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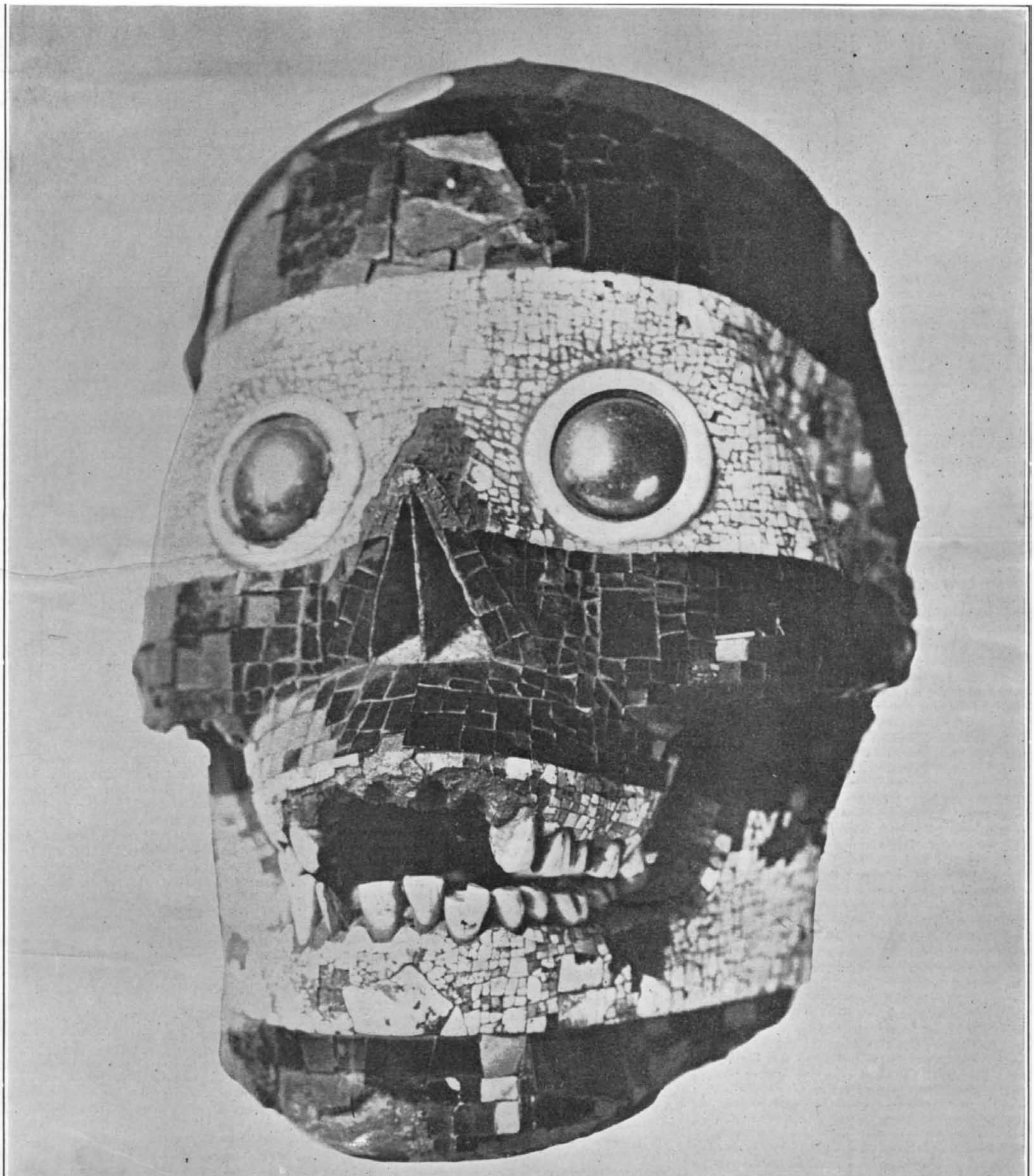

Aztec Ceremonial Mask, consisting of a human skull inlaid with turquoise, jet, pyrites and shell, representing the god Tezcatlipoca. The back is cut away to permit its use over the face of the wearer. The front is covered with five transverse bands of settings, alternately of jet and turquoise, symbolizing some exceptionally important deity. This mask was probably intended to be fitted over the face of an important idol, or the priestly representative of some deity on great ceremonial occasions. The original is in the British Museum.

THE TURQUOISE.—[See page 344.]

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Radiations From Atoms and Electrons—IV*

A Study of the Character of the Mechanism Within the Atom

By Sir J. J. Thomson

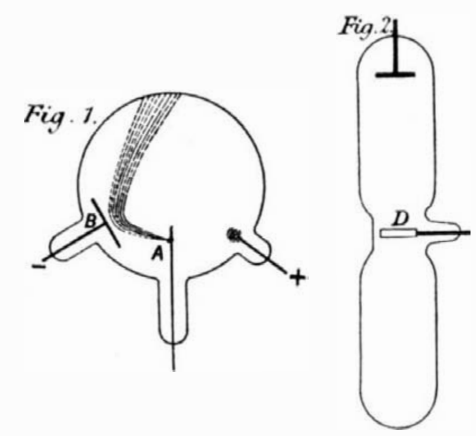
Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2107, Page 323, May 20, 1916

IN opening his fourth lecture on the above subject, Professor Thomson said that he wished to consider on that occasion a very important point in connection with radiation from luminous bodies, which, perhaps, might be illustrated best by taking a definite case. Suppose an atom or a molecule of a gas to be exposed to agencies of violence sufficient to make it luminous. The point in question was, would any disturbance whatever, if of the appropriate type, produce some luminosity, or must the intensity of the disturbance exceed a limiting value before any light at all was given out? This matter was very much to the front nowadays in connection with the quantum theory, according to which the energy in the light of any wave-length was made up of definite units. It should therefore be as impossible to excite this light with a supply of energy equal to less than one of these units as it would be to obtain a mass of any element less than one atom in amount. Two views, in short, were possible as to the manner in which luminosity was produced. It might, in the first place, be supposed that the vibrator, responsible for the emission, had the characteristics of a violin string, which the least disturbance would cause to give forth some sound; on the other hand, the vibrator might resemble a bell with a heavy pendulum or clapper, in which case no sound was emitted unless the disturbance received was enough to make the clapper strike the side. If the first analogy held, the light-giving particle would respond to the smallest possible disturbances; but if the second assumption were the correct one, there would be no light emission unless the disturbance received exceeded some definite limiting value.

Indications as to which of these classes the atoms of luminous bodies belonged were first obtained from the comparative study of flame spectra, arc spectra, and spark spectra. In the flame spectrum of a given element certain lines could be observed, but others were absent. In the arc spectrum further lines appeared; while in the spark spectrum we got lines which were present neither in the flame nor in the arc spectrum. This observation suggested that certain lines required, to bring them out, the supply of a definite amount of energy, or at any rate of a disturbance of a definite amount. Some lines were not to be seen in the flame, and others not even in the arc, so that it looked as if the missing lines came in only when the violence of the disturbance responsible was in excess of a certain definite value.

The conditions in which flame, arc, and spark spectra were developed were, however, not suitable for giving a perfectly definite answer to the problem set. Flames, for example, were gases, and owing to the law by which the molecular velocities were distributed, almost every intensity of energy was represented in them. A certain small proportion of these molecules were, in fact, endowed with very large amount of energy. Matters were still less definite in the case of arc and spark spectra. The observations quoted gave, therefore, no very decisive response to the question at issue.

During the last few years, however, experiments had been made in conditions very much more precise, and physicists had in consequence been brought to the conclusion that in some cases, at any rate, a definite and determinate amount of energy was necessary for the production of light. Within these last few years spectra of the simplest possible type had been discovered, each consisting of only one line. The condition in which the light emission was restricted to this had first been realized by Franck and Hertz. In the method used by them the luminosity was not excited by temperature, as in flames, or by a discharge, as in the case of the arc and spark, but the vapor studied was bombarded by cathode rays. These rays were produced in a definite field of force, so that all had the same speed, and this speed was, moreover, determinate. The rays were derived from a Wehnelt cathode, which consisted of a piece of platinum foil maintained at a red heat, and carrying at one point a speck of oxide of barium. In such conditions this oxide liberated negative particles in enormous quantity, and these particles could be given any velocity desired, by establishing an appropriate potential difference between the platinum foil and the corresponding anode. He could not repeat this experiment in the lecture-room in its original form, but by the modification of the apparatus represented diagrammatically in Fig. 1 he was able to show that the color of the light excited by the bombardment varied with the speed of the rays.



The speck of barium oxide on the platinum strip was represented by *A*. The particles were shot out from *A*, all with the same velocity. An inclined plate *B* was placed in the path of the rays. So long as this plate was uncharged the negative particles emitted from *A* proceeded in straight lines and with uniform velocity. As these particles passed through the gas they knocked against the molecules and made them luminous, and the character of the spectrum thus produced could be determined in the usual way. By charging the plate *B* negatively the particles were repelled. As a consequence they were slowed down and their paths bent round into parabolas, as indicated. At the points of nearest approach of its path to the plate the particle would accordingly be moving less rapdly than elsewhere, and the color of the light excited in this neighborhood was reddish, while where the speed was high it was blue. This experiment therefore showed that the color of the light emitted depended on the speed of the negative particles by which it was excited.

The apparatus used by Franck and Hertz was, he proceeded, essentially the same as the foregoing, but with the plate *B* omitted, so that the speed of the particles depended solely on the potential of the platinum foil, and was constant throughout the apparatus. They filled their apparatus with vapor of mercury, and observed the appearance of the spectrum as the potential of the platinum strip was step by step increased. They found that so long as the effective potential difference was less than some 5 volts, the light emitted yielded merely an ill-defined continuous spectrum. So soon, however, as this potential reached 4.9 volts a single bright line made its appearance, having a wave-length of 2536 Angström units. Moreover, the line thus excited was the first member of a special series in the spectrum of mercury. A further peculiarity was that the energy of each of the negative particles constituting the rays was, at the critical moment at which this line appeared, practically exactly that indicated as necessary by the quantum theory. According to this theory, the energy requred to excite light of a particular wave-length was equal to 6.6 $\times$ 10^{-27} $\times$ frequency, where the "frequency" denoted the number of vibrations per second. Substituting in this formula the frequency corresponding to a wave-length of 2536 Angström units, we got, he said, 4.5 volts as the potential difference through which a negative particle must fall to acquire the above amount of energy. This result provided, therefore, a remarkable confirmation of the view that definite units of energy were required to produce light of any specified wave-length.

This single-line spectrum was the simplest known. If the potential difference were increased beyond 5 volts, then for a certain range the spectrum still consisted of this single line. Professor McLennan, of Toronto, had, however, discovered that when the potential reached 12.5 volts the spectrum suddenly became very complex, being, in short, the ordinary line spectrum of mercury. The most interesting point about this discovery lay in the fact that certain of the lines which then appeared lay on the red side of the original single line. According to the quantum hypothesis, these lines, being of longer wave-length than the original line, should require a smaller unit of energy to excite them. It would have been natural to expect, therefore, that these lines in the red would have made their appearance earlier than the single line first developed, which lay actually in the ultra-violet. As a matter of fact, however, experiment showed that to obtain these red and yellow lines of mercury it was necessary to provide more than double the energy which sufficed to bring out the original single-line spectrum. This point was of great importance in connection with the mechanism of radiation. It appeared, as stated, that the red line was not produced by the supply of its "energy equivalent" to the radiating atom, but that a much greater quantity was necessary. It seemed, therefore, as if it were necessary to alter the atom in some way before the red line could be made to appear. In fact, these red lines were not excited until the energy supply was three or four times that necessary for the original single line. The long waves subsequently emitted formed, in short, part of a system which could not be excited until the energy supply was enough for the blue components of the system, or, at any rate, until the constitution of the atom had in some way been altered.

In addition to mercury, McLennan had also worked with vapors of zinc, cadmium, and magnesium. In all cases he had obtained these single-line spectra, the wave-lengths being as follows:

Mercury	2536	Angström units.
Zinc	3075	" "
Cadmium	3260	" "
Magnesium	2852	" "

All these elements could be made to yield single-line spectra, and what was of the greatest interest was that in each case this single line was first member of the same spectral series of the metal. This fact supplied a remarkable confirmation of the view that the series into which spectroscopists had been led to divide spectral lines had really some physical meaning.

So far as the speaker knew, single-line spectra had not yet been obtained with other elements than the four named. In particular nothing of the kind had been noted with such gases as hydrogen, chlorine, or oxygen, but the discovery had undoubtedly opened up a very interesting field. It was not merely the existence of this single-line spectrum that was of interest, but also the stage at which it appeared. The experiments permitted the hope that in this way the stages at which certain types of spectra appeared might be determined. This would establish the connection between different lines by sorting them out into different series. In fact, an important means of classifying some of the complicated spectra would be obtained if it could be established that certain lines made their appearance at definite stages. So far, however, the method had only been applied to the vapors named, but it could probably be extended to other elements.

Another way of showing, at least qualitatively, the connection between energy supply and luminosity was to insert an exhaust bulb, containing a trace of gas, near a coil traversed by a rapidly alternating current. If the bulb were placed close to the coil it experienced a strong field, while if withdrawn a little the field was weakened. In exhibiting this experiment the lecturer pointed out that the character of the light in the bulb varied abruptly as its distance from the coil was altered. If the bulb were more than a certain distance away, the light given out was diffused throughout the whole bulb; but on the critical limit being passed a brilliant ring of light sprang into being inside the bulb, which disappeared just as abruptly as the distance was again increased. The ring was in all cases either exceedingly bright or entirely absent. The spectrum of the light from such a bulb also changed, the lecturer stated, abruptly with the appearance and disappearance of the ring. Hydrogen, for example, had two spectra—viz., its ordinary line spectrum, and a second exceedingly complicated spectrum, with almost innumerable lines, especially in the red and yellow. With a bulb filled with hydrogen, this latter spectrum was that observed until the ring appeared. At this instant the line spectrum of hydrogen sprang out with great brilliance, all the lines being present and all bright.

This observation afforded further testimony in favor of the view that these lines only came in when the

*From *Engineering*.

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energy exceeded a certain amount. The same general effect was obtained with other gases, but each had its characteristic strength of field at which the ring appeared inside the bulb. The first stage came in at one definite value, and the second at another definite value. These values were characteristic of the gas under observation, being alike for no two gases. To the abrupt change in the appearance of the bulb from the general glow to the bright ring corresponded, he proceeded, a similar change in the strength of the induced current inside the bulb. As soon as the ring appeared the energy absorbed became as great as if the bulb had been filled with the best conducting mixture of sulphuric acid and water. The energy absorbed prior to the appearance of this ring was by no means on the same scale, and the bulb could be run under these conditions for hours without getting hot.

Another method of showing the discontinuous way in which luminosity arose was to bombard gases with positive rays; that was to say, with atoms of the gas itself, instead of with the cathode rays. The spectra obtained with the two kinds of bombardment differed remarkably, even when the energy of the particles was the same in both cases. With the same energy the positive particles, being much the heavier, moved more slowly than the negative particles.

The difference in the character of the light in the two cases was illustrated by means of a vacuum tube containing helium, and of the form indicated diagrammatically in Fig. 2. The electrode at *D* was perforated, so that positive rays passed down it to the helium below, causing it to shine with a red light, while the cathode rays in the upper part of the tube produced a bluish light. In a variant of this experiment the helium was contained in a bulb fitted with opposing electrodes, each in the shape of a triangular plate, the two being spaced parallel to each other and a short distance apart. On passing the discharge positive rays streamed out from the corners of the triangular space, giving pencils of red light, while the negative particles, which came out at the mid-points of the sides, produced pencils of bluish light. In this case both kinds of particles had the same energy, but the spectra excited by them were entirely different. In another experiment the lecturer bombarded lithium chloride, at first with negative particles and then with positive rays. The chloride gave out a bluish light in the former case, while with the positive rays the light was red. It was noteworthy in this connection, the lecturer said, that the effect was much more marked with compounds than with the pure elements. With the latter very little was to be seen. Thus when a pool of the liquid alloy of sodium potassium was bombarded, the specks of oxide which contaminated the surface shone with the characteristic sodium light like stars in a dark sky; the intervening clean surface remained, however, perfectly black.

In all these cases, in which luminosity was produced by bombardment, it was necessary that the particles should travel above a certain speed. Hence the light always made its appearance more or less abruptly when the potential under which the rays traveled rose beyond a certain limit. The value of this limit had been measured for a good many substances, and in general it was found that a potential difference of 600 to 700 volts was necessary to make a salt yield the characteristic lines of an element. To make lithium chloride luminous, for example, 700 to 800 volts were required. All these experiments concurred in indicating that to excite luminosity it was necessary to communicate definite amounts of energy, and the luminosity was therefore not proportional to the disturbance producing it, but came in discontinuously when the energy of the disturbance exceeded a certain limiting value.

The next point which arose was to determine the nature of the luminous particles. Were they atoms or molecules, or something still more complex, when the characteristic spectral lines were emitted? The positive rays provided a means by which this question could be decided. If they were sent through hydrogen, for example, the particles of hydrogen which gave out the light were moving at a speed which was not insignificant as compared with that of light. By Doppler's principle the spectrum given out by a moving particle was not the same as that of the same particle at rest, the lines being all displaced, toward the violet if the particle were approaching the observer, and towards the red in the contrary case. If this displacement were measured, the velocity of the particle emitting the light could be determined. On examining the positive rays, Stark had found that all the lines given out were displaced, and by an amount capable of accurate measurement, so that the velocity of the light-giving particles could accordingly be calculated. As the atoms and molecules of hydrogen were moving at different speeds, it was thus possible to determine from which of the two the light was derived.

(To be continued.)

Metals to Replace the Carbon Arc and Platinum

Whatever its *motif* in the cloistered laboratory, research as conducted in the modern works has only one end—to assist trade and industry. Pure science has little place in the average engineering works, but without applied science progress would soon cease. Practically all our great works now have their own testing and research laboratories, where every batch of material as it enters the works is subjected to rigid scrutiny. There also new processes are evolved and gradually perfected.

To illustrate the manner in which the works laboratory can directly assist industry we may mention two cases that have recently come to our notice, one in this country and the other in America; both, curiously enough, depending upon a metal which itself has only just been taken from its swaddling clothes by applied science workers.

HIGH EFFICIENCY TUNGSTEN ARC.

The experiments of Sir J. J. Thomson, Dr. Fleming, and others have made us aware of the fact that the filament in an incandescent electric lamp gives off a strong negative discharge, and that if an additional electrode adjacent to the filament be charged to a positive potential a current passes between the filament and this electrode.

An application of this principle has been used to overcome the difficulties encountered in the production of an arc incandescent lamp, the latest electrical marvel. The new lamp is the result of experiments commenced in 1913 in the lamp research laboratory of the Edison and Swan United Electric Light Company at their Ponder's-end works, with the object of obtaining a lamp possessing the usual characteristics of the ordinary incandescent lamp—that is to say, as regards the shape and size of bulb, stem, and cap, but having as the source of light an arc possessing electrodes of tungsten or other suitable refractory conductor burning in an inert gas such as nitrogen or argon.

In operation the current first passes through an ionizer circuit, causing the ionizing heater to incandesce at a temperature sufficient to ionize the gas between it and the positive electrode. Thus the arc is caused to strike, after which the ionizing circuit is cut out, the striking being assisted by the removal of the ionizer circuit, which, of course, shuts the arc circuit.

Practically the whole of the intense white light of the lamp emanates from a small globule of fused tungsten 1-10 inch in diameter, suspended above a straight length of tungsten wire which forms part of the ionizer circuit.

ARC AND INCANDESCENT LAMPS.

As compared with the carbon arc lamp no regulating mechanism is required, and there is therefore a saving in the initial cost of production. The loss of light due to obstruction by the electrode is small compared with that in the carbon arc, and there is no trouble from flickering or from the arc wandering. The arc is completely enclosed, so that there is no danger from fire. No recarboning is required, and the lamp needs no attention while in use. The light-giving service for the same output is greater than the crater of the carbon arc, and the electrodes can be so arranged as to concentrate the light in any desired direction.

Filaments of incandescent lamps are always distributed around the stem, and thus occupy a fairly large area, whereas in the new lamp the light-giving surfaces are concentrated in the center of the bulb. In the same way that a carbon lamp appears yellow in comparison with the ordinary half-watt lamp, so does the latter appear yellow when contrasted with the new incandescent arc. For high candle-power lamps the bulbs are much smaller than for metal-filament lamps of corresponding candle-power, e. g., electrodes to give 500 candle-power can be placed with safety in a bulb 4 inches in diameter.

As compared with the carbon-filament lamp (3.5 watts per candle-power) with an intrinsic brilliancy of about 375 candle-power per square inch, and metal-filament lamps giving 1,000 candle-power per square inch, the intrinsic brilliancy of the new lamp at an efficiency of 0.5 watt per candle-power or two candle-power per watt, is approximately 10,000 candle-power per square inch. The color of the light can be made to vary from a bright yellow when running at low efficiencies to a very intense white light when the lamp is run to the sputtering point of the electrodes. The range of intrinsic brilliancy between these limits is approximately 400 to 30,000 candle-power per square inch.

SUGGESTED USES OF THE LAMP.

The lamp is made for both alternating and continuous current circuits, but the present intention is to put forward only the continuous-current lamp in its existing form for optical projection and general scientific work where a concentrated point source of light is required. The lamp is so suitable for projection work that there is reason to believe that it will supersede all other sources of light for this purpose. It gives constant, uniform screen illumination, while there is no flickering and no danger of fire in kinematograph work as there often is from the intense heat of the ordinary carbon arc. The bulb of the lamp, although smaller, does not become so hot as do those of the half-watt metal-filament lamps. Moreover, the lamp requires no attention while burning, so that the whole of the operator's time is free to attend to his apparatus. Lamps of 1,000 to 2,000 candle-power would appear to be very suitable for kinematograph projection, and lamps of 200 to 300 candle-power for ordinary lantern work.

The lamp is very suitable for use in searchlights, for daylight and night signaling, and as projection arcs for stage purposes. It should prove useful in photography, and for the purpose of color-matching by artificial light. Microscope illumination and micro-photographic work offer two fields of usefulness for the new lamp, and undoubtedly there are many special purposes for which the lamp is particularly adapted.

Experiments have shown that the lamp burns satisfactorily in series on high-voltage circuits, and future development should lie in the adaptation of the lamp for street lighting, and for the illumination of large halls and other interiors.

PLATED TUNGSTEN AS PLATINUM SUBSTITUTES.

We now turn from the domain of electricity to that of metallurgy. Here also we find tungsten to have engaged the attention of the applied science worker, and to such good effect that practically a revolution is indicated in many industries hitherto dependent upon platinum.

Since discussing in these notes a fortnight ago the question of substitutes for platinum—made urgent by the action of the Ministry of Munitions in seizing all supplies of platinum in this country—we have received some details from America of an important industrial research that has just been completed there on this subject, and which will be published *in extenso* at the February meeting of the American Institute of Mining Engineers.

The results of the experiments, as conducted by Mr. Frank Alfred Fahrenwald, of Cleveland, Ohio, lead to the conclusion that metals or alloys of metals outside of the precious-metal groups are unsuitable as substitutes for platinum.

The gold and silver alloys of palladium have been found to be excellent substitutes for platinum in its softer forms, and, while not so chemically resistant, fill all requirements where conditions are not too rigid.

Except in two respects, pure ductile tungsten—and, to a lesser degree, molybdenum—meet all of the specifications of a practical substitute for platinum and its alloys. These two defects are its ease of oxidation and the difficulty with which it can be soldered, and they have been overcome by coating with a precious metal, usually gold, silver, or palladium, or alloy of these metals, the resulting material being in many ways far superior to platinum or its alloys.

This material has met with instant demand, is in many cases replacing the best platinum-iridium alloys, and permits the performance of work which has been impossible with the materials hitherto available.

Wrought tungsten and molybdenum were produced on a laboratory scale, but no success attended the attempted production of alloys of tungsten with gold and palladium; while, on the other hand, the alloys of the tungsten-molybdenum series were produced in wrought form. These operations were governed entirely by metallographic control, and their success suggests the possible application of a similar method in a treatment of such metals as indium, tantalum, rhodium, osmium, etc., in combination with each other, or with tungsten or molybdenum, which may result in the production of alloys possessing properties far superior to those of any material now available.—*The London Daily Telegraph.*

Brittleness of Annealed Copper

In a paper read by W. E. Ruder, of the General Electric Co., at the 29th General Meeting of the American Electrochemical Society, the speaker said that it has been shown that the brittleness of copper developed during heating in the process of manufacture and frequently ascribed to "burning," is in reality a deoxidation. With ordinary commercial copper, serious brittleness begins to appear at 400° C. in dry hydrogen, at 600° C. in wet hydrogen, at about 800 to 850° C. in CO, and at 700° C. in steam. Copper which had previously been deoxidized by the addition of boron remains unaffected at all temperatures in a reducing atmosphere. This brittleness is therefore due to the reduction of the cuprous oxide around the primary copper grains, leaving a spongy mass of little mechanical strength, and not to any direct action of the hydrogen upon the copper itself.

Diesel Engines in Germany

It is stated that Diesel engines to the extent of 850,000 horse-power are in use in Germany, of which 150,000 horse-power is produced by the use of tar or tar oils as fuel.

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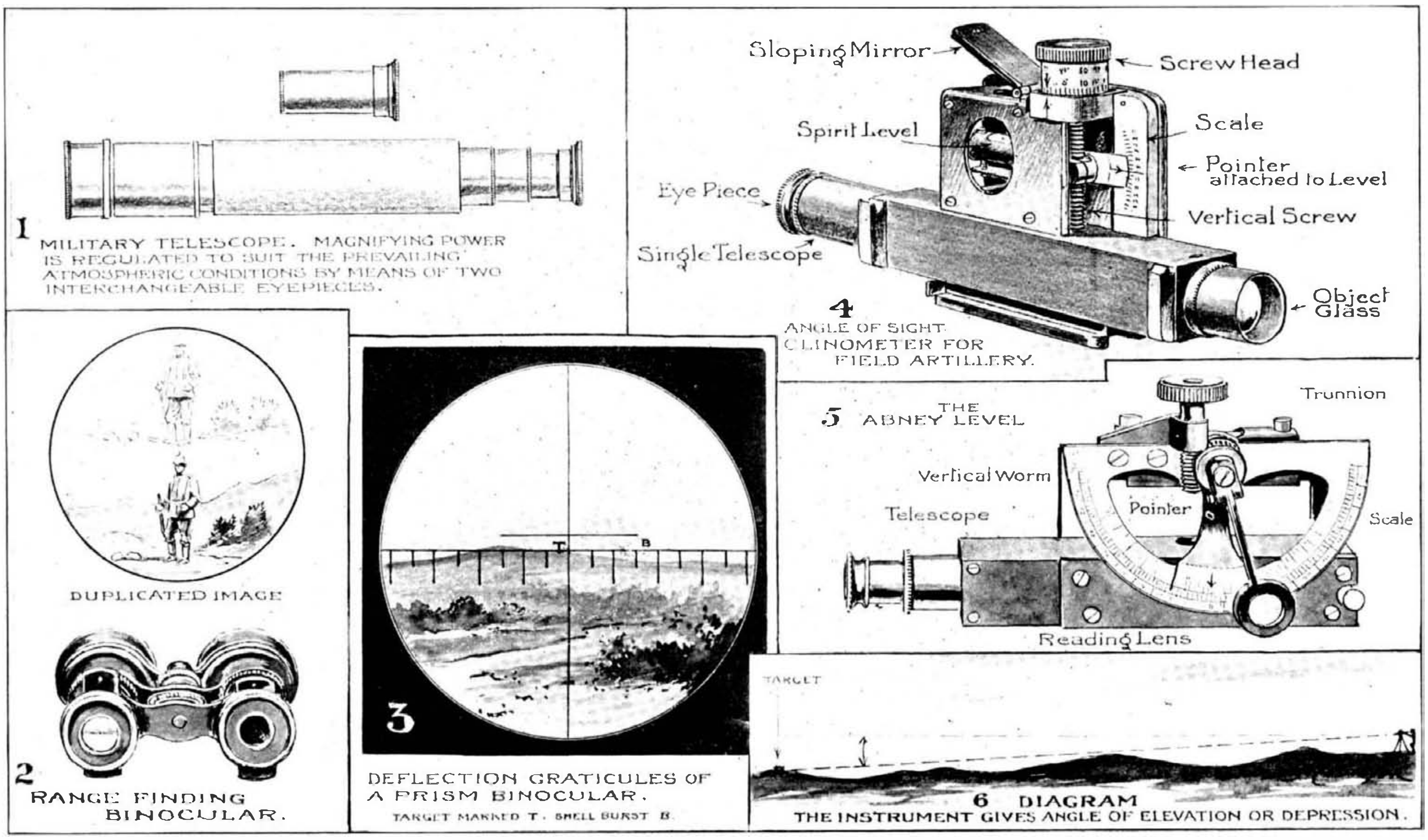

Courtesy of the Illustrated War News.

Military Telescopes and Binoculars*

Some of the Scientific Instruments Used by Field Officers

The work of a field officer of the present day involves the use of a large number of interesting scientific instruments, among which the telescope in its various forms takes a leading place. An ordinary pattern of single telescope used by artillery officers gives good definition up to 6,000 yards in clear atmosphere, with a magnifying power of 18 diameters and a "field" whose diameter is about 52 yards at a distance of 1,000 yards from the instrument.

In very clear atmosphere a telescope with a high magnifying power can be used, but better results are obtained from a lower-power instrument in misty or hazy weather. In order to provide for this it is usual to supply two separate interchangeable eyepieces with each telescope, so that the lower-powered one can be used when weather conditions require it (Fig. 1).

Although a single telescope has a greater range than a binocular, the latter instrument is more useful for quick work, its "field" being wider than that of the single instrument and its general shape more convenient to handle. There are two distinct systems of binocular construction—that known as the "Galilean," in which the line of sight passes directly from the eye-lens to the object-glass; the other the Prismatic System, in which the line of sight is deflected by means of prisms situated between the eye-lens and the object-glass. One pattern of service binoculars of the first-named type magnifies to three diameters only, but the field covered at 1,000 yards is about 80 yards. It is evident, therefore, that an object is more quickly found by this type of glass, although the magnification is much less and the power consequently lower. A wide-angle binocular for airmen's use is constructed to cover a field of 117 yards at 1,000 yards range.

The prismatic binocular (Fig. 8) is a more complicated instrument, the object of its design being to permit the use of a long-focus object-glass in a short-bodied instrument. This result is obtained by placing a right-angled prism in a position to receive the light from the object-lens and to reflect it back to a second prism, which again alters its course and directs it on to the eye-lens. In this way the ray of light is enabled to travel a considerable distance after it passes through the object-glass before it strikes the eye-lens, and consequently a powerful long-focus lens can be used.

Fig. 7 shows the relative positions of the lenses and prisms in the instrument, the dotted arrow showing the course of the ray of light. In this device advantage is taken of the fact that a ray of light passing into a transparent prism will not pass out of it through a plane surface placed at an angle with the direction of the ray, but will be deflected by this surface, the angle at which the ray leaves the surface being equal to that at which it meets it. If the outside of the plane surface be dulled by moisture or otherwise, the intensity of the reflected ray is reduced. A prismatic binocular can be made to cover a field of about 80 yards at 1,000 yards range with a magnification of 8 diameters. A glass diaphragm called a "graticule" is frequently placed in front of the right eye-piece of one of these instruments a number of lines being engraved on its surface to represent angular distances in its field (Fig. 3). An artillery officer can, by means of this device, observe the angular error of his shell-bursts, and make necessary corrections. A graticule can also be used with the single telescope for the same purpose.

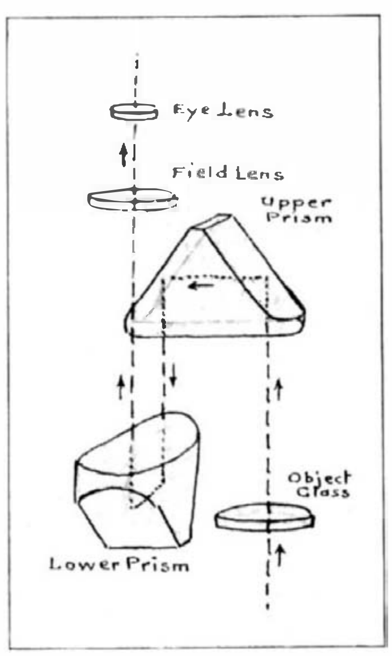

Fig. 7.—The lens action in the prismatic binocular.

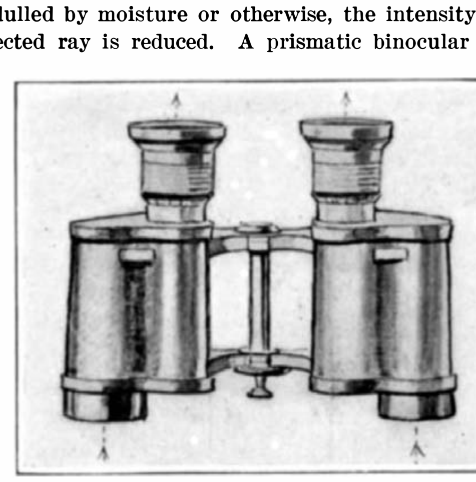

Fig. 8.—Exterior of the prismatic binocular.

In a prismatic binocular it is possible to arrange so that the object-glasses are farther apart than the eye-pieces: the stereoscopic effect in thereby increased.

An angle-of-sight clinometer for artillery use (see Fig. 4) consists of a single telescope above which a spirit-level is mounted on trunnions, whose angular movement in relation to the telescope is controlled by a vertical screw of which the head is graduated in minutes, while a pointer attached to the spirit-level shows degrees on a scale fixed to the frame. The spirit-level can be observed through a hole in the side, and also by means of a sloping mirror above it. The instrument is fixed on a tripod, and the telescope laid on the object under observation (Fig. 6).

The spirit-level is then set by the vertical screw and the angle read off from the scale. The Abney level (Fig. 5) is a similar instrument, but in its case a semicircular scale is provided and the spirit-level trunnion carries the pointer, together with an adjustable reading lens. It is operated by a vertical worm engaging with a worm on the trunnion. A prism placed over one eye-piece of a binocular deflects the image seen through that particular barrel at a given angle, the effect of this arrangement being to produce the impression of two images some distance apart from one another (Fig. 2). As this distance varies directly with the range, the latter can be estimated from it, and the binocular becomes a simple range-finder.

*The Illustrated War News.

Noise Means Loss of Power

A large part of the noise in a manufacturing plant may be translated into loss of power, unnecessarily rapid depreciation of equipment and a reduced efficiency of employees resulting from the distraction which is created and from the indirect effect upon physical health. Many users of machinery have awakened to the fact that their manufacturing rooms should be as quiet as possible, and in selecting new equipment have had this in mind. Some operations cannot be performed without disturbing sounds. To produce quiet running at the higher speeds, the gears must be most perfectly fashioned. In some of the machinery produced to-day the gear speeds are excessive when compared with the accuracy of the machining, and they are consequently noisy, and the fault increases with use.

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How Men Work in the Depths of the Sea

Facts Relating to Diving and Diving Apparatus

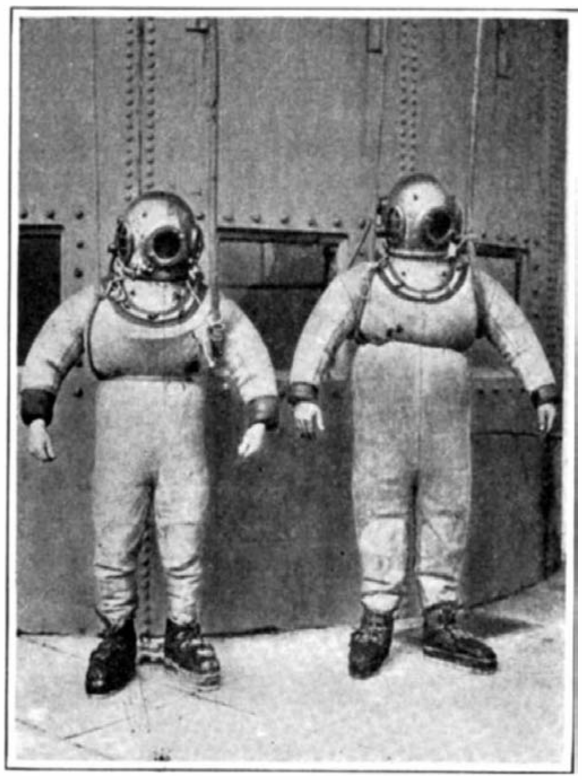
VARIOUS references have lately been made to the works of Jules Verne, whose vivid imagination—may we say prophetic instinct—protrayed in word pictures those stories which delighted us in our youthful days, and when we allow our thoughts to dwell on either of the subjects of aeroplanes or submarines, we inadvertently turn to the suggestive title of one of his books: "Up in the Air and Down in the Sea."

The origin of the diving apparatus appears to date back to the sixteenth century, when a crude form was tried with some success. Subsequent trials resulted in modifications and improvements, which led to a machine of some service and paved the way for its ultimate use in operations connected with the construction of harbors and docks. The difficulty experienced, after the initial stages of the shape, construction and lowering of the diving bell were worked out, was that of maintaining the air in a condition fit for the divers to live in for a length of time sufficient to accomplish work or to investigate. At a depth of water rather over 60 feet, the air, due to the open bottom of what became known as the diving bell, on account of its shape, was compressed to about two atmospheres; and although this pressure was no great annoyance to the inmates, the air soon was so vitiated as to be uncomfortable, and as in the early days of its career no provision was made to change the air, the time limit of human endurance was short. A plan was tried of sinking vessels charged with fresh air to give new supplies, an arrangement being made for the vitiated air to escape. This expedient was the stepping stone to the modern system of supply by means of an air pump. Among the first works where the diving bell was used with advantage was the building of a harbor, when Smeaton adopted an improved type fitted with a force pump connected to the chamber, by which the air was maintained at the required pressure for the depth of the working level. The length of time the bell could remain down with safety to the workers was thus materially increased. The depth to which the diving apparatus can be used depends on the human element locked up within it and to some extent on the individuality of the diver; the normal depth may be stated to be about 28 to 30 fathoms, but instances are known where 32 to 35 fathoms have been reached and work accomplished. The time spent by the diver at these depths is necessarily short, especially when account is taken of the descent, the breathing time at different stages descending and ascending, and the ascent. The balance of the pressure of the atmosphere is a head of salt water of about 33 feet, hence at 11 fathoms the pressure becomes two atmospheres, and when the diver is at work the slight variation of pressure, due to change of position from standing to stooping, may cause an uncomfortable air lock within the dress, which is readily removed by assuming the erect position, when the valves in the helmet will act and equalize the pressure within the dress. The increase in the percentage of CO_2 in the air breathed by the diver, as the pressure is increased within the dress to correspond with the pressure of water due to the depth, is not the most dangerous element to be guarded against, as the absorption of nitrogen by the blood at high pressure requires special safeguards, so that not only the absorption may take place gradually, but the elimination process also. With this object a time-table has been prepared under the direction of the Admiralty for the guidance of divers, so that they may descend into the depths and remain at work and ascend to the surface with the greatest safety. The greatest depth, and the pressure consequent upon it, which has been found for a diver of experience and of good physique to descend to, is 35 fathoms, the pressure being about 100 pounds. The pressure on the outside of the diver's dress due to the head of water is counterbalanced in the inside by the air pressure delivered by the air pump.

An interesting book, published by Messrs. Siebe, Gorman & Co., with a copy of which we have been favored, contains much information for the guidance of those who have the conducting of diving operations, with the safety of the diver under their superintendence. The following figures quoted from the table given in this book show the care which is exercised in the movements of the diver so that he may suffer as little inconvenience as possible and minimize his risk. A table is also given showing the pump capacity and revolutions for the degrees of depth up to 34 fathoms.

The constituents of the atmosphere are given as nitrogen 79.1 per cent by volume, oxygen 20.9 per cent, and carbon dioxide (CO_2) 0.03. Air expands 1/493 of its volume for every increase of 1 deg. Fahr., and its volume varies inversely as the pressure. Normally, the volume of air breathed by an average healthy adult male is about 30 cubic inches per inhalation = 450 cubic inches = about 0.25 cubic foot = 7.3 liters per minute. Exhaled air contains on the average 79.1 per cent of nitrogen, 16.5 of oxygen, 4.4 per cent of carbonic acid. The "dead space" formed by the larger air tubes is about 10 cubic inches. The air in the lungs contains about 14 per cent O_2 and 5 per cent to 6 per cent CO .

Depth.	Pressure.	Time From Leaving Surface to Begin Ascent.	Stoppages at Different Depths in Minutes. Feet								Total Time for Ascent, Min.
Ft.	lbs.	Hours.	80	70	60	50	40	30	20	10	
66	29½	over 3	..	..	..	..	..	..	10	30	42
78	34½	over 2½	..	..	..	..	..	..	30	30	62
90	40	over 2½	..	..	..	..	..	20	35	35	92
108	48	over 2	..	..	..	..	15	30	35	40	122
132	59	over 1½	..	..	..	15	30	35	40	40	163
156	70	over 1	..	..	20	25	30	35	40	40	193
180	80½	over 1	..	15	25	30	30	35	40	40	218
204	91½	over 1	15	20	25	30	30	35	40	40	238



Divers prepared for a descent with their suits inflated with air.

The superficial area of an ordinary sized man's body is about 2,160 inches × 15 pounds = 32,400 pounds. At a depth of 33 feet of sea water the total pressure would be 64,300 pounds. So long as the pressure is equally distributed throughout the body by the body fluids, it has no effect. The total weight of a diver's equipment and the part which he actually wears, and exclusive of his air pipe, is about 175 pounds, therefore a diver—say a 12-stone-man—fully equipped, would have a total weight of 343 pounds.

An ordinary sized man (naked) displaces about 0.075 ton of sea water; a fully equipped diver with dress deflated, about 0.15 ton, and with dress fully inflated about 0.31 ton. But if fully inflated he would float, and in so doing would displace exactly the weight of himself and dress, or 343 pounds = 0.153 ton, as his displacement would be greater than the equivalent weight of water if entirely submerged.

A submerged body displaces in the sea a weight of water equal to the cubic capacity of the body × 64 pounds (the weight of a cubic foot of sea water). Thus a pontoon or camel measuring 15 feet long by 4 feet diameter = 188.5 cubic feet, would displace nearly 5.4 tons of sea water, if entirely submerged, and its buoyancy would be represented by this figure, minus the weight of the pontoon itself. The pumps used for supplying air to the divers for all conditions of work have been carefully thought out and constructed. Should there be two divers at work, provision is made at the pump so that the supply of air can be adjusted to meet each of them, whether at the same or different depths, by means of a patent air distributing cock.

The helmet of the diver is a fine piece of work made of tinned copper. There are several different types with special arrangement of valves for the air supply and exhaust. There are three windows in the head piece, ½ inch thick glass secured in brass frames; in addition to these there may be a window in the top of the helmet. The inlet valve in the helmet is non-return and is very important, as in the event of the ar pipe being broken the valve closes and gives a short time for the diver to realize his danger and act for safety. The outlet valve can be regulated at will by the diver under water to suit the depth to which he descends; the outside water pressure acts on this valve to keep it on the face. The breast plate and corselet are also fine pieces of work and important, in that they join the helmet to the body dress and preserve the air-tightness of the whole. It is necessary to add weight to the diver to overcome the too great buoyancy which otherwise would cause him to rise to the surface or prevent his descent, due to his displacement. These extra weights of lead are secured by hooks at the neck. The remainder of the dress is composed of rubber and necessarily carefully made and perfectly air-tight. The cuffs at the wrists are made secure by vulcanized rubber rings. The air-connecting pipes from the pumps to the divers are so made and arranged that the least inconvenience due to weight will be experienced by them. The boots are of stout leather with wooden soles and lead oversoles and metal toe caps. Electric lamps and telephones are provided, so that not only has the diver the best means of seeing around him, but can communicate to those above him regarding his operations and be communicated with.—*The Marine Engineer and Naval Architect.*

Bags From Straw Fibre

A new sort of fiber, known as "Straufa" fiber, and made from straw, has recently been patented in Germany, according to *Die Umschau.* Every sort of straw can be employed, the yield of fiber varying with the moisture content. The straw-fiber obtained is prepared for spinning in the same way as jute, and jute machines are used in its further elaboration. It can be employed in a pure state or mixed with jute and other fibrous material. Pure *straufa* can also be used to fill bolsters, in felt manufacture and cable fabrication. Severe tests have been made of articles made from straufa and jute mixtures with reference to durability and non-tearing qualities. Experts declare the strength of the straw-fiber equals that of jute. A straw-fiber bag was filled with wrought-iron nails and thrown a distance of 15 feet down to the stone floor of a cellar, without any rent being perceived after careful examination. Sacks of 81 kilogramme capacity were made to hold heavy grain, and found to be amply firm of fabric. They are not, however, suitable for flour-sacks for two reasons—the roughened surface retains too much flour clinging to it on the one hand, while on the other loosened bits of fiber become mixed with the flour.

Extensive experiments were made, too, as to their fitness for transporting salt. They were found very suitable, and the dampness of the salt does not appear to affect the firmness of the fabric.

Every Man His Own Electric Lamp

A BUDAPEST engineer, Mr. Karl von Dreger, after three years of experiment, has perfected an electric lamp which operates without a battery, the power being obtained by the transformation of muscular action into electric energy. The pocket lamp, which corresponds in size and lighting power to the ordinary battery lamps, obtains its power from the thumb of the hand which carries it. The thumb moves a small projecting lever along the sector of a circle with a moderate expenditure of strength. A spring draws the lever swiftly back to the original position. By correspondingly rapid pressure on the lever, and utilizing a ratchet, a spring is stretched or "wound up," and this, by the interpolation of a few cog wheels, drives, with an approximately regular number of revolutions, a small magnet with a permanent magnet as a field. Usually the lever is worked continuously as long as it is desired to have the light burn, but Mr. von Dreger has succeeded in storing up so much energy in the spring that the lamp will continue to burn for several minutes after the lever motion has ceased.

The lamp is manufactured in another form intended to be carried (*Traglampe*). Here the power is obtained by pressing together two handles attached to the casing of the lamp. One of these is fixed and the other is movable and is operated by the whole hand instead of by the thumb alone. It gives a correspondingly larger amount of light. The same principle can be employed for other uses, i. e. to operate ignition dynamos for blasting.—*Elek. Ztg.*

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War Projectiles*

Details of the Shells Now Used by the Different Nations

By C. A. Tupper

In the production of war munitions, one practical question with which manufacturers have been concerned is the working range of the equipment which it will be desirable for them to provide, having in view possible future requirements. In this the calibers of the shells likely to be in greatest demand by the various belligerent nations cuts a very considerable figure. At first the call was for 2.95 and 3-inch shrapnel; then in rapid succession for 3.29, 4.5, 4.72, 5.87 and 6-inch high-explosive shells, and finally for the larger sizes, including 9.2, 9.45, 12 and 14-inch projectiles.

In the minds of manufacturers who contemplate going into this work or increasing their facilities for it the questions naturally arise as to what is the total of the shell calibers in actual service; what does the exact diameter of each measure; which are the most commonly used, and how are they distributed among the varous nations, both those now at war and others that may be involved? The question of which calibers were designed in inches and which in millimeters also has a more important bearing than might be imagined by the casual thinker.

The tables accompanying this article show the calibers of the ordnance and consequently of the shells used with it. They comprise the shells for all classes—field, naval, coast-defense and even anti-aerial guns, in use to-day by the leading nations of the world. As a matter of convenience all figures below the heading have been reduced to an inch basis for purpose of comparison. The inch measurement, however, applies strictly and invariably only to ordnance used by England and the United States. The artillery and ammunitions of other countries is figured in millimeters, except where it has been supplied by English or American ordnance works in accordance with their own standards. The larger metric calibers are also commonly designated by centimeters; but here again, for uniformity and convenient reference, all metric dimensions stated in this article are given in millimeters. Other information supplementary to the tables follows.

THE GERMAN HOWITZERS.

While an 18-inch gun for coast defense has been designed in this country and shows in a list prepared by the Bethlehem Steel Company, the largest pieces of artillery thus far subjected to the actual test of warfare are those turned out at the Krupp works, in Essen, Germany, and the Skoda works of Pilsen, Austria. These take shells 420 millimeters and 405 millimeters in base diameter. The bore of the former slightly exceeds 16.5 inches, and the latter is a little under 16 inches. Thus far the use of such ordnance on European battlefields has been confined to howitzers in the service of the central powers; hence, as the latter are compelled by the sea blockade of the entente powers or "allies" to rely entirely upon their own arsenals, there is no present likelihood that American works will be required to turn out 420 or 405-millimeter shells. Nor is there any information available regarding the weights of the high-explosive projectiles used with the howitzers of those calibers. The nearest equivalent known to American ordnance experts, the 16-inch shell for coast defense artillery, has a weight of approximately 2,100 pounds. A Krupp gun of the same class (405 millimeters) for land batteries calls for a hardened cap projectile weighing 2,028 pounds (920 kilogrammes), with a firing charge of 555 to 624 pounds (252 to 283 kilogrammes), accordding to the range required. Fragments of the German and Austrian howitzer shells secured on Belgian, French and Russian battlefields show the same special construction as that of the 320 millimeter or 14.96-inch shell next referred to.

It was howitzers of the 380-millimeter bore which bombarded Dunkirk from a distance estimated to be over 20 miles. The shells from these, as well as from the 420 and 405-millimeter guns, have two copper driving bands and a front steadying band of the same material. For naval service the Germans have placed 380-millimeter guns on the latest super-dreadnaughts of the "Ersatz Wörth" class. Ordnance of identical size is in use by Italy and has also been developed by France, while the Armstrong works in England have produced an equivalent in the 15-inch gun. For naval work this appears in the primary battery of the "Queen Elizabeth," operating at the Dardanelles, as well as in sister ships, which were not completed until after the outbreak of the war. The weight of the standard 380-millimeter shell is 1,675 pounds (760 kilogrammes) with a driving charge of 456 to 694 pounds, while the 15-inch shell varies somewhat either way from 1,700 pounds. The German 14.5-inch gun (370 millimeters) was not a success. A 13.5-inch gun has been designed but is not in use. The French 340-millimeter gun, equal to 13.35 inches, is an odd size which has seen little service, while another that belongs in the same category is the 12.5-inch gun used by Japan.

SHELLS FOR THE 12-INCH GUN.

Shells to fit the 12-inch gun, for many years the standard maximum caliber for the turret armament of battleships of the pre-dreadnaught class, are required by all of the leading nations of the world and by some of the minor powers. For guns manufactured in England and the United States the diameter of the shell is exactly 12 inches. In France, Germany, Italy, Spain and other metric scale countries having ordnance works, it is figured as 305 millimeters. The projectiles for the 12-inch gun and its equivalent vary a great deal in weight, according to length and composition. They range all the way from 772 to 981 pounds, the nearest approach to a standard being that set by the Krupps at 860 pounds (390 kilogrammes) and the American 870-pound shell. Driving charges weigh from 213 to 357 pounds.

The so-called 11-inch caliber is really the 280-millimeter (11.02 inches) originating with Krupps and patterned after them by the Skodawerke. It is used principally by Germany and some of the lesser powers which have ordered Krupp ordnance. The Austrians have not taken to it to any great extent. There is no technical objection to this caliber, but guns designed for it have been found of little effect when opposed to the 12-inch size, and the widespread adoption of the latter "killed" it. For German naval service it was installed on the first deadnaughts, of the "Nassau" class, but succeeding dreadnaughts were equipped with 305-millimeter guns. The 280-millimeter Krupp shell weighs 661 pounds (300 kilogrammes) while others of the same caliber vary between 505 and 761 pounds. Driving charges weigh 164 to 275 pounds.

France has developed the 275 and 270-millimeter Creusot works guns, whose calibers are slightly larger than 10.8 and 10.6 inches respectively. For naval service these sizes are open to the same objection as the 11.02 inches, i.e., the preponderance of the 12-inch, and others nations have not followed the French lead. For field guns, however, the French seem to have found advantages in the 270-millimeter (10.63-inch) caliber, and it is playing a considerable part in offensive action on the central Western front.

An Austrian gun of which much has not been heard—in fact, practically nothing outside of that country—is the 260-millimeter (10.24-inch) caliber manufactured at the Skodawerke. The only shell used with this on which the writer has any figures weighs 572 pounds (200 kilogrammes) and the driving charges are given as 141 to 184 pounds. The base of a 260-millimeter shell picked up within the Italian lines west of the Isonzo front, however, indicated a somewhat heavier projectile, and the range would tend to show a greater driving charge than even the maximum above named.

THE 10-INCH GUN.

The 10-inch shell represents a size confined almost entirely to English and American practice, although Italy and the Argentine Republic have purchased Armstrong guns of that caliber. It is also listed in Befors tables as the 254-millimeter gun, taking a shell weighing 441 to 564 pounds, with a driving charge of 123 to 153 pounds.

The 250-millimeter or 9.84-inch caliber appears to have been adopted in Sweden only. An armor-piercing naval projectile used for guns of this size weighs 462 pounds (210 kilogrammes) with driving charges of 94 to 127 pounds.

A caliber designed as 240 millimeters, or 9.45 inches, is one which has been very generally adopted outside of the United States, England, Russia and Japan. Austria, besides using that caliber largely, has tried the 235-millimeter or 9.25-inch gun. Projectiles for the former weigh 375 to 474 pounds, with usual firing charge of 103 to 129 pounds. The Krupp standard is 419 pounds (190 kilogrammes) with a firing charge of 113 to 173 pounds. The last-named maximum indicates that the comparative range of shells fired from the 240-millimeter gun may be considerable.

England, which started to develop a 9-inch gun and made deliveries of Armstrong (Genoa) ordnance of that caliber to Italy, compromised on the 9.2-inch (233.7-millimeter) size, and still adheres to it as a standard, despite the manifest advantages in this war of interchangeability with French ordnance and ammunition. For naval purposes the United States is abandoning that size. Some were formerly used, but they were worked off on Greece with the sale of two battleships, and will be a source of future worry to that nation in providing shells for them.

A German gun which has come under the same ban as the English 9-inch is the 210-millimeter (8.27-inch) size. It was principally manufactured, with its shells, for Denmark and Norway, and bought by them, one is inclined to suspect, because the ordnance could be had at a bargain. It has also a Befors rating. The weights of shells used with it are 249 to 309 pounds, with driving charges of 68 to 84 pounds.

THE AMERICAN 8-INCH CALIBER.

Enumeration of the above brings us to the distinctively American 8-inch caliber, which has been tentatively copied in some foreign countries as the slightly larger 205-millimeter size. While widely scattered over the earth, however, as the result of sales made from this country, the aggregate tonnage of shells which can be fired from guns of the 8-inch caliber cannot be very considerable; and, outside of Russia, which has been supplied with some 8-inch shells from Japan, it is playing practically no part in the European war. The standard Bethlehem 8-inch shell weighs 260 pounds.

Next in order are the 7.6-inch gun and the slightly larger 194-195-millimeter (howitzer) of France, the English 7.5-inch gun and the 190-millimeter or 7.4-inch German auto-carriage rifle. Of these the 194-millimeter size has been most widely adopted. It takes a shell weighing 198 to 251 pounds, with driving charges approximating 55 to 68 pounds. For the 190-millimeter caliber the weight of the shell, Krupp standard, is a trifle under 210 pounds (95 kilogrammes) with driving charges of 65 to 88 pounds.

The 7-inch caliber, whose standard shell weight is 165 pounds, seems to be peculiarly American, while two other odd sizes are the German 170-millimeter (6.7-inch), which calls for a shell weighing 154 pounds (70 kilogrammes) impelled by a charge of 48 to 63 pounds, and the French 165-millimeter (6.5-inch) gun which uses elongated projectiles almost as heavy.

THE MEDIUM CALIBER MOST GENERAL.

We now come to the ordnance which, of all the medium calibers, is the most generally used and ought to be taken into particular account when planning facilities for the manufacture of ordnance or ammunition, viz., the 6-inch English and American gun and the 150-millimeter artillery of other nations, both being used as field pieces and for naval guns. Any shop manager who provides equipment for turning out 6-inch shells or their metric equivalents can always be certain of a demand for them as long as any buying is being done by the belligerents. Weights of 6-inch shells range between 90 and 115 pounds, with driving charges of 24 to 35 pounds. The American standard for the projectile alone is 105 pounds. Shells of 150-millimeter (5.9-inch) Krupp standard weigh 101 to 112 pounds (46 to 51 kilogrammes) and require driving charges of 32 to 40 pounds.

Between the ordnance last named and the American 5-inch gun which, with the British 4.5-inch, will probably pass into the discard after this war, are the French 140 and 130-millimeter (5.5 and 5.1-inch) sizes. These will undoubtedly be abandoned also, as they are practically out of use now.

The first size below 6 inches which seems to have come to stay is the French and German 120-millimeter or 4.72-inch caliber, that has been adopted by nearly all important nations. Shells used with guns of this size range in weight between 43 and 62 pounds, the Krupp standards being 53 to 59 pounds (24 to 27 kilogramme). Driving charges are from 13 to 22 pounds.

Before settling on the 120-millimeter caliber as a field piece and naval standard, the Krupps and the Creusot works developed the 105-millimeter or 4.14-inch size, and guns of this class were also largely turned out by the Skodawerke; but Germany, Austria and France do not appear to be using them to any extent now, and their future service in war will probably be confined to the smaller nations who were unfortunate enough to purchase them. The weights of the shells used with 105-millimeter field pieces vary between 31

* *Iron Age.*

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and 40 pounds (14 to 18 kilogrammes) and their impelling charges call for 9 to 15 pounds.

What has been said of the 120-millimeter caliber also applies to the English and American 4-inch gun and the French and Austrian 100-millimeter or 3.9-inch cannon, also the German 88-millimeter (3.46-inch) ordnance, although so many of all of these were originally provided that the percentage still in use is considerable. Shells manufactured for the sizes mentioned range in weight between 29 and 35 pounds as standards, but actual field service conditions have made any figures unreliable, as the tendency has been to use just as heavy shells as the guns would possibly take, in order to get service out of them approximating the 4.7-inch calibers with which they are being replaced. Shells picked up on European battlefields and brought to this continent show by the condition of the copper driving bands that the rifling of these odd-size guns has been badly worn, also that they are being utilized to a considerable extent for shrapnel, which is generally confined to calibers between 75 and 88 millimeters (2.95 to 3.46 inches). Shrapnel cases are, however, also fired from 150 and 120-millimeter (5.91 and 4.72-inch) guns.

THE 3-INCH CALIBERS.

The most widely used caliber below the 120 millimeters is the French and German 85 millimeters (3.31 inches), which reappears as the English 3.29-inch size. Then comes the celebrated French 75-millimeter (2.95-inch), also in use by other metric scale nations, and the English and American 3-inch gun whose caliber is the equivalent of 76.2 millimeters. A German size is 77 millimeters, as well as 75 millimeters. The tendency at present seems to be to retain this size (2.95, 3 or 3.03 inches) for shrapnel, but to use high explosive shells of the larger caliber mainly, and the 85-millimeter will probably be adopted altogether for small shells of that type unless superseded by the new 90-millimeter, which has yet to be brought into service. Meanwhile, the French have extended the usefulness of the 75-millimeter caliber by developing at the Creusot works trench mortars of that size. These will take the same shell as that used for the field piece, thus overcoming one difficulty experienced with the latter, whose trajectory is so low that dropping shells into a nearby trench of the enemy has often been found impracticable.

At this point it should be noted that guns of 3 inches or under are ordinarily chambered for fixed ammunition, the projectiles used with them being each fitted with a brass cartridge case containing the driving charge. Ordnance from 3 to 6 inches is similarly designed, particularly the 4.72, or can be chambered for loose charges, with the powder in bags or cases separate from the projectile. Guns above 6 inches are usually chambered for loose ammunition only.

Below the 75-millimeter caliber are the 70-millimeter, 65-millimeter, 57-millimeter, 47-millimeter and 37-millimeter. The three last named are in practically universal service, being known to the English and to Americans as 6-pounders, 3-pounders and 1-pounders. Their sizes figured in inches will be seen from the table. These find their greatest sphere of usefulness as rapid-fire naval guns. Shells for them are manufactured in government arsenals and the conditions of the European war have not called for any great supply, nor do they seem likely to. Actual service with them has been principally confined to patrol vessels equipped to hunt down submarines.

THE ANTI-AIRCRAFT GUNS.

A more interesting and important development has been the relatively large production of guns and shells for defense against air-craft. They are known as "anti-aerials." Of these the Krupp works manufacture six standard sizes, whose calibers are equivalent to 5.91, 4.72, 4.14, 3.43, 2.95 and 2.76 inches. The weights of the shells used with them, including cartridge cases and driving charges, are 101 pounds (46 kilogrammes), 53 pounds (24 kilogrammes), 34 pounds (15.5 kilogrammes), 21 pounds (9.5 kilogrammes), 13 to 14.3 pounds (5.8 to 6.5 kilogrammes) and 11 pounds (5 kilogrammes) respectively. All of these will take shrapnel, and high-explosive shells are also used in the larger sizes. Similar guns and shells have been turned out by the Rheinische Metallwaaren & Maschinenfabrik (Ehrhardt) of Duesseldorf, Germany; by the Skodawerke in Austria and at the Genoa and Spezzia arsenals of Italy. In France, England and for Russian account similar provision has been made, but concerning the anti aerials of these nations the writer has no definite figures.

PENETRATING POWER REQUIRED.

For all of the shells above enumerated an invariable requirement is a certain standard of penetrating power or "perforation," which reaches the manufacturer translated into terms of hardness, toughness, etc., shown by physical and chemical analyses. To the ordnance expert, however, this is expressed as muzzle energy and velocity and the penetration of wrought iron or soft steel plate according to De Marres', Gavre's or Tresidder's formulæ. For armor-piercing projectiles the penetration test is made on Krupp armor steel or its equivalent by the Krupp, Ehrhardt or Davis formulæ. In comparing muzzle penetration tests on iron and steel not hardened, 1 inch thickness of steel is taken as the equivalent of 1¼ inches of iron, so that 10 inches penetration of iron plate would equal 8 inches through steel, and *vice versa*.

Other features of artillery rating which affect shell manufacture aside from caliber and penetration are the length of gun bore, total length of the piece, weight of the gun mounted and interior measurements which include the dimensions of the rifled section, powder chamber, etc., as well as the number of rifling grooves and twist in calibers. Muzzle energy is expressed either in meter-tons or foot-tons. One meter-ton (dinamode) is equivalent to 3.2291 foot-tons, and conversely 1 foot-ton equals 0.3097 meter-ton.

To take up all of these factors, in connection with the present article, will hardly be practicable; but the above will give an idea of the present range of shell production. The present war has demonstrated that there are in use to-day many more calibers than have been found either necessary or desirable; so that a natural process of selection will bring about their reduction to a few effective standards. Among these the calibers which seem most likely to survive are those which approximate 1.85, 2.24, 3, 4.7, 6, 7.6, 9.45, 12, 15 and 16.5 inches. Meanwhile, however, there will be considerable demand still for the 4.5 and 9.2 sizes and a limited need for 14-inch and other shells used for naval service.

The information contained in this article and the accompanying tables have been gathered by the writer gradually and over a considerable period of time beginning with notes made in Europe before the war in connection with gun lathe work. As an outline it is probably more comprehensive than will be found anywhere outside of army and navy bureaus and established ordnance plants.

Table of Medium to Light Gun Calibers Used by Various Nations

Calibers originally designed in millimeters	140	130	120	..	105 / 104	..	100	88	85	..	77	75	70	65	57	47	37
Exact metric equivalents of calibers designed in inches	..	127	119.3	114.3	..	101.6	..	..	..	83.5	76.2	..	..	..	..	..	..
Equivalents in inches of metric calibers	5.51	..	4.72	..	4.14 / 4.1	..	3.9	3.43	3.31	..	3.03	2.95	2.75	2.56	2.24	1.85	1.46
Calibers designed in inches	..	5	4.7	4.5	..	4.	..	..	..	3.29	3	..	..	..	..	..	..
Germany	..	5.1	4.7	..	4.1	..	..	3.43	3.31	..	(3.03)	2.95	2.75	2.56	2.24	1.85	1.46
France	5.5	5.1	4.7	..	4.1	..	3.9	..	3.31	..	..	2.95	..	..	..	..	..
England	..	..	4.7	4.5	..	4	..	..	..	3.29	3	..	2.75	..	..	..	..
Russia	..	5.1	4.7	4.5	4.1	..	..	3.43	3.31	3.29	3	2.95	..	2.56	..	..	..
Austria	..	5.1	4.7	..	4.1	..	3.9	3.43	3.31	..	(3.03)	2.95	2.75	2.56	These three light gun calibers, generally known as 6, 3 and 1 pounders, are in practically universal use.		
United States	..	5	4.7	4.5	..	4	3.8	..	..	..	3	2.95	2.75	..			
Japan	..	..	4.7	4.5	..	..	3.9	3.43	..	3.29	3	2.95	..	2.56			
Italy	..	..	4.7	..	..	..	3.9	..	3.31	..	..	2.95	..	..			
Sweden	..	5.1	4.7	..	4.1	..	..	3.43	..	..	..	2.95	..	2.56			
Holland	..	..	4.7	..	4.1	..	..	..	3.31	..	..	2.95	..	2.56			
Denmark	..	..	4.7	..	4.1	..	..	3.43	..	..	..	2.95	..	..			
Norway	..	..	4.7	..	4.1	..	..	3.43	..	..	3	2.95	..	..			
Greece	..	..	4.7	..	4.1	4	..	..	..	..	..	2.95	..	..			
Roumania	5.5	..	4.7	..	4.1	..	3.9	..	3.31	..	..	2.95	..	..			
Bulgaria	..	5.1	4.7	..	4.1	..	..	3.43	..	..	..	2.95	..	2.56			
Servia	..	..	4.7	4.5	4.1	..	..	3.43	3.31	..	..	2.95	..	..			
Turkey	..	5.1	4.7	..	4.1	4	..	3.43	..	..	..	2.95	..	2.56			
Spain	..	..	4.7	..	4.1	..	..	..	3.31	..	..	2.95	..	..			
Portugal	..	..	4.7	..	4.1	..	..	..	..	..	3	..	..	..			
Argentina	..	..	4.7	..	..	4	..	..	..	..	3	..	..	2.56			
Brazil	..	..	4.7	..	4.1	..	..	3.43	..	..	..	2.95	..	2.56			
Chile	..	5	4.7	..	4.1	..	..	3.43	..	..	..	2.95	..	2.56			
China	..	..	4.7	..	..	4	..	..	..	..	3	..	..	2.56			

Table of Heavy to Medium Calibers Used by Various Nations

Calibers originally designed in millimeters	250	240	235	..	210	..	195	190	..	170	165	..	150
Exact metric equivalents of calibers designed in inches	..	..	233.7	228.6	..	203.2	193	190.5	177.8	..	..	152.4	..
Equivalents in inches of metric calibers	9.84	9.45	9.25	..	8.27	..	7.68	7.48	..	6.7	6.5	..	5.91
Calibers designed in inches	..	..	9.2	9	..	8	7.6	7.5	7	..	..	6	..
Germany	..	9.4	..	..	8.3	..	..	7.5	..	6.7	..	..	5.9
France	..	9.4	..	..	..	..	7.6	7.5	..	6.7	6.5	..	5.9
England	..	..	9.2	..	..	*(8)	..	7.5	*(7)	..	..	6	..
Russia	..	*(9.4)	..	..	..	8	7.6	7.5	..	6.7	..	6	5.9
Austria	..	9.4	9.25	..	..	..	..	7.5	..	6.7	..	..	5.9
United States	..	..	*(9.2)	..	..	8	7.6	7.5	7	..	..	6	..
Japan	..	*(9.4)	9.2	..	..	8	7.6	..	..	6.7	..	6	5.9
Italy	..	9.4	9.2	9	..	8	..	7.5	..	6.7	..	6	..
Sweden	9.8	9.4	..	..	8.3	..	..	7.5	..	6.7	..	6	5.9
Holland	..	9.4	..	..	8.3	..	..	7.5	..	6.7	..	..	5.9
Denmark	..	9.4	..	..	8.3	..	7.6	7.5	..	6.7	..	..	5.9
Norway	..	..	9.2	..	..	..	..	7.5	..	6.7	..	..	5.9
Greece	..	..	9.2	..	..	..	7.6	7.5	7	..	..	6	5.9
Roumania	..	9.4	..	..	..	..	7.6	..	..	6.7	..	..	5.9
Bulgaria	..	9.4	..	..	8.3	..	..	7.5	..	6.7	..	..	5.9
Servia	..	9.4	9.2	..	..	..	7.6	..	..	6.7	..	..	5.9
Turkey	..	..	..	..	..	..	..	..	..	..	..	6	5.9
Spain	..	9.4	..	..	..	8	7.6	..	..	6.7	..	..	5.9
Portugal	..	..	..	..	..	8	..	7.5	..	..	..	6	..
Argentina	..	9.4	..	..	..	8	..	..	..	..	..	6	..
Brazil	..	9.4	..	..	..	..	..	7.5	..	..	..	6	..
Chile	..	9.4	..	..	..	8	..	7.5	..	..	..	6	..
China	..	..	..	..	..	..	..	7.5	..	..	..	6	..

*See text.

Table of Heavy Calibers Used by Various Nations

Calibers originally designed in millimeters	420	405	380	370	355	..	340	..	..	305	280	275	270	260	..
Exact metric equivalents of calibers designed in inches	419.1	406.4	381	..	355.6	342.9	..	330.2	317.5	304.8	279.6	..	..	..	254
Equivalents in inches of metric calibers	16.53	15.94	14.96	14.57	13.98	..	13.35	..	..	12.01	11.02	10.83	10.63	10.24	..
Calibers designed in inches	16.5	16	15	..	14	13.5	..	13	12.5	12	11	..	..	..	10
Germany	16.5	16	15	14.5	14	Not	..	..	..	12	11	..	..	..	..
France	..	..	15	..	14	in	13.35	..	..	12	..	10.8	10.6	..	..
England	..	..	15	..	14	use	..	..	..	12	..	..	..	..	..
Russia	..	..	..	..	14	..	..	..	..	12	..	..	..	..	..
Austria	16.5	16	15	..	14	..	..	..	..	12	11	..	..	10.24	..
United States	..	..	..	..	14	..	..	13	..	12	..	..	..	..	10
Japan	..	..	..	..	14	..	..	..	12.5	12	..	..	..	..	10
Italy	..	..	15	..	..	..	..	..	..	12	..	..	..	..	10
Sweden	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..
Holland	..	..	..	..	..	..	..	..	..	12	11	..	..	..	..
Denmark	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..
Norway	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..	..	12	11	..	10.6	..	..
Roumania	..	..	..	..	..	..	..	..	..	..	..	..	10.6	..	..
Bulgaria	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..
Servia	..	..	..	..	..	..	..	..	..	..	..	..	10.6	..	..
Turkey	..	..	..	14.5	..	..	..	..	..	..	11	..	..	..	..
Spain	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..
Portugal	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Argentina	..	..	..	..	..	..	..	..	..	12	..	..	..	..	10
Brazil	..	..	..	..	..	..	..	..	..	12	..	..	..	..	..
Chile	..	..	..	..	14	..	..	..	..	12	..	..	..	..	..
China	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Eye-piece for Use with Optical Instruments

In working with microscopes and similar optical instruments requiring only one eye, either the unused eye is closed, thus straining the muscles, or it is kept open and the vision is liable to become impaired. Although with practice there ceases to be conscious vision, since the brain is entirely concentrated on the impressions received from the working eye, the very suppression of the perceptions from the other eye may be injurious to the optical nerve, to say nothing of the useless expenditure of energy. These disadvantages are said to be obviated by a simple eye protector recently put on the market by Paul Altman of Berlin, described and illustrated in *Prometheus* (Berlin). It consists of two dead-black mussel-shaped disks carried on the eye-piece of the instrument, so arranged that either can be applied to one eye, leaving the other eye free to use the optical apparatus. The retina of the shielded eye is fully shielded from both direct and reflected light, so that the eye can rest without even the strain of holding its lid tightly closed.

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The Turquoise

And Its Supposed Medical Properties

By R. I. Geare

The turquoise has been employed medicinally from time immemorial and in widely distant lands. Dioscorides in the first century of the Christian era remarked, "It is believed by swallowing a lapis-lapuli that one is rendered immune for internal ulcerations. Besides this, it represses growths in the eyes, such as warts and pustules, and even glues together their broken membranes." These properties were ascribed later to turquoise, which Dioscoroides probably had in mind.

Writing in Latin about the beginning of the 13th century, Saxo stated that the turquoise had the quality of preserving the eyesight from external injuries when superimposed on the eyes. The same statement, substantially, was made by Albertus Magnus (1193-1280) in his work on minerals, who referred to the turquoise as follows: "This stone is of a golden yellow color, glistening and glowing as if milk had entered the golden yellow color and leaped back to the upper surface. It is neither clear nor of a loose texture. Moreover, they say it preserves sight and protects those wearing it from harmful accidents."

In an old Persian manuscript on precious stones occurs the remark that the "piruzeh" (turquoise) was regarded as auspicious on account of its name, which signifies "victorious" or "fortunate," and a famous Arabic botanist of the 12th century wrote: "The turquoise shines when the air is pure and becomes pale when it is dim. . . . It enters into the remedies of the eye. Triturated and administered as a potion, it is useful against the stings of scorpions. . . . It is given also for internal ulcerations."

In a work called the Mani-Mala (Tagore) occurs the following derived from the views of Arabian and Persian writers on gems: 'The turquoise cures all diseases of head and heart. By application over the eyes in the shape of Surmá, it increases their luster, prevents the fall of fluid therefrom, brings back the color of the pupils if they become white, and restores natural vision to those who are almost blind at night. It is a sovereign remedy for hernia, swellings, flatulence, dyspepsia, insanity and ulcers inside the stomach or abdomen. In combination with other ingredients it would relieve and cure the pains and swellings of the body caused by assault. Whether taken with other drugs or simply with honey, it has the power of curing the epilepsy, spleen, stricture, etc. In case of poisoning or snake bite, a durm or quarter tola weight, of turquoise should be given with wine; for scorpion bites a third of this quantity would suffice. But as the above prescription might cause harm to the stomach, it should always have added to it a quantity of Katita. Worn on the fingers as a ring, the turquoise brings about happiness of mind, dispels fear, insures victory over enemies, and removes all chance of being drowned, or being struck by lightning, or of being bitten by snakes or scorpions. He who, after looking at the moon in the first day after new moon (Pratipada) casts his eyes over this tone, becomes the master of fabulous wealth."

It is believed by the Persians that the use of the turquoise averts the effects of the "evil eye," and sometimes horses, camels and mules have beads attached to their tails, and a highly valued animal may even wear a blue necklace. They also believe that looking on a turquoise the first thing on waking insures prosperity and highly strengthens the sight during the whole day. They also regard it as having power to avert poverty, and Persian soldiers are said to prize it as a protection against contagion.

In the 16th century Gracia ab Horto wrote that in Mauretania, an ancient country of northern Africa, turquoise was employed medicinally, while in 1502 Camillus Leonardus, an Italian, characterized turquoise as follows: "Turchion, or Turchesia, is a yellow stone bordering on white, and if passed through milk, is of a yellow color. It is very agreeable to the sight and took its name from the country. There is a vulgar opinion that it is useful to horsemen, and that so long as the rider has one with him, his horse will never tire him, and will preserve him unhurt from any accident. It is said to defend him that carries one from outward and evil casualties." In Afghanistan it is believed that cataract in the eye may be cured if a turquoise set in a silver ring and dipped in water be applied to the part affected during the chanting of the name of the Almighty.

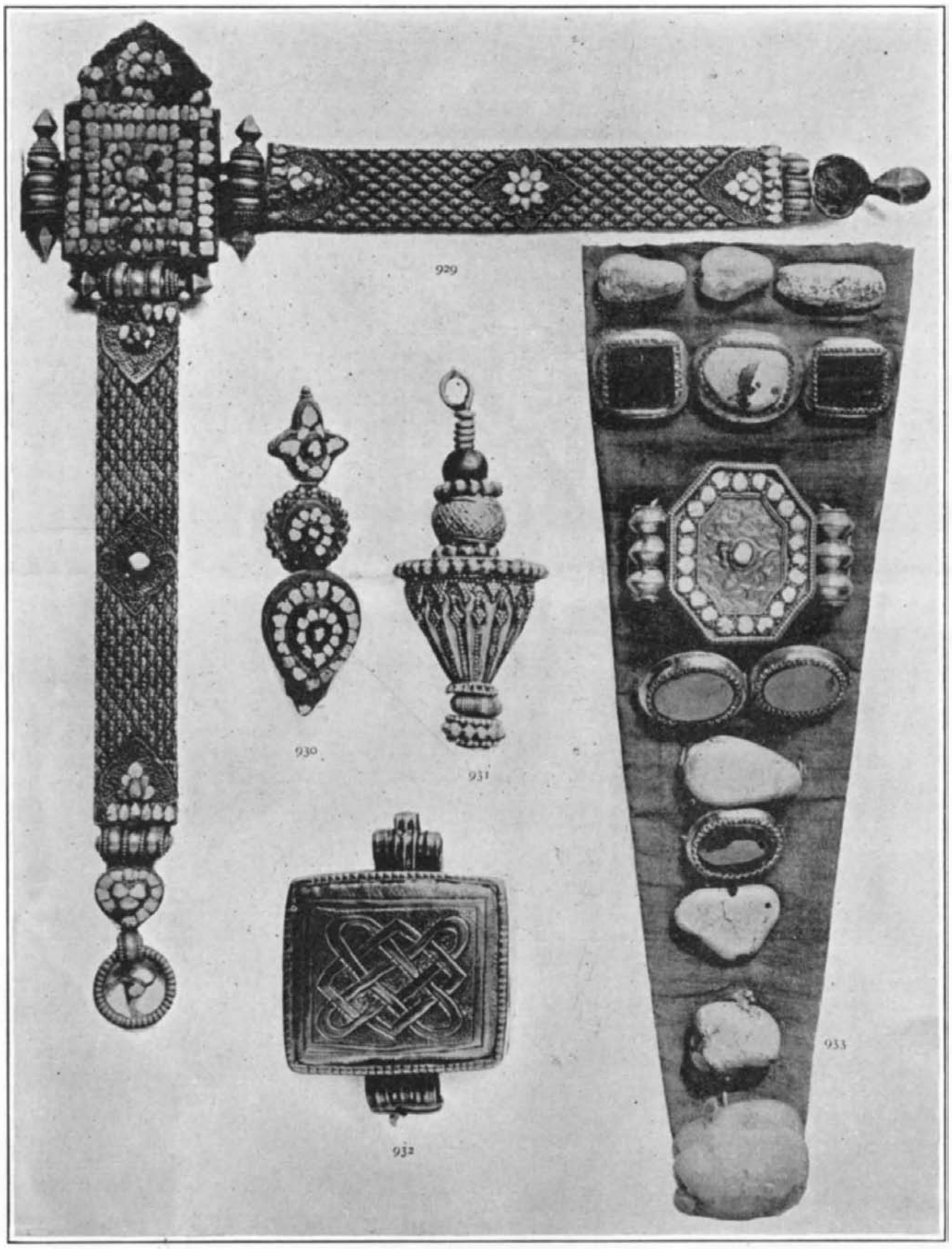
Aristotle, writing about the turquoise, said: "The turquoise is a stone with which the Kings of Damascus never failed to adorn their necks and hands and to employ for many other purposes because, among the great, the stone possesses the property of removing from its wearer the danger of being killed. . . . Furthermore, when reduced to powder it is of assistance in case of stings from scorpions and dangerous and venomous reptiles."

Probably it was during the Middle Ages that the turquoise came into greatest prominence and a remarkable array of medical properties was ascribed to it. On account of its changeability in color it was believed to possess wonderful powers of divination and was regarded as productive of good luck and efficacious in securing health and prosperity to the wearer. One writer in the Middle Ages remarked: "Other precious stones have lost all the marvelous powers that belonged to them for centuries; the emerald no longer relieves the fatigued eyesight; the diamond cannot now dispel fear; the sapphire, though cold to the touch, has ceased to be able to extinguish fire. . . . But the turquoise still retains its mysterious properties and flaunts them in the face of modern science." And another wrote: "The turquoise should be in the adornment of young girls so as to inspire them with good and sincere thoughts, because it possesses extraordinary virtues and miraculous gifts."

Eastern countries, however, have not a monopoly in ascribing curative powers to the turquoise. The Pueblo Indians of North America and the Apaches value this stone very highly, and their medicine men are almost always provided with turquoise stones or some other supposedly potent minerals. The turquoise is in many cases their badge of office and in olden times they could not exercise their medical functions without it. They assert that by fixing a small turquoise bead to a bow or a gun the weapon cannot fail to reach its mark. They also connect the turquoise with the power of compelling rain, and they believe it could always be found "at the end of a rainbow" after a storm by searching in the damp earth.

In Southern Arizona the Pima Indians believe that the loss of a turquoise is due to magic and that the loser will be afflicted with some mysterious ailment which will yield only to the skill of a medicine man, who, as a preventative, places another turquoise, a piece of slate or a crystal, in water and gives the remedy to the patient to drink.

The general reader may be interested in knowing that important productive deposits of turquoise occur only in Persia, Tibet, China, and Southwestern United States.



929, Waistband of silver set with turquoise and coral. Modern Indian. (Thibetan?) I. M. 519.—930, Earrings of brass and turquoises. Thibet. Cramer-Roberts collection, I. M. 10.—931, Head ornament, "Begah." Silver embossed. Nagode, I. M. 3462.—932, Amulet of brass and copper. Thibet. I. M. 1208.—933, Part of ornament for the back hair. "Parak." Rough turquoises, set and unset, with brass and turquoise amulet sewn on cloth. B. C.

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Plants From China.

Results of the First Plant Introduction Expedition Yields Promising Specimens

The third expedition into China to discover new plants suitable for introduction into the United States has been completed by the plant explorer of the United States Department of Agriculture, who has just returned to Washington after a three-year trip in the Far East. As a result of this expedition through the center of China, and two previous explorations covering extremely cold Manchurian regions and the arid regions of Chinese Turkestan, there have been sent to America for planting and testing for commerical adaptability, seeds, roots, or cuttings of some 3,000 food and forage plants, flowers, ornamental shrubs and vines, shade and timber trees. The previous expeditions brought to America specimens of many cold-resistant and dry-land grains, sorghums, soy beans, alfalfas, and forage plants, and also certain semi-tropical plants, such as the bamboo, which are now under experimentation to determine their usefulness for the extreme South.

Of the many specimens forwarded to this country during the last expedition, the specialists regard as most significant the jujube, a fruit new to this country, which may be suitable for use in the Southwest; a wild peach resistant to alkali, cold, and drought, the root system of which offers great possibilities as a grafting host; certain Chinese persimmons larger than any hitherto known in this country; a number of aquatic food roots and vegetables which offer promising possibilities for the utilization of swamp land; some thirty varieties of vegetable and timer bamboos; and a number of Chinese vegetables, bush and climber roses, shrubs, and trees.

Of scientific rather than commercial interest is the discovery on this expedition, near Hangchau, of a hickory tree, the first found in China. The existence of this tree, together with the facts that the sassafras and tulip trees are common in both countries and the Chinese tea box tree is closely related to the sweet gum of the South, confirms the fact that the flora of the southeastern United States and that of sections of China are closely related. Another discovery of botanical interest was the finding in a remote and hitherto unvisited valley in Tibet of a hazel tree 100 feet high—a surprising departure from the hazel bush. Elsewhere English walnuts were discovered in a wild state; and the discovery of the wild peach is regarded as significant because it seems to establish that the peach may have been a native of China rather than of Persia, to which its origin has been ascribed. The discovery of native and hardy oranges and other citrus fruits, a number of which have been brought to this country for breeding work, give added evidence that China was the home of the orange, which was introduced into other countries probably by early Portuguese travelers. Similarly many plants commonly ascribed to other countries, such as the wistaria, chrysanthemum, lilac, azalea, and certain peonies and rambler roses, have been developed by the Chinese, although, because they reach Caucasian use through other nearby nations, their Chinese origin often has been overlooked.

The first or experimental exploration for new plants in China in 1905 was undertaken by the department because the wide range of climate, rainfall, elevation, and soil conditions in that immense country gave promise that the Chinese, who had been farming successfully in some sections for about 4,000 years, might have found solutions for special difficulties which confronted American farmers in regions of excessive cold, or drought, or alkaline or swampy soils.

The investigators quickly found that China also offered a particularly fertile field for plant introduction work because for many centuries the Chinese farmers, in a crude way, had been selecting seeds and developing improved varieties now ready for commercial use in the United States. In many cases all that is needed is to bring the seed or plant to this country and use it, although in other cases, inasmuch as Chinese methods rarely produce pure strains, some further seed or plant selection is necessary to obtain constant varieties.

To locate these special varieties, however, it is necessary for the explorers to visit not merely individual villages but even to study single farms. There are no seed stores in China and no mechanism for extending the use of improved varieties. Superior varieties grown on one farm often are not used on adjoining farms, and are unheard of ten miles away. The farmer who develops an improved variety guards it jealously and gives seeds or cuttings or scions only to his immediate relatives. In the case of fruits, the Chinese farmer is averse to spraying or other treatment for diseases, largely because his ancestors have never done this, and the adoption of modern methods would be considered irreverent. As a result, excellent varieties which are traditional or mentioned in Chinese literature have either disappeared completely, or are to be found only on isolated farms. A striking example of this is the fact that the section around Shanghai even forty years ago was famous for a special kind of peach, although to-day this variety has completely disappeared.

In the last trip the explorer penetrated through the center of China 1,500 miles on foot to the borders of Tibet and returned to the coast by a different route. On this expedition he covered territory the agricultural conditions of which are very similar to those of the southern Rocky Mountain regions and portions of the Great Plains.

In this territory the most important discovery probably was the jujube tree, which bears a heavy crop of a brownish fruit, which is delicious when fresh and when dried offers a confection very similar in taste to the Persian date. This tree is of particular interest to the department because it can withstand cold and drought

Head ornament of red cloth, adorned with rough turquoises and turquoise charm box, worn by women of Laddakh.

and neglect. The section in which it is productive in China is a semi-arid belt where winter temperatures do not go much below zero Fahrenheit. This indicates that it would be of particular value to Texas, California, New Mexico, Arizona, southern Utah, and perhaps even farther north. Already several thousand seedlings have been grown at the Plant Introduction Garden at Chico, Cal., from the specimens sent to this country, and some of these have borne desirable fruit, which confirms the experimenters in their belief that this tree may contribute a new fruit industry to the sections indicated.

The wild peach discovered in China, and now brought to this country for the first time, is considered of great interest although its fruit is not desirable. Investigation in its native habitat showed that the roots of this plant are not as susceptible as our native peach to alkali in the soil, while it will withstand cold and does not require much moisture. Experiments are under way, therefore, to determine the usefulness of the rootstock of this peach for grafting with different hardy American varieties. If success is achieved, the specialists believe that they can develop peach trees which will make possible the raising of peaches in the Southwestern or alkaline sections, and at the same time offer possibilities of peach cultivation in many droughty and cold regions, and possibly even into portions of Iowa beyond the northern edge of our present peach region.

Of special interest also are the collections of aquatic food plants secured in the recent expeditions. These include water chestnuts, water nuts, and a number of aquatic bulbs, as well as the water bamboo. The Chinese, the explorer found, have mastered through centuries of experiments the process of using swamp lands for the raising of food crops, and their success is believed to point to commercial possibilities for some of our swamp regions where reclamation by drainage is not practicable. Whether the American farmer would ever be willing, however, as a commerical enterprise, to grow crops which call for cultivation in water waist-deep is, the specialists admit, open to question.

The kauba, sometimes called wild rice or water bamboo, now to be made the subject of experiment, is a vegetable in taste somewhat between grass and asparagus. The swollen stalks of the plant are eaten much like our asparagus. The ordinary bamboo, contrary to the prevailing opinion, is not an aquatic plant, and for successful cultivation calls for fertile and well-drained soil.

In selecting Chinese vegetables for introduction the explorer was greatly limited by the fact that many articles favored by Mongolian palates would be unpleasant to Caucasians. He has sent over, therefore, only those things which promise to add valuable vegetables or fruits to the American table, and also which fit in with a general plan for the introduction of certain food crops which will find a ready market among our Chinese populations. The Chinese, in many cases, are importing large quantities of favorite native foods in canned or dried form from China because they find difficulty in getting them in a fresh state in our larger cities. Some of the vegetables brought over which promise to find a dual market are a number of varieties of vegetable bamboo and improved varieties of pe tsai, the odorless Chinese cabbage, some kinds of which already are on sale as "celery cabbage" in American markets. This cabbage is suitable for cooking or for cold slaw and can be grown wherever ordinary cabbage is raised. A vegetable novelty now under experiment is a Chinese radish with a root as large as a child's head. This is somewhat coarser and inferior in flavor to the small radish, though the Chinese cook it much like turnips, and also pickle it in strips in brine for use as a relish.

This and other explorations have given to this country a Chinese cherry, very successful in California because of its early maturity; and a number of varieties of wild pears and apples, wild almonds, and hardy citrus fruits which offer possibilities for hybridization with American varieties.

The explorer also brought over specimens of the Chinese pistache tree, which it is hoped will give the United States a new and valuable tree for the adornment of city avenues in Georgia, Alabama, the Carolinas, Florida, Texas, California, Arizona, and Oregon. Plantings were also secured on this trip of a Chinese white pine tree remarkable for its white bark. Because of its drought-resisting qualities, this strikingly ornamental tree offers possibilities for the beautification of parks and grounds in Arizona, Texas, New Mexico and California.

Especial attention was given on this trip to investigations of chestnut blight, which was found by the explorer first in China and later on in Japan. In the eastern United States this blight appears in virulent form and is exterminating our beloved chestnut. The explorer, however, found Chinese chestnut trees which were to some degree blight resistant. Many of these trees had suffered from the disease but had apparently recovered from severe attacks and succeeded in covering the old scars with new wood.

To lovers of flowers the new Chinese rose known as the *Rosa xanthina* should be of special interest, particularly in view of the fact that there is at present a great demand for yellow roses. This bush has small, light yellow flowers, but its great quality is its hardiness, which will enable it to flourish in the North even as far as Canada The chief promise of this rose, however, lies in the fact that it will in all probability lead to the production of new hardy types of yellow roses adapted to cultivation in America. It may produce varieties which will not drop their leaves as our Persian yellow roses do, and yield varieties with larger and more showy flowers. In addition the explorer found a number of new rambler roses, particularly certain yellow ramblers which, if locally successful, will meet a demand for a climbing rose with a flower differing in shade from the crimson and pink flowers of the well-known rambler varieties.

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Babylonian Cosmology*

Early Groupings of Humanity After An Explanation of the Mystery of Being

By Hector Macpherson, M. A., F. R. A. S.

From the earliest ages the human mind has been confronted by the great questions presented by the natural world—the earth, its nature and origin—and the outer universe—its structure and origin. The name of the first actual student of Nature must remain forever in obscurity. It is tolerably clear, however, that astronomy is the oldest branch of science, because the heavenly bodies are the most prominent of natural objects. The early students of Nature must have noted the phases of the moon and the fact that the starry skies presented different aspects at different seasons. Later men must have observed that the sun itself did not remain fixed in position, but varied in its altitude above the horizon.

Probably this kind of knowledge grew up in various countries simultaneously. There are traditions of early astronomers and astrologers in China, in India, in Egypt and in Babylon; for early astronomy was inextricably mixed up with astrology and religious ceremonial, and thus the priests of the ancient religions were in many cases the pioneers of astronomical observation.

An observant study of Nature, however, is almost invariably accompanied by what is called a cosmology or world-concept. The mind of man, even in primitive conditions, is not content with mere appearances; it desires to know things as they are, and to penetrate behind the veil of appearances. The human mind ever seeks a world-concept. Thus, even in very primitive times, men formulated theories of the natural order and of the relation of the earth, our dwelling-place, to the outside world as a whole.

Every ancient people has its cosmology, or concept of the order of the world, and accompanying this, its cosmology or theory of the world's origin. That these early ideas were crude and fantastic is not to be wondered at; they are interesting as illustrating the first groupings of humanity after an explanation of the mystery of being.

Among early peoples, as the late Prof. Pfleiderer points out, "cosmology is at the same time theogony." We might also say that cosmology is at the same time theology, for if not quite identical, the two were inextricably connected. To the ancients Nature was full of deities. There were gods of land and sea, gods of sun and stars, gods of storm and tempest. Both religion and service were born of a crude cosmo-theology, largely the product of wonder and fear—wonder at the marvels of external nature and fear at its caprices and vagaries.

The closeness of the connection between early cosmology and theology is obvious when we consider the influence of climate on early religious cults. We find the sidereal cult in countries like Babylonia, India and Egypt, where the skies are clear and the brilliant stars force themselves on the attention of mankind. In the words of Prof. Cumont: "Every sidereal cult, properly so-called, was originally foreign to the Greeks as to the Romans—a fact which undoubtedly proves that the common ancestors of the Italians and the Hellenes dwelt in a northern land, where the stars were frequently concealed by fogs or obscured by clouds. For them nearly all the constellations remained a nameless and chaotic mass and the planets were not distinguished from the other stars. Even the sun and moon, although they were regarded as divinities, like all the powers of Nature, occupied but a very secondary place in the Greek religion."

In Babylonia, as in Egypt and India, science and religion were almost inextricably mixed, fused in a popular mythology. As Pfleiderer points out, "Among the eastern Semites of Mesopotamia, the Babylonians, or Chaldeans and Assyrians, the old Semitic star-worship was mixed up with the more naturalistic beliefs of the original inhabitants of the land, now generally distinguished by the name of Accadians or Sumerians. From the intermixture proceeded alike the mythology, the *cultus* and the art of the Babylonians."

In the old animistic worship, animals, plants and stones, rain, winds and storms were regarded as divine, while the Semites worshiped the stars, which they were thus compelled to study closely. The Babylonian priest-astronomers devoted themselves first of all to the measurement of time and the distinction of the planets and the stars. On a tablet, dated 539, is to be found the relative positions of sun and moon, calculated in advance. The conjunctions of the moon and planets and of the planets among themselves, and the zodiacal positions of moon and planets are noted with their exact dates. These planetary bodies were always in some way or other associated with the divinities whom the priests worshiped.

In the Babylonian system of divinities, the five gods of the planets were combined with two triads of deities, which correspond with the upper world, the middle world, and the under world. Above all, supreme over the other gods, was the Lord of Lords, the "Bel Beli," who was also known as "Ilu," "the god." The star gods were also prominent in the local cultus of the town of Babel. These were Naba (Mercury), the god of revelation and priestly wisdom; Nergal (Mars), the god of war; Merodach (Jupiter), the lucky or propitious star; and Istar or Bilit, the Hellenic Venus, goddess of fertility and also of death.

From this connection between planets and gods arose the Babylonian system of astrology. Of all natural objects, the Babylonians ascribed a chief influence to the stars. This is not to be wondered at, for the stars in the clear air of Syria and Mesopotamia shine with a brilliance quite unknown in western lands. The brilliant stars and the even more brilliant and at the same time mysterious "planets," or wanderers, filled these Oriental peoples with a sense of superstitious awe. Hence arose the astrology of the Babylonians. The priestly astronomers because pre-eminently astrologers. As Schiaparelli truly remarks, "the tendency which dominates the whole Babylonian astronomy as to discover all that is periodic in celestial phenomena and to reduce it to a numerical expression in such a manner as to be able to predict its repetition in the future." Hence, astrology and religion remained in the closest union among the Babylonians. Theology and cosmology—and therefore theogony and cosmogony—were closely intermixed.

The Babylonian cosmology consists of speculations as to (1) the present state of the world and (2) how the world came to be.

In regard to the constitution of the world, the Babylonian conception did not differ much from those of other primitive peoples. The heaven was believed to be a solid vault, whose foundations rested on "the deep" (âpsu), on which the earth also rested. Higher than the vault of heaven were the "upper waters," while higher still was the dwelling of the gods, "the interior of the heavens." From this celestial house the sun emerged through a door in the morning and into the same house he passed in the evening, through another door. The earth itself was supposed to be a huge mountain, of which the under portion was hollow. In the east is the mountain of sunrise and in the west the corresponding mountain of sunset, while in the north is an unknown and mysterious country. Inside the earth, above the hollow central portions, is the abode of the dead, the entrance into which lies toward the west. Finally, between the vault of heaven and the crust of the earth, are the waters of the eastern and western oceans, which, along with the southern ocean, form part of the deep or the "âpsu."

The conception of the deep played a very important part not only in Babylonian cosmology proper, but in cosmogony as well. The culture of primitive Babylonia, as Prof. Sayce has pointed out, radiated from two chief centers, the sanctuary of Nippur in the north and the seaport of Eridu in the south. The former was an inland sanctuary, while the latter was on the coast, and, as Sayce remarks, "what I may term the geographical setting of the two streams of culture varied accordingly." The great temple at Nippur was known as "E-kur," the "house of the mountain land," while Eridu was the home of Ea, the "god of the deep." In the cosmogony of Eridu, water was the origin and source of all things. The solid earth itself was believed to have sprung from the deep. The deep, however—subject to the scheme of things presided over by the gods of light—was no mere chaos in which there was no law. "Chaos," it is true, was the designation of a lawless realm. But the conception of the "chaos of Timiat" belongs, in the opinion of Sayce, to the cosmogony of Nippur. "The world of Nippur was a world from which the sea was excluded; it was a world of plain and mountain and of the hollow depths which lay beneath the surface of the earth. . . . The earth and not the water would have been the first in order of existence. . . . In the chaos of Timiat, accordingly, I see the relics of a cosmology which emanated from Nippur and was accepted wherever the influence of Nippur prevailed." The two conceptions, so obviously antagonistic, belong to separate schools of thought. They were destined to become considerably modified in the course of time. Merodach was the god of the city of Babylon and he took the place of Ea as the creator. The early cosmology of Nippur was afterward blended with that of Eridu and, as a result, again to quote Sayce, "there are two creations, the first chaotic, the second that of the present world."

The Babylonian Epic of Creation, which has attracted so much attention in recent years on account of its similarity, real or supposed, to the creation story in the Book of Genesis, is a combination of these two legends by a much later writer. First, there is a struggle between Timiat, the dragon of darkness, and Merodach, the god of light, resulting in the victory of the latter and symbolizing the triumph of the forces of order over chaos, of creation over the void, of law over anarchy. The victory over chaos was only the beginning of creation. The gods of the triad—Anu, Bel, and Ea—were given particular positions in the heavens. Next comes the creation by Merodach of the heavenly bodies.

> "He prepared the stations of the great gods;
> The stars corresponding to them he established as constellations.
> He made known the year and marked out the signs of the zodiac.
> Three stars he assigned to each of the twelve months.
> From the beginning of the year till its close
> * * * * * *
> He made the moon appear, illuminating the night."

Generally, it was believed that the account of the creation of the heavenly bodies was followed by an account of the creation of the animal world, but Zimmern thinks that it belongs to another story, in which not Merodach, but "the gods" collectively, exercised the functions of creation.

Another account of the creation was discovered by an English scholar, Mr. Pinches. This legend, which is believed to go back to Sumerian times, emanated from the temple at Eridu, and is less complicated than the Epic of Creation. It has certain points of resemblance to the second account of the creation in Genesis; in another fragment the analogy is still more striking. The story is distinctly parallel to the Biblical account of Adam and the Fall.

The Epic of Creation itself is a comparatively late production. It is the final word of Babylonian thought on the origin of things and is distinguished by the three principles underlying the cosmology and cosmogony of Babylonia. These were: (1) The belief in water as the primal element, (2) the conception of a lawless chaos from which the world has been rescued as a result of the conflict of light and darkness, and (3) the conception of generation as the chief creative force.

Interesting in itself, the Babylonian cosmology is still more interesting when viewed in relation to the Hebrew cosmology and the early philosophic conceptions of Greece. Widely as the Hebrew and Greek races differed in their essential characteristics, widely different as were the ultimate forms of their cosmological speculations, they both betray affinities to the Babylonian world-view. Whether the creation story in Genesis is derived from the Babylonian account or whether both are derived from an earlier document does not concern us here; but the similarity between the two is by no means accidental. On the other hand, Babylonian thought exercised a great influence on early Greek speculation. Thales, the founder of Greek philosophy, fixed on water as the primary substance of the universe. From Babylonian science, then, Greek and Hebrew thought drew a certain degree of inspiration.

* *Popular Astronomy.*

Testing Insulation

The voltage which is sufficient to puncture solid insulations varies greatly with the time of application, and this is principally due to the heating effect, says a writer in the *General Electric Review.* Breakdown tests can be carried out on three methods: (1) The voltage may be rapidly raised till breakdown takes place; (2) it may be varied more slowly at intervals of a minute; or (3) it may be varied still more slowly at intervals of an hour. Thus with varnished cloth 3 millimeters thick, between 10-centimeter metal disks with rounded edges, the "one minute" dielectric strength is 12.5 kilovolts per millimeter; the rapidly applied voltage gives 26 kilovolts per millimeter. The apparent strength of an insulation varies greatly with its thickness, and the best results are obtained with laminated insulations, as weak spots are likely to be less dangerous. There are also with factors to be considered such as operating apparent, temperatures, permittivity, etc.

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The Buoyancy of Zeppelins*

What is the Function of the Ballonet?

It is to be admitted that both on the construction and on the handling of Zeppelins successful secrecy has been maintained in many respects, and that an authoritative statement as to the precise function of the ballonets inside the gas chambers is, so far as we can discover, not within our power to quote. It is, of course, generally known that one of the functions of the ballonets is to keep the gas chambers constantly distended to their full extent without incurring either a loss of gas or excessive stress in the envelopes of the gas chambers. If the gas chambers are filled and closed before the start, then when the vessel has risen in the air the lessened atmospheric pressure outside the gas chambers, coupled with the ground-level atmospheric pressure inside, may severely stress the material of which the envelopes are composed. Ordinarily, this would be avoided by deliberately allowing some of the gas to escape. On coming down again the increasing external atmospheric pressure tends to overcome the now reduced internal pressure, and so causes the gas chambers partially to collapse. In each chamber of a Zeppelin there is a ballonet, which at will may be blown up or deflated. It is wholly or partially charged with air before the start. To meet the increased pressure in the gas chamber due to an ascent, some or all of the air is allowed to escape from the ballonet until the extension of the gas volume allows the gas pressure to fall to the external value. On descending, the ballonets are once more blown up by air to the required degree to prevent the gas chambers from partially collapsing.

There is every reason, however, to believe that the gas pressure in a Zeppelin is always maintained at some pressure above the atmospheric. A suitable fabric capable of withstanding such pressure and at the same time giving the requisite degree of imperviousness has, if we can trust Count Zeppelin's own words, been discovered, and is in use. By using a pressure greater than that of the atmosphere the density of the gas is, of course, greater than it need be, so that the lift obtained per cubic foot is proportionately less. There are, however, certain compensating advantages in the use of a super-atmospheric pressure in the gas which compensates for this drawback.

Under these conditions the ballonets must obviously be connected to the delivery of a fan or a compressed air flask or other source of the requisite super-atmospheric air pressure.

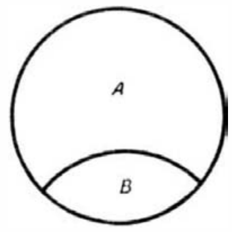
We have stated that there is ground for believing that super-atmospheric pressure is employed in the gas chambers of Zeppelins. An interesting piece of evidence on this point is directly available. A cubic foot of air weighs 0.08071 lb. and a cubic foot of hydrogen 0.00562 lb., both at 0 deg. Cent. and 76 cm. pressure. The net lift obtained from a cubic foot of hydrogen is thus the difference of these two numbers, or 0.0751 lb. Now, according to Herr Dornier, Count Zeppelin's engineer, the designers reckon on a buoyancy of only 0.0686 lb. per cubic foot of gas. In other words, the density of the gas used is 0.08071 — 0.0686, or 0.01211 in lb. per cubic foot—a little over twice the normal density of hydrogen. The pressure used, it may be hazarded, is therefore about twice that of the atmosphere. There is a little doubt in this matter, for we are not sure that Herr Dornier's figure is taken from the standard basis of temperature and pressure. The point, nevertheless, affords interesting evidence.

It may be incidentally remarked here that the figures given above are sufficient to show that the "marvelous tales of new German gases half the weight of hydrogen," to which our correspondent refers, cannot influence anyone of the least importance or intelligence. With hydrogen at atmospheric pressure the lift obtained is 0.0751 lb. per cubic foot, as stated above. If an absolutely weightless gas or a vacuum were used the lift obtained would be equal to the weight of a cubic foot of air, or 0.08071 lb. The increase of lift would be only 7 per cent or so. For a gas half the weight of hydrogen it would only be about 3½ per cent.

We have also stated that there are certain advantages in using super-atmospheric pressure in the gas which may be held to compensate for the loss of lifting power involved—a loss amounting on the above basis to some 9 per cent. These advantages relate to the control of the vessel during flight, and are dependent upon the fact that it is within the power of the navigator to pump air into or extract it from any or all of the ballonets at will.

To make the principle involved in this matter clear, consider a closed spherical balloon divided internally into two chambers by a collapsible partition. Before starting let us pump gas into the upper chamber until the whole sphere is filled with gas at a pressure a little in excess of the atmospheric. Now blow up the lower chamber to its full or a fraction of its extent with air. As this is being done the pressure in the gas, of course, rises. At the end of the operation the gas and air will have reached a common pressure, say, for example, twice that of the atmosphere.

It is in some such condition as this that, according to our way of thinking, a Zeppelin sets out on its journey across the North Sea to raid us. Let the weight of air displaced by the whole sphere in the figure be W_s. Let the weight of compressed gas in the compartment *A* be W_g and of compressed air in the compartment *B*, W_a. Then the buoyancy of the sphere at the beginning of its journey is $W_s - W_g - W_a$. Suppose that through the



accumulation of a snow load or of condensed moisture or from other cause, it is necessary on the journey to increase the buoyancy of the sphere without entailing a descent to a lower level. The navigator under these conditions can release the compressed air in the ballonet to the required extent. If he releases it wholly the gas will refill the whole of the sphere. Its volume increases and its density decreases. Its weight remains constant. The buoyancy of the sphere becomes $W_s - W_g$. It has been increased by the amount W_a, represented by the weight of air originally pumped into the ballonet. Put in the briefest way possible, air ballast is used instead of sand ballast.

It is clear that there being no additional load in the matter the ballonets give the navigator the power of suddenly increasing his buoyancy and so rising quickly to escape his enemy's defenses. The analogy in this respect with the submarine and its ballast tanks for diving purposes is very complete and obvious. It is further to be remarked that by emptying or filling the ballonets forward or aft as required the navigator has at his command a means of steering his vessel in the vertical plane. For by working them independently he can increase or decrease the buoyancy of his ship at the forward or after end to suit his needs. This is not a fantastic suggestion. It is the principle adopted both by Parseval and by Major Gross. Of course, the Zeppelin is provided with vertical rudders, and possibly still with water ballast tanks, but it may be suggested that these are merely used to correct small departures from the fore and aft trim which it is desired to maintain, and that the ballonet method is used to increase the facilities for maneuvering in the vertical direction. There is no reason why both methods should not be provided on the one ship, just as both trimming tanks and hydroplanes are provided on a submarine.

The question may be asked: Could ballonets of a reasonable size be used in the manner indicated to give a reserve buoyancy of any amount worth mentioning? A cubic foot of air at twice the atmospheric pressure weighs 0.1614 lb. To secure a reserve buoyancy of a ton, therefore, by the ballonet method there must be provided ballonets having a capacity of 13,880 cubic feet. The gas capacity of the "Sachsen"—a Zeppelin built just before the war—is 734,550 cubic feet, more than fifty times the ballonet capacity indicated as required. There is reason to believe that the ballonets fitted have capacities considerably in excess of a fiftieth of the gas volume, and that they are somewhere in the neighborhood of a tenth. Obviously, then, a very considerable reserve buoyancy can be obtained by means of the ballonets, and still leave them partially inflated, so as to exercise their normal function after the full reserve buoyancy is in use.

It must be remarked in conclusion that reserve buoyancy is essential if a balloon or dirigible is to fulfill any practical purpose. In a balloon, of course, it is obtained by taking ballast on board at the start and dropping it overboard as required on the journey. Such a method, in the words of a German authority, Colonel Hoernes, "is too crude and primitive to be followed in the case of a dirigible. And," he adds, "even if the method is to some extent applicable to the dirigible in a modified form, it should, nevertheless, only be used during the last part of the journey in landing," for "otherwise it will greatly curtail the length of the journey." The method is open to two other objections. First, ballast of the sand bag or water type once discharged cannot be recovered as may be required at some later stage of the journey. Secondly, sand bags dropped from Zeppelins flying over hostile country would give the alarm and lead to the detection of their presence and of the route being followed before they reached their objective. To neither of these objections is the ballonet method open. The ballast used is simply the medium surrounding the vessel.

* *The Engineer.*

The Molting of the King Penguin

At a recent meeting of the Royal Society of Edinburgh a joint communication on "The Molting of the King Penguin" was submitted by Professor Cossar Ewart and Miss Dorothy Mackenzie. The penguins form an order of divers which has for countless ages inherited the Southern Ocean. In Miocene times there were penguins in the vicinity of Patagonia, which probably closely resembled the modern king penguin (*Aptenodytcs Patagonica*), and in Eocene times there were giant penguins in the areas now occupied by New Zealand and the South Shetlands. Huxley thought the penguin from the limestone near Otago was 4 or 5 feet in height, and the extinct South Shetland species is said to have been as tall as a man, twice the size of the living emperor penguin. About the ancestors of these ancient penguins nothing is known. They may have sprung from the same stock as the large but almost wingless diver hesperornis, of the Kansas cretaceous deposits, and have as their remote ancestor the lizard-tailed archæopterryx found on rocks, deposited some millions of years ago in Bavaria. But all that we can say in the meantime is that penguins are probably descended from their ancestors with functional wings.

Penguins differ from all modern birds in their wings, in the arrangement of the contour feathers, in the way they molt, and in their habits and behavior, more especially during the breeding season. In the great northern diver there are wing quills or flight feathers attached to the bones or the hand and forearm. In the penguin there are neither wing quills nor wing coverts; moreover, in penguins the digit corresponding to the middle finger of man is longer than in any other bird. In ordinary birds there are feather tracts, separated by featherless spaces; in penguins, the feathers are arranged in transverse rows, and clothe the whole body, leaving no bare spaces. If the scales of a lizard were converted into feathers they would agree very closely in their arrangement with the feathers of the penguins.

The young of some flying birds are quite naked when hatched, others have a coat of down, which is, as a rule, soon displaced by the adult plumage. The ringed penguin has first a coat of white, silky down, then a coat which looks more like hair than feathers, and eventually this gray fur-like second down coat is exchanged for the adult coat. A first down coat has not yet been found in the king penguin, but there is a well-marked coat of brown hair-like down, which lasts for six or more months, and may reach a length of from 1½ to 3 inches. As long as the down persists the young penguin never enters the water. This implies that for six, it may be for eight or ten, months the fledgling requires to be regularly fed by the parents or other members of the community.

When the molting begins, the withered and often matted down feathers are rapidly shed. How long the shedding of the down takes in the case of the king penguin under normal conditions has not yet been determined. In the case of a year-and-a-half old bird in the Scottish Zoological Park, the whole of the adult coat was got rid of in ten days. Three or four weeks before the molting set in, the bird was out of sorts and off color, but as soon as the shedding of the feathers started the health improved. During the ten days of molting the penguin avoided entering the water, and could not be induced to take any food.

A few days before the molting actually begins, the bird expands until it seems to have twice the girth it had before. This increase in size is mainly due to the old feathers being raised until they form a nearly right angle with the new feathers to which they are still attached, and by which they are being rapidly displaced. The old feathers, owing to their being attached to the sheaths investing the new feathers, do not readily fall off, the most of them are rubbed off by the beak or the feet. The feathers seem to be shed in nearly the same order as the scales of lizards. The first to disappear are the tail quills, then the feathers from the lower part of the breast and the under surface of the wings; next, from the upper part of the breast and the outer surface of the wings. On the fourth day the back is looking very untidy, and by the eighth day the greater part of the back is clear of old feathers. On the ninth day one especially notices that the old feathers form a nearly complete collar round the neck, above and below which are tufts of various sizes. By the middle of the tenth day only a fragment of the collar is left, and on the morning of the eleventh day, with the exception of three belated feathers on the head, the molt was complete. The new coat having been acquired, the appetite gradually returned, but for the first few days the penguin seemed to obtain more satisfaction from swimming or diving, or quietly floating on the surface of its pool, than in gratifying hunger.

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Surface Combustion*

Some Recent Experiments on a Valuable Method of Heat Production

By L. J. Bradford and C. D. Corwin

The phenomenon of surface combustion was first observed by Davy in 1823 and discussed by Graham, Faraday and Dulong. No satisfactory explanation was reached, and the matter was dropped with no practical results attained.

There are two kinds of combustion—homogeneous, taking place throughout the system as a whole, and heterogeneous, occurring in layers in contact with an incandescent surface. The latter is the more rapid and is the kind present in surface combustion.

It has been found that all hot surfaces accelerate combustion, the extent of their action being dependent on the temperature and the character of the surfaces. The surfaces should be incandescent. Surface combustion itself is accelerated by first putting the surface in contact with the gas to be burned. If it is brought into contact with oxygen first, the combustion is retarded.

A practical system of surface combustion has been devised by Wilson and Mathiesons, Leeds, England, but it does not seem to have been much used. There seems to be no good reason for its use not being more general, as the meager literature published on the subject mentions many advantages and few disadvantages.

CATALYSIS AIDS COMBUSTION.

In his experiments Sir Humphry Davy noticed that a mixture of two gases that would ordinarily unite only at a high temperature could be made to combine at a much lower initial temperature by passing them through platinum sponge. He also found that if a mixture of oxygen and hydrogen was passed over finely divided platinum or through a platinum sponge, it would ignite, even though both gases and the platinum were initially at room temperature. The platinum did not take part in the chemical reaction, but merely caused the two gases to combine at a temperature below that at which they would normally do so. This action is known as catalysis. No satisfactory explanation of catalysis has ever been given, though there seems to be reason to believe that it is due to the catalytic agent ionizing the atoms of the gas adjacent to its surface and thus hastening combustion. It has also been found that all surfaces act more or less as catalytic agents and that their power increases with their temperature. For example, combustion is materially assisted when a mixture of gas and air is forced through an incandescent porous substance. The combustion becomes flameless and takes place much more rapidly than it would under ordinary conditions. Apparently, all combustion occurs on the surfaces of the granules composing the porous material, and hence the name "surface combustion" has come to be applied to this form of combustion. It is characterized by an absence of flame, high temperatures and remarkable efficiency, complete combustion being obtainable with practically no excess of air.

It is only within the last decade that surface combustion has been applied to industrial purposes, and as far as can be ascertained, only two men have conducted any work looking toward its utilization; namely, C. E. Lucke in America and W. A. Bone in England.

Bone's efforts have been directed principally to applying surface combustion to industrial apparatus, notably boilers and crucible furnaces. His first device consisted of a diaphragm, Fig. 1; a mixture of conbustible and air was introduced at *A* and passed through a plate of porous firebrick which formed the face of the diaphragm. It was found that all the burning took place in the outer ¼ inch of the plate, that it was flameless, and that when using coal gas a temperature of 800 deg. Cent. (1,472 deg. Fahr.) could be obtained. Fig. 2 shows a typical crucible furnace using surface combustion. With such a furnace Bone attained a temperature of 1,880 deg. Cent. (3,416 deg. Fahr.).

Fig. 3 shows an experimental boiler to which Bone had adapted surface combustion. The tubes were plugged at one end with a fireclay nozzle having a ¾-inch hole for the introduction of the mixture of gas and air. The remainder of the tube was filled with broken firebrick. Gas and air were supplied in quantities theoretically correct for complete combustion, and under a pressure of 17.3 inches of water, 99.6 cubic feet of gas at 760 millimeters (30 inches) Hg and 15 deg. Cent. (50 deg. Fahr.) was used per hour. The boiler was lagged so as to make the radiation less than 2 per cent. Under these conditions he obtained an efficiency of 94.3 per cent.

From available published matter it appears that Lucke has devoted his experiments chiefly to applying surface combustion to domestic uses. Practically all his work has been done with gas and air at low pressures, seldom exceeding 1 inch of water. The rates of combustion have also been comparatively low. He investigated various refractories and found that white alundum was the best for withstanding the high temperatures obtained.

Both authorities agree that through the use of surface combustion gas may be burned completely with practically no excess of air and that the resulting temperatures are high; Bone placing the upper limit with natural, water or coal gas at 2,500 deg. Cent. (4,532 deg. Fahr.).

From the writings of these men it appears that the greatest difficulties encountered are those that arise from backfiring, and fusing of the refractories. Since the gas and air are mixed in proportions theoretically necessary for complete combustion, it is clear that unless steps are taken to prevent it, the flame will run back down the supply pipe and perhaps cause disastrous explosions. This can be prevented in two ways: first, by chilling the flame by means of some form of screen in the pipe and thus extinguishing it; and second, by supplying the mixture at a velocity greater than the velocity of flame propagation.

Of the two methods the latter is the best, for unless special precautions are taken the screen will eventually become hot and no longer hold back the flame, while the second method is effective even though those portions of the passages adjacent to the fire become red-hot. The velocity should be above 5 feet per second.

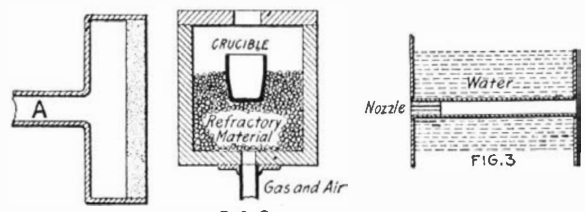

Fig. 1.—Bone's diaphragm for surface combustion. Fig. 2.—Section of surface combustion furnace. Fig. 3.—Section of part of boiler where surface combustion occurs in the tube.

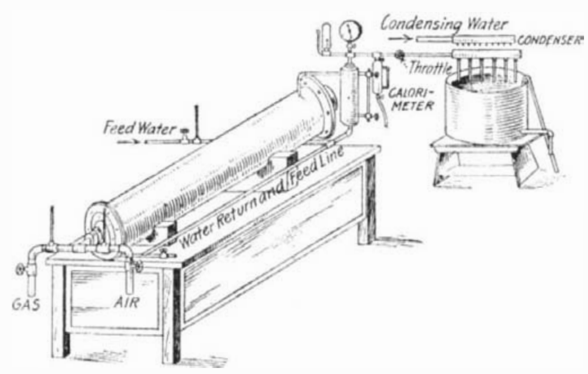

Fig. 4.—Boiler ready for testing.

The investigation described herewith was prompted largely by the writings of W. A. Bone, which were referred to previously. It was not intended to be an exhaustive study of the application of surface combustion to the production of steam, but preliminary to a more complete investigation. Writers on the subject have made but slight mention of difficulties encountered in making use of surface combustion, and these must be known before any apparatus can be designed for thorough study. The apparatus used by us was designed to bring out the general features of the problem, to be inexpensive and easily altered.

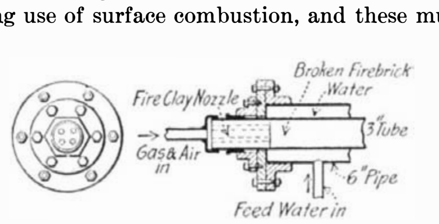

Fig. 5.—Stuffing box section.

A single-tube boiler, Fig. 4, made up of a 6-inch pipe 6 feet 6 inches long and having a standard flange screwed to each end was used. To each of the flanges was bolted a cast-iron plate having a hole in the center large enough to slip over a 3-inch pipe, which acted as the tube. The stuffing-boxes shown in Fig. 5 were provided at each end of the pipe to take care of expansion. A baffle 3 feet long made of light galvanized iron shaped as shown in Fig. 6 was placed inside the boiler below the tube to assist circulation, the lower end of the baffle being about 10 inches from the fire head of the boiler. The boiler was inclined so as to give a rise of 18 inches in 6 feet. Water was supplied from the city mains through a ½-inch pipe entering the experimental boiler about 4 inches from the fire head.

Trouble from priming was anticipated, and to care for it a special separator, Fig. 7, was made. Steam was taken off by a ½-inch pipe connected about 4 inches from the waste gas head. This pipe led into a separating chamber, at the top of which was attached the steam gage and a ¾-inch pipe leading to the condenser and calorimeter, while the bottom was attached to the pipe supplying the water. Steam and water coming from the boiler were separated in the tee; the water returning to the boiler by means of the feed pipe, while the steam went to the condenser and calorimeter. The water column was also attached to the separator. The separator, feed pipe and boiler, with the exception of the heads, were lagged with asbestos cement applied over a ¾-inch air space.

Within the lower end of the tube was placed a cylindrical fireclay nozzle 6 inches long, containing four ⅜-inch holes through which the mixture of gas and air was supplied. The tube was packed with pieces of firebrick ½ to ¾ inch diameter for a distance of 4 feet from the end of the nozzle, the remainder of the tube being empty. The mixture of gas and air was supplied to the nozzle through a ¾-inch pipe attached to a 3-inch cap fitting over the lower end of the pipe. This cap also served to keep the nozzle closely against the broken firebrick.

A surface condenser, Fig. 8, was used, consisting of six 1¼-inch pipes connected in parallel to two 1¼-inch headers. The lower header and about half the length of the tubes were immersed in a barrel filled with cold water which was kept continually trickling over the upper header and upper half of the pipes.

Air and gas were brought to the desired pressure separately by means of a pair of Root No. 3 rotary pressure blowers. From the blowers the gas and air passed through separate receivers to the gas and air meters. The pressure on the gas and air was measured by means of mercury manometers attached to the supply pipes at points a few inches from where these entered the meters. All instruments used in connection with the work had been calibrated previously by standard methods.

From the meters the gas and air each passed through a throttle valve and thence to a tee, where they were combined, and the mixture passed directly to the nozzle. The temperatures of the gas and air were taken just before they entered the mixing tee. The proportions were controlled by adjustment of the throttles. (See Fig. 4.)

Before the apparatus was evolved a number of other arrangements were tried. The boiler was originally horizontal. Two rather serious difficulties were met with it in this position. First, owing to the small steam space possible and to the high rate of evaporation in the region of combustion, the boiler primed so badly that it was found impossible to separate the water from the steam. Second, the firebrick could not be packed uniformly in the tube, an open space being left at the top, though the brick packed closely at the bottom. Inclining the boiler was found to improve both conditions, and probably the best results could be obtained from a vertical boiler.

METHOD OF CONDUCTING THE TESTS.

The fire was started by first turning on the gas and lighting it at the end of the tube. No air was supplied at this time, and the gas burned outside the tube with a yellow flame. Air was then gradually admitted, and as the amount was increased the color of the flame changed from yellow to blue, and soon there was formed at the end of the tube a distinct greenish cone resembling the inner cone of a Bunsen burner. After this condition was reached a slight increase of air (making the ratio of air to gas 5 to 1) caused the flame to travel down the tube and become concentrated just outside the nozzle. The adjacent pieces of firebrick were soon heated to incandescence and surface combustion established. Among the several difficulties encountered in starting the fire were the following: When the apparatus was cold the flame would strike back violently and be extinguished, either by the shock of the explosion or by the chilling action of the firebrick and tube walls. Sharp explosions also had the peculiar effect of driving the nozzle forward. As far as could be ascertained by appearances of nozzle and mixing chamber, no explosion occurred behind the nozzle, although the sharp explosions drove it forward, pushing the firebrick ahead of it. No satisfactory ex-

* From *Power*.

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planation of this action can be offered at present. It was also found that when a space of more than ½ inch was left in the tube behind the nozzle, these explosions rendered it difficult to start or to maintain a fire. No explanation for this behavior can be offered. When, however, the nozzle was so placed as to have ¼ inch between it and the back face of the mixing chamber, only slight difficulty was experienced in starting and none at all in running.

COMBUSTION NOISY AT START.

When first started, that is to say, before surface combustion was established, the flame was quite noisy. This was due to the vibrations of the flame; such vibrations being amplified by the tube, which acted as a resonator. As the firebrick in front of the nozzle became heated, the sound decreased and finally ceased. When proper conditions of mixture were obtainable, the only sound was that made by the passage of the gases over the refractory material. The ceasing of the sound may be accounted for by the fact that surface combustion is flameless, hence when this stage was reached the flame disappeared. Its gradual disappearance is accounted for by the fact that a short time was necessary for the firebrick in front of the nozzle to become heated sufficiently to cause surface combustion. The surface of these pieces of brick was not large enough to cause all the gas to burn. Part of the mixture burned flamelessly and part did not. Hence it will be readily seen that the gradual decrease in the size of the flame caused a simultaneous diminution of the noise.

RAPID COMBUSTION CAUSES PRIMING.

In preliminary runs considerable difficulty was experienced from priming of the boiler. In surface combustion all the gas is burned within a few inches after leaving the end of the nozzle. This rapid combustion, together with the small excess of air, is productive of very high temperatures and consequently high rates of heat transfer through that portion of the tube surrounding the zone of combustion. This caused a large bubble of steam to form, which forced the water lying above it in the boiler up into the steam space and pipes. This trouble was found to decrease as the inclination of the boiler was increased.

Once the fire was started, the gas throttle was adjusted until the desired amount of gas was being burned, then the air throttle was adjusted until 5¼ volumes of air were being supplied for each volume of gas. This was found by flue-gas analysis to give but a slight amount of free oxygen in the waste gases. Steam pressure was allowed to build up to the desired amount, and then the throttle valve was opened and sufficient steam to keep the pressure constant was allowed to flow into the condenser. As soon as conditions became steady the quality of the steam was determined by the use of a separating calorimeter. After this had been done a flying start was taken on the power test. A vessel that had been previously weighed was placed under the pipe leading from the condenser, and the time noted.

The quality of gas and air used was found by taking with a stop-watch the time required for the meters to register one cubic foot. The temperature and pressure of each were also noted, the pressures being obtained by mercury manometers. From these data the actual quantities of gas and air under standard conditions used during the run were easily calculated. From time to time water was fed into the boiler, the object being to keep the water level constant. The temperature of this feed was taken, as was also that of the waste gases, calibrated mercury thermometers being used in all cases. At the end of the run the vessel receiving the condensed steam was removed and weighed. The difference between the final weight and that of the vessel gave the weight of water evaporated.

LITTLE EXCESS AIR USED.

All the tests were conducted in the same manner, the only difference being the quantity of gas burned per hour. In all the tests slight leakage occurred through the stuffing-boxes and around the steam connections. A sample of the flue gas was taken during each run and an analysis made of it, using the Orsat apparatus. These analyses showed that practically complete combustion had been obtained with small excess of air.

In one of the preliminary tests a pyrometer was placed in the tube, and the temperature at the end of the tube and at the end of the firebrick were measured. In this case the tube was filled with brick 3 feet from the nozzle, and about 90 cubic feet was burned per hour. The temperature at the waste-gas end of the tube was 280 deg. Fahr.; that just outside the firebrick, only 320 deg. Fahr.; showing that at that rate of combustion the last three feet of the tube were practically useless.

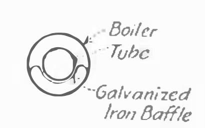
The maximum amount of gas burned per hour was 125 cubic feet at 60 deg. Fahr., and 29.92 inches mercury. At this rate the boiler performed satisfactorily in all particulars. Higher rates of combustion were not employed, because it was found impossible to obtain more gas from the ½-inch supply pipe.

CONCLUSIONS DRAWN FROM THE EXPERIMENTS.

As a result of the work described in the foregoing, the following conclusions are drawn:

High efficiencies are attainable. In the tests made by Bone the radiation and leakage were reduced to 2 per cent and an economizer was used. He obtained an efficiency of 94.3 per cent. In the tests herein described the radiation and leakage amounted to an average of about 11 per cent and no economizer was used. Even with these defects of apparatus an efficiency of between 75 and 80 per cent was obtained. Assuming other things to have remained constant and the radiation to have been reduced to 2 per cent, the efficiencies would have ranged from 84 to 89 per cent. No economizer was used, so the agreement with Bone's results is close. The large radiation and leakage loss was due to the stuffing-boxes, through which leakage occurred and whose presence compelled leaving the ends unlagged. Another reason for the large radiation loss lies in the fact that but one tube was used. Radiation takes place from the surface of the boiler shell. This increases much less rapidly than the heating surface when additional tubes are introduced and the size of the boiler increased. The apparatus used was therefore operating under most unfavorable conditions and yet gave good efficiencies.

The efficiency varied with the rate of combustion, increasing with the amount of gas burned per hour. Stack



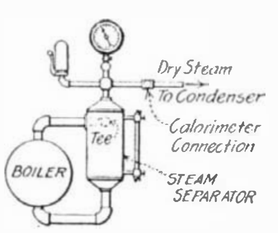


Fig. 6.—Baffle. Fig. 7.—Steam connections.

conditions are probably truer indices of the efficiency of the apparatus as an absorber of heat than is the ratio of the heat in the condensed steam to the heat supplied. The latter charges the radiation, as well as losses in combustion and transfer, against the boiler. The efficiency based on the heat in the steam is therefore a measure of the boiler's ability to hold as well as to absorb heat. In this investigation the object was to determine the value of surface combustion as a means of getting heat out of the fuel and into the boiler. This is shown clearly by the temperature difference between the flue gases and the steam. This difference was found to increase with the rate of combustion, but not rapidly, the maximum difference being only 74 deg. Fahr. The sensible heat lost in the waste gases was therefore small, varying from 3½ to 4 per cent.

The main loss in the flue gases occurs as latent heat in the water vapor formed by the combustion of the hydrogen in the fuel. From this it will be seen that surface combustion will be most efficient when using a gas low in hydrogen, such as producer gas made from anthracite. Blast-furnace gas would give good results were it not for

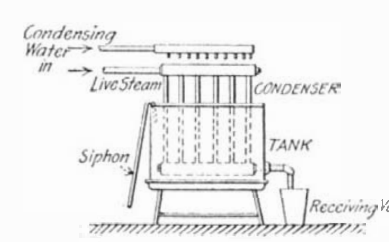


Fig. 8.—Experimental condenser.

the large amount of inert gas present. A curve (not shown) shows that the water evaporated per hour when the rate of combustion was 125 cubic feet per hour was less than the general direction of the curve would lead one to expect. This was because the mixture entering the nozzle contained a larger excess of air than did the mixtures used in the other tests. It brings out clearly the deleterious effect of an excess of air, even though that excess is small. The efficiency was not computed for this run, because the heating value of the gas was not available.

RANGE OF COMBUSTION RATES.

The system is a flexible one. No difficulties were experienced while burning either large or small quantities of gas, and the change from one rate of combustion to another was accomplished almost instantaneously. This feature makes the system particularly desirable where the load is extremely variable.

The amount of gas that can be burned per unit of time seems to be limited only by the supply and by the ability of the refractory used to withstand the high temperatures. Combustion seems to be as good at high as at low rates. A large part of the transfer of heat from burning gases to the water is effected by radiation from the incandescent refractory material in the tube.

The rate of heat transfer by means of radiation varies directly as the fourth power of the absolute temperature, so an increase in the temperature of the radiating body is accompanied by a rapid increase in the amount of heat transferred by radiation. Since the temperatures within the tube increase with the rate of combustion, it follows that the heat transferred by radiation will increase. In the ordinary boiler a great loss in heat transfer occurs in getting the heat through a thin film of stagnant gas adhering to the surface of the boiler shell or tubes. Since the film is practically stagnant, little or no heat is passed through it by convection.

The gas offers practically no resistance to radiant heat so the capacity of the heating surface will be increased by increasing the proportion of radiant heat liberated from the fuel.

It was found that the furnace, once started, gave no trouble provided no large space existed directly behind the nozzle. When such a condition did exist, combustion became unsteady and rather sharp explosions occurred, which drove the nozzle and firebrick forward. This difficulty was greatest when starting, it frequently being impossible to get a fire established until the nozzle was pulled back and the space back of it made quite small. Some difficulty was experienced in starting, even when the nozzle was in the correct position, because of chilling of the flame by the cold walls of the tube.

The main difficulty found with the apparatus was priming. There should therefore be considerable steam space above the surface of the water, and circulation should be as direct as possible.

LARGE STEAM SPACE RECOMMENDED.

The foregoing work indicates that the vertical type of boiler would probably give the best results, as the space available above the water can be made as large as desirable and the circulation is rapid. The boiler should not be over 4 feet in length and probably 3 feet would be satisfactory, as observations made of the temperature inside the tube show that there is only a small drop in temperature in the last 3 feet of a 6-foot boiler.

The application of surface combustion to the production of steam for power seems feasible. The small size and consequent small cost of the boilers would result in a saving in space and a reduction in fixed charges. These advantages would largely or entirely be offset if gas producers were necessary, but for natural or blast-furnace gas the system appears to be almost ideal, and in localities where coal is poor it combines the reliability of the steam engine with the economy of the gas engine.

Concrete Workshop Floors

Concrete makes a cheap floor for a workshop, but in many cases its efficiency is often spoiled through its getting cracked after some little time, and eventually more or less broken up. As the cause of this is not generally understood, the following remarks by Mr. B. Davis, H.M. Inspector of Factories for the Kent district, may be of interest. He remarks: In addition to the obvious reason that builders often use too much sand in proportion to the cement, an insufficient thickness and bad foundation, there are others due to ignorance when the intention is good. Mixtures of sand and cement expand when they are wet, and contract as they dry, and within limits the greater the proportion of cement the greater the expansion and contraction. A common practice is to put down a first layer of material with a small proportion of cement, to let this dry, and then put on top of it a thin layer with a large proportion of cement. This top part thus remains a separate layer instead of bonding with the lower part, as it would have done had it been put on at once on the still unset lower portion, while, being richer in cement, it expands and contracts more than the lower part, with the result that it may be rapidly broken up. For large surfaces, however good the work and material, the expansion and contraction are almost certain to produce cracking unless the work is divided up vertically into sections with thin strips of wood between them.—*The Engineer.*

Producing Pure Iron

During an investigation of the magnetic properties of iron and iron alloys Dr. Trygve Yensen, at the University of Illinois, discovered what is claimed to be a new method of producing pure iron. This consisted of melting electrically refined iron in a vacuum, thus reducing the impurities far below any point that had been reached by previous investigators. The magnetic properties of this vacuum-fused iron have proved to be as remarkable as its purity. Its maximum permeability—that is, measure of ease with which it can be magnetized—was found to be two or three times higher than for the best magnetic iron or iron alloy previously produced. A practical result of this investigation is that if it should turn out to be commercially practical the amount of material needed for electrical machinery, such as transformers, would be reduced by half, and the losses that occur continuously as long as the machine is in operation would be greatly minimized.

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Steam Power for Aeroplanes

A Survey of the Various Systems Available and the Feasibility of the Form of Power

By James G. Dudley, A.B.

Basis of Survey.—Necessarily the feasibility of the use of steam as the motive power of aeroplanes is best determined by comparison with known performances in the field of aeronautics, hence the following data are taken as the fulcrum for analysis.

Hydro-Aeroplane Data (Explosion Engine):—The calculations and construction of an assumed design comprehend the following:

Weight.		
Lifting capacity @ 40 miles an hr........	= 4,000	Lbs.
Weight of structure only (approx.)......	= 1,900	"
Weight of 100 B. H. P. engine and accessories	= 550	"
Weight of two (2), aeronaut and observer	= 320	"
Weight of (gasoline) fuel for 6 hours....	= 515	"
Weight of tank for fuel..................	= 65	"
Weight of lubricants for 6 hours........	= 125	"
Weight of tank for lubricants...........	= 25	"
Total weight in flight approx.	= 3,500	Lbs.

Rotative speed of propellers.. = 800 R. P. M.
Peripheral speed of propellers. = 20,100 ft. @ min.
Rotative speed of engine.
Two-stroke cycle 6 cyl....... = 1,200 @ 1,600 R. P. M.
Speed of flight (maximum).. = 85 miles per hour.
Duration of flight (maximum). = 6 hours.

Aeronautical Datum:—Aerial flight is (to-day) predicated upon: The design, material, construction, efficiency, pitch, rotative and peripheral speeds, of the propeller, hence this element is the determining premise of any analysis.

Propeller design in the present state of the art is delimited by peripheral speeds of 40,000 @ 50,000 feet per minute, which determines the rotative speed of the motor (if direct connected) at, say, 1,200 @ 1,600 R. P. M.

Power Plant Data:—Aerial propulsion is differentiated from land or water propulsion in two fundamental respects, namely, in that the power plant load factor, at practically all times, approximates 100 per cent; and that motion takes place in trackless and unimpeded paths in three dimensions of the supporting medium.

Aerial power plant design is governed chiefly by lifting efficiency, the relations of live load to dead load, and by duration of flight. Initial or operating costs are of secondary importance.

Desirable Standards:—To arrive at satisfactory conclusions as to power plant, standards of desirability of design, construction and performance must herein be set up—which necessarily will be somewhat empirical. Judgment must be largely guided by the advanced requirements of marine practice, which more nearly approximates the science of aeronautics than does any other field.

Stated in order of importance the desiderata of such a plant would seem to be: (1) Absolute reliability; (2) weight efficiency; (3) space efficiency; (4) endurance efficiency; (5) control simplicity; (6) durability of elements; (7) balance perfection; (8) thermal efficiency; (9) temperature range; (10) direct-drive; (11) simplicity; (12) silence; (13) friction elimination; (14) costs: initial and operating.

Power Medium:—The most desirable medium for aerial power should, in like manner, possess the following: (1) Absolute reliability; (2) calculability; (3) completeness of development; (4) availability of data; (5) breadth of human experience; (6) availability for wide use; (7) adaptability; (8) flexibility; (9) controllability; (10) range of applicability; (11) range of initial and final temperatures; (12) range of altitude operation; (13) expansive vice explosive impulse; (14) frequency of impulse; (15) torque efficiency; (16) absence of fouling.

Aeronautical Fuel:—The fuel most desirable for aeroplane use should be: (1) Readily available; (2) widely distributed; (3) of maximum thermal efficiency per unit of weight; (4) of maximum safety; (5) free from residue; (6) stable under wide temperature range; (7) free from natural waste; (8) low in cost.

Friction and Lubrication Reduction:—Reduction of friction in an aerial power plant is proportionately as desirable as economy in fuel, since this means reduced lubrication, hence saving in live load.

Supplementary Functions:—It is not enough to analyze the fuel and a motive power of maximum thermodynamic efficiency, but in addition a critical examination must be made of all such auxiliary power plant functions as: Fuel storage, fuel movement, fuel conversion, fuel utilization, systems for preventing destruction of power elements (such as motor cooling, etc.), the economizing of waste heat (or energy), the movement (circulation) of liquids or gases, etc.

Creature Comforts:—The need and desire for advance in power generation and utilization presupposes longer flights and (possibly) higher average altitudes, hence to disregard the human factor would leave this investigation incomplete. Even now the needs for warming, lighting and even cooking are not to be brushed lightly aside.

RESUME OF PROBLEM.

Having now marshaled the desiderata of any (assumed) aeroplane it is in order to compare seriatim and item by item, not only the theoretical possibilities inherent in the use of steam in expansion engines as against gasoline in explosion engines, but actual performance as well.

Steam Power Plant:—Only a cursory examination of power practice is needed to show that in order to equal or exceed the performance of an aeroplane driven by gasoline explosion engines the steam plant must embody: (A) steam motor, (B) steam generator, (C) supply of motive medium (water), (D) supply of liquid fuel, (E) a liquid fuel burner and furnace, (F) condensing system, (G) feed water heater, (H) waste gas economizer, (I) water feed pump, (J) dry air pump, (K) hot well, (L) fuel blast production, (M) heat insulation, (N) plant control, (O) friction reduction, (P) fuel tank.

Such a schedule of elements must not be assumed to (necessarily) complicate the problem of mechanical flight, since simplification of construction or duplication of function will be found upon investigation to be no bar to the use of steam.

Comparison of the steam power plant in detail or as a whole, with the "desirable standards" set forth above, or even of steam with the requirements of "power medium" as described above, can best be arrived at by citing the design, construction and performance attained, or obtainable, with the several elements incorporated in the hydro-aeroplane steam power plant necessary for the assumed design.

Steam Eliminations:—If examination be made of all existing types of steam motors it is at once apparent that a number must be eliminated from consideration.

Such types may be divided into the following broad groups: (1) oscillating, (2) reciprocating, (3) revolving, (4) rotary and (5) turbine. No. 1 and No. 3 may be eliminated not only for prohibitive steam consumption but for obvious mechanical shortcomings as well. No. 5 must be dropped on the score of prohibitive weights, to wit: 30 pounds @ horse-power as a minimum. No. 2 and No. 4 remain.

Reciprocating steam motors subdivide into "counter flow" and "uniflow" types, but the former must be dropped, since it develops that, for fundamental thermodynamic reasons, these must be designed for triple expansion and of equal weight to match the steam consumption of the latter uncompounded.

Rotary steam motors, while not strictly answering the accepted definition of the so-called "uniflow" cycle, nevertheless are obviously not "counterflow," hence may properly be so classed along with the accurately denominated reciprocating "uniflow" steam motor.

It is an undoubted fact that even a large section of the engineering world (at least in the United States) is not as yet informed as to the classic performance of simple "uniflow" reciprocating steam motors.

It is also scarcely open to question that a multitude of failures to produce even a mechanically sound operating rotary steam motor have so prejudiced the minds of engineers that an assumption of "inherent impossibility" usually estops even an investigation of the underlying theory of the mechanics or thermodynamics of this type scientifically conceived and executed.

Feasible Steam Motors:—Scientific analysis and mathematical computations of a most exhaustive and exacting nature demonstrate that steam motors when run condensing under a vacuum of 24 inches from an initial pressure at the throttle of 450 pounds gauge and 100 degrees superheat, or at a sensible temperature of 556.5 deg. Fahr., will develop one brake horse-power hour with: ten pounds (10 lbs.) of steam for the best of the reciprocating "uniflow" type; and for under twenty pounds (20 lbs.) of steam for the best of the rotary "uniflow" type when properly compounded.

Such a double acting reciprocating "uniflow" steam motor can be built to weigh less than three pounds (3 lbs.) per brake horse-power, and the compound rotary "uniflow" for less than one pound.

Note:—The classic record is for an aeronautical compound reciprocating "counterflow" steam engine which developed 363 horse-power for a weight of 640 pounds, or for one and three-quarters pounds (1.75 lbs.) per horse-power.

Both types (as above laid down) can be built to approximate the maximum requirements of practically all the engine standards of the (assumed) desirable power plant.

Feasible Steam Generator:—The published "world's record" of water evaporated from and at 212 deg. Fahr. is given as 18.7 pounds (avoirdupois) per square foot of heating surface and 15.3 pounds of water per pound of (liquid) fuel—crude oil.

Marine engineering has developed (drum) water—tube boilers which, under service test conditions, have evaporated 17 pounds of water (f. and a.) per 22,000 B. T. U. (approx.).

Motor vehicle engineering has developed "flash" boilers which, under most exacting test conditions by professional experts of unquestioned and unquestionable standing, have evaporated as high as 19 @ 22 pounds of water (f. and a.) per pound of kerosene.

Gauge pressures for such steam generators have frequently run to 1,000 pounds @ square inch and have shown sensible temperatures of 750 deg. Fahr.

A "boiler horse-power" of 34½ pounds of steam from and at 212 deg. Fahr. has been, hence can be, evaporated per square foot of heating surface.

Combined boiler and (liquid fuel) furnace thermal efficiency has reached 90 per cent.

The highest of authorities cites that "the heating plates of a boiler will transmit all the heat that can be delivered to them," and that "water can absorb heat as fast as the heating plate is able to conduct it," and that "the heat transferred varies directly as the density of the gas, directly as the velocity of the gas over the dry surface of the tube, and directly as the temperature difference between the hot gas and the water."

It is not only possible but feasible to produce a steam generator capable of serving a 100 B. H. P. "uniflow" steam motor while carrying a working pressure of 750 pounds @ square inch, and showing a sensible (steam) temperature of 650 deg. @ 750 deg. Fahr. and evaporating not less than 17 pounds of water (f. and a.) per 19,890 B. T. U. supplied in (liquid) fuel and per square foot of heating surface.

Such a generator may be built to weigh less than 2 pounds per square foot of heating surface complete, including furnace and insulation, but exclusive of burner. This represents a weight of less than one and two-tenths pounds (1.2 lbs.) per "uniflow" engine brake horse-power.

Such a generator can be built to approximate the maximum requirements of practically all the boiler standards of the (assumed) desirable power plant.

Feasible Fuel:—Since any available solid fuel is prohibited for aeronautical use primarily because of incombustible content and inability to obtain complete combustion without weights of fuel, furnace and blast production which would be excessive, the use of steam only becomes feasible by adopting some (available) liquid fuel.

The highest of authorities cite the following heat values of liquid fuels available in the U. S.:

					B. T. U.
.73 S. G. Gasoline..	11,368..	Calories	@	Kilogram	20,462
.80 S. G. Kerosene..	11,050..	"	"	"	19,890
.90 S. G. Gas Oil...	10,000..	"	"	"	18,000
.95 S. G. Crude Oil.	10,000..	"	"	"	18,000

Since the fuel would, and could, be completely burned in a furnace instead of the motor cylinder, scarcity and cost alone should eliminate consideration of gasoline.

Since kerosene more nearly answers every requirement of the assumed desirable fuel as specified above, and since this fuel alone is readily available, not only in the U. S., but in all parts of the civilized world; and since it is available in excess amount and at a low cost, it will be taken as satisfying analysis.

Feasible Combustion:—The complete combustion and control of combustion of kerosene have been developed to so high a degree of mechanical and thermal efficience as to satisfy all the requirements of any desirable "burner."

Practically the same contentions may even be made for the external combustion of gas oil and crude oil.

Research heretofore carried out in this field indicates

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that simplifications of apparatus and increase of furnace temperatures with any and all of these liquid fuels is not only possible but feasible—the speed of flight insuring blast conditions almost theoretically ideal.

Feasible Heat Insulation:—Conservation of heat in generation, or after utilization, becomes of the utmost importance in view of temperature-range and velocity of flight to which the aeronautical power plant is subjected.

Steam generators fired with crude oil continuously developing furnace temperatures well in excess of 2,500 deg. Fahr. have been, and can be, so insulated that the loss by conduction, radiation and convection (excluding the waste gases) will not exceed seven and one-half per cent (7½%) and may even fall as low as five per cent (5%).

Naturally methods equally efficient insure the minimum loss in all other elements of the power plant and fully satisfy the desirable standard above set up.

Feasible Heat Economizing:—Careful design and utilization of the fundamental heat-transfer law of counter-flow currents of gases and liquids insures maximum efficiency and also satisfies the desirable standards set up on this score.

Feasible Steam Condensing:—The thermic and mechanical principles which make feasible the aeronautical steam generator insure the greater feasibility of designing and constructing a steam condensing system capable of producing vacuum as high as twenty-four inches (24″) and so meeting the requirements of the standard for this plant element.

Speed of flight, low average atmospheric temperatures and low pressures imposed on apparatus supplement, and confirm this feasibility.

Starting with a supply of water purified for the motive medium condensing precludes the possibility of troubles to the interior of the power plant.

Feasible Piping, Etc.:—Conditions which negatively affect pipe, fittings, valves and specialties, such as pressures and temperatures, are at a maximum; but offsetting these, it will be noted that distances and areas are at a minimum, velocities at a maximum and load practically constant.

The welding art simplifies the mechanics, and modern metallurgy insures maximum strength with weights which are almost negligible, again insuring that the standard of desirability may be reached.

Feasible Pumps and Accessories:—High velocities and pressures and the use of the rotary principle in designing any necessary pumps and accessories as well as the employment of light alloys guarantees that these shall easily reach the set standards of desirability and feasibility.

Feasible Friction Reduction:—Critical examination of the reciprocating, or rotary "uniflow," steam motor develops the fact that cylinder lubrication is eliminated—hence mechanical friction is only to be provided for on revolving shafts or on the (almost) negligible reciprocating parts of motor, pumps, etc. Even without the use of anti-friction bearings the lubrication required can be kept down to below one per cent (by weight) of the fuel consumed.

Research develops that it is apparently feasible by the proper use of highly perfected anti-friction bearings to reduce friction to such an extent as to warrant the omission of any lubrication whatever, thus even exceeding the set standard.

Feasible Plant Control:—Starting of an aeroplane steam power plant with feed water, fuel and atmosphere at a temperature of 60 deg. Fahr. should not consume to exceed 15 minutes and may possibly be reduced to 10 minutes.

Simple standby apparatus and methods employed in other steam fields, such as in fire engines, might even enable military aeroplanes to start from a hangaar or ship quicker than could be done with an aeroplane equipped with an explosion engine.

With steam once raised to flight pressure practically no attention whatever would be required by the power plant—all control, as well as starting after a stop, which did not involve suppressing combustion, being lodged in manipulation of the throttle valve.

REVIEW OF STEAM POWER PLANT.

The foregoing analysis, comparison, and review of advanced steam practice, contrasted with the achievements of the explosion engine in aeronautics, warrant the following contentions:

(A) *Desirable Standards:*—(1) Steam power should prove more *reliable;* (2) should show a higher *weight efficiency;* (3) should not greatly exceed the *space efficiency* even in small units; (4) should far excel in *endurance* efficiency; (5) should reach the ideal in *control simplicity;* (6) should show a *durability* of *elements* closely approximating marine practice; (7) should be capable of a *balance perfection* only excelled by the rotary steam motor; (8) computes a net *thermal efficiency* matched only by stationary or marine plants of exceptional design and construction, and excelled only by high grade internal combustion stationary engine plants; (9) capable of a *temperature range* equaling any known heat engine plant; (10) capable of rotative speed design to *direct drive* any known form of propeller; (11) of the utmost *simplicity* in operation; (12) operates with such silence (propeller whirr excepted) as to be practically noiseless; (13) *favors friction elimination* almost to the theoretical minimum; (14) should match *initial costs* and reduce *operating costs* to less than one-fifth.

(B) *Steam Power Medium:*—Expansive steam (compared with explosive gas) when employed as specified for aeronautical use: (1) should show *absolute* reliability; (2) is capable of more exact *calculability* as to results; (3) has attained almost the limit of *completeness* of *development;* (4) possesses an overwhelming mass of *available* data to substantiate its claims; (5) has been tested by a *breadth* of *human experience* as yet impossible for the competing medium; (6) if developed as outlined should be *available* for wide *use* wherever commerce prevails; (7) possesses the maximum of *adaptability* to all sizes, types and designs of aerial vehicles; (8) has a *flexibility,* and (9) *controllability* of action impossible to the explosive medium; (10) has a wider *range* of *applicability* to all (known) aeronautical needs; (11) has as wide, if not wider, *range* of *initial* and *final temperatures;* (12) practically unaffected by a *range* of *altitude* operation from sea level to the limits of human endurance; (13) fundamentally excels by reason of *expansive* vice *explosive* impulses; (14) the *frequency* of impulse per cylinder per revolution is 2 in the double-acting reciprocating "uniflow" engine and 4 in the two-piston rotary "uniflow" engine, while there is a maximum of but one impulse per revolution per cylinder in any explosive engine in known aeronautical use; (15) *torque efficiency* is necessarily greater because of more frequent and expansive impulses; (16) *absence* of *fouling* is insured owing to complete (external) combustion and a purified (internal) medium.

Hydro-Aeroplane Data (Expansion Engine):—The calculations and construction of the assumed steam power plant design, operated with double acting reciprocating "uniflow" engine, comprehend the following:

Weight.	
Lifting capacity @ 40 miles @ hr..........	4,000 Llbs.
Weight of structure only (approx.).........	1,900 "
Weight of 100 B. H. P. engine, pumps and feed water heater	300 "
Weight of steam generator for 1,000 lbs. steam @ hr.—including furnace, waste gas economizer and insulation............	250 "
Weight of water for plant..................	75 "
Weight of pipe, fittings, valves, etc..........	25 "
Weight of oil burner........................	30 "
Weight of breeching, etc....................	25 "
Weight of condensing equipment............	150 "
Weight of two, aeronaut and observer.......	320 "
Weight of (kerosene) fuel for 6 hours......	375 "
Weight of tank for fuel.....................	50 "
Weight of lubricants for 6 hours............	00 "
Total weight in flight (approx.)........	3,500 Lbs.

Rotative speed of propellers.... = 800 R. P. M.
Peripheral speed of propellers. = 20,100 ft. @ min.
Rotative speed of engine..... = @ 1,200 R. P. M.
Double-acting "uniflow" 4 cyl..
Speed of flight (maximum).... = 85 miles per hour.
Duration of flight (maximum) = 6 hours.

The calculations and construction of the assumed steam power plant design, operated with compound rotary "uniflow" engine, comprehend the following:

Weight.	
Lifting capacity @ 40 miles @ hr..........	4,000 Lbs.
Weight of structure only (approx.).........	1,900 "
Weight of 100 B. H. P. engine and pumps and feed water heater........................	125 "
Weight of steam generator for 2,000 lbs. steam @ hr.—including furnace waste, gas economizer and insulation	500 "
Weight of water for plant..................	150 "
Weight of pipe, fittings, valves, etc.........	35 "
Weight of oil burner	50 "
Weight of breeching	30 "
Weight of condensing equipment	250 "
Weight of two, aeronaut and observer......	320 "
Weight of (kerosene) fuel for 6 hours......	750 "
Weight of lubricants for 6 hours...........	00 "
Total weight in flight..................	4,110 Lbs.

Rotative speed of propellers.. = 800 R. P. M.
Peripheral speed of propellers. = 20,100 ft. @ min.
Rotative speed of engine..... = 2,000 R. P. M.
Compound rotary "uniflow"...
Speed of flight (maximum)... = 85 miles per hour.
Duration of flight............ = 6 hours.

COMPARATIVE PERFORMANCES.

(SPEED ASSUMED 85 MILES PER HOUR.)

TWO-CYCLE EXPLOSION ENGINE.

Net. Wt.	Miles.	Cost.
3,500 lbs.	510	$27.50
4,141 "	1,020	55.00
4,782 "	1,530	82.50
5,423 "	2,040	110.00
6,064 "	2,550	137.50
6,705 "	3,060	165.00

DOUBLE-ACTING "UNIFLOW" EXPANSION.

Net. Wt.	Miles.	Cost.
3,500 lbs.	510	$3.00
3,860 "	1,020	6.00
4,220 "	1,530	9.00
4,580 "	2,040	12.00
4,940 "	2,550	15.00
5,300 "	3,060	18.00

COMPOUND ROTARY "UNIFLOW."

Net. Wt.	Miles.	Cost.
4,110 lbs.	510	$5.40
4,830 "	1,020	11.80
5,550 '	1,530	16.20
6,270 "	2,040	21.60
6,990 "	2,550	27.00
7,710 "	3,060	32.40

ASSUMPTIONS.

Gasoline of.......... .75 S. G. @ 30c @ gal.
Kerosene of.......... .80 S. G. @ 6c @ gal.
Lubricant of.......... .90 S. G. @ 50c @ gal.

Available Steam Equipment:—While it cannot be proven that any single given power plant has hitherto been computed, designed or constructed embodying each and every element of the desirable (steam) aeroplane, or of the co-ordinating efficiencies cited, yet it is sufficient answer to assert that this is because the demand for, and financing of, such a plant has not been in evidence.

The conditions imposed upon this survey have been to review steam practice to ascertain the feasibility of its use for driving an aeroplane.

The mechanics, thermodynamics and complete feasibility of design, construction and operation of each separate element, of the respective efficiency specified, has been, or can be, proved by the acid analysis of mathematics or use.

Computations of the specified "uniflow" reciprocating steam engine plant demonstrate that therein is embodied an equipment which should unquestionably surpass in speed, or duration, of flight the highest achievements known in the field of aeronautics.

Computations of the specified "uniflow" rotary steam engine plant demonstrate its entire feasibility for a large percentage of aeronautical requirements—and especially where high rotative speeds of propellers, or low cost of motor, or minimum weight of motor, or minimum space of motor are governing factors.

Possible Expansion Equipment:—Research and shop experiments of a high order indicate that it is feasible to operate steam motors of practically any type, design or efficiency with a compressed mixture of steam and the products of combustion of liquid fuel in the proportion (in a cited size) of 22 pounds of air plus 15 pounds of steam plus 1 pound of (crude oil) fuel, by substituting an electrically fired generator comprising but a small fraction of the space and weight of even the "maximum efficiency" steam generator heretofore cited.

Throttle temperatures of 650 deg. Fahr. are obtainable with exhaust temperatures as low as 180 degrees, the cycle and construction computing—according to the best of professional experts—net thermodynamic efficiencies higher than hitherto recorded for any commercial heat engine.

It has not as yet, however, been determined that it is possible, or feasible, to operate this cycle "condensing for the aeroplane—although no inherent impossibility is foreseen.

It is quite within the bounds of sound thermodynamic theory to suggest that it may prove entirely feasible to successfully employ as a substitute for water, in the aeroplane expansion engined plant, some medium of low specific heat value such as diluted alcohol, naphtha, bisulphide of carbon, or even carbonic acid gas, thereby still further raising net overall efficiencies.

CONCLUSIONS.

As a result of experience, investigations, information, calculations and the survey above submitted, it is the careful and deliberate conviction and conclusion of the author that:

Not only is steam feasible for aeronautical use, but also that steam is (almost) ideal for aeroplane service, just as aeroplane service is (certainly) ideal for steam as a motive power—owing to the fundamental fact inherent in the aerial power field that: The power plant load factor (at practically all times) approximates 100 per cent.

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Varnish Troubles*

CRACKING or crazing, blooming, turning white, sinking, or becoming dead, and losing its gloss, sweating, pin-holes, wrinkling, crawling, blistering, and failing to flow out, etc.

The great question is: "Who is responsible for all those troubles?" We will first consider the responsibility of the manufacturer. If he expects to continue and prosper in business by selling to the best mechanics, he must select the best gums suitable for the different varnishes and have experts who can melt these gums without scorching them, and he must supply these experts with properly refined and aged linseed oil, having all the foots abstracted in order to get a uniform drying varnish. He must use turpentine to properly thin out the varnish, and then he must have the proper facilities for filtering the product before it is placed in the aging tanks to be aged from three to eighteen months, depending upon the quality of the varnish. When we consider the millions of gallons of varnish made, it is easy to see the vast sums of money necessary in order to keep a stock of properly aged goods on hand at all times.

There is, from a certain class, a demand for very heavy bodied varnishes. These heavy varnishes the better class of varnish makers hesitate to send out owing to the fact that they invariably cause trouble. They are not bodied up as a rule with high-grade gums, because the price will not admit of it. They do not dry through like a varnish with medium body. They are much more likely to crack when they are dry, and the varnish maker, who feels his responsibility to the user of his products, avoids the sale of them as far as possible.

The varnish maker is then held responsible for producing an article that is made of the proper gum, that contains enough refined and aged linseed oil to give it the necessary elasticity as well as long life, and is aged in the aging tank, after it is made, to give it the fine flowing qualities all high-grade varnishes should have. The varnish maker, who feels his responsibility to the user of this product, will surely produce a thoroughly combined and ripened article.

A varnish maker, then, should be held responsible if he furnishes a high-priced varnish, the gum of which is rosin, and that contains very little oil and practically is not aged at all. This is the class of goods that by even the most careful handling will crack, craze, and turn white.

Varnish is the most delicate of all finishing material, and troubles very often come up with the best of finishers. Here is where the master painter's responsibilities come in.

There is a cause for all effects. You expect cheap varnish to crack or craze, but when you are using a good varnish you wonder why it cracks or crazes.

Cracking or Crazing.—This trouble is sometimes caused by subjecting a varnished surface to a severe change of temperature at a time when the varnish is not thoroughly dry and hard. An inexpensive varnish, if flowed on too heavy, is very liable to crack.

Again, if a slow-drying varnish is applied over a quick-drying varnish, the finish is almost sure to crack. The safe plan in all cases is to use the same quality from start to finish. The use of two entirely different drying varnishes on the same surface is, in my opinion, the height of folly. The practice of using a cheap first-coater and an elastic or long-oil varnish for the finishing varnish is the cause of much grief to the varnisher. I might add the practice of using shellac as a first-coater is bad because shellac, even when pure, is very brittle, and it prevents the varnish from penetrating the wood, and, here, like all finishing, the ground or first coat is the important one if you expect to have a lasting job.

Most of the crazing, even on our fine pianos, is caused by use of shellac for an undercoat, and I wish to add that no mechanic can use shellac successfully as a first coat, no matter how good the varnish may be that he applies over it, because if any water is allowed to stand on the surface for a short time, the surface will spot.

Some makers say in their literature: "Do not interfere in any way with this varnish by thinning it—use it as it comes from the can." This is correct as far as second and third coats are concerned, but on hard woods like maple and oak, the first coat should always be thinned by adding at least 25 per cent pure turpentine. This carries the varnish right into the wood and makes a better surface for succeeding coats than anything you can use. Of course, it will not dry quickly like shellac, but when it is dry, you have an elastic undercoat that becomes a part of the succeeding coats, and you will have no trouble with checking or crazing.

Blooming.—Means that a bluish film or cloud comes over the varnish. The finest of varnishes are liable to bloom under certain conditions; gases escaping in or through the varnishing room, sometimes coming from a basement that is not properly ventilated, will cause the varnish to bloom.

A master painter of this city called me to look a school building over. He had varnished all the walls of the first story and on just one side of the building the varnish had bloomed badly; on the other three sides the varnish looked perfect. The secret of the trouble was that gas was coming up from the basement, the openings being on that side of the room, and a beautiful blue cast was spread over the wall, but it was not the fault of the varnish.

Varnish Turning White.—Of course, a cheap rosin varnish will turn white if moisture comes in contact with it, but any varnish, no matter how expensive, will turn white if applied over liquid wood filler, because when water is allowed to remain on the surface a few hours, the moisture will penetrate through the varnish and the white in the liquid filler will in turn reflect through; moreover, it will scratch white—liquid filler and shellac are very much alike in this respect—both seal the pores and the varnish simply lies on top, but does not penetrate the wood.

Sinking or Turning Dead.—On open grain wood, where a poor quality of paste wood-filler is used, the better the varnish the more likely it is to sink and lose its gloss. In many cases this sinking is caused by thinning the varnish from start to finish: in other cases the trouble is caused by applying the succeeding coat before the under-coat is dry and hard.

Sweating.—The trouble is generally caused by rubbing the varnish before it is dry and hard all the way through. A long oil-varnish is very liable to sweat because it requires a number of days to dry hard. It is naturally a slow dryer.

Pin-Holes.—Pin-holes are mostly the result of improper or careless filling. On close-grain woodwork where no filler is used the first coat of varnish has not been thinned properly, and consequently does not penetrate the wood as it should. The result is a series of little pin-holes where the varnish goes in.

Wrinkling.—Wrinkling is caused by applying too heavy a coat of varnish, which often happens when using a heavy-bodied varnish.

A varnish will frequently wrinkle if exposed to a great change of temperature while it is drying.

Crawling.—By crawling, I mean that the varnish will not stay where you put it. This is a very common complaint with those doing new houses, particularly in the winter season. The plaster is wet and cold, a fire is started, the heat draws the moisture from the walls and a film of lime-water settles on the woodwork. All that is necessary to remedy this is to dip a rag in warm water, then rub it dry and the varnish will stay. Sometimes greasy or oily rags used for rubbing will cause crawling.

If the temperature is too low the varnish will not work well. To get the best results the varnish and the room should be about 70 deg. Fahr.

Blistering.—This trouble is often caused by using an elastic varnish over shellac as a first-coater, and if the surface is exposed to heat, or if the rays of the sun fall directly on the work, the shellac will soften and the varnish will blister.

Varnish That Does Not Flow.—If varnish is kept in a freezing atmosphere it will not flow freely and should not be applied until it has been warmed through. The easiest way to do this is to set the varnish-can in a pail of hot water.

If a can of varnish has been opened and exposed to the air for some time, the varnish will thicken, and it will not flow evenly again until it has been warmed and properly thinned with turpentine and allowed to stand for a few days.

*A paper read before the Pennsylvania Association of Master House Painters and Decorators by A. D. Hoagg.

Galvanizing Processes in Germany

A WRITER in *Verein Deutscher Giessereifachleute* says that in Germany since the outbreak of war copper has been replaced by galvanized iron for many purposes. Galvanizing may be effected by the hot process, the electrolytic process, Schoop's metal-spraying process, or by sherardizing. In the hot process if the bath of molten zinc is allowed to solidify it must be heated from above for re-melting, otherwise the tank may be damaged owing to expansion of the zinc. The temperature of the bath must not be allowed to rise too high (see Diegel, this J., 1915, 1147). Sheet iron galvanized by the hot process has about 400 grammes of zinc per square meter instead of about 1 kilo of zinc as formerly. Cables for use in mines are now largely made from wire galvanized by the electrolytic process because in wire galvanized by the hot process, unless the conditions are very carefully controlled, the strength may be materially reduced owing to the formation of a relatively brittle zinc-iron alloy. An advantage of electrolytc galvanizing is that it reveals defects, such as fine cracks or the like, in the iron, which would be concealed by hot galvanizing. It is also specially suitable for articles such as springs, which must not be heated to a high temperature. In the case of electrolytically galvanized sheet iron a coating of 200 grammes of zinc per square meter is sufficient to prevent rusting. Schoop's metal-spraying process is specially suitable for galvanizing large objects. Sherardizing is particularly suitable when it is desired to preserve the finest details of the article to be galvanized; iron screws which have been galvanized by this process are ready for use without further treatment. Narrow tubes can be galvanized inside by sherardizing, and this process is used in making the 5 pfennig galvanized iron coins recently introduced in Germany.

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