adjusting lever and its bearing. A washer *R*, $3/32$ inch thick, is placed over *Q*, then *L*, and finally *S*, which is a washer $1/16$ inch thick. The projecting end of *Q* is now riveted over, but not so tightly as to prevent its moving with entire freedom.

The last part to be made is the adjusting tube *E*. This is made from a glass tube $\frac{3}{8}$ inch diameter. About 3 inches from one end the tube is bent at right angles and then drawn out in a fine end, as shown. The parallel part is then cut to correct length and glued (with

shellac varnish) into *P*, taking care that the point of *E* is exactly opposite the hole in the glass plate *B*.

We can assemble, now, all the remaining parts, i. e. the lead plates and adjusting gear.

Two binding posts *V* are required, which should be screwed into the cover *H*. *I* is a 10-ampere fuse, which was added for safety's sake, and is screwed to the wooden cover *H*.

We have now to connect the parts as shown in thick chain-and-dot lines. The binding post *V'* is connected to one screw *D'* of the fuse, the other screw is connected to the lead plate. The other binding post *V* is simply connected to the lead plate *B*. It is a good plan to solder the connecting wires to the lead plates, taking care to make a good contact. The bottom side of the cover *H* and the lead plates *D D*, to about $2\frac{1}{2}$ inches from the cover, now get several coats of good black insulating paint, which can be bought from stores catering to the experimenter.

The interrupter is now completed and has to be filled with acid. This is sulphuric acid 1 part, water 10 parts. The acid should always be poured slowly into the water, under constant stirring with a glass rod.

Mix acid and water in a porcelain or earthenware vessel as the liquid heats up during the mixing process, and, after it has cooled down, pour it in the glass jar of the interrupter up to about 3 inches from the top. Pour a thin film of oil (about $\frac{1}{8}$ inch thick) on top of the acid, as this prevents spraying or escape of vapors. Place, now, the cover *H* in position, and the interrupter is ready for service.

By moving the adjusting handle *M* you move the glass tube *E*, and this in turn opens or closes the hole in *B*.

By using a smaller opening you get a higher rate of interruptions, by using a greater opening you get more current, so you can adjust the interrupter to give the maximum effect for the conditions required.

The interrupter is connected in series with the primary of the coil; that means the current flows from the main, through the fuse to the first lead plate, through the liquid to the second lead plate, and from here through the primary of the spark coil back to the main.

The binding posts *V* should be of the insulating type, if possible.

A condenser is not required when using an electrolytic interrupter.

Photographing Colors

EVERY layman has noted that in a photograph blue clothes appear light while red garments show dark. This arises from the fact that most plates are sensitive to blue light, but not to red. Interesting investigations regarding the effects of the primary colors upon different photographic plates are described, says *Die Umschau* of March 4th, in a recent German work entitled "Photography for All," by A. Lassalldy.

For the purpose of his experiments the author employed plates of three different types of sensitivity; the ordinary commercial plate, the orthochromatic plate whose range of color sensitivity includes the yellows as well as the blues, and the panchromatic, which reacts more or less to all colors. In order not to confuse

reproduces rather satisfactorily the general visual effect of the original.

The panchromatic plate (Fig. 4) appears to be but slightly more sensitive to red than the orthochromatic with filter; but it distinguishes rather well between blue, green and red. When used with the yellow filter (Fig. 5) it is more sensitive to red and yellow, and separates the latter distinctively from the blue; but it fails altogether to distinguish between green, blue and black. The substitution of the autochrome filter or the red filter (Figs. 6 and 7) increases the sensitivity to red and yellow; in fact, in the latter case, the plate appears to have been completely light-struck by these parts of the pattern, so that the print shows no trace of these colors. When used with a green filter, how-

aid of the female members of his own family, the Rev. Mr. Brown, about 1829, began offering "string collars" for sale, and soon developed a profitable new branch of his business.

All of the work on these first separate collars was done by hand, for the sewing machine had not yet been invented. The linen was cut on the kitchen table, which was also used for the ironing after the collars were sewed and starched. After the business became established, the cutting was done in the merchant's store, and he bargained with a number of women to take the cut pieces to their homes, and there make, wash, and iron the collars. At this early day the business afforded only occasional employment to only a few women, and each made and laundered not more than a dozen collars



Fig. 1.



Fig. 2.



Fig. 3.

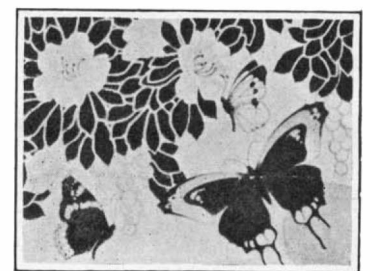


Fig. 4.



Fig. 5.



Fig. 6.



Fig. 7.

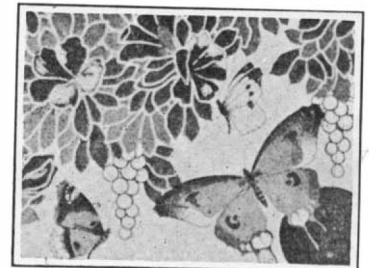


Fig. 8.

the issue with shades and shadows, perspectives, and light striking the plate at various angles, designs printed in colors on a flat surface were selected as the objects of the experiments.

In Fig. 1, reproducing a photograph made on the ordinary commercial plate, it will be observed that the blue tinted leaves and the blue parts of the two larger butterflies are almost as light as the gray background. The rest of the figure is practically uniform in shade, indicating, since these cuts are positives, not negatives, that this type of plate is practically unaffected by colored light except that from the upper end of the spectrum.

Fig. 2 exhibits the workings of the orthochromatic plate. We observe that the yellow berries and the yellow wings of the small butterfly are now distinguishable from the rest of the figure, while the blue is, if anything, even lighter than before. Note that not only here, but in nearly all the cuts, the green leaves are dark, showing that photographic sensitivity does not run continuously along the spectrum, but jumps around.

With the yellow filter (Fig. 3) the orthochromatic plate shows great extension of sensitivity. The yellow is now quite as bright as the gray. The blue is considerably darker than it was; in fact, almost as dark as the green, to which, here, for the first time, the plate appears to have reacted. Even the red of the sun, the flowers, and the borders of the berries, is slightly differentiated from a dead black. On the whole, since the yellow appears brighter than the blue, and this in turn brighter than the green and the red, this apparatus

ever (Fig. 8), this plate gives what would be easily the most satisfactory result of all, were it not for the confusion of red and green.

The results of these experiments afford a guide for one desiring to photograph a scene in which color plays a prominent part. For example, if the subject were an interior decorated in blue and yellow, it would be desirable to distinguish between these, without making either too dark. This could be done by the methods of Figs. 2, 3, 8, or possibly 6. If greens also entered, it would probably be desirable for them to print dark; so the method of Fig. 3 might be rejected. And similar considerations would indicate the most advantageous plate and filter for any combination of simple colors.

History of the Collar

SEPARATE collars for men's shirts are said to have been first made about 1825 by the wife of a blacksmith in Troy, N. Y. This woman did the family washing and ironing, and realized that shirts with separate collars would not have to be washed as often as did shirts with collars attached. She applied her idea not only by making separate collars for her husband's shirts, but by making them also for sale.

This innovation attracted the attention of the Rev. Ebenezer Brown, a retired Methodist minister, who kept a small drygoods store in Troy. Enlisting the

¹The City of Troy and its Vicinity: By Arthur James Walse. Troy, 1886.

a day, for which she received 3 shillings worth of store goods, the value of what was commonly called a shilling being $12\frac{1}{2}$ cents.

Except the bands, the first separate collars were generally all linen and of two thicknesses, although some were faced with cotton cloth. They were slightly stiffened, had high points extending above the chin on either side, and were tied around the neck with a string of tape attached to each end of the collar, hence the name "string collars." The collar was supported by a stock made of bombazine or satin, stiffened with hair-cloth, and this also was tied around the neck. The collars in assorted sizes were placed in paper boxes 16 or more inches in length, and sold at 25 cents each or \$2 a dozen.

False or detached shirt bosoms, made of linen, and often called dickeys or shams, were then worn. They were frilled, plaited, or plain, and were held in place by strings that went around the waist and neck.

The sewing machine was introduced into the collar industry in 1852—after some hesitation by the collar makers, according to Weise. Steam power was first used in 1855.²

Electric cutting machines were introduced in shirt and collar factories about 1870, buttonholing machines about 1880, and button-sewing machines about ten years later.—*Miscellaneous Series, No. 36, of the Department of Commerce.*

²*Ibid.*, pp. 75 and 271. See also Twelfth Census of the United States, Census Bulletin No. 188, June 12th, 1902, Collars and Cuffs, by Arthur L. Hunt.

Indian Hand-Painted Calicoes*

Their History, the Complicated Methods of Production, and Influence on Modern Methods

By George Percival Baker

FOR many years past I have been an eager collector of early Oriental fabrics. At first I found the designs a source of much inspiration in the development of my own work; then followed the spirit of investigation as to their origin and the method of their production, and in this work I appear to have struck, as it were, a field somewhat neglected by my contemporaries; for although some few writers and chemists have contributed articles on the processes adopted by the Hindus, they have not dealt with examples of the goods produced by the very complicated and laborious methods employed by the natives of India. It is only by such study one can appreciate how much the print industry of the world is indebted to India.

Some of these hand-painted calicoes are still to be found in the art and technical museums of Europe, and there are more in the private collections of professional designers. From inquiries I have made in India amongst art museums, it appears that no good specimens have been preserved in that country.

My first task will be to deal with the historical side of printing. I find that it is generally agreed, amongst those who have studied the history of printing, that the art of impressing and imparting a design upon cotton or linen in colors which will withstand washing, originated in India, and that whatever science there may have been in the art, when Europe was so largely supplied with the painted and printed fabrics of India in the seventeenth and eighteenth centuries, the chemical processes adopted by the Hindus at that period were the same in principle as those described by the elder Pliny, who wrote A.D. 70. Pliny's writings are the bedrock from which all research of this nature begins.

He says, in referring to Egypt (Lib. xxxv. chap. 11): "Garments are painted in Egypt in a wonderful manner, the white cloth being first stained in various places, not with dyestuffs, but with drugs, which have the property of absorbing colors. These applications do not appear on the cloth; but when the cloths are afterwards plunged into a cauldron containing the dye liquor they are withdrawn fully dyed. It is wonderful that, although there be only one dye in the cauldron, the cloth is dyed of several colors, according to the different properties of the drugs which have been applied to different parts; nor can the colors be afterwards removed. A cauldron which would of itself only confuse the colors on cloth previously dyed, in this way imparts several colors from a single dyestuff, painting (or dyeing) as it boils." From this passage it is evident that the drugs employed to stain the cloths were different mordants, and that some knowledge of calico printing or dyeing was known by the Egyptians, acquired no doubt from Hindustan.

I shall now, at this stage, pass over 15 centuries and deal with my subject from about the time when the several rival East India companies were instrumental in making known to Europe, among our goods, these printed and painted cottons. The first in the field were the Portuguese, they having reached the East Indies by way of the Cape in 1498. This route transferred to them much of the trade then in the hands of the Venetians and Genoese, by way of the old trade route through the Persian Gulf to Bussorah, Bagdad, and Aleppo, from whence, *via* Alexandretta and Beyrout, the merchandise found its way to Venice and other parts of Europe. At that time Bruges was the distributing center over Northern Europe, afterwards Antwerp, and later on, after the destruction of that city by the Spaniards in 1576-85, Amsterdam became the center. For nearly a century the Portuguese held undisturbed supremacy of the Indian trade *via* the Cape. The early Dutch trade with India was indirect, and came through their connection with the Portuguese, who had, as I have said, diverted the Eastern trade direct to Lisbon by water. By an interdict in 1580, issued by Philip II. of Spain, the merchants of Amsterdam were precluded from trading with Lisbon. The energies of the Dutch were, in consequence, devoted to more direct intercourse with India. Merchant adventurers making successive journeys to the Indies eventually amalgamated in 1602 into one corporation, under the title of the Dutch East India Company.

In 1587, among the ships seized by Drake when the Spaniards were about to invade England, was the "St. Phillip," a Portuguese carrack coming from the East Indies. The papers of this vessel afforded much information as to the value of the Indian trade. In 1592

another carrack, the "Madre de Dios," was captured by some English privateers, who brought her to Dartmouth; and it is mentioned that among her cargo were calicoes, lawns, quilts, carpets, and other rich commodities. It was the capture of these vessels that determined the English to establish direct communication with India, and led to the memorial of the promoters of the London East India Company to Queen Elizabeth in 1599, to be followed in 1600 by the granting of its Charter. The French do not appear to have been in the field quite so early, and it was not till 1664 that Colbert, the Controller of Finances, induced his Sovereign, Louis XIV., to grant the Charter to the French East India Company.

Coming now to the references made by travelers and merchants on the subject of the prints under review, I find that in 1498 Odoardo Barbosa, one of the Portuguese adventurers who visited India immediately after the discovery of the Cape route, refers "to the great quantity of cotton cloth admirably 'pintadoe'" (painted—the word was later adopted as a trade phrase by the factors and officers of the Dutch and English East India Companies).

In 1563 Cesar Frederick, who traveled to India *via* Bussorah, described the "extensive trade carried on between St. Thomay and Malacca in fine bombast cloth (cotton) of every sort, painted, which is a rare thing, because these kind of cloths show as they were gilded with divers colors, and the more they are washed the livelier the colors will show."

In 1657 Boullaye-le-Gouz writes: "Hitherto it is not known how the natives apply so successfully the colors to the 'foyes' and *toiles peintes* in such a way that they lose nothing in the washing. I showed some in France to several dyers who were filled with admiration at them, assuring me that the dyes in India are pure and quite simple, whereas those of Europe are sophisticated (*alterées*)."

In 1693 Dr. Havart, M.D., a Dutch botanist, in a work entitled the "Rise and Fall of Coromandel," writes with much detail on indigo dyeing, and in the same work makes meagre reference to "the chintsen, which are painted at Palicol, after designs which are given to the painters, which they imitate very well, for the natives are so stupid that they are unable to produce anything original; but they can imitate and produce a perfect copy; but one chintsen is not always as good as another, although both may have been painted by the same hand . . ." In another passage he says: "They have at this place four kinds of painters, who have each his special duty, connected with the painting establishment, among whom the work is shared; they in their turn sublet the work to their subordinates, who actually do the work. These latter are mostly people without means, so that, in order to pay their debts and yearly poll-tax, they are obliged to work very laboriously or else they would be reduced to beggary. For this reason more chintzes are produced in Palicol than in the south. The painting of chintzes proceeds in the most leisurely manner in the world, in a manner similar to the crawling of snails, which appear to make no headway. Anyone who would represent patience, and had no other model, could use one of the chintz painters of Palicol."

The writer in another place has a few lines describing the painting process, but it is so vague and incomplete that I forbear to quote it.

In 1777 Abbé Raynal, who is the author of a work entitled "Histoire Philosophique et Politique," says among other things: "Quite a colony of Europeans of various nationalities are located at Masulipatan. They are engaged in the export cotton goods. They also buy the painted cottons, which, however, European printers have not the enterprise to copy."

"It will be an abuse of the reader's patience to trace the slow processes used by the natives of India in the art of painting these cloths. They say they are due more to the antiquity of the art than to the fertility of their genius. There is one thing apparent in this conjecture, and it is that they have not advanced a single step in the art for many ages."

I propose at this stage to introduce the most important information we possess of a technical nature on the methods adopted by the natives. This is to be found in certain letters written by a Jesuit missionary at Pondicherry, Father Cœurdoux, to another Jesuit father resident in Europe. They appear in "Lettres Edifiantes et Curieuses," and are dated 1742. Briefly, they are as follows:

"Take a length of half-bleached cloth and immerse it in a bath of buffalo milk to which is added the dry fruit

of a myrabolan, called kadou, reduced to a fine powder. When the cloth is thoroughly steeped, withdraw, wring and put it to dry in the sun. The next day lightly wash in plain water, dry in the sun, and afterwards leave in the shade. This internal preparation is followed by an external one, having for its object the smoothing of the cloth, so that no obstruction is offered to the brush when they come to paint. This operation is to fold the cloth into quarters or sixths and then beat it with a smooth piece of fine grained circular wood, about the thickness of one's arm, upon another similar piece. This operation we know as beetling, and imparts to the cloth the smooth surface so necessary in the operation of penciling or painting. The pleats are reversed and the operation repeated. Two men, seated opposite each other, beat the cloth as they think fit until appearance and experience lead them to know that it is sufficiently polished and smooth.

"The painter or artist, having prepared his design upon paper, next has to transfer it on to the cloth. He begins by pricking the main outlines of the design with a fine needle, then lays his paper on the cloth, and passes over it a pad containing charcoal powder, which, penetrating through the pricked holes, by this means transfers the main features of the design on to the cloth.

"This black is the first color to deal with, and for this purpose I should describe its preparation. They collect a heap of iron filings and dross, which they subject to the heat of a fire made of banana leaves—which they prefer to any other fuel, presumably on account of their reducing action—to reduce any oxide present. When cool, the filings are placed in a vessel and hot rice-water liquor is poured over them—it is probable that this rice had been boiled some time previously and allowed to ferment and become acid. The solution is then exposed to sunlight, and later the liquor thrown away, and the vessel containing the iron is refilled with sour cocoanut-tree wine. The solution thus obtained is acetate of iron. The preparation is again subjected to exposure in the sun for several days, and is then ready for use in the form of an iron liquor, care being taken not to give an excess of iron, which has destroying properties. A good black is formed with the tannin or astringent of the kadou, already applied with the buffalo milk.

"Having penciled in the design over the charcoal tracing with the iron liquor, wherever needed for black, the next stage is to subject the cloth to boiling water, to which some of the astringent kadou is now added in order to form a good deep black. The next step is to prepare the cloth to receive the blue, and for this purpose it is required to be freed from the astringent already applied, by inserting the cloth in a maceration of goat's or sheep's dung, well washing and drying in the sun; failure to do this would cause the blue when dyed to become black. Furthermore, the cloth at the beginning was half bleached, and the properties of the dunging are to help to whiten the cloth. The beating process already explained is repeated very profusely. The blue is not painted on, with a brush, but a wax resist is painted over the whole cloth, except only in the places appropriated to blues and greens. Liquid wax is put on with an iron pencil, and when done the cloth is exposed to the sun and care taken that the wax penetrates to the other side of the cloth. The cloth is then sent to the indigo dyer to be dipped. When dyed the wax must be thoroughly removed by boiling the cloth in water, and when cool the wax which floats on the surface is skimmed off with spoons. Then follows dunging, hot-water washing with a sort of impure soda, or fuller's-earth, renewed steeping in dung, and beating about 400 times on a stone. The cloth is then strongly wrung out, and left for 24 hours in a maceration of cow's dung, to be followed by the usual washing and boiling process. In this way it is rendered ready to receive the kadou and buffalo milk treatment as given in the first instance. The cloth is again beetled by beating, and in this way is gradually being prepared for the next dyeing operation—that of red. Then it is that wax is penciled in, as a resist, on all such places where fine tracery of white appears over reds and pinks and lilacs. The cloth is now ready to receive the red, pink and lilac mordants, and this is done by applying Pliny's method of painting or penciling in the various mordants, and afterwards dyeing the whole cloth in a red liquor bath. In this case the mordants employed, as described by the Jesuit father, were drugs composed of alum and certain kinds of hard water, obtained in Pondicherry, to

* From the *Journal of the Royal Society of Art.*

which would be added japan wood, just enough to stain the emulsion when painting, as alum alone is invisible. The places on the cloth for reds would require to be painted with a stronger emulsion of alum than the places for pinks; while the violets would require to be painted with a mixture of alum and iron liquor, composed of the iron rust and the sour rice-water.

"The 3 varied mordants having been applied, the next step is to subject the cloth to a severe washing in water (which I conclude had alkaline properties, because he remarks this is the principal thing in sight, having for its object, so far as I can judge, the fixation of the alumina and iron). Then beat on a stone in order to remove certain of the greasiness occasioned by the buffalo milk, and to prepare it to more evenly imbibe the red dye liquor, which now forms the next operation. This bath is made up of tepid water with the roots of a plant called chay (*Oldenlandia umbellata*), reduced to a powder which has been treated with bitter water, and while the cloth now inserted is in the dye liquor it is brought to the boil; then it is taken out in order that the dyer may remove any stains or splashes or red which may be developing in their wrong places, owing to the carelessness of the painters when applying the mordants; for this purpose they use lemon juice. When this operation is done they return the cloth to the dye bath, increase the boiling, completing the operation by a gradual cooling down. After this the cloth is subjected to the same severe treatment of washing in various baths of dung and soap, exposed to the sun and watered occasionally until the whites are a good bleach, and the stain from the reds removed from such parts where it is not required.

"Yellow has next to be applied, and this is made up with a solution comprised of alum, myrabolan and the rind of pomegranate, which is painted or penciled over places where yellow is required, and also where the blue already dyed is to be turned into green. The yellow you will observe, is directly applied, and in consequence is the weakest of all their colors."

Before concluding, a word must be said as to the Indian pencils. They are nothing more than a small piece of bamboo, sharpened and split at the end for a distance of a finger-point.

These letters from Father Cœurdoux exhibit remarkable patience; he seems to have followed every process communicated to him by the natives with infinite detail. In concluding his letter he says: "What I have to tell you, my Rev. Father, has been acquired from various neophytes skillful in this sort of work with whom I have conversed since baptism. I have questioned them frequently and separately, and their replies I now send you."

A certain M. Poivre reviewed these letters, and, writing to Father Cœurdoux, says: "Amateurs in the art, not calico printers, but amateurs or beginners, should willingly acknowledge these new discoveries, which you have been able to furnish them with"—and then, asking for further information, he suggests that: "If you could possibly divest yourself for a short period of your apostolic zeal, you would render a real service to our *curieux* in Europe." He concludes his letter by saying that "it is surprising that no Europeans have striven to enrich their country on the subject of an art from which much advantage would accrue, and that it should be the desire of our travelers, in quitting their country, not to be forgetful that there are no people who are not in possession of some particular art, the knowledge of which would be useful to Europe, etc., etc. Up to the present, you, Rev. Father, and those who work among the Chinese missions, are the only travelers who have given an example of work so useful. The pains they have taken to discover the methods of the Chinese workers of porcelain, the cultivation of the mulberry and the nurture of the silkworm, have merited the thanks of all their countrymen, whom they have so well served. Why is so brilliant an example so little followed?"

Although I have been unable to find that these communications were made public till nearly twenty years after they were written, we may with safety conclude that certain printers had the benefit of the information imparted by the Jesuit missionary.

Although the letters I have quoted from Father Cœurdoux were rendered somewhat incomplete, either by reason of the Hindus not understanding the principle underlying the success of the operation of dyeing the reds or else the difficulty the Jesuit father would have in interpreting their description of the processes, the general operations were undoubtedly of great service to the calico printers of Europe, as is evinced from the many text-books on the industry published between the years 1760 and 1800. Furthermore, the general operations formed the key to the process of madder printing, and, as madder was known in Europe at this period, this was the dye root used by European printers and dyers in the place of the Hindus' chay root.

Thus it will be seen how important a part does chem-

istry play in the production of these Indian painted cottons, and one might well ask, how came the natives of India to possess the knowledge of the art? Were the secrets handed down to them from father to son, through those 20 centuries of civilization which are credited to them? Or was the art originally acquired by "some lucky chance, or from a slight and contemptible beginning," or have they "by long experience and curious observations and various improvements, matured and brought the art to perfection"?

Whatever the beginning, certain it is that the art since evolved step by step in the manner recorded by the observant Jesuit father no longer exists; in fact, the Hindu dyer and printer to-day is entirely dependent on synthetic dyestuffs.

From the communications I have quoted, no less than 26 separate operations at least were needed to complete a chintz cloth, employing in its production a complement of such colors as black, red, pink, blue, green, puce and yellow, and this whatever size the piece of cloth.

The special feature in their production which must be emphasized is the fact that they were produced by the method technically known among textile printers as madder printing, and although the process was a long operation, the colors employed were few, and no modern method of printing in direct colors can produce them, so far as I am able to judge, so fine, so solid, and so beautiful.

It will now be my purpose to trace the influence of the Indian methods of calico painting on the print industry of Europe at the period under review, and in dealing with the word "painting" I should include printing as well, for although I have no specimen of these printed goods, we may safely conclude that the early cotton prints of two or three colors, particularly of small repeats in the design, which came to Europe through the agencies of the various East India Companies, were produced by block printing. Furthermore, it should be noted that in the Middle Ages the industry was well established throughout Asia Minor, where it is said to have been introduced from India by Armenians and Greeks. This I consider very probable, because Asia Minor offered every opportunity for a calico print country; it possesses its own cotton, alum, madder, yellow berries, pomegranates, galls, and other dyes. Furthermore, the Armenians were among the more important traders of the foreign communities in Madras, Calicut, Masulipatam, Guzerat, Ormuz, and other places. In the literature of the Levant, in the Middle Ages, and also among the records of the Dutch and English East India Companies, one is constantly coming across these traders, the following being a typical case taken from Mr. Foster's work on the English factories in India. Henry Barnford records an account of his journey from Agra to Tatta Mar, 1639: "Agra is little frequented unless by Armenian and Persian merchants, the commodity that took them there being only chintz, which are here made in good quantities, well colored, in appearance little inferior to those of Masulipatam, all of which commodities are by the Persians and Armenians transported to Spahan, and other parts thereabouts by the way of Candahar."

In like manner the Greeks introduced into Europe the Turkey-red process of dyeing, brought originally from India, and in this way we may readily understand the possibility of the art of printing filtering through Asia Minor westward into Europe, through the medium of the Armenians and Greeks. The opening up of the East Indies round the Cape in 1498 would introduce a number of new dye products, and with them came also information as to their methods of use, which we may surmise were treated as trade secrets and not published to the world—in fact, there are indications in the communications from the Jesuit father that such was the case. We may also believe that among the first to communicate the processes would be the Dutch, for I find that among the earliest text-books are those of Holland.

As to England, I find that in 1619 a special privilege was granted to George Wood for 21 years, who has found "a waie to printe upon lynnne cloth." This process I regard as printing in oil or pigment color for wall decoration, and my reason is that there is evidence that the earlier printings in England, Germany and France were such.

There are also the following letters patent—in 1624, to William Shipman, "sowing, selling and planting of the herabe, roote and plant called madder."

1676, Will Sherwin, "new and speedy way for printing broad cloth, being the only true way of East India printing and stayneing such kind of goods."

1715, Peter Dubison, "printing, dyeing, or staining of calicoes in grain," which "shall equal if not exceed in beauty and use those stained in the Indies."

I think we may take 1676, which was the date of the patent to William Sherwin, as about the time to fix the date when the art of printing was introduced into England. Sir Josiah Child, a director of the E. I. C., in a

pamphlet published in 1677, mentions that goods then coming over from India were for the purpose of being printed upon in imitation of Indian chintzes.

More direct evidence gives 1690 as the date of the first printing factory established in England, at West Sheen, now known as the Old Deer Park, Richmond, and about 150 feet from the Thames. It is said to have been started by a Frenchman who came over from Holland, where he had taken refuge after the revocation of the edict of Nantes in 1685. A large number of persons were employed at this establishment, both male and female. It is recorded that they were "a saucy and independent lot," and that Richmond was overrun by the calico printers.

Very soon after the Richmond establishment, we find a considerable printing works being carried on at Bromley Hall, on the Lee in Essex, followed by many others on the outlying streams around London.

Wherever there is good water and an abbey, there would also be found the whitster or bleacher, to be followed by the calico printer.

I find records of printers at Waltham Abbey, Merton Abbey, Mitcham, Wandsworth, Isleworth, Lewisham and Crayford.

The new industry of calico printing was just growing in importance, and had "taken on"; the chintzes produced by our people were for the home trade as well as for export. The industry was encouraged furthermore by the prohibition in 1700, by Act of Parliament, of the importation of the real article from India. This Act of William III. was intended to protect the English woollen and silk manufacturers from the competition of Indian goods. The weavers had all along manifested the greatest hostility to the use of printed calicoes from the East. In the year 1680 they mobbed the India House, in revenge for some large importations then made of the chintzes of Malabar. In spite of the prohibition and the excessive penalties of £200 imposed on smuggling, the imported goods found their way into the country. Fashion had to be gratified, and the greater the restrictions the more determined were the ladies to have their own way.

The Act of 1700 did not preclude the plain cloths of India from being admitted into the country, under a duty; to which was imposed, in 1702, an excise tax of 3d. per square yard on all home-made printed calicoes, afterwards increased in 1714 to 6d. per yard. In spite of all these taxes our people had become accustomed to the use of printed calicoes; they were cleaner, offered a greater choice for the women of this country, they made dainty garments, and it is natural that the prevailing kerseys, serges and camlets, which formed the staple goods of the country, would suffer.

A new alarm was raised among the manufacturers, with the result that the legislators of that day, intimidated as would appear by the East London mobs, enacted in 1720 an absurd and summary law prohibiting the wearing of all printed calicoes whatsoever, either of foreign or domestic origin. The enactment proved a terrible blow to the rising industry in that it confined the operations of the printers to the printing of linens and cloths with a linen warp and cotton weft.

The business continued to flourish though in a lesser degree, and was carried on almost exclusively in the suburbs of London, till after the middle of the eighteenth century, when a greater commercial revolution was in progress—that of Arkwright's spinning Jenny, and Watt's improvement of the steam engine. Gradually it had the effect of driving the industry to the North, to cheaper fuel centers, where, in conjunction with cotton-spinning and weaving, that new and brilliant era of machinery was in store for this country, which in time gave greater scope to the activities of the rising generation of calico printers.

About the period of 1714 to 1760 our printers had reached a degree of such excellency as to merit the praises of Jean Rhymer of Bale. He wrote a very valuable record of the earliest days of calico printing in Bale, and bought Indian goods in Holland and England, to be afterwards printed by himself in his own country and by others in Holland. He was of all men eminently qualified to judge, and his testimony I regard as most interesting, as it helps to place this country in the foremost position as printers at about the time he wrote. Among other things he says: "It was only at Neuchatel that the printers sought to combine glory with profit, and to make goods imitating the English and Indian prints. Now the English had closely followed the Dutch in printing, and soon surpassed their teachers in excellency." In another passage he says: "It was reserved for the English to attempt an imitation of the best Indian work in prints, and to arrive at a degree of perfection which no one would have thought possible. All the world knows this people, whose industry and plodding patience in overcoming every kind of difficulty exceeds all imagination. This nation cannot flatter itself with having made many discoveries, but it may glory in having perfected all that has been invented by

others. Whence the saying to have a perfect thing it must be invented in France and worked out in England."

Turning to France, the influence of these Indian goods, to which must be added the gradual creation of a new industry, led to chaos and much disaster in the history of that country. At that period, viz., at the middle of the seventeenth century, textile printing was not known in France. I gather from certain writers that some such industry existed in the Middle Ages, but as I am by no means satisfied as to the style of work it may have been, I will refrain from offering an opinion. Whatever the process, it is evident it was very limited in palette of colors, and that little by little the industry sank into oblivion. The real article from India appears to have revived the ancient industry, and many works and small *ateliers*, I read, were installed throughout the country, encouraged by Colbert, the Minister of Finance. The production in the early stages of the revival in no way resembled the real article, though they bore the name of Indienne. They were in the most part, so far as I can gather, printings by block and paintings by hand on various fabrics in pigment colors, just as one would print in these days upon wall-papers.

It is very clear that whereas our printers in the early days of the industry, 1690 to 1720, were printing on the lines of Indian methods, the French had not yet acquired any of those processes known as the madder style. It is the more remarkable, and makes it difficult for me to comprehend, how such faked goods, plus the importations of the real goods direct from India, and also through the intermediary of the English and Dutch Companies, could possibly upset the equilibrium of France's national industries. That they did is certain, and to such an extent that one writer, Edgard Depitre, says, in the preface of his work entitled "La Toile Peinte en France au dix-septième et dix-huitième siècles":

"So much was written in the seventeenth and eighteenth centuries on the subject of *toiles peintes* as on the subject of cereals, that it occupied the central authorities, and inflamed the people; for three-quarters of a century it remained established a burning problem and created lively discussions; it was the object of two edicts, and some 80 decrees in council; at one time it became a state question; it divided France into 2 camps, gave birth to an abundance of literature, provoked passionate controversy, in which the best-known economists of those days took sides. It was, in fact, a question, *furieusement historique*."

The question is interesting and requires that I should review the situation. Already in 1664, when the F. E. I. C. was founded, instigated as I have said by the Minister Colbert, the real goods were well established on the market. The French, we must understand, were in those days, as we know them in our time, the leaders of fashion, and the effect of these Indian goods having become not only universally fashionable, but also a necessity for purposes of decoration, the national industries of France suffered in consequence, in proportion to their export as well as to their home trade.

In 1683 the return cargoes of the F. E. I. C. comprised mostly *toiles peintes* and plain cottons, and produced £1,500,000, the company gaining 300 per cent. From 1675 to 1684 8 vessels returning to France with cargoes costing £1,870,000, realized in France £4,370,000; these *toiles peintes* being the most profitable of the company's imports. Already the silk and wool weaving industries had been provoked to great hostility, and now the article of another country (which in no way was reciprocal in its trading) had usurped, as it seemed to the French, their prerogative of supplying goods of fashion, and robbed the country of an export trade which had hitherto added to the national wealth of the country; furthermore, the importation of the Indian goods through the English and Dutch East Indies Companies aggravated the grievances. Drastic measures had to be taken to curb the increasing discontent of the manufacturers. For a long time past religious persecutions had precluded many skilled Protestant workmen from pursuing their regular vocations. It would appear that, in consequence, they occupied themselves in this new industry of printing Indiennes, which I have no doubt was not included in the barred occupations.

But a more severe blow was struck at the industry when, in 1685, the Edict of Nantes was revoked, since this industry, like so many other industries, was in the hands of the Protestants.

Notwithstanding the large exodus of workmen created by this enactment, it failed to improve the situation and when at this period, on the arrival of a vessel at Rouen laden with large quantities of *toiles peintes*, the sale of home-made serges suddenly ceased, and other measures had to be devised, and so a double decree was passed prohibiting the importation of all real Indian printed and painted goods, and also the production of all home-made prints, whether for wearing apparel or for decorative purposes. The decree further enacted that all printers were to cease work; printing blocks

and all apparatus connected with the industry were to be destroyed. It also prohibited, under severe penalties, the wearing of chintzes.

The "Indiennes," as forbidden fruit, became the passion of the better class of women. They openly defied the law by establishing clandestine depots for the sale of these goods at Versailles and at Fontainebleau to serve the Court. The wives of Ministers who were expected to carry out the edicts were the first to break the law and wear the *toiles peintes*. Madame Pompadour, the Court favorite, furnished a chateau at Belleville with the contraband goods. The war lasted 73 years, and much property was destroyed and dire punishment enacted; but fashion in the end was the winner.

During all these years of inertia as calico printers, France had been slowly coming to the front as wool printers; and later, when the government realized the uselessness of the struggle and decided in 1759 to annul the prohibitions, she was ready to take her place among the foremost calico printers of Europe, basing her work on the processes of the Hindus, and reproducing the designs of Persia and India. Very soon a hundred works were to be counted throughout the country, the best known and the one whose name was printed on the *toiles peintes* being that of Oberkampf at Jouy.

In Germany, in the seventeenth century, such printing as existed in that country was by block with pigment colors mixed with oil; gold and silver were also used. They printed on linens and pile fabrics for decorative purposes. The type of designs seems to have been Gothic and Byzantine. Owing to the strongly established German weaving industry, there does not at this time appear to have been a call for prints for wearing apparel. Toward the end of the seventeenth century English and Dutch prints began to be imported, and they threatened to swamp the German productions. About 1690 Neuhöfer, a printer of Augsburg, seeing that his styles were being pushed aside, went to England and Holland to learn how printing was done in those countries. He came back, and after a certain amount of initial difficulty and opposition from the dyers, he made a success of these new methods and built up a large industry. The dyers opposed him when they saw that dyeing (madder dyeing) was part of his process; they said that he was infringing on their privileges. After him a great number of other concerns got to work on this, to them, new process of printing fast and washable colors. In 1750 Schüle, the most important of the Augsburg printers, was printing on cotton all manner of madder reds, browns and violets, on white and colored grounds, and he imported large quantities of cotton piece-goods from the East Indies *via* Holland for printing on. This incurred trouble from the local weavers' union, which brought legal proceedings against him.

I must now close my story. The subject covers a wide field with most interesting matter, which cannot be told in the short time at my disposal. I must, however, express a hope that some native student of India, preferably one interested in dyeing and conversant with the literature of his country, will make an investigation of this subject and place upon record full descriptions of how the natives of India came to acquire the methods recorded by the Jesuit father.

A Possible Substitute for Jute

JUTE is the most widely used material in the world for making the sacks for packing cotton, sugar, coffee, grain, wool, etc., and most of it comes from India, which is said to export over a billion yards of jute cloth each year and over a third of a billion bags made of the material. Besides this India also exports a billion and three-quarters pounds of jute yarn, not to speak of the raw jute for manufacture elsewhere. So far there has apparently been little effort made to find a substitute for jute, as its cost has been regarded as fairly satisfactory. Since the commencement of the war, however, the price of jute has gone up, and consequently substitutes are being sought, with the result that it has been found that Cuba has a plant of considerable promise. This is known as "Malva," heretofore considered as a weed, that grows wild in many parts of the island. There are eleven species of this plant known in Cuba, but the one that is considered the best suited for the production of textile fibers is known as "malva blanca," and it has of late been cultivated to some extent. Malva sometimes grows to a height of twenty feet, but averages from six to ten feet in height, with a stalk ranging from half an inch in diameter to three times that size. The fiber is contained in the bark, that of the young plant containing a single layer, while older plants may contain as many as eight layers. This fiber is equal in strength to the Indian jute, but much finer, and more resembling flax, and it is therefore believed it will be found useful for rope making as well as for bag fabric.

Increasing the Yield of Toluol

IN the *Journal of Gas Lighting* (English), Mr. G. Stevenson gives the result of experiments for increasing the yield of benzene and toluene at the Long Eaton Gas Works. With coal alone, 1,563 pounds of benzene and 0.941 pound of toluene was obtained. When 5 per cent of limestone was mixed with the coal the amounts were increased to 2,941 pounds of benzene and 1.409 pounds of toluene.

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