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Guard on the bridge at El Paso looking across the Rio Grande into Mexico.

THE MILITARY RIFLE.—[See page 324.]

Radiations From Atoms and Electrons—III*

A Study of the Character of the Mechanism Within the Atom

By Sir J. J. Thomson

Continued from Scientific American Supplement No. 2106, Page 307, May 13, 1916

In opening his third lecture Sir J. J. Thomson said that on the present occasion he wished to consider a comparatively simple case, viz., the emission of light from certain substances at the ordinary temperature of the room, even when these substances were not exposed to electrical or other disturbances. Such bodies were said to phosphoresce. Prominent among them was luminous paint. The basis of this was calcium sulphide, and its discovery was due to the alchemists, who produced it in the course of their search for some method of transforming base metals into gold. There had been few greater stimuli to research than this idea of the possibility of transmuting baser metals into gold. This lure apart, there would have been practically hardly anything accomplished in the way of experimental research at the times in question; but where curiosity as to the truth of natural phenomena failed as adequate incentive, the desire for money and power proved effective. In the outcome, the result had been closely analogous to that in Æsop's fable, in which the dying farmer set his sons to dig up the garden in search of a buried treasure. The quest failed, but the result of the digging was an enormous crop of fruit. These researches of the alchemists were, he continued, quite interesting reading at the present time, leading into by-paths now largely left on one side.

Taking a case of test-tubes filled with different substances and exposing them for a few seconds to the light of an arc lamp, the lecturer showed that, after removal, the tubes phosphoresced strongly, giving out a light which, in different specimens, ranged from red to blue. While these bodies were rendered active by exposure to light, it was, the lecturer proceeded, not every kind of light that was capable of acting as a stimulus, the effective portion lying in the ultra-violet end of the spectrum, where the wave-length was too short to affect the eye.

A characteristic feature of nearly all substances that phosphoresced to a marked extent was that they contained sulphur in some form or other, and of these sulphide compounds only one, viz., zinc sulphide, comprised less than three constituent elements. The color of the light produced was, moreover, very sensitive to the nature of the metal combined with the zinc, and to the presence of small impurities. In fact, in each of the tubes shown, the characteristic color was probably due to the presence of mere traces of some metal or other. These phosphorescent bodies were, in fact, solid solutions of some sulphides. They were made by taking a large quantity of one substance and adding to it a very small quantity of another. The mixture was dissolved and precipitated, thus producing a very intimate mixture of the two ingredients, which yielded results not to be obtained from mere mechanical admixtures of one component with the other. Some complex substance appeared to result from the mutual interaction of the two ingredients, and this was peculiarly susceptible to light.

These bodies had been studied very completely by Lenard and Klatt, who had established some very interesting points throwing light on the way in which phosphorescence arose. They found that all the phosphorescent bodies produced with any one metal—copper, for example—were charactrized by a peculiar system of bands in the spectrum. The position of these bands might shift slightly from specimen to specimen, but the system still preserved its characteristics sufficiently to enable the metal to be identified. In the case of copper, the light capable of acting as stimulus was confined to two narrow bands close together in the ultra-violet portion of the spectrum. The effect showed a sharp maximum at each band, but disappeared between them. Corresponding results were observed with other metals and the bands were as characteristic of the metal as was the color of the phosphorescence produced. It was found, moreover, that the metals which gave the brightest light had high valencies, such as III. or IV., and could therefore give rise to compounds of different types. It was further observed that the heavier metals were better than the lighter, manganese being the lightest with which success was attained.

There is much evidence in support of the view that in these cases certain conditions must be fulfilled. In the first place, there must be a greedy absorption of light to supply the requisite energy, and this light must be derived from the neighborhood of an absorption band. The energy, corresponding to the absorption, went to produce within the mixture some kind of chemical change by which certain complex compounds were transformed into a different and less stable type. The latter naturally tended to go back to the original form; but reversion proceeded slowly, and was accompanied by the phosphorescence.

It was known that the action of light on a substance tended to make it give out negative particles of electricity. Hence it might be supposed that the effect of the light absorbed by the substance was to take from one of the compounds present a negative particle, which would naturally try to settle on any electro-negative element present, such as sulphur, in which, accordingly, the expelled particle found a temporary home. The new arrangement was, however, not permanent, but the reversion took place slowly. Each negative particle, however, as it was shot out of the sulphur fell back to its original resting-place with considerable energy, and this energy was that responsible for the phosphorescence produced.

The complete process consisted accordingly of a storage of energy, in the first place, due to the action of the light in causing negative particles to shoot out from the substances acted on, the work necessary for this being provided by the energy of the light absorbed. In the second place, these particles lodged in the sulphur, their position in regard to their original location being equivalent to that of a stone raised high above the earth. Finally the particle fell back to its original position, giving up its energy, which was then radiated out as luminous vibrations.

By exposing the phosphorescent body after excitation to extreme cold, as by dipping it into liquid air, this return of the particles could be stopped. In preparing liquid air that morning for this experiment, there had been, the lecturer said, a very serious catastrophe, since the tremors of the engine had cut short the life of Sir James Dewar's soap-bubble, after an existence of thirty-seven days. Had he had any suspicion of the danger, he would have deferred the matter till the bubble had succumbed to old age.

By the action of extreme cold it is possible to suspend indefinitely the transformation into phosphorescence of the potential energy due to the lodgment of the displaced particle in the sulphur. Light could thus, as it were, be "put into cold storage," since the substance, on warming up again, would show its normal phosphorescence. In the foregoing case the production of phosphorescence was stopped by the extreme cold. With some bodies, however, the return of the displaced particle was so quick that under ordinary conditions no phosphorescence was visible after excitation by light. By keeping these bodies in liquid air during the process of excitation, the return could, however, be made slow enough for the bodies visibly to phosphoresce. This was the case, the lecturer showed, with an ordinary paraffin candle and with an egg-shell, both of which, treated as stated, continued to phosphoresce for some time after removal from the exciting light and the liquid air.

Light provided one means of producing the phosphorescent effect, but there were others, though he had no doubt but that the mechanism involved was the same in all. Thus phosphorescence could be produced by simply bombarding some bodies with cathode rays, in which case negative particles were driven into the substances in question. The general effect was thus much the same as that produced by the action of light on ordinary phosphorescent bodies. This production of phosphorescence by means of cathode rays, the lecturer showed with powdered Iceland spar which, treated as stated, continued to glow with an orange-colored light long after the bombardment ceased. A similar effect was shown with fluorspar, which was one of the earliest bodies known to be phosphorescent. A detailed study of this phosphorescence of fluorspar had, he continued, been made by Mr. Morse, who found that on stimulating it with light of a definite wave-length the spectrum of the consequent phosphorescence comprised a whole series of sharp lines. Mr. Morse had used in some cases terminals of zinc for his discharge-tube, and in others aluminium terminals, and the consequent phosphorescent spectra showed a number of bright lines, which had, however, no relation either to the spectra of the metals used as terminals or to that of fluorine. If these results were confirmed, they would, the speaker said, form an important addition to the few cases known in which spectra consisting of bright sharp lines had been obtained from solid bodies.

A somewhat similar case was provided by didymium, which yielded a spectrum of quite definite lines, which differed from compound to compound. In the case of didymium there would seem to be a resemblance to the resonance spectra of mercury, sodium, and iodine, discovered by Prof. R. W. Wood. In Morse's experiments the resonance lines obtained with aluminium terminals formed one series, while the use of zinc terminals gave another series.

Thermo-luminescence, a phenomenon shown by certain solid solutions is of the same character as the foregoing, but in this case the new body was so stable and the return so slow that in ordinary conditions no visible light was produced. The return could, however, be accelerated by heating the body, in which case the energy was liberated at a rate sufficient to affect the eye. Taking a solid solution of manganese sulphate in calcium sulphate, the lecturer bombarded it with cathode rays, and showed that there was no sign of phosphorescence when the rays were cut off. On slightly warming it, however, it glowed brightly. In this case, he said, the new system formed by the action of the rays was so stable that the chemical reversion was not rapid enough to yield light unless it was accelerated by raising the temperature. The case was, in fact, quite analogous to that in which a body naturally phosphorescent was kept in liquid air, since the luminescence of the mixed sulphates could be developed a week after the original excitation.

It was not only with solids that luminescence was observed, but gases also could be made to phosphoresce. This the lecturer showed by inserting in a coil, traversed by an alternating current, a bulb containing pure oxygen at so low a pressure as to be conductive. The bulb formed a secondary to the primary coil, and as the current passed through the latter the induced current in the bulb made the oxygen luminous, and this luminosity was retained for an appreciable time after the bulb was removed from the exciting coil. This phosphorescence, he proceeded, arose because the excitation produced a modification of the oxygen, which gradually reverted to its original state when the bulb was removed, and in thus going back gave out light. The lecturer further showed that the rapidity of this reversion was greatly increased if the bulb were heated, as the luminescence then ceased almost instantly. A similar glow could, he showed, be obtained with pure nitrogen, a discovery due to Prof. Strutt, thus proving that changes of the character in question could be obtained in the case of gases as well as in that of solids. With liquids, on the other hand, fluorescence was more common than phosphorescence, but the distinction between the two phenomena was a matter of time, rather than a difference in action. "Phosphorescence" was the term used when the light lasted long enough after the excitation ceased for the light to be visible to the eye; but if the time of reversion was so short that the light was visible only so long as the excitation lasted, the phenomenon was known as "fluorescence." So far as was known, however, the effects were exactly the same in kind. Light fell on the fluorescing body and produced something else not so stable, which, in going back to its original condition, gave out light of a different wave-length from that which had acted on it as a stimulus. Most cases of fluorescence followed Stokes's law, according to which the light given out was always of greater wave-length than the exciting light. Some exceptions to this law were now known, in particular the resonance spectra discovered by Prof. Wood.

Chemists had paid marked attention to the connection between chemical composition and the property of fluorescence, the matter being of interest in connection with dyes. The conditions necessary for fluorescence were that the body should be able to absorb energy from the light, and it must accordingly possess strong absorption bands. Its constitution must be complicated, so that new modifications might be readily formed, and these modifications must not be very stable, so that they might be able to revert readily to their original form. Certain theories had been advanced as to the kind of rings which best lent themselves to this kind of change. The subject had, however, been mainly studied in con-

*From *Engineering*.

nection with dyes, where it was essential that the fluorescence must lie within the visible part of the spectrum, and this circumstance had, perhaps, hampered the formulation of a satisfactory theory. Simpler ideas might, perhaps, have been arrived at had more study been given to the cases in which the fluorescence lay in the ultra-violet, instead of imposing the condition that the incident ultra-violet light must produce a fluorescence of sufficiently long wave-length to affect the eye.

For his own part the lecturer thought that a certain distinction between the various organic compounds to which he had called attention on a previous occasion might have something to do with the question whether an organic compound was fluorescent or not. He had brought forward evidence to show that in certain of these compounds the individual atoms were electrically neutral, while in other compounds some of the atoms might have an excess of either positive or of negative electricity. Some radicals accordingly functioned as if uncharged, and others as charged compounds. The most evident effect of ultra-violet light was its property of dragging out particles of negative electricity, so that if it fell on an uncharged compound it might cause it to become charged—a condition which was not stable—and the potential energy represented by this charge was responsible for the light generated, as the original condition was reverted to. Hence fluorescence might possibly be due to an oscillation of a radical between a charged state and an uncharged one. The primary cause was thus to be sought in the action of the incident light in causing a negative particle to be ejected, and on reversion the energy absorbed in this process was turned into light of a definite wave-length.

There was much evidence to show that the energy expended in such transformations was greater the shorter the wave-length. To illustrate this, the lecturer placed an exhausted bulb in the primary coil of the apparatus, previously used to show the phosphorescence of oxygen, and showed that the ring of light produced within the bulb was bluish near its outer edge, where the electric force was greatest, and reddish at its inner edge, where the electric force was weaker. This experiment, he said, indicated that there was a very important connection between the energy put into a system and the kind of light emitted in consequence thereof. Planck's relation between the two, which had led to some very interesting results, was that the energy necessary to produce light of a particular kind was inversely proportional to the wave-length.

Photometry of the Gas-Filled Lamp

The new high efficiency gas-filled lamp introduces variables not hitherto encountered in the photometry of incandescent electric lamps. On account of the comparative broadness of the filament spiral and the dissymmetry of the filament mounting there is considerable irregularity in the distribution of the light about the vertical axis. Consequently, when the lamp is rotated, as is commonly done in rating lamps at the factory, the light as seen in the photometer flickers so excessively as to render accurate measurements of candle-power practically impossible without the use of auxiliary apparatus. However, as is sometimes done, if two mirrors inclined to each other be placed back of the lamp, the flickering is so much reduced as to permit accurate candle-power measurements even at very low speeds of rotation.

But this expedient does not eliminate the most serious trouble caused by rotation. It was found that at constant voltage both the current consumed and the candle-power are different when the lamp is rotating than when it is stationary, the current changing in one direction and the candle-power always in the opposite direction; that is, there is a change in the operating efficiency of the lamp. Furthermore, this change in efficiency may be either positive or negative, depending upon the speed, and it is about twice as great when the lamp is rotating tip up as when it is rotating tip down.

Fortunately, from the standpoint of photometry, there is for each lamp in either position a particular speed at which the current and the candle-power have the same values, respectively, as when the lamp is stationary. Hence, with the lamp rotating at this speed its candle-power can be measured with accuracy in spite of its rotation. The speed for the above condition is practically the same for all lamps having the same number of loops in the filament; but for lamps having different forms of filament mounting it varies from lamp to lamp, being greatest for those having the smallest number of loops in the filament.

If the above precaution as to speed adjustment is not observed and lamps are rated while rotating at speeds ordinarily used in photometering vacuum lamps, the errors which enter may amount to as much as 1 to 2 per cent in current, or watts, in one direction, and as much as 15 to 20 per cent in candle-power in the opposite direction. Hence the voltage found for a desired operating efficiency may be so much in error as to give a lamp on test at this rated voltage a fictitious life value three or four times as large as the lamp would give if it were operated stationary at a voltage corresponding to that efficiency which during the rating was only apparent. That is, the lamp may be given credit for a much longer life than it really deserves. On the other hand, the speed may be such as to cause errors in the opposite direction, resulting in a lamp life much shorter than would be expected from the apparent efficiency rating.

Another peculiarity of the gas-filled lamp is that while it burns the blackening occurs, not all over the bulb in approximate proportion to the light distribution as in the vacuum lamp, but principally at the top of the bulb because the volatilized material is carried upward by the gas. Hence in making a life test a true measure of the reduction in total light during the life of the lamp can not be obtained. in the usual manner, by mean horizontal candle-power measurements, but by determinations of the total flux or mean spherical candle-power. This is accomplished most rapidly and conveniently by means of an integrating photometer, such as the Ulbricht sphere, in which the lamp is measured stationary, and thus all the complications arising from rotation are entrely avoded.

As to the cause of the variations observed in candle-power and efficiency when the lamp is rotated, it is concluded from the results of a number of special tests that the whole effect is produced by a change in the convection currents of the gas, a consequent variation in the temperature distribution in the bulb, resulting in a change in the resistance, and therefore a variation in the current and candle-power of the lamp.—*Scientific Paper, No. 264, of the Bureau of Standards.*

A Test of Physical Fitness*

The conservation of national vitality has become a popular theme in this country. It is a part of a still greater problem which is designated as national efficiency. The old fatalistic belief in the inevitable occurrence of ill health and early death in certain instances has given way to the rapidly growing conviction that premature death and disease are for the most part avoidable and that it is within the power of man to rid himself of many of the enemies to comfort and good health. The aim of hygiene is to approximate, with respect to health, the ideal of a life free from illness and disability of every kind.

In this effort to bring about a maximum fitness of mankind, many agencies are being brought into play. Our physical environment is being subjected to closer scrutiny; and by means of private and public regulation, a protection is frequently rendered to mankind in ways more important than that provided by the work of police or fire departments. The abatement of nuisances, inspection systems, regulation of labor and trades—these are a few reminders of the vigorous attempts at the conservation of health through public hygiene. To this may be added the improvement of the social environment and the effects of what has been called semi-public hygiene, that is, the disciplines relating to institutions and the medical profession. The diffusion of knowledge regarding the laws of health and its control, the care of individuals who are for some reason unfitted to adjust themselves to the needs of the day, along with numerous other potential agencies for bringing about health, are illustrative of the prophylactic tendencies of the times. It is being found that "philanthropy and profit are not always antagonistic." Finally, public hygiene is receiving the support of personal hygiene, without which it must remain ineffective. Here nutrition, fresh air, exercise and rest, sports, and the combat with the social diseases find their place. Some one has well remarked that the present world-wide interest in personal hygiene and physical education is not due to any startling discoveries, but to the rediscovery of the importance of truths long insisted on by the medical profession. The knowledge of the value of fresh air and good food is old. It is the application which is new.

A healthy organism calls into play almost innumerable functions, both physical and mental. How to measure the efficiency with which they are carried out and the fitness of the individual to undertake or endure them has become a problem of the day. Mental capacity has been investigated by a variety of standards, some of which have gradually become widely accepted. As an instance of how the quantity and quality of intellectual product per unit of time can be studied, we may refer to such psychologic tests as the naming of colors, cancellation, addition, mental multiplication, typewriting, grading of various performances, and exercises in English composition. The ability to accomplish set tasks of this sort varies with environmental as well as personal and hereditary conditions. The physical working capacity of the individual can likewise be measured by a variety of apparatus designed to test muscular strength.

The fitness of man involves something more than the ability to do sums or lift dumb-bells. The propaganda for health and increased vitality obviously calls for some added mode of measuring the results of supposed benefits and menaces, long-continued activities, such as physical training, gymnastics, play, athletics and good ventilation on the one hand, and fatigue-producing activities on the other. The record of the incidence of disease, the school record, the blood count, etc., are not a sufficient criterion. Among the added tests which are intended to show the beneficial or depressive effect of various conditions supposed to affect health is the "blood ptosis test."[1] This has been designed by Dr. C. Ward Crampton of the Bureau of Educational Hygiene in the New York City Department of Education to measure a function easily wearied and damaged by unhygienic influences. It is based on the fact that the vasomotor control of the splanchnic area in man experiences a change of adjustment when the body is moved from the horizontal to the upright standing position. According to Crampton, the efficiency of this control is measured by placing the subject in a horizontal position and taking the systolic pressure in the brachial artery. The subject is then required to stand, and without removal of the cuff, the blood pressure is taken in a vertical position. In a perfectly strong and vigorous subject the splanchnic vasotone will increase and the blood pressure will be found raised about 10 millimeters of mercury. In an individual weakened by dissipation, overwork, lack of sleep, or by the incidence of disease, the blood pressure will tend not to rise but to fall. It was found that in the vigorous subjects the heart rate did not increase on standing, and in the wearied subjects it increases as much as forty-four beats per minute. It was further found that this difference varied with the blood-pressure differences and in some cases took the place of the blood-pressure variation. In other words, the same subject under the same conditions would show a weakness sometimes by a decrease in blood pressure, and at other times by an increase in heart rate, and *vice versa*. After further observation, it was determined that a decrease of 1 millimeter of mercury had a value of an increase in heart rate of approximately two.

By taking into account both of these features and adjusting the changes in heart rate into terms of corresponding blood-pressure variations, Crampton has devised a percentage scale of vasomotor tone ratings which have been put to the test by numerous observers. Experience already shows that the measurement of the changes in the performance of the heart and the vasomotor system in different postures may reveal damages before subjective or objective symptoms are apparent. For example, the New York State Commission on Ventilation has recently reported that a very high room temperature, such as 86 deg. Fahr., with 80 per cent relative humidity, produces a marked fall in the Crampton value of subjects.[2] The use of fans afforded some improvement. The new test obviously does not measure numerous important features, such as the structural condition of the heart; yet it seems likely to have considerable value in furnishing added data for the estimation of what we may, for the want of a better term, call physical fitness.

* *Journal* of the Am. Medical Association.

[1] Crampton, C. W.: The Blood Ptosis Test and Its Use in Experimental Work in Hygiene, Proc. Soc. Exper. Biol. and Med., 1915, xii, 119.

[2] Some Results of the First Year's Work of the New York State Commission on Ventilation, Am. Jour. Health, 1915, v, 101.

Effects of Sulphur in Cast Iron

E. Leber, in *Stahl u. Eisen*, says that in certain cases the results show that a higher sulphur content results in an unmistakable rise in strength of cast iron and a partial improvement in flexibility. The tendency to segregaton and the formation of cavities increases, however, with the sulphur content, and for this reason sulphur may be prejudicial. Segregation does not affect the strength so much as do cavities. The action of sulphur in promoting the formation of cavities is in causing the internal friction of the particles during the transition from the molten to the solid state, not only to become very great, but to increase so rapidly that frequently pouring must be stopped because the casting has solidified. This difficulty is overcome by pouring the iron as hot and as quickly as possible, and lack of success in casting iron with a high sulphur content is due to these precautions not having been observed.

The Military Rifle*

A Review of the History of the Development of the Breech Mechanism

By Douglas T. Hamilton

THE modern military rifle is an evolution from the musket or shoulder gun, which came into use in Europe in the fifteenth century, displacing the matchlock. The matchlock musket was superseded, in turn, by the wheellock, the snaphance, the flintlock and the percussion gun. The flintlock (Fig. 1) was the first shoulder firearm to be generally used in warfare. Although the method of firing the charge was crude, it permitted the soldier to aim and fire quickly. The flintlock musket had a smooth bore of comparatively large diameter, and fired spherical bullets. The invention of fulminate of mercury percussion caps for igniting the powder charge in 1799 brought the percussion lock to the front and displaced the clumsy, slow and non-dependable flintlock. All these early guns were muzzle loaders, the powder charge and bullet being inserted into the bore at the muzzle and pushed to the breech by a ram-rod. An improvement in firearms ranking with the percussion cap or primer was the rifled bore which appeared early in the sixteenth century. Little is known of the origin or early development of rifling or helical grooving of the bore to give rotation to the bullet in flight. It has been attributed to several men, one of whom was Gaspard Koller, a gunsmith in Vienna, Austria.

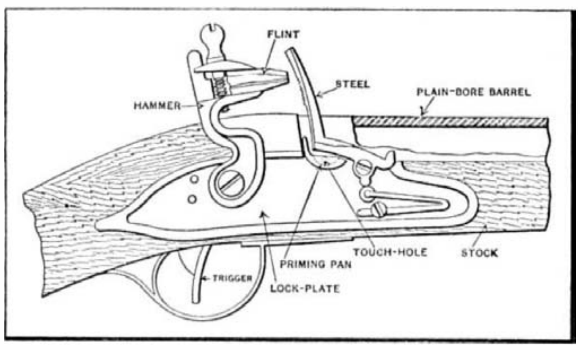


Fig. 1.—First successful military shoulder gun, employing a flintlock.

IMPROVEMENTS IN MILITARY RIFLES.

The rifled bore improved the accuracy of fire, but difficulty was experienced in expanding the ball so that it would follow the rifling grooves. Various devices were adopted for expanding the ball, such as ramming it onto a pointed projection at the breech end of the barrel, etc., with more or less success. After the adoption of the rifled bore, attention was directed more to the bullet than to the arm itself. The first bullet was of spherical shape similar to that which had been fired from the smooth-bore musket, but for obvious reasons this was not satisfactory. Bullets were then made with bands, "wings," cup-shaped, etc., the development gradually leading up to the design of a bullet of oblong shape. No marked improvements were made, however, until 1849 when Capt. Minié devised a hollow base bullet which was expanded by the explosion of the powder charge. This bullet was designed for use in the Thouvenin rifle, and was oblong in shape, with a hollow base in which a hemispherical iron cup was inserted.

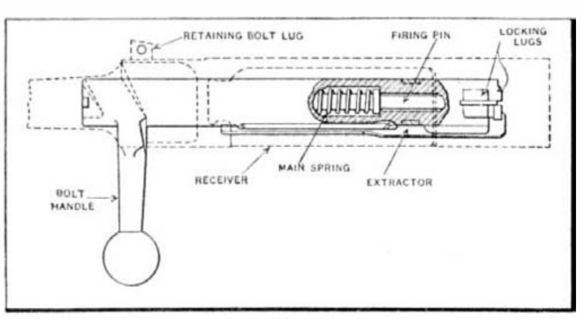


Fig. 5.—Diagram illustrating Mauser type of bolt action.

The first rifled muskets had seven grooves in the bore with a twist of about one turn in ten feet. The twist of the rifling grooves was increased with improvement in accuracy, and in the Brunswick rifle, brought out in 1836, the twist was made one turn in 30 inches—the length of the barrel. This proved unsatisfactory, however, as it was found that the bullet was driven across the lands instead of following the grooves. The grooves were then made with an increasing depth to assist the bullet in following them, but this made a difficult rifling proposition. An increase in the depth of the grooves also proved unsatisfactory.

*Reproduced with cuts by courtesy of *Machinery*.

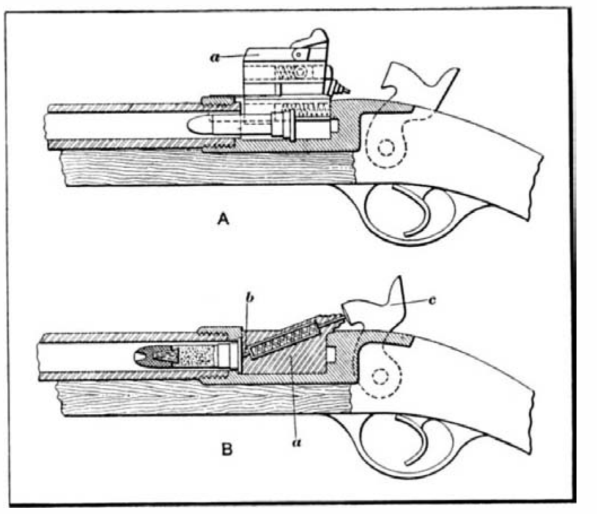


Fig. 3.—Breech mechanism designed by Jacob Snider in 1866.

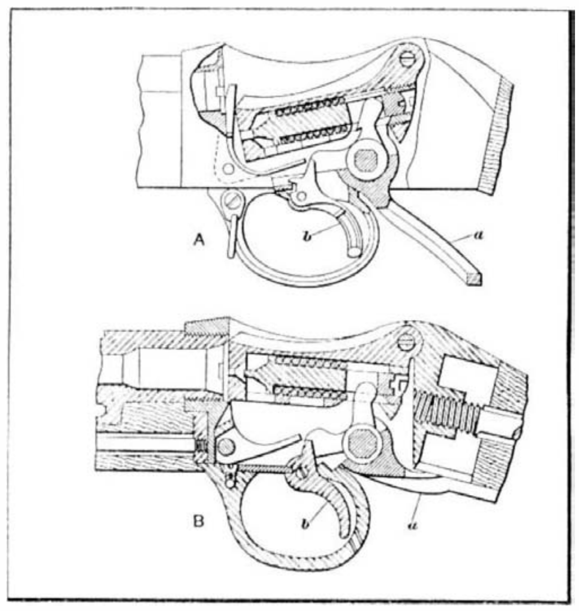


Fig. 4.—Martini bolt action designed in 1870.

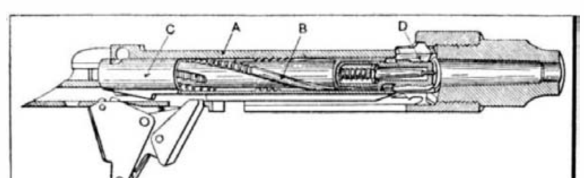


Fig. 7.—Ross straight-pull bolt action designed in 1907.

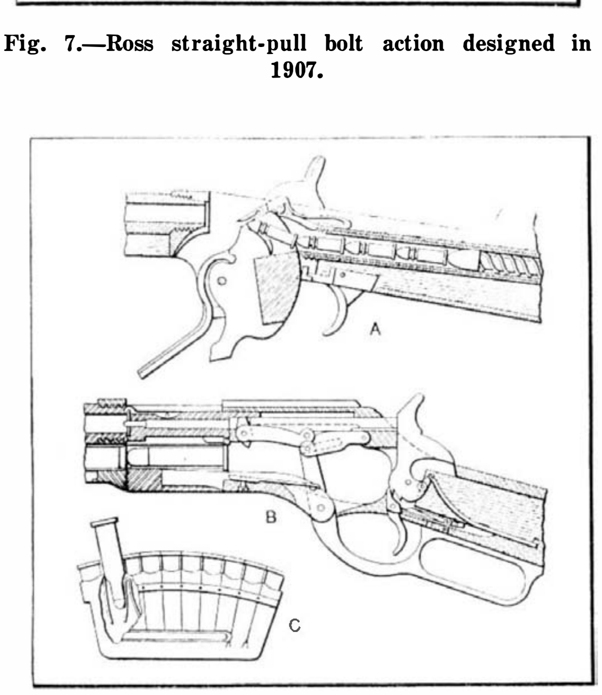


Fig. 8.—A, One of the first successful magazine rifles, known as the "Spencer." B, Winchester magazine repeater. C, Russian Kranka quick-loader, forerunner of present day clip charger.

In 1854 Mr. Whitworth brought out a rifle with a hexagonal bore having a twist of one turn in 20 inches and measuring 0.450 inch across the flats. The bullet was also made of hexagonal shape. Other rifles having bores of polygonal shape were tried but discarded. Owing to the difficulty of producing hexagonal and polygonal bores, rifling was again resorted to, and in 1865 Mr. Metford produced a rifle of 0.450 caliber, having five shallow grooves and firing a lead bullet hardened with antimony and wrapped in a thin paper patch.

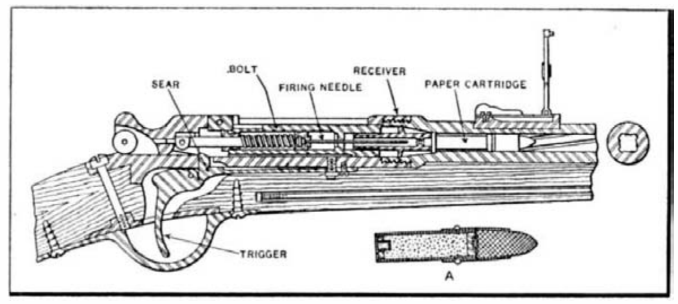


Fig. 2.—French Chassepot rifle of 1866.

Expansion of the bullet, which was made cup-shaped, was effected by the force of the powder explosion on its base.

DEVELOPMENT OF BREECH-LOADING RIFLES.

The disadvantages of the muzzle-loading rifle were early appreciated, and many attempts were made to load at the breech. Even as early as the sixteenth century rifles were designed to load at the breech. One of the first attempts consisted in having a side entrance to the bore at the breech through which the bullet and powder were inserted, the cavity being closed by a screw. The first practical breech-loading rifle was the Prussian needle gun invented by Dreyse in 1838 and adopted by Prussia in 1841. In this rifle the breech was closed by a mechanism resembling the turn-bolt of a door. Ignition was effected by a long needle carried in the bolt, which was driven forward by a spiral spring upon pulling the trigger. The needle, when forced forward, pierced the base of the cartridge and ignited the powder charge by striking a disk of fulminate of mercury contained within it. The escape of gas from the breech proved troublesome, but the gain in rapidity of loading more than compensated for this defect. This rifle, while unsatisfactory in many respects, was an improvement over previous designs and was used generally by Prussia with marked success in the wars of 1848, 1866 and 1870.

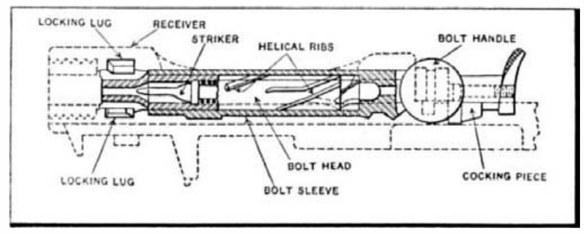


Fig. 6.—Principle of construction of Mannlicher bolt action.

TYPES OF BREECH MECHANISM.

The advantages of the breech-loading rifle were soon designated in the first half of the nineteenth century. The majority of breech mechanisms were provided with some sort of a hinged block which was turned over to give access to the chamber in which the charge was placed. The type known as the "Lefaucheux System" had the barrel hinged at the breech end somewhat similar to the present-day shotgun. While this system proved satisfactory for shotguns, it was never considered of practical value for military rifles. Another breech mechanism, known as the revolving type, consisted in rotating the barrel eccentrically in relation to the breech end, but this was soon discarded owing to the difficulty of preserving the correct alignment between the two members, and the leakage of gas between the chamber and the barrel.

In most of the breech-loading guns invented between 1850 and 1860, the percussion cap was separated from

the charge, being located on a nipple. The flame from this cap had to pierce the cartridge and ignite the charge. This system was adopted in the early Sharp, Terry, Greener and Westley-Richards rifles. The Sharp, which was an American rifle, was patented in 1852. The breech end of the barrel was closed by a slide, actuated by a lever forming the trigger guard. To load the rifle, the slide was drawn down to insert the cartridge, and when raised it closed the breech, and at the same time the sharpened top edge cut off the end of the cartridge, exposing the powder to the flame of the percussion cap.

In the Terry rifle a tallowed wad was fixed at the base of the cartridge, and the charge was ignited from the center. The ball was made larger than the bore so that it filled the grooving when forced into the rifling. The Westley-Richards rifle had a hinged block that opened forward, and like the Terry, used a felt wad that served as a gas check. In the Greener carbine, the barrel was unlocked from the breech and slid forward. The escape of gas was prevented by a sliding tube having a tapered ring at its rear end, which acted in the same manner as the obturator used on large caliber guns.

This principle was also taken advantage of in the French Chassepot rifle, designed in 1866 (Fig. 2), which had a straight-pull bolt, and was arranged to carry a combustible cartridge *A*. This was made with a paper

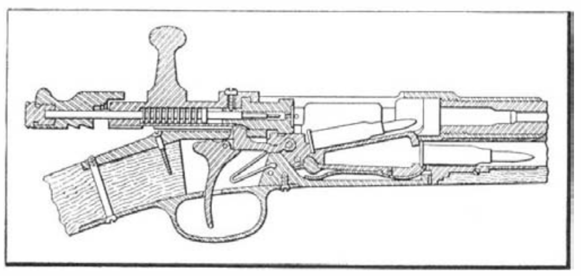


Fig. 9.—Diagram of breech action of French Lebel rifle.

case, and it had a cap in the center of the base; the face of the bolt was provided with a rubber washer to check the escape of gas. About the same time Colonel Boxer devised a cartridge with a case made from coiled brass instead of paper. This was first used in the Snider rifle. The invention of the coiled brass cartridge case gave great impetus to the development of breech-loading rifles. The Boxer case was made from sections of coiled brass; the head, which carried the percussion cap or primer, was attached by solder. Previous to the invention of the brass case, all cartridge cases were made from paper, and consequently were not gas tight. The breech mechanism had to be made so as to prevent the escape of the gases, which was practically impossible. The built-up cartridge case designed by Colonel Boxer was much superior to the paper cartridge case, but it was bulky and not altogether a perfect gas check because of defects in construction. The principle, however, was sound and the later development of the one-piece drawn cartridge case overcame the objections inherent in the Boxer cartridge.

THE SNIDER BREECH MECHANISM.

One of the early breech mechanisms used with considerable success was that designed by Jacob Snider and adopted by the British Government in 1867. In this rifle a swinging block was held in a recess in a short receiver screwed to the breech end of the barrel. The block *a*, as shown in Fig. 3, was hinged on the right-hand side of the receiver, which on being opened gave access to a tapered chamber in the breech end of the gun. A projecting spring pin held the block in place when opened. Located on the front end of the block was a hook extractor that engaged the head of the cartridge case to withdraw it after being discharged. In lifting up the block, it also could be withdrawn a short distance; this extracted the cartridge from the chamber, and it could then be thrown out by turning the rifle over. The striker *b* was located diagonally in the block and when struck by hammer *c* was caused to hit the cap in the head of the cartridge. The bullet had a hollow in its base in which a taper plug of wood or clay was inserted to cause it to expand into the rifling grooves. The front end was also made hollow so as to distribute the weight evenly and thus increase the accuracy.

THE MARTINI BREECH MECHANISM.

The Snider breech block had several disadvantages, chief among which was the difficulty experienced in pre-

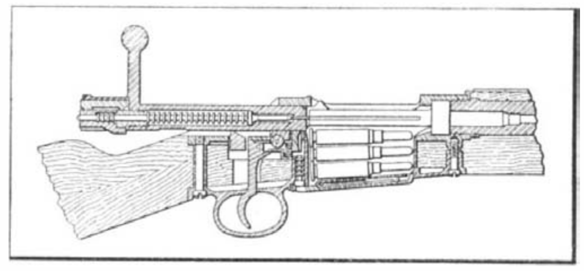


Fig. 10.—Diagram of breech action of Spanish Mauser.

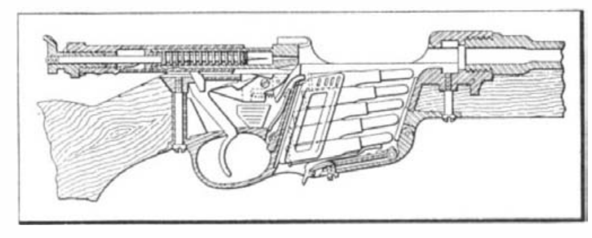


Fig. 11.—Diagram of breech mechanism of Austrian Mannlicher rifle.

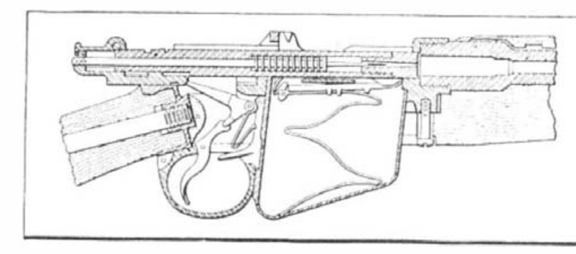


Fig. 12.—Diagram of British Lee-Enfield breech action.

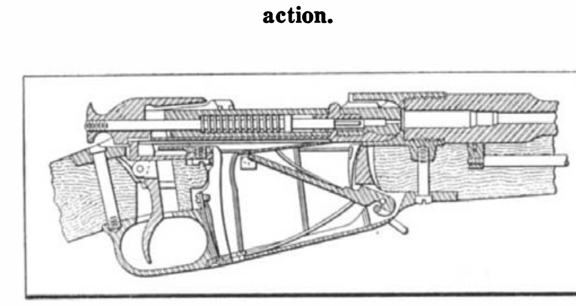


Fig. 13.—Diagram of breech action of the Russian three-line Nagant military rifle.

venting the escape of gas. A considerable improvement in breech mechanism was devised by Mr. Martini in 1870 and finally adopted in 1871. As shown in Fig. 4, this action was designed along the lines of some of the present-day sporting rifles. Instead of the block being hinged to lift up, it was dropped down by operating lever *a*. This gave access to the chamber in the barrel and when the block was raised the breech was effectively closed. The firing pin was carried in this block and was released by pulling trigger *b*. This breech mechanism was applied to the Henry barrel, and the combination was known as the Martini-Henry rifle. The barrel was 33.2 inches long, 0.450 inch caliber, and had seven shallow grooves making one turn to the right in 22 inches. The muzzle velocity was 1,350 feet per second.

MODERN RIFLE BOLT ACTIONS.

The bolt actions used in modern military rifles may be divided into two groups: (1) those in which the bolt is rotated by raising the bolt lever before the bolt can be withdrawn; (2) those that can be drawn straight back to the rear without any rotary movement of the hand-lever, known as "straight-pull" bolts.

Those in the first group are used by all the principal countries with the exception of Austria, Switzerland and Canada. These three employ the "straight-pull" bolt action. One of the advantages of a rotating bolt is that a powerful loosening action can be exerted on the fired cartridge case by the bolt handle working on the receiver cam surface. If the bolt is supported by symmetrical lugs as in the Swiss rifle and Austrian pattern of 1895, the lugs have to be rotated to clear them from

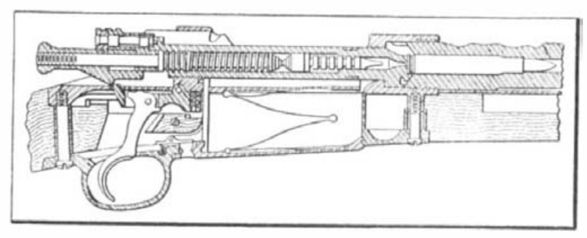


Fig. 14.—Diagram of breech action of Springfield Model 1903 rifle.

their seating in the receiver. In the rotating bolt action this is avoided by rotating the bolt by the bolt lever.

There are many forms of rotating bolts. For instance, in some cases the bolt head does not rotate, and the bolt itself is locked at the rear instead of at the front end. In others, there is no separate head and the locking lugs are on the front end of the bolt, no lugs being provided at the rear. Then there are bolts with both a rotating bolt head and locking lugs. One of the rotating bolts, the Lee-Enfield, is the only one with the lugs near the rear part of the bolt. The disadvantage of this arrangement is that upon firing, unsymmetrical stresses are set up in the bolt and receiver, causing lateral vibration and affecting the accuracy of fire. When the lugs are on the front end of the bolt, the symmetrical front of the receiver and bolt resist the backward motion of the cartridge on firing, but the recess in which the lugs work is difficult to clean out if sand gets into it, which may happen in hot countries where dust storms occur. The French and Russian rifles have bolt heads which carry the locking lugs and rotate with the bolt. This system appears to have no advantage except for repair purposes. The most desirable bolt is one in which the fore end is solid and is locked in cam-shaped grooves in the front end of the receiver, as in the Mauser rifle.

THE MAUSER BOLT ACTION.

The Mauser bolt, which is shown diagrammatically in Fig. 5 is of strong and simple construction without a movable bolt head. It can be stripped without the use of tools and is locked by lugs on the front end engaging with cam-shaped grooves cut in the receiver. This form of bolt, which is of the "turn" type, is used with slight modifications on the greater number of military rifles. The Belgian, German, Spanish and Turkish Mauser breech mechanisms vary to a slight extent in the construction of the bolt. Of these four, the Spanish bolt is the simplest, but it has been found to be rather weak as compared with the German bolt. On the German bolt an extra lug engaging in a recess in the cylindrical

TABLE I. THE PRINCIPAL DIMENSIONS AND SPECIFICATIONS OF MILITARY RIFLES USED BY THE VARIOUS GOVERNMENTS

Country	Model (year)	Designation	Magazine System*	No. of Cartridges in Magazine	Weight in Pounds (without bayonet)	Total Weight, Pounds	Length (without bayonet), Inches	Total Length, Inches	Length of Barrel, Inches	Caliber of Bore, Inches	No. of Rifling Grooves	Depth of Grooves, Inches	Shape of Grooves	Twist of Rifling, Inches	Muzzle Velocity,† Feet per Sec.
Austria and Bulgaria	1895	Mannlicher	Fixed Vert. Box	5	8.34	8.98	50.00	59.50	30.12	0.315	4	0.0080	Concen. Beveled Edge	9.842	2840 2034
Belgium	1898	Mauser	Detach. Vert. Box	5	8.03	9.56	50.25	59.75	30.67	0.301	4	0.0065	Concen.	9.842	1975
Canada	1907	Ross	Fixed Vert. Box	5	8.06	9.08	52.00	58.80	28.00	0.300	4	0.0055	Concen.	10.000	2800
Denmark	1889	Krag-Jorgensen	Fixed Horiz. Box	5	9.73	10.28	52.75	63.00	32.90	0.315	6	0.0075	Metford Segmental	11.811	2535
France	1907-15	Lebel	Fixed Vert. Box	3	6.91	7.83	51.12	71.84	31.49	0.315	4	0.0059	Concen.	9.450	2310
Germany	1898	Mauser	Fixed Vert. Box	5	9.00	9.87	49.40	69.75	29.05	0.311	4	0.0065	Concen.	9.390	2960
Great Britain	1907	Lee-Enfield Mark I	Detach. Vert. Box	10	9.25	8.64	49.50	61.50	30.19	0.303	5	0.0065	Concen.	10.000	2060
Great Britain	1907	Lee-Enfield Mark III	Detach. Vertical Box	10	10.22	9.64	44.50	61.50	25.19	0.303	5	0.0058	Concen.	10.000	2440
Greece	1903	Mannlicher-Schoenauer	Fixed Vert. Box Rotary Platform	5	8.34	9.00	48.37	58.12	28.56	0.256	4	0.0065	Concen. Round Edge	....	2400
Holland	1895	Mannlicher	Fixed Vert. Box	5	9.68	10.42	51.00	60.75	31.12	0.256	4	0.0065	Concen. Round Edge	7.874	2433
Italy	1891	Mannlicher-Carcano	Fixed Vert. Box	6	8.40	9.18	50.75	62.37	30.75	0.256	4	0.0060	Concen.	Increasing from 19¼ to 8¼	2300
Japan	1907	Year 38 Pattern	Fixed Vert. Box	5	8.63	9.56	50.75	65.75	31.30	0.256	4	0.0060	Metford Segmental	7.875	2420
Portugal	1904	Mauser-Verguiero	Vert. Box Mov'bl Box	5	8.81	9.59	48.00	59.25	29.08	0.256	4	0.00575	Concen. Round Edge	7.780	2347
Roumania	1893	Mannlicher	Fixed Vert. Box	5	8.80	9.59	48.50	58.25	28.56	0.256	4	0.0065	Concen. Round Edge	7.874	2430
Russia	1894	Mauser-"3 Line" Nagant	Fixed Vert. Box	5	8.95	9.70	51.87	69.00	31.50	0.300	4	0.0070	Concen. Round Edge	9.500	2886
Spain	1896	Mauser	Fixed Vert. Box	5	9.42	10.34	48.62	58.50	29.03	0.276	4	0.0055	Concen. Round Edge	8.680	2330
Switzerland	1900	Schmidt-Rubin Short Rifle	Detach. Vert. Box	6	8.03	8.64	43.12	58.75	23.33	0.295	3	0.0039	Concen. Round Edge	10.630	2705
Turkey	1893	Mauser	Detach. Vert. Box	5	9.06	10.50	48.60	66.60	29.13	0.301	4	0.0055	Concen. Rond Edge	10.000	2140
United States	1903	Springfield	Fixed Vert. Box	5	8.69	9.69	43.21	59.21	24.006	0.300	4	0.0040	Concen.	10.000	2750

Machinery

* In connection with the magazine systems of the various rifles, a charger instead of a clip is used, with the exception of those used by Austria, Bulgaria, Holland, Italy and Roumania; the Canadian rifle uses neither a charger nor clip. Of the rifles listed, only those used by Canada, Denmark, Germany, Great Britain, France, Turkey and United States have cut-offs in the magazine.

† Due to the adoption of improved smokeless powder since the time these data were compiled, some of the muzzle velocities have been increased from 10 to 25 per cent above those given in the table.

part of the receiver gives additional support when the cartridge is fired.

The face of the bolt is recessed to receive the head of the rimless cartridge. The lever on the bolt is straight and extends at right angles from the rear end. The left-hand lug has a slot cut in it in which the ejector slides when the bolt is withdrawn to eject the cartridge. The extractor fits on the outside of the bolt and is held in place by a spring collar working freely in a groove cut in the body. On the Spanish Mauser this extractor is exposed and unsupported, except for the retaining ring, whereas on the German Mauser a rib is provided which supports the extractor, giving it greater strength at the time of primary extraction. The operation of this bolt will be more fully described in connection with the description of the Mauser rifle.

THE MANNLICHER BOLT ACTION.

As has been previously mentioned, the Mannlicher bolt action is of the "straight-pull" type. This is diagrammatically shown in Fig. 6. The bolt proper is a hollow cylinder with ribs on each side which work in straight grooves in the receiver. Inside the middle portion of the bolt are two helical feathers or ribs which work in corresponding grooves in the tail of the bolt head and give it a rotary movement in opening and closing the bolt. A groove is cut on the inside of the right rib of the bolt sleeve or cylinder for the extractor.

The bolt consists of the head proper, which projects beyond the face of the bolt cylinder, and the tail, which enters the cylinder. The bolt head has locking lugs on each side which enter the recesses in the receiver by way of the cam-shaped grooves, and support the bolt head in the firing position. A groove is cut in the head for the ejector. The rear end of the tail has two external helical grooves in which the feather on the cylinder works. The helical grooves have a small groove leading out of them parallel to the axis of the bolt, one to the front and the other to the rear. The one to the front is on top of the tail and that to the rear on the right-hand side when the bolt is open.

This bolt is operated by a pull and push action. When the lever is pulled to the rear, the bolt cylinder cannot revolve because the ribs on it work in the grooves of the receiver and the feathers in the under-cut grooves in the tail. The bolt head, on the other hand, cannot move to the rear until the locking lugs have been disengaged from the recess in the receiver, and this is effected by the turning motion given to the tail of the bolt head by the helical feathers in the inside of the bolt cylinder working in the bolt head tail. Primary extraction is effected by the cam-shaped ends of the grooves in the receiver in which the bolt locking lugs work. The first motion of the bolt to the rear partly compresses the main spring, and as soon as the locking lugs are disengaged from the receiver "cams" they are in line with the ribs on the bolt cylinder and the entire bolt can then be drawn to the rear until arrested by the feathers on the under side of the bolt coming in contact with the horns of the trigger. In closing the bolt, the above movements are reversed, the sear tooth engaging the stud of the cocking-piece and completing the compression of the main spring. The action can be cocked without opening and closing the bolt by pulling back the cocking-piece. At full cock the locking bolt can be used as a safety bolt.

THE ROSS "STRAIGHT-PULL" BOLT ACTION.

The Ross "straight-pull" bolt action used in the Canadian military rifle was designed by Sir Charles Ross in 1907. It is a modification of the Mauser bolt, coupled with the "straight-pull" feature of the Mannlicher type, and is shown in Fig. 7. It comprises a bolt sleeve *A* which acts as a carrier for the bolt *B* and is provided with a handle at the rear. On the exterior bolt surface are two ribs which slide in corresponding grooves in the sides of the receiver. The left rib has a lug engaging with the bolt stop. The extractor is held in an under-cut groove in the top. A slot is cut in the rear end to guide the cocking-piece. The interior is provided with spiral ribs similar to those on the body of the bolt which give the turning movement necessary to lock the bolt. The bolt and the bolt head are made in one piece and are machined to receive the striker and main spring. The lugs *D* on the front end engage shoulders in the receiver and support the bolt while the cartridge is being fired. The front face of these lugs is cam-shaped to facilitate extraction of the cartridge. With this bolt mechanism a straight pull back releases the lugs from the shoulder in the receiver, and extracts the cartridge; and a straight push forward inserts the cartridge and cocks the arm ready for firing.

DEVELOPMENT OF MAGAZINE RIFLES.

The first military rifles which were loaded from the breech end were of the single-shot type. The advantages to be gained by increasing the rapidity with which the rifles could be discharged were recognized early in the history of small arms. A great advance in this direction was made by the adoption of breech-loading rifles, when the powder charge, bullet and igniting agent were contained in one case. Weapons known as repeaters were the first really successful rifles that contained a reserve of cartridges. In this class of weapon the cartridges lay nose to base in a tube contained in the butt or in the fore end of the stock. The breech was opened, the empty case extracted and a fresh cartridge introduced in the chamber. The breech was then closed and the weapon cocked ready for firing. The earliest successful weapon of this class was the Spencer rifle shown at *A* in Fig. 8, which was patented in 1860. This rifle, as the illustration shows, carried the reserve cartridges in a tube in the butt end of the stock, which were followed up by means of a spring-controlled plunger.

The Winchester repeater, shown at *B* in Fig. 8, carried nine cartridges in the magazine, one in the carrier, and one in the chamber. This rifle belonged to that system in which a fixed chamber was closed by a bolt sliding in line with the axis of the barrel and operated by a lever from below. The receiver was divided by a vertical partition into two parts, the carrier occupying the front portion, while the rear contained, with the exception of the breech block lever, the mechanism necessary to operate the breech block and carrier. The breech block was a single piece, the upper end of which had an extractor of the spring hook pattern pinned to it, and at its rear end it supported two side links that formed a knuckle joint.

The hammer was cocked by the end of the firing pin when the breech bolt lever was thrown forward. The rifle was fired by a center lock of the usual pattern. A safety device prevented pulling the trigger when the rifle was cocked. The shells were ejected by the carrier, which lifted up as they were withdrawn, striking them at a distance of about one-third their length from the rear, rotating them about the extractor and throwing them clear of the rifle. The magazine was in the fore end of the stock, and was loaded through a gate in the side cover of the receiver.

THE KRANKA QUICK-LOADER.

The Winchester repeater just described was used by Turkey in the Russo-Turkish war of 1877-1878 with such striking effect that the Russian Government was called upon to adopt a similar method of handling the single-shot gun at that time used by the Russian troops. The defects of the single-loader were partially overcome by the adopion of a quick-loading device known as the "Kranka quick-loader." It consisted, as shown at *C* in Fig. 8, of a receptacle attached to the side of the rifle, in which there were ten pockets. The cartridges were placed in each pocket in a line, head uppermost, so that they could be quickly withdrawn and forced into the receiver of the rifle in front of the bolt. The rifle was then ready for firing, upon closing the breech mechanism. This quick-loader was the forerunner of the present-day chargers and clips used in connection with a large number of military rifles.

MODERN MILITARY RIFLES.

Following the successful use of the Spencer rifle in 1860, practically all the military powers devoted their attention to the adoption of magazine rifles. The first great power to provide its army with a magazine rifle was the German Government. In 1884, it converted the 1871 pattern of the Mauser rifle of 0.433 inch caliber into a magazine rifle, holding eight cartridges in a tube magazine located in the fore end of the stock. All the magazine rifles up to this time were over 0.44 inch caliber, and the French Government was the first to reduce the bore below this, when it brought out the Lebel rifle in 1886. This had a bore of 0.315 inch—which is the caliber of the present rifle—and contained eight cartridges located in a tubular magazine in the fore end of the stock. At the beginning of the present war, however, this tubular magazine was dispensed with and a breech magazine holding three cartridges was adopted in its place.

In 1886, the Austrian Government adopted the Mannlicher rifle of 0.433 inch bore with a "straight-pull" bolt and at the same time adopted Lee's box magazine, which was patented in 1879 and consisted of a box below the entrance to the chamber, containing the cartridges placed horizontally one above the other. A platform actuated by a spring pushed the cartridges upward, so that when the bolt was pushed forward it struck the head of the top cartridge and pushed it into the chamber of the barrel. Another important improvement introduced with this rifle was the principle of multiple loading, which was effected by a sheet steel clip containing five cartridges. The clip full of cartridges was pushed into the magazine and retained by a catch until the cartridges were expended, when it fell out through an opening in the bottom of the magazine. In 1888 the bore of the Mannlicher rifle was changed from 0.433 to 0.315 inch, which is also the caliber of the latest 1895 model. The development of military rifles has been toward a gradual reduction of the bore, the smallest at the present time being 0.256 inch. This caliber has been adopted by Greece, Holland, Italy, Japan, Portugal, and Roumania, as shown in Table I.

The Lebel rifle, shown in Fig. 9, was the first small-bore rifle adopted by any nation, and with it smokeless powder was first used. It is of the turn-bolt type, the bolt being a cylinder bored out from the front end of the main spring, and with a straight lever terminating in a knob near the rear end. It differs from other military rifles in that the stock is made in two pieces, the butt and fore end being joined to the receiver that extends clear down to the bottom of the stock. Some slight modifications have lately been made in this rifle to convert it from a tube magazine rifle to one using a charger that holds three cartridges.

The action of the breech mechanism of this rifle is briefly as follows: Upon turning up the bolt lever, the tooth on the cocking-piece rides up on the inclined face of the cam recess. This compresses the main spring partially. The cocking-piece is prevented from turning with the bolt by the projection being supported by the sides of the receiver. As the bolt is being opened, the lugs on the bolt head are turned in front of their support into a vertical position and the front end of the projection on the bolt is forced back by the curved face of the receiver. The bolt lever and rib are now in line with the openings in the sides of the receiver, so that the bolt and empty cartridge held by the extractor can be drawn back. When the bolt is fully withdrawn it is stopped by the lower lug striking the end of the partition in the receiver. At the same time, the end of the ejector screw strikes behind the left ledge of the cartridge head and ejects the empty cartridge to the right.

Upon pressing the bolt forward, the face of the bottom lug strikes the base of the cartridge in the carrier which has just been raised and pushes it forward into the chamber. As the front of the rib meets the curve on the receiver, the sear engages the cocking-piece and when the bolt lever is turned down, the lugs on the bolt head pass along the curved entrances to the recesses and force the bolt in, completing the compression of the main spring.

THE GERMAN MAUSER RIFLE.

The German Mauser rifle is the model of 1898 and is of the turn-bolt action, after which practically all the modern military rifles have been patterned. This rifle has a bore of 0.311 inch and a muzzle velocity of approximately 2,900 feet per second. It fires a nickel-coated steel-cased bullet, weighing approximately 154½ grains. It is supplied with a fixed vertical box magazine and is loaded with a charger containing five cartridges. The bolt is locked in the receiver by lugs on the fore end and is additionally supported by a lug at the rear end. The extractor differs from the one used on the Spanish Mauser in that a lug supports it during primary extraction. The extractor is held to the bolt by means of a split collar. The construction and operation of the bolt has been previously described.

THE SPANISH MAUSER.

The Spanish Mauser, shown in Fig. 10, differs very little from the German Mauser. The only modifications aside from the sights and other less important details, are in the bolt and bolt plug. The bolt is made extremely plain, having only two locking lugs on the fore end that fit in corresponding cam grooves in the receiver, and is plain on the rear except for a flat, cocking cam slot, safety bolt lock slot, and a locking slot, for the cocking-piece. The extractor is held by a collar the same as in the German Mauser, but is not supported by a lug during primary extraction. The other important details of this rifle are given in Table I.

AUSTRIAN MANNLICHER RIFLE.

The Austrian Mannlicher rifle, shown in Fig. 11, is of the "straight-pull" bolt type, as has previously been described. The magazine carries five cartridges which are held in a clip. As soon as all the cartridges have been removed, the clip drops out of the magazine through an opening in the bottom. The bore of the rifle is 0.315 inch, and it fires a lubricated steel-cased bullet weighing about 244 grains. The "straight-pull" bolt action can be operated slightly faster than the turn-bolt type, but has not the same strength as the latter.

THE ITALIAN MANNLICHER CARCANO RIFLE.

In this rifle, the Mannlicher type of clip holding six instead of five cartridges is used. The breech mechanism is that introduced by M. Carcano of the Turin Small Arms factory, and is a modified Mauser action. The Italian rifle bears a marked resemblance to the Austrian as far as exterior appearance is concerned. The bolt, which is not provided with a separate bolt head, has a lug on each side at the front end. The extractor passes through a slot in the right lug into its seating in the rear. The front end of the bolt is recessed to fit the head of the cartridge, and the rim or recess is cut away at the bottom to allow the cartridges to move up the face of the bolt so that the extractor may enter into the groove, thus avoiding any chance of double loading. The rifling is of the progressive twist type, beginning at the breech end with one turn in 22.9 inches and ending with one turn in 7.5 inches at the muzzle.

THE BRITISH LEE-ENFIELD RIFLE.

In the British Lee-Enfield rifle, shown in Fig. 12, the bolt is designed on the Mauser principle and the bolt head does not rotate with the bolt proper. The Lee-Enfield is the only one of the rotating bolts which has the locking lug near the rear. The disadvantage of this arrangement in firing is that unequal strains are introduced in the receiver and bolt, which cause lateral vibration and necessitate placing the foresight to one side of the barrel as previously explained. The caliber of this rifle is 0.303, and it fires a nickel-jacketed pointed bullet weighing approximately 150 grains, with a muzzle velocty of 2,200 feet per second. Another variation in the British Lee-Enfield is that the magazine, instead of holding five or six cartridges, holds ten and is fed by a charger instead of a clip. A magazine cut-off is provided.

THE RUSSIAN THREE-LINE NAGANT RIFLE.

The Russian three-line Nagant rifle, shown in Fig. 13, is of the turn-bolt type, having a magazine that works on the charger principle. The bolt is provided with a separate head which turns with the bolt and, together with a connecting bar, acts as a guide to the cocking-piece and helps to retain the bolt in the body. To charge the magazine, the charger is placed into the recess cut for it in the bridge of the receiver and the cartridges are forced out by a pressure of the thumb. The charger when empty must be removed by hand. There is no cut-off and the rifle can only be used as a single loader when the magazine is empty. It carries five cartridges.

JAPAN YEAR 38TH PATTERN RIFLE.

This rifle, which was introduced in 1907, is patterned after the Mauser rifle. The locking lugs of the bolt are on the front end and the extractor is attached to the bolt in the same manner as in the Mauser. The bolt, however, instead of being exposed is covered by a sheet steel bolt cover, somewhat similar to that used on the Lee-Enfield rifle. The magazine, which holds five cartridges in two columns, is made of sheet steel, the bottom part fitting into an opening made in the front end of the receiver. The bottom of the magazine is closed by a hooked plate. When the magazine is empty, the rear end of the platform prevents the bolt from being closed and thus indicates that the magazine requires refilling. A charger is used instead of a clip.

THE AMERICAN SPRINGFIELD RIFLE.

The American Springfield rifle, shown in Fig. 14, was brought out in 1903 to displace the Krag-Jorgensen formerly employed. This rifle is almost identical with the German Mauser. Of course it has a few modifications, but those are of comparatvely minor importance. The extractor is held to the bolt by means of a collar, the same as the Mauser, but in addition it is backed up by a lug, thus reducing the strain on the collar when forcing the extractor over the head of the cartridge. The bolt handle is bent down as on the Lee-Enfield. The bullet, of the Spitzer type, is 0.303 caliber and has a muzzle velocity of 2,750 feet per second.

Thorium

How It Is Extracted for Making Gas Mantles

By Thurston Owens

THREE hundred million gas mantles consumed annually throughout the world are dependent upon the supply of thorium. Some eighty million are used yearly in the United States, double the quantity consumed ten years ago. These and other valuable facts are brought out in a recent publication of the Bureau of Mines, prepared by Mr. Karl L. Kithil ("Monazite, Thorium, and Mesothorium," Technical Paper 110, Bureau of Mines, Department of the Interior, Washington).

The property of emitting light radiations in the visible part of the spectrum under the application of heat has been known and applied for over a century ("The Rare Earths: Their Occurrence, Chemistry, and Technology," by S. I. Levy), but it was Dr. Auer von Welsbach who discovered (1886) that thorium had the unusual qualities of holding together without other materials being used as a support; hence the mantle mesh ("Incandescent Gas Mantles," M. C. Whitaker, Johns Hopkins Lectures on Illuminating Engineering).

It was not until 1891 that Dr. Auer perfected his formula of 99 per cent thorium and 1 per cent cerium, which produced the highest light efficiency and also the nearest approach to white light in color. For 25 years the mantles used by the gas industry have been produced with this formula as a base.

Thorium is one of the constituents of monazite sand, the others having great chemical interest but little commercial value (Whitaker). There are numerous occurrences of monazite sand throughout the world, but it has only been mined successfully in North and South America (Kithil). This last statement is open to question, as the deposits at Travencore (India) have been the subject of considerable British wrath in the past few months.

"Germany, by underhand as well as straightforward methods, was steadily proceeding toward the fulfilment of her ambition to control the thorium supply of the world when war broke out." The article from which this is quoted goes on to explain how the Auer Company obtained a controlling interest in the leases at Travancore, which was nullified by an edict of the Secretary of State for India reducing the voting power of the "enemy shares" and instructing the company to sell all purchasers upon an equal basis. The British India sand which has reached this country is reported to be far superior to the Brazilian product. The mining of monazite sand in America has been practically abandoned since 1906, and none of the large users see any commercial possibilities in this field.

In order to obtain thorium two definite steps are necessary. The first consists of separating monazite from the other materials mined, which is done in the neighborhood of the mine. The monazite sand is then shipped to the laboratories of the mantle manufacturers, where the thorium is manufactured.

"The manufacture of nitrate of thorium from monazite sand is a very difficult and complicated chemical process. It requires from 4 to 6 months to recover the small percentage of thorium and render it sufficiently pure to be used in the manufacture of lighting fluid" (Whitaker).

The treatment of monazite for the extraction of thorium described by Soddy ("The Chemistry of the Radio-Elements") is as follows: After the sand has been ground the cold mass is dissolved in water and left to settle. The solution is then fractionally precipitated with magnesia, the thorium being concentrated mainly in the first fractions precipitated. The commonest and most useful reagent for precipitating the rare earths from a solution containing common earths, such as alumina, iron, etc., is oxalic acid. Now, thorium oxalate is, of all the rare-earth oxalates, the least soluble in acids, so that by working in fairly strong nitric acid solution thorium oxalate may often be precipitated and separated, at least partially, from the other rare earths and from calcium. The same is true of the rare-earth phosphates, that of thorium being one of the most insoluble in dilute acids. On the same principle thorium is often precipitated by weak bases, such as the substituted ammonias, for example, dimethylamine, while zirconium, etc., remain dissolved. The potassium salt of hydrazoic acid, KN_3, precipitates thorium hydroxide only from mixture of thorium and cerium on boiling. The same separation may be effected by means of sodium thiosulphate on boiling, thorium alone being separated, as hydroxide. This ready hydrolysis of weak thorium is characteristic of the element. The oxalates of thorium and ziconium alone of the rare earths are soluble in ammonium oxalate, and on strongly acidifying the solution the former alone is reprecipitated. The solution of the oxalate of thorium and its conversion into soluble salts may be effected by means of concentrated ammonium or sodium carbonate and precipitation of the concentrated solution as thorium hydroxide with strong ammonium or sodium hydrate. Thorium is distinguished from the yttrium group of the rare earths by its power of forming a double sulphate with potassium sulphate, insoluble in excess of the latter reagent, and so may be separated from a mixture of the sulphates by saturating the solution with potassium sulphate. Alike in the old, now obsolete, as in the present technical methods of purifying thorium, the peculiar solubility relations of thorium sulphate in water have been largely applied. The older method consisted in volatilizing the excess of sulphuric acid from the material being treated, and in dissolving the anhydrous sulphates in ice-cold water—a tedious operation—and in heating the solution till the hydrated thorium sulphate was precipitated. The latter was then dehydrated at 300 degrees to 400 degrees and the process repeated. In present practice the sulphuric acid is always kept in great excess in the initial treatment of the mineral, but the sulphate method may be employed at the final stage of manufacture as follows:

The thorium hydroxide is dissolved in hydrochloric acid, so that the solution contains not more than 30 per cent ThO_2, and sulphuric acid is added to the extent of 0.5 per cent more than the equivalent quantity, the temperature being kept low, and in any case below 40 degrees as a maximum. Under these conditions the hydrate $Th(SO_4)_2 8H_2O$ is precipitated, departure from the conditions causing the separation of the tetrahydrate, which is in every way less easily manipulated. The precipitated sulphate is converted into hydroxide, and the process repeated as often as necessary to remove all impurities.

Thorium forms a curious compound with acetyl acetone $Th(C_5H_7O_2)_4$, which is soluble in chloroform and alcohol, and can be distilled in a vacuum, and so can advantageously be employed for the purification and separation of the element.

It may be mentioned that in the fusion of refractory minerals, as with sodium carbonate, the thorium if present is converted into the highly insoluble oxide, ThO_2, and its presence is apt to be overlooked.

Thanks largely to the mantle industry, in which a product unusually pure is essential, there exist therefor a great variety of exceedingly good and sharp methods for the separation and purification of thorium, and it must be understood that ionium if present and radiothorium always remain unseparated from thorium in these processes as far as they have been examined.

In the manufacture of thorium nitrate from monazite a large amount of residues of the cerium group of rare earths is obtained. Monazite containing 60 to 70 per cent of the cerium group or other rare earths besides thorium, and 3,000 tons, which is the annual consumption of monazite, gives about 1,000 tons of cerium and about 1,200 tons of a mixture of the rare earths lanthanum, neodymium, and praseodymium oxides. Considerable research work has been done in order to utilize these waste materials, and experiments have been made with almost every one of them. In order to obtain and separate the rare-earth elements thousands of crystallizations and fractionations are necessary, although cerium itself is separated with comparative ease. The untiring work carried on in the research laboratories of the industries as well as by the scientists in both America and Europe will no doubt in time be crowned with successful technical applications of the by-product.

The monazite resources are given by Kithil as follows:

It is difficult to give even a rough estimate of the quantities of monazite obtainable in the various countries. From close calculations, however, it is estimated that the lands in the marinhas along the seacoast of Brazil may yield from 15,000 to 20,000 tons of pure monazite. This does not include coast lands, where the deposits have been formed in comparatively short time.

In the interior of Brazil the writer knows of about 18,000,000 tons of monazite-bearing gravel deposits, which should yield monazite containing 4½ per cent of thorium oxide, and it can be estimated that these gravels contain 45,000 to 60,000 tons of monazite. No doubt there will be found many other deposits of greater or less extent in the interior of Brazil, but no single deposit in the interior, so far as known, would warrant the erection of a large plant. In sections where several large deposits are found together or near each other a washing and concentrating plant might be profitably established, provided the price for the monazite obtained were higher than at present (May, 1915), and especially if transportation facilities from the interior to the coast become better.

The amount of purified monazite available in the Carolinas may be conservatively estimated at about 15,000 to 20,000 tons (4½ per cent ThO_2).

With better methods of mining and refining perhaps these deposits could be profitably exploited at the present prices for monazite and thorium nitrate, especially if the mining of monazite were carried on in connection with the manufacture of thorium nitrate and mesothorium.

It is known that attempts have been made to extract the monazite from the native rock, but this operation with even the richest rock known—0.1 to 0.2 per cent of monazite—has proved too expensive.—*Chemical Engineer.*

Artificial Limbs

And Prothetic Apparatus for the Crippled

The sorry business of wrecking human bodies now in full swing in Europe has caused an enormous stimulation of the art of construction artificial limbs and prothetic appliances, i. e., devices which are ingeniously adapted to enable the cripple to carry on the ordinary affairs of life, such as eating, dressing, walking, etc., or to grasp and use various tools, though without pretense of semblance to the aspect of the missing member. Thus vast quantities of human wastage are rescued from the scrap-heap and enabled to lead useful and happy lives despite mutilations that in earlier days would have reduced them to the level of idle pensioners upon the public, whether in State institutions or as eye-offending beggars upon the highways.

Moreover, the sudden demand for such articles has stimulated inventors to unprecedented activity along this line. It is a notable circumstance, too, that more than ever before technologists and engineers are lending their practical ingenuity to the aid of the physicians, orthopedists and bandage-makers for the benefit of the footless and the handless, the armless and the legless who throng the military and civil hospitals. It is natural that there should be a great diversity of excellence as well as of price among the apparatus thrown upon the market, and the grave importance of the subject has led to the formation in Germany of a bureau for the testing of artificial limbs, whose directorate is made up of prominent physicians and engineers. Besides examining and testing the various apparatus on the market for excellence and adaptability, this bureau will arrange for the hospitals to furnish skilled and intelligent maimed men to act as demonstrators to other cripples of the method of using such apparatus in various crafts and trades. The institution is connected with the Permanent Exhibition for Workingmen's Welfare in Charlottenburg, where the government maintains a large collection of artificial limbs adapted to various kinds and degrees of mutilation.

Fig. 1.—A war victim with a full set of artificial arms and legs of American make.

Most important, of course, are the substitutes for the arm and hand, the very symbol of the workingman, and indeed the distinctive mark of humanity. Likewise this offers the most difficult problem to the instrument maker. Yet the ingenuity of its solution is truly marvelous. It is interesting to learn from a writer on this subject in *Umschau* that an arm of American manufacture, made by a firm in Kansas City, is the best on the market, its only disadvantage being its comparatively high price, $200 to $250. With this it is possible to open and close the hand, to bend it, to hold an object in a fixed position, to revolve it on the lower arm in an arc of ninety degrees, and to hold an object steady at any point of the arc. Thus the ordinary movements and "complexes" required for the daily needs of life are provided for. This arm is operated by a harness of straps fastened around the shoulders and finishing in several ends. The pull of the straps is transmitted to leather thongs and is exerted by a slight motion of the shoulders, as well as by the raising or dropping of the arm. The fingers open automatically when the arm is stretched out, and close when it is bent or lowered, thus enabling the owner to grasp the desired article.

In Figs. 1 and 3 (*Umschau*) schematic illustrations of the construction of such arms are given.

Obviously the more there is left of the arm the easier it is to provide a satisfactory substitute. In all cases the first requisite is a comfortable, well-fitting sheath for the stump. This sheath is made of flexible, padded or lined splints. The manner in which the motive power is transmitted is of especial significance. The "prothesis," or tool-holder, must be so attached to the stump as to best utilize whatever muscular power remains. Experience has shown that the stump can never exert the power of a similar portion of a sound arm, since the necessary firmness of attachment interferes both with the muscles and the circulation of the blood. But this difficulty is partly overcome by making use of the shoulder power, which can be exerted without great fatigue and with remarkable force. Indeed, it is stated that a sound hand draws its chief strength from the shoulder.

The German writer referred to above gives first place in point of excellence to the Hoeftman protheses, a collection of which is shown in Fig. 8 (*Umschau*), while Figs. 4 to 9 show them in use. As shown they facilitate even such complex movements as those required in eating, in writing, in crocheting, etc., as well as in such labor as digging, shoveling, planing, etc.

Fig. 2.—Writing is readily accomplished with the artificial hand.

The making of serviceable feet and legs is less difficult. Two things are particularly indispensable—a comfortable and solid placement of the stump in the sheath, and the feeling of elasticity in the limb itself. Such elasticity is secured either by spiral springs or by rubber. Fig. 10 shows a leg of German make provided with a heel-joint, which helps to give elasticity. Toe-joints of springs are shown in Fig. 11; this foot has the core of wood and the outer part of felt. The joints in the knee and in the fore part of the foot are of prime importance, as well as in the ankle. An excellent jointless foot, however, is made of rubber by a New York firm. This is shown in Fig. 12; the core is of wood, the rest of rubber, containing in its interior many springy layers. Fig. 13 shows a leg with an elastic band at the knee, which holds the leg stretched out when it is lifted. Fig. 14 shows a leg of French manufacture. Here the movability of the foot is secured by a screw connection in the thigh and two such in the foot, while the shin contains elastic sinews which stretch out the foot; this arrangement, however, is said to make repair work difficult.

To appreciate the practical value of such substitutes in making life livable once more to the human wreck whose existence would otherwise be largely a stultified one, both of body and of mind, it is instructive to turn to the record of a remarkable instance of injury, not in battle, but in industry. The victim in this case, a report of which we find in another number of *Umschau*, quoted from the Vienna *Klinische Wochenschrift*, was a man named Gürtelschmied, employed in the building trade in Spokane. While supervising the hoisting of an iron balcony to the fifth floor of a new building he received a current of sixty-seven thousand volts, caused by the accidental contact of the balcony with an electric light wire. Flames burst from his hands and feet and he collapsed, without, however, losing consciousness, strange to say. Both hands with the lower forearms and both feet with the lower part of the shins were so charred that four weeks later it was necessary to amputate them. It is stated that after the first terrific shock he experienced a strong burning in his feet, but had no sensation in his hands. Fig. 1 shows him with his prothetic apparatus in position. This apparatus, which was made in Spokane and cost altogether about $250, was first worn five months after the amputation. One hour after putting on the leg protheses he was able to walk about the room without a cane, and five days later he went out walking on the street. Fig. 2 shows him seated and writing. His hand protheses enabled him to feed himself at once, though rather painfully, and he soon acquired some facility in caring for his personal needs. The good workmanship of the apparatus is proved by its being still in use at the end of eight years. It is so simple in construction, moreover, that an ordinary handicraftsman, such as a blacksmith or shoemaker, can readily mend it when it gets out of order. Indeed, the wearer himself is able to make minor repairs with hammer, screwdriver and awl. He is said to be able not only to walk a distance of 16 to 20 kilometers in one lap, but to run, to climb stairs, ride a wheel, lie down and stand up without assistance, kneel without a stick, and dress and undress himself. On his return to Europe he married and opened a small tobacco shop in Mahren, the business of which he was able to conduct himself. His gait is steady, and the protheses do not rattle and creak loudly, which is the fault of some. His stride is rather longer than normal, which is possibly due to the circumstance that the apparatus is lighter than the flesh and bone it supplants. When unoccupied, the artificial hands, which are, of course, encased in gloves, fall naturally and symmetrically against the body. Curiously enough, the frightful accident which robbed him of his former occupation at the age of 29 has provided him at 37 with a new one of profound importance and opportunity for public service. At the instance of a well-known Vienna surgeon, Baron von Eiselsberg, Mr. Gürtelschmied was engaged as a special demonstrator in the crippled wards of the Vienna hospitals, so that he might not only instruct companions in misfortune in the use of similar appliances, but inspire them with courage and good cheer in the confidence of being able to earn their own livelihood.

Fig. 3.—Climbing a ladder with artificial limbs.

Two inventions devised as special helps for men wearing artificial limbs deserve mention in this connection, an electric rolling-chair and a work-table. The former has been specially arranged by a German engineer for


Fig. 4.—Doing carpenter work.


Fig. 5.—It makes farm work easy.


Fig. 6.—Crocheting with the protheses.

the use of cripples having little strength. The latter, an account of which we take from the *Zeitschrift für Handelswissenschaft und Handelspraxis*, is made by a firm in Leipzig. The head of the firm has zealously devoted himself during the past year to social service in the Leipzig hospitals, instructing one-armed men and men with injuries of arms and hands in typing, bookkeeping and other office work. His efforts in this line suggested to him the idea of a work-table which

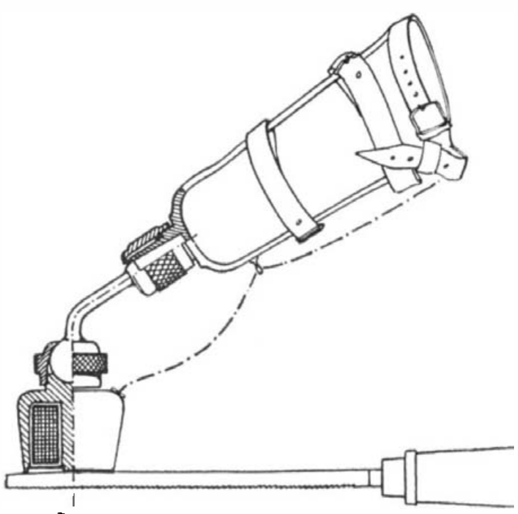


Fig. 15.—Magnetic hand, using a file.

should so far as possible minimize the handicap of such patients. By a system of clamps and holders worked by pedals in surprisingly simple manner the invalid is able to make the table do the work usually performed by a second hand. Thus it becomes easy to write letters and cards, keep books, open and arrange letters, sharpen lead pencils, change pen points, draw lines, open pocket knives, cut cards, etc. The Prussian, Saxon and Bavarian Ministers of War have all shown great interest in this utensil. The appliances can be adjusted to any work-table and are expected to be of great service not only to clerks and office men, but to invalided writers, merchants, officers, officials, scientists, professors and many others whose profession involves clerical work.

This article would be incomplete without reference to yet another ingenious arrangement for enabling the

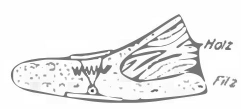


Fig. 11.

Fig. 12.

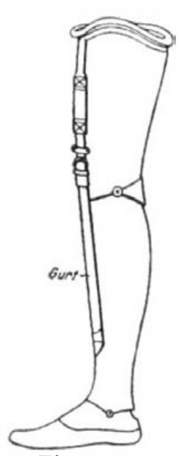


Fig. 13.

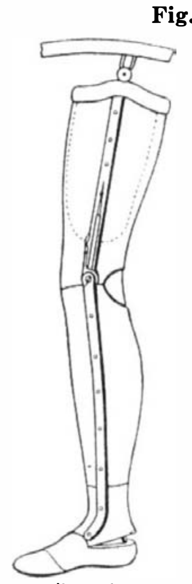


Fig. 10.

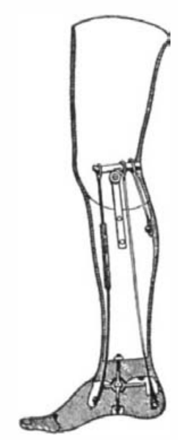


Fig. 14.

cripple to earn his living in industries where two sound arms and hands have hitherto been considered essential. This is the so-called magnetic hand. As the name indicates, the place of the artificial hand is here taken by a magnet of suitable form for grasping the handles of various instruments. It is attached by ball bearings, and is capable of being fixed firmly or made movable with a slight degree of resistance. It is thus very flexible and adaptable to various needs. While primarily intended for workers in the iron trades, it is easily applicable to many others. For example, a carpenter's plane may have a plate of iron so attached to it that the magnetic hand can easily grasp it and move it. It may be connected with the source of power by means of a movement of the sound arm, of the

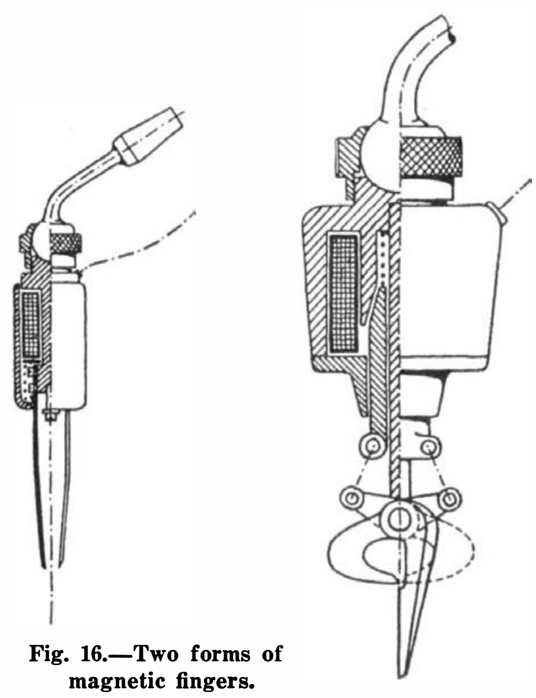


Fig. 16.—Two forms of magnetic fingers.

foot, of the chin, or even of the whole body. It is even possible to so modify it that the grasping motion of fingers and thumb may be imitated. In this case the four artificial fingers are moved by one magnet and the thumb by another. While there are few modern workshops where electric power is non-obtainable, when this is so the magnetic hand is easily operable by a portable battery of convenient size. As a final advantage it may be mentioned that the workman thus equipped is capable of exerting even more strength and with less fatigue than his sound-limbed fellow.


Fig. 7.—The prothesis used for writing.


Fig. 8.—A collection of the Hoeftman prottheses.


Fig. 9.—The protheses in use for eating.

Economy in Study—III

Books and Their Educative Use

By George Van N. Dearborn, A.M., (Harv.,) M.D., Ph.D., (Col.,) Sargent Normal School

NEXT we will discuss some practical points on books and their use in the learning process. Many wise minds have written volumes and essays on books and their use. We may refer you directly to Francis Bacon, Montaigne, Carlyle, Emerson—at hand everywhere. Our talk about books will be very explicit and as directly practicable as possible. But let me first suggest to you that your choice of them, both of text-books indirectly through the college and of other kinds more directly, will be a test, a criterion in a way, of your likelihood of becoming well educated, of your educability. Nothing will get your range so to say more quickly than your choice and use of books. Millionaires sometimes furnish the library of a new home with books bought by the linear shelf-yard and, next to their space, think most of their bindings. But alas! there is no known subtle influence passing from a printed idea in a book to the subconscious mind of a person, however great may be his desire to learn, or however closely surrounded with such symbols of ideas he may be.

The transfer from a printed page to the cortex of the brain means long and continuous *labor*, years of it, nights and days of it unnumbered. There cannot be a rule for the actual study of all books.

The amount of time actually spent on some lessons in seventy-five classes in the University of Iowa has been reported by Prof. Irving King ("School and Society," December 4, 1915). Of the 2,567 students who answered the questions of the investigator about 61 per cent used one and a half hours or less on the particular lesson assignments from which the statistics were made. Eight per cent used one half hour or less, and 5 per cent, three hours or more. If we may take these figures as average values (and they are the only available data at present) the reader can judge for himself fairly well whether or not he is doing himself, his time, and his money justice in the effort he habitually puts forth in reading or in studying lessons. If he be assigning himself lessons he can judge roughly from these averages whether they are of average traditional length and properly used. The concentration of the attention is far more important to easy learning than is the length of its continuous application—here in the most certain way is quality far more than quantity. Thus Prof. King's statistics are more suggestive than really significant for any one student. In any one reported case it might have been that he concentrated and learned not only faster but better (as we shall see shortly) than another who misused six-fold as much time. Still, this factor would seem to be averaged as much as the others and we need not suppose that it would harm the validity of the results. As a practical point they suggest that *one and a half hours is plenty long enough for most students to spend on a lesson.*

Despite the necessity of "keeping everlastingly at it" if one would become really learned, and the consequent need of using time to the best advantage, there is small profit or none at all in carrying books about in one's pocket and in one's school-bag, as we see some people do, for reading on the steam cars, electric cars, etc. It is in general, of course, pure affectation. Any one who does it out of a serious intention of making the most of his time, however, is doing so on a real misunderstanding, for in general the time is far too much broken to allow any adequate learning-compensation for the loss of rest of the eyes and the brain, and the loss of observation during travel, even though it be only down town. Every man, woman or child sitting across the aisle, every intelligent horse or dog, is a book for study under such circumstances better than most book-binders have ever put together. Therefore I say, it is idle to try to get knowledge out of books in the haphazard way in distracted periods lasting only a very short time each:

Let us for our present purpose make two classes of books. First, text-books and books which are usable as such, and, second, others.

1. Text-books.—These are for direct, detailed study; that is, the purpose of text-books. A good text-book contains the important facts and principles of the subject of which it treats. A text-book as compared with other books is concentrated mind-food, sweet chocolate with large nut-meats in it, while the other books are more like vegetables, and fruits—pleasant but generally not concentrated. *Real familiarity with full and authoritative text-books is the backbone of educational information and understanding.* Text-books are our "old reliable" means of learning. This can be scarcely too much emphasized in these days of many lectures and of other fashionable modes of learning. The intensive use of books is based on the substantial old-fashioned recitation. One can be very successful in reciting to himself, as we shall see.

For practical purposes I wish next to suggest the essential dynamic relationship between the four obvious elements of the problem of learning from books by intensive study of them. These four elements we may denote as follows: First, the adequate text-book itself. Second, the real desire to learn its facts and its wisdom. Third, the forced and attentive study under the requisite pressure great or small. Fourth, the transfer to the brain, and the associative process of interweaving with the knowledge and the wisdom already there. Of course, there is every grade of learning-effort. When the effort based on interest is the strongest, the outlines and some details of a whole new subject may be fixed in the mind in a few weeks, or even in a few days. That is to say, by a person who *knows how to study*, how especially to control his muscles, and so to force his voluntary attention along the desired and therefore the interesting line of work. We are back again then obviously to generalized skill, the universal control over at least the voluntary muscles. It is sometimes actually surprising to observe how much of a new subject an active, vigorous boy and girl can learn in a short time. I suspect that this "cramming" is done in schools much more than most teachers realize. Very many students everywhere neglect study day by day almost entirely, and then by a dynamogenic spurt learn the whole subject, and sometimes adequately, and now and then permanently, within a few weeks or even a few days. In order to accomplish this they have to have this training of mind which is really a training of the body. But one who lacks this knowledge of how to study, how to steadily force his mind for repeated effective periods along hard because definite directions, cannot accomplish this either soon or easily.

I am speaking of the use of text-books by one who knows how to make the most of them. This dynamogenic process (the word's meaning is obvious) is a pleasure as well as a necessity, and is widely open to you all. But few indeed realize that they possess this all-important power of rapid and easy leaning from text-books, of transferring the text-books almost bodily, so to say, and in a short time and for good, into their minds by way of their brains. One's organism, body and mind, has to be trained to it. But, on the other hand, anyone may train himself once for all simply by doing this: *Forcing the issue with all one's might.* This we may call the intensive use of books. I am not sure that this is very economical in the long run for the most of us for "it takes a bit out" of one. It is not, as I have often said, what we can do but what we can do economically that interests us in education. It is important, however, to us all to know how much we *can* do in emergency; and the mechanism, in part, thereof; a new chapter in educational science as well as in psychology and physiology.

Prof. W. B. Cannon and his associates in the laboratory of physiology of the Harvard Medical School have recently worked out further details of the relations of emotional excitement to energy-expense in a way useful for our present purpose of learning how to study. Says Dr. Cannon: "The close relation between emotion and muscular action has long been perceived. As Sherrington has pointed out, emotion "moves" us, hence the word itself. If developed in intensity, it impels toward vigorous movement. Every vigorous movement of the body . . . involves also the less noticeable co-operation of the viscera, especially of the circulatory and the respiratory. The extra demand made upon the muscles that move the frame involves a heightened action of the nutrient organs which supply to the muscles the material for their energy! The researches here reported have revealed a number of unsuspected ways in which muscular action is made more efficient because of emotional disturbances of the viscera. Every one of the visceral changes that have been noted—the cessation of processes in the alimentary canal (thus freeing the energy supply for other parts); the shifting of blood from the abdominal organs, whose activities are deferable, to the organs immediately essential to muscular exertion (the lungs, the heart, the central nervous system); the increased vigor of contraction of the heart; the quick abolition of the effects of muscular fatigue; the mobilizing of energy-giving sugar in the circulation [an increased coagulability of the blood; and the dilation of the bronchioles, both demonstrated by Cannon]; every one of these visceral changes *is directly serviceable in making the organism more effective in the violent display of energy which fear or rage or pain involve.*"

Now this forcing the issue through a book with one's natural inertia, not to say, frankly and truly, oftentimes with one's laziness, also comes in here to be explained by Cannon's work. This firm and warm and vigorous determination to learn as fast as possible undoubtedly employs and gets its often perfect success from just these same dynamogenic processes. The bodily changes would be here less conspicuous than in acute rage or fear, but no psychologist can doubt that just the same they are in action also then.

This "learning against time" has been recently studied carefully with measuring instruments directly by Dr. G. C. Myers of the Brooklyn Training School for teachers. The work tested was the learning of a list of unrelated words. Twenty-six normal school girls were given the task, thirteen having for it all the time they wished to use, and thirteen being required to do the "stunt" in nine minutes. "Ten of the twenty-six," says Prof. Myers, "made perfect records, and the imperfect records were, on the whole, about as good as those of the first group. This means that when the subjects knew they had only a limited time in which to do the task, almost half made perfect records in the time in which a perfect record was made by one of the first group, working without a time-limit. Furthermore, one does not know how many of the ten could have done the task in a shorter time than the nine minutes given. Furthermore, these ten of twenty-six made perfect records in five minutes less time than the average time required by the nine who made perfect records in the first test. Moreover, the second group, though belonging to the same class, was a little inferior to the first in scholastic averages." These results certainly make out a strong argument, everywhere in general corroborated by experience, for the advantage of intensive effort in learning and in doing.

But does this speed conduce also to retention as well as to time-saving and to mind-training? In other words, is work so done remembered? Apparently it is. This matter of the rapidity of learning in relation to the retention of the matter learned, Prof. W. H. Pyle of the University of Missouri has studied accurately. His summary of the results reads: "Twelve subjects were tested for their rate of learning a passage of easy prose, and for their retention of the passage after a lapse of twenty-four hours. The most rapid learners showed the highest percentage of retention."

Here again we are reminded, and forcibly, of the great importance, for economical learning, of *expending much energy for short periods at a time.* This matter can scarcely be too often emphasized as a practical point for easy learning.

Note-taking is just as essential in either the intensive or the extensive use of books as in using lectures if one would do the learning both well and easily. The process required is something like this: Abstract each paragraph or topic after carefully reading it through twice, and write the gist of your abstract, in your own words as far as possible. Use of your own words alone will show that you really have abstracted the meaning, and that you appreciate it sufficiently well to be able to write it concisely out of your inner understanding. If you make your abstract of a paragraph or a topic in words before you, on the other hand, in the book, it will be apt to degenerate practically into a process of copying.

After a little more experience, the motor note-taking, that is, on paper, will be discontinued by most of you, for you will soon have discovered that the mental part of the process of taking notes has been transferred to your reading habit. In other words, after a little experience of this practice you will find yourself studying and *reading by the abstracting and note-taking method*, but without writing notes save on the productive and constructive tablets of your brain. If you try along this line you will soon learn to think (i. e., abstract and extend) and read at the same time. Note-abstracting, and integrating each paragraph or chapter or topic in the book, is a very fundamental thing indeed, because in this way you symbolically impress on your brain the gist of the matter in a wholly other part of the brain, and in a wholly different manner.

Another highly important and often neglected practical thing is *the systematic use of a dictionary* alongside of the book which you are reading. I believe that the very general neglect of the dictionary is one of the chief defects of present-day learning methods. This strange neglect is the cause, first, of the small diction or vocabulary of which so very many educators are everywhere complaining. In the second place, it is the cause in part of the lack of power to use good English. In the third place it is partly the cause of the lack of the thinking-habit (see the next article), because it means a lack of associative material for the mind's use. One who

wishes to develop these three large and basal factions of an education, a good vocabulary, a good use of language, and a good thinking-habit, will cultivate intimacy with dictionaries, year on end. As one reads *he should keep a list of the words encountered which are not familiar or effectively familiar, to be looked for and investigated in the dictionary.* The knowledge and mental breadth thus acquired are rapidly accumulative and bear interest of intelligence compounded not semi-annually but every night while one is asleep. Dr. A. A. Berke has expressed it well in timely "Teaching in the Home," 1915: "Now it must be reasonably clear that if books are to be used in the later education, the first thing to do is to get the ability to read them. Therefore the child-trainer will see to it that wherever a choice is possible the choice will fall upon the word which will be used in books, rather than in colloquial assemblies. I think I have said elsewhere that half the children in our high schools cannot read their text-books, and this is undoubtedly true. Through our entire grade system we stick to the colloquial habit when we should be making the book habit. But it should be made even before that, namely, in the home. At first sight this seems like making the home conversation stiff and void of the vivacity which is said to be the chief charm of non-bookish talk. But my observation and experience lead me to think that exactly the reverse is true. No conversation is so bright, so sparkling, or so enjoyable, as that which uses words with precision and enables the thought to play swiftly and with discrimination upon the fine shadows of meaning. Nothing enables one to use quotations with such telling effect. Nothing moves the mind to greater expertness or appreciation. One reason why an older generation had so much purer speech than ours seems to have, was because the fine old habit of reading aloud prevailed then, which introduced the reading vocabulary into the area of common conversation. Children heard their elders use not only pure speech but the dialect of knowledge. They gained from hearing poetry and fiction and sermons and classic literature read at the family fireside, a great instrument of comparison which was a thought-builder, second to nothing."

Obviously then intensive training must think first and foremost and all the time of English, and that not merely the pure English of popular speech, but the *English of books.* The next few years, at Harvard as well as in the elementary grades, will certainly develop much advance along just this line of educational and psychologic wisdom. This is the road to true education, to the essential habit of productive self-reliant *thought.* The place for the student to begin is in his text-books.

You should have as large a variety of text-books as is possible for you. This is an investment, rather than an expense; it means an income, not a deficit. These text-books, most of them, should be kept. They are, in a sense, an important part of your *mind.* If one would set a desirable number of text-books to be owned, let us say *three* text-books on every subject. These will give you a considerable variety of points of view on the same branch of learning or the same science.

You should have, furthermore, as much as is expedient of *collateral reading* if you wish to get all you can out of your text-books. It adds interest and many details, and makes for breadth of mind in the subject which you are studying.

For purposes of completeness, and even of comparison, with the principles of the present book, it may be useful to have in hand also a summary of the ideas of another writer on how to study, Prof. F. McMurry of Columbia University, as made by Prof. J. E. W. Wallin:

"McMurry finds eight requisites of economic study. (1) The child must at the very outset feel a definite, specific purpose or need in his study—not the vague, general aim to acquire knowledge, culture, efficiency, power or skill, but some specific problem in the lesson assigned. This will supply a vital interest to energize effort, focalize and sustain attention; it will transform knowledge-getting from a mere collecting of facts at random to a discriminating choice of data relevant to the specific aim; and it will divert knowledge into practical channels. (2) Pupils should be taught to organize their reading matter around these leading points, and to subordinate the supporting data in the order of value. This involves keeping the central thoughts clearly in mind, the rapid gleaning or neglect of the unessential details, and the observance of a certain procedure in teaching. (3) Since the text must treat topics fragmentarily, require the child to reconstruct and supplement the text-book treatment by his own ideas and experiences.

This requires the use of developmental instruction, with abundant details, emphasis on reflection as against verbal repetition, and versatility in methods of reproduction. (4) Children should be encouraged to assume a critical attitude toward what they read, and to pass independent judgments upon the credibility of the statements in print, owing to the fact that the latter are often exaggerated, one-sided, inadequate or false. (5) They should likewise assume an unprejudiced, tentative attitude toward knowledge, because many of our conclusions are possibilities or probabilities rather than established certainties, because our attitudes are so prone to become dogmatic and ultra-conservative, and because children incline to base their opinions on authority rather than reason. (6) Studying also involves memorizing, but its importance has been grossly exaggerated in past educational practice and theory.

It has been made the pack horse of education, becoming practically synonymous with studying, so that children have rebelled against the intolerable drudgery of school life. The drill likewise has usurped too much attention, and has been a prolific cause of educational waste, stultifying instead of nourishing the child. This chapter, in contrast with the others, is destructive rather than constructive in tendency. (7) Children should be obliged to apply the information gained through study, since use or adaptation to environment is the end-point of ideas, of the capacities and abilities of animals and men, of the subject-matter of any branch of study whatsoever, and of all education. This is the goal of ideas as well as ideals, and can be realized not only in manual and constructive execution but also in skillful talking about the subject-matter. (8) Lastly, there should be ample provision for individuality in study." (These are the most explicit directions for scientific economical learning which the present writer has seen save those of these lectures.)

II. A few words regarding books other than text-books, and especially their use, may properly be added in this connection, since oftentimes these are important factors in one's easy learning. They lend breadth to one's education as nothing else can do. Some books written, for example, for popular sale, have much basal science and philosophy in them because they are often summaries of many other far more fundamental treatises. Most of them are fragmentary, however, rather than really integrative, their material being chosen by some more or less incompetent person on other than a scientific basis. The reading of, or at least the acquaintance with, the range and the main theses of numerous current and older books on subjects allied to those being studied is quite necessary in order that a student may be accurately oriented, and remain so. A thinker without books is apt to become a pedant and a crank, just as a bookworm without thought is an encyclopedia and not a man or woman at all—a passive vegetable at most.

Many hard and serious students and scholars, especially adults, read evenings, or at other times, purely for recreation, and many high school and college students find time for much reading not directly related to their curriculum. In the early part of 1916 Prof. J. C. Bell and Itasca B. Swett of the University of Texas reported the results of an investigation which they had made into the reading interests of the high school students of Austin, 440 of them: "With the girls, light fiction forms the largest part of voluntary reading. The general tendency is for this to decrease during the high-school period, but a decided fall in the low tenth grade is followed by a rise in the high tenth and low eleventh. With the boys, books of adventure take the high place occupied by light fiction with the girls. On the other hand, books of adventure with the girls drop to practically the same position as that held by light fiction with the boys. . . . The interest in standard fiction increases with both boys and girls as we go upward through the grades. The short story does not hold as high a place as might be expected either with boys or girls. Its position remains fairly constant through the grades. With the boys, children's books take about equal rank with short stories. With the girls they are much more popular. Their popularity with the girls increases as we advance in the grades, while with the boys it remains about stationary. Biography and essays show a slight increase in popularity with both boys and girls, but they don't take a high rank at any time." History, science, and fairy stories were so little read that their variations were not put into graphic form. In general, *plot* provides the maximum interest for both girls and boys—a matter that adults will numerously confirm. These results may be used as norms for general reading guidance.

If I may suggest certain very practical hints on the use of books, I would note, first, that books are tools; that private books are seldom worn out; and that second-hand books are of little value, usually only about 10 per cent of their original retail cost, even when not far from new. For these reasons and others *one should not affectedly make fetishes of his books, but rather use them for all they (and he) are worth.* It is a lot better to "break the back" of a book than to be long bothered in using it by its improper and inconvenient binding. It is far better to spoil it commercially by writing notes on its margins than to miss the value of these notes in your learning minds. Buy good editions if you can afford them, but if not, cheap editions. The difference in the print, paper, etc., if the reading-light be good, is not of relatively large importance for the simple reason that type and paper now are much cheaper and therefore better than in former times.

A note-book should be near by, "handy," in all reading, provided one wishes to learn the book, and learn it economically. One should read the preface, and usually the introduction of a book (however contrary this advice may be to common habit, especially of the feminine mind) because the preface and the introduction together usually *orient* you, and will satisfy that curiosity which is sure to be aroused during the reading of the book. If your impatience positively cannot be withstood, do by all means look second at the last chapter, so that curiosity may not disturb your mind any further. Always look over the table of contents so that you may know at all times where you are in the book. Then, too, you will know better what, if anything, to "skim," and what to lay permanent hold of. In general one should be warned against skimming a book unless he is certain in advance that the book really deserves skimming. This is a habit essentially of inattention; but, on the other hand, sometimes one's attention can be used just in this way to the best advantage, provided one acquires the habit of rapidly picking out, as he skims, the real essence of a page. This procedure is allied to the process of abstracting, already considered. Certainly much time is wasted in the real reading of certain books.

Remember that a book intends, at least, to be some sort of a set of *ideas.* Take this for granted anyhow, and *make it your sole business as a student in reading it to pick out these vital ideas.* Since this means essentially comprehension, it is not surprisingly easy; yet it must be done, since nothing will replace practice and careful training in this important matter. The young student reads or studies a book equally from the beginning to the end, putting the same amount of time and effort on each page. But the mind never works that way, outside of books. As you walked down the street yesterday looking in the windows your mind did not spend as much time on some things along the way as on others; at Camp, last summer, certain salient points made up your particular mental day, and no other camper's day as a unit was like it. Each one's experience is unique for each human soul. So with books. Francis Bacon familiarly says, "Some books are to be tasted, others to be swallowed, and some few to be digested." More and more, with the ever-swelling tide of published books, is this old dictum appropriate. Your mind's associations, your interests, and so on, *select* what for you are the most salient points. Thus it is in reading too. We buy each a copy of the same elaborate book, printed from the same type, yet your book is never like my book. It *means* more or less or differently to you than it means to me, and its meanings are itself. Your books are not my books although materially identical. They are not the same simply because your mind is unlike mine. Thus it is that in every book there are many books for many minds. *Try always to get yours* out of every book you read. Learn in reading and studying to pick your own individual book out of a volume. In other words, learn to note the part that is for yourself, and learn not to waste time on those parts of it that are not for you.

Learn to read a book without reading on the average more than a quarter of it. Learn to get the meat out by a process more like the sampling of a huge Swiss cheese than the process of grinding up Hamburger steak. With the enormous number of books that are of real importance, no other method is feasible; as economical learning nothing in the long run is more essential than this, the intensive method. Learn to abstract, learn (as reviewers have to do) to become really familiar with the most of a book without undue loss of time. In reviewing I learn the gist of many difficult books in the course of a year but (save exciting novels) I read every word of scarcely half a dozen. The training-road to this goal is abstracting a paragraph by a sentence, and then a chapter by a page of notes and so on to the end. Do not read into your notes of a book your own ideas that have been suggested by the reading; this is a common bad habit of young students.

A few words as to periodical literature before we stop. Learning is slow and old fashioned to-day which does not include the special technical magazines. Elementary study requires these as collateral reading, and advanced study requires them for advanced information and for integration.

The importance of bibliographies to students can scarcely be overestimated, because the knowledge of the name and title of a volume is often the next best thing to its actual possession. Knowledge of the available libraries is essential, and the proper way of using them is wholly necessary to the really progressive student. The next best thing to really knowing a good book is to know, first, that it exists, second where, and very often this is enough!

All these factors of book-use count not only in themselves, but also as indirect means of keeping the less conscious parts of the mind on its task of arranging and pushing your scholastic work.

The Rennerfelt Electric Furnace*

A Successful Device for Use in Foundries

THIS is a new type of electric furnace for melting and refining metals. Up to the present it has found its main application in steel foundries, where it has been extremely successful in units of small and moderate size up to two tons capacity; and the inventor expects to extend its use to large refining steel furnaces of fifty tons or more.

Principle.—The furnace is heated by means of electric arcs, as in the Heroult or Stassano furnaces, but the principle of the arc is different. There are also essential differences in the construction of the furnace.

Electric melting furnaces heated by arcs may be divided into two main classes: (1) the "independent-arc" furnaces, such as the Moissan and Stassano furnaces, in which an arc is maintained between two or more carbon electrodes, and (2) the "direct-heating" arc furnaces, such as the Heroult and Girod furnaces, in which each arc is formed between a carbon electrode and the metal or other material to be melted. In the direct-heating arc furnaces the heat of the arc is conveyed more directly to the material to be melted than in a furnace of the Stassano type, and the efficiency will on this account tend to be higher; but the direct-heating arc is less easily operated, and causes more serious fluctuations of the power, especially when, as is usual in foundry practice, the furnace is used to melt cold steel scrap or any cold metal.

So long ago as 1892, Henri Moissan employed a magnet with his experimental furnace to force down the independent arc upon the metal to be melted. In this way, he increased the efficiency of the furnace without losing its steadiness and ease of operation. The writer was not aware of any large electric furnace in which a magnet has been used to direct the arc upon the metal to be melted;[1] but Mr. Rennerfelt has obtained the same result by a special arrangement of the electrodes without the use of an external magnet.

This arrangement, as shown in Fig. 1, consists of three leectrodes, two of which are horizontal and the third vertical. They are supplied with two-phase current the vertical electrode serving as the common return for the other two. The electric arc produced does not flow directly between the three electrodes, but forms a vertical flame extending downward from the vertical electrode. In this arrangement the electric arc is deflected downward by the magnetic force produced by the electric current flowing in the electrodes, and the larger the electric current the more strongly is the arc forced downward in the furnace.

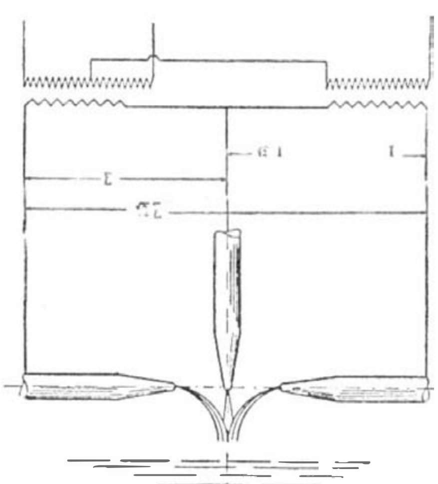


Fig. 1.—Diagram of the Rennerfelt frnace.

Fig. 1 also shows the electrical connections for obtaining low voltage two-phase current from the high voltage three-phase supply.

Construction.—The furnace consists of a cylindrical steel shell mounted on trunnions, so that it can be tilted to pour out the contents. An opening at one end, furnished with a door, serves both for charging and for pouring. The shell is lined, first, with asbestos board 1¼ inch thick, to retain the heat and allow for the expansion of the bricks, then a course of good firebricks, and within this a working lining of magnesite bricks, fettled, in the lower part of the furnace, with a sintering composition of dolomite or magnesite.

This mode of construction which resembles that of the Pearce and Smith basic copper converter, allows magnesite bricks to be used for the roof as well as for the hearth of the furnace, and on this account a very high temperature can be maintained without danger of melting the roof.

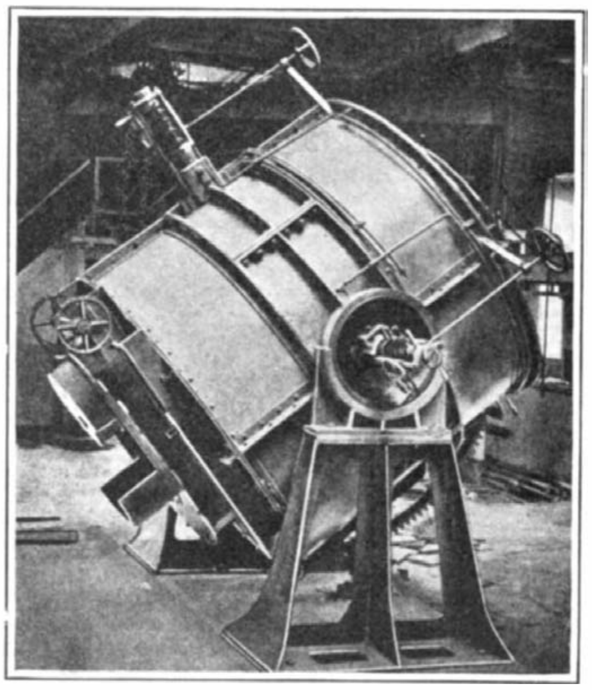


Fig. 3.—The Rennerfelt furnace.

The arrangement of the three electrodes in the furnace is shown in Fig. 2, in which it will be seen that the furnace cavity is egg shaped with an opening at the small end.

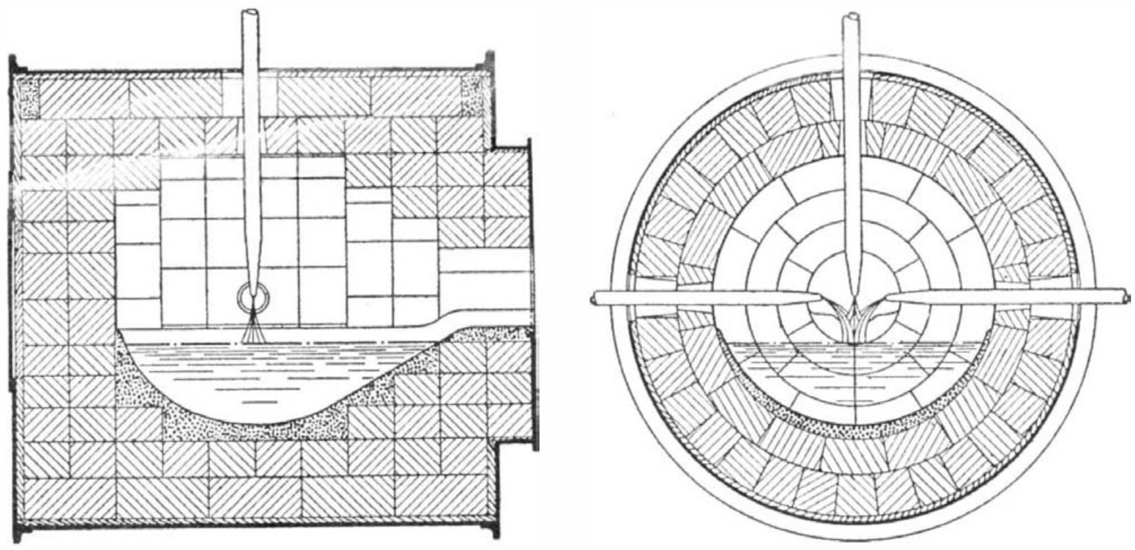


Fig. 2.—Longitudinal and cross section of the Rennerfelt furnace.

Graphitized electrodes are used instead of the cheaper amorphous carbon electrodes usual in electric steel-melting furnaces. On account of their greater electrical conductivity the graphitized electrodes can be much smaller than equivalent amorphous carbon electrodes, and for this reason the difference in cost need not be serious. Moreover, on account of their smaller size, the furnace roof is not weakened so much by the necessary openings, even though there are three electrodes instead of two to provide for.

There has been no difficulty connected with the use of horizontal graphite electrodes up to the largest furnace so far constructed. For larger sizes (above, perhaps, three tons) additional sets of electrodes are provided, thus avoiding the necessity of using very large electrodes, and also spreading the heat production more evenly throughout the furnace.

Fig. 4 shows the design of a Rennerfelt furnace having four sets of electrodes. It is cylindrical and is provided with a charging door and a tapping hole at each end. It rests on a cradle that can be tilted by a screw mechanism, instead of the trunnion support of the smaller sizes.

Fig. 3 is a view of a 2½-ton furnace, built in Stockholm (where the writer saw it), and ready for shipment to Nobel's Works, St. Petersburg. The construction of the furnace, with charging door, trunnions, electrode holders, and regulators, can be clearly seen.

Results.—The first furnace of this type was constructed in the year 1912, and it has been utilized very quickly by the owners of small steel foundries. The writer visited four such foundries in Sweden, and has seen three Rennerfelt furnaces varying from ½ to 1 ton capacity in regular commercial use, besides the 2½-ton furnace just referred to. The users of these furnaces were most enthusiastic in regard to them, and the furnaces appear to be very well suited for use in steel foundries, and for many purposes where small quantities of metals are to be melted.

Small furnaces of 600 kilogrammes capacity will produce molten steel for castings, from a cold charge, with an expenditure of 700 to 800 kilowatt hours per ton, while in regular operation: a consumption which is quite moderate for so small a furnace. Allowing for standby losses one may take a figure of 1,000 kilowatt hours per ton of steel for castings, as being a safe figure with these small furnaces. The electrode losses are given as 3 kilogrammes per ton of steel. In most of the foundries visited the electric power was used during the day time for running machinery and during the night for melting steel in the electric furnace. This method of utilizing power that would otherwise be wasted is very advantageous financially, but does not show the furnace to its best advantage in respect to kilowatt hours and electrode losses per ton of steel, which were somewhat higher than those given above. During the day time the furnace must be kept hot by means of an oil burner, or by a small amount of electrical power.

The power required for a 600-kilogramme furnace is 125 kilowatts at 80 volts; and for a 1,000-kilogramme furnace, 200 kilowatts. For larger sizes, the power needed per ton of capacity would decrease to about 120 kilowatts.

In addition to its normal use for melting steel for castings, the Rennerfelt furnace has been employed for melting ferromanganese for use in the Bessemer or open-hearth processes, and tests made at Hallstahammar and Ljusne with this furnace compare very favorably with similar tests using other types of furnace.[2] The melting of one ton of ferro-manganese in a previously heated Rennerfelt furnace took about 450 kilowatt hours, and less than 2 pounds of electrodes. The loss of ferro by oxidation was a little more than 1 per cent.

Up to the present, about twenty furnaces have been built for plants in Sweden, Norway, England, and Russia; the largest having a capacity of 3 tons.

Larger Sizes.—Furnaces holding more than about 3 tons of steel are not heated by a single arc, as in the smaller sizes, but have two or more sets of electrodes, as shown in Fig. 4. Mr. Rennerfelt informs me that the 12-ton furnace will have three sets of electrodes and will be 16 feet 6 inches long; it will use 1,500 kilowatts. A 40-ton furnace would have four sets of electrodes of 6 inches and 7 inches diameter, and would use 4,800 kilowatts.

* From a report of the Department of Mines, of Canada, on Electrothermic Smelting of Iron Ores in Sweden, by Alfred Stansfield, D.Sc., F.R.S.C.

[1] The Anderson furnace employs electro-magnets. These are placed beneath the furnace, with the object of controlling the arc. D. Carnegie, "Liquid Steel, Its Manufacture and Cost," p. 452.

[2] A. Sahlin. The use of liquid ferro-manganese in the stee process. *Journ.* Iron and Steel Inst., 1914, II, p. 213.

Modeling Clay

THE following preparation, which is said to have many advantages over the patented clays now in use, is given in *The Spatula.* Mix powdered soapstone, 200 ounces, wheat flour, 100 ounces. Stir into the above mixture melted paraffin wax, 300 ounces. Not too hot. This can be colored any color with oil soluble aniline dye. If the paraffin you use is hard, the melting point can be lowered by adding a small quantity of paraffin oil to get it to the desired consistency so it can be worked readily.

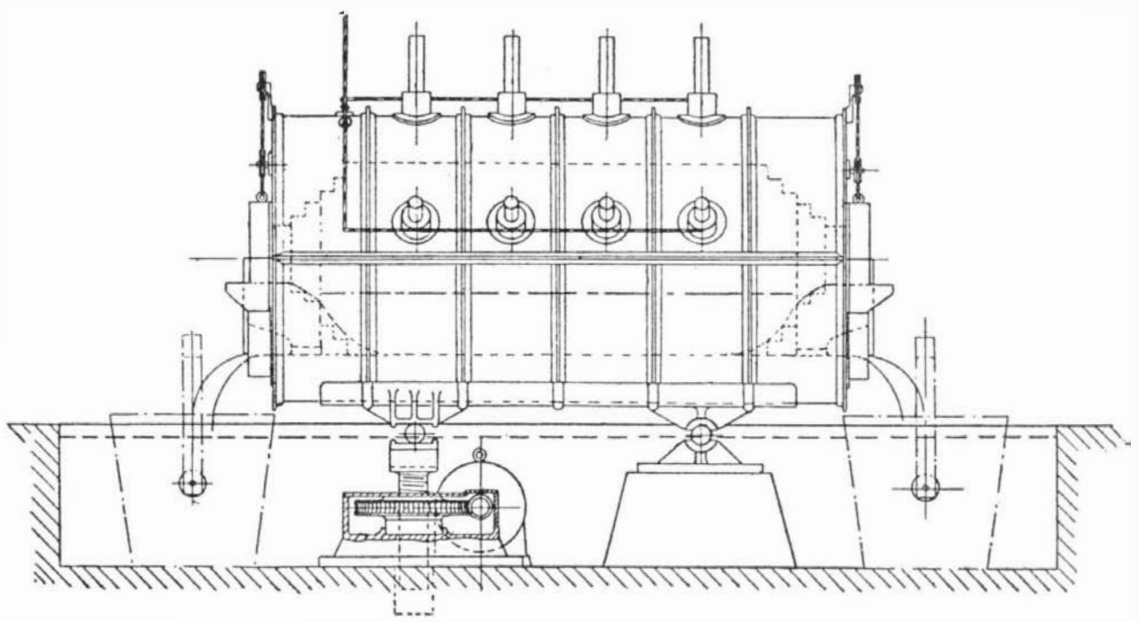


Fig. 4.—A multiple arc Rennerfelt furnace.

Coating for Blue-Print Paper

Economical Method of Preparing Potassium Ferricyanide

As a result of the great increase in the price of potassium ferricyanide or red prussiate of potash, which is extensively used as a coating material for blue-print paper, an economical method of preparing the substance has been devised by the Department of Agriculture. Before the beginning of the war, potassium ferricyanide could be obtained for 55 cents a pound. It now sells for about $6 a pound, and, moreover, it is exceedingly difficult to obtain in this country even at that price. Since blue-print papers in this country are coated almost exclusively with potassium ferricyanide and all coating, blue printing, and washing equipment is built for use with this as the coating material, the rise in price has worked quite a hardship upon both the producers and users of blue-print paper.

Potassium ferricyanide is produced by oxidizing a solution of potassium ferrocyanide with chlorine gas. At the same time a small amount of potassium chloride is produced. Investigations by the Bureau of Chemistry show, however, that the presence of this amount of potassium chloride in the coating of the paper does not interfere with the color and durability of the print. It is unnecessary, therefore, to separate the potassium chloride by crystallizing the potassium ferricyanide, provided that the latter is to be used on the spot and soon after it is prepared.

The apparatus devised by the Bureau of Chemistry for preparing in this way potassium ferricyanide solution is simple. The chief precaution to be taken in its operation is to see that the finished solution does not contain an excess of chlorine. At the prevailing prices of the materials, potassium ferricyanide solution can be made by this process at the cost of approximately $2.80 per pound, calculated on the dry salt basis.

Allowing for possible loss, 100 pounds of potassium ferrocyanide should yield about 75 pounds of potassium ferricyanide. Probably 10 pounds of chlorine would be required also. That is, 1⅓ pounds of potassium ferrocyanide oxidized with approximately ⅛ pound of chloride, would yield 1 pound of potassium ferricyanide.

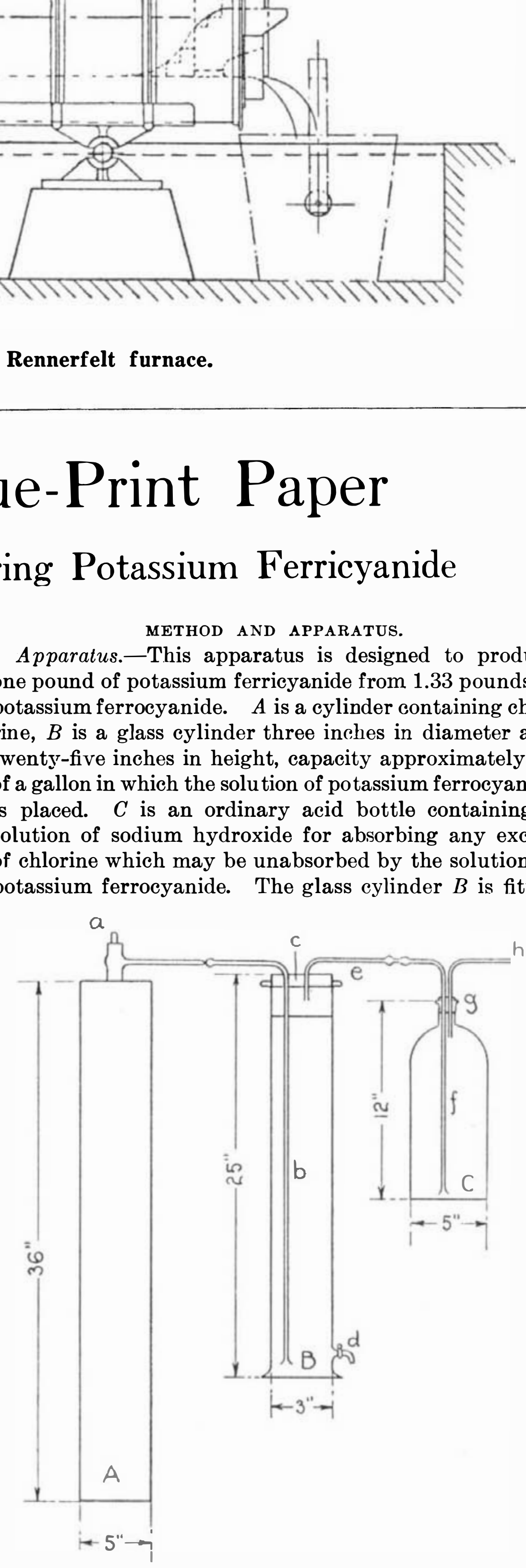
In February potassium ferrocyanide was quoted at $2 per pound and liquid chlorine can be obtained in iron cylinders for 15 cents a pound. At these prices, as has already been said, a pound of potassium ferricyanide in solution can be made for approximately $2.80 per pound, whereas it is now quoted on the market at $6 a pound.

This saving is, of course, much greater than under normal conditions when technical potassium ferrocyanide can be obtained for 25 cents per pound and technical potassium ferricyanide for 55 cents per pound. The price of the potassium ferricyanide at all times will be greater than the price of potassium ferrocyanide, since the former is prepared by oxidizing the latter with chlorine followed by repeated crystallizations to separate the potassium chloride formed at the same time. It seems probable, therefore, that even under normal conditions the simple procedure devised by the Department of Agriculture for the preparation of potassium ferricyanide solution will prove profitable for users of large quantities of blue prints.

The necessary apparatus has been developed primarily for use in the government service, but it is equally available for other purposes. The method and apparatus for making potassium ferricyanide are described as follows:

METHOD AND APPARATUS.

Apparatus.—This apparatus is designed to produce one pound of potassium ferricyanide from 1.33 pounds of potassium ferrocyanide. *A* is a cylinder containing chlorine, *B* is a glass cylinder three inches in diameter and twenty-five inches in height, capacity approximately ¾ of a gallon in which the solution of potassium ferrocyanide is placed. *C* is an ordinary acid bottle containing a solution of sodium hydroxide for absorbing any excess of chlorine which may be unabsorbed by the solution of potassium ferrocyanide. The glass cylinder *B* is fitted



with a glass petcock (*d*) near the base for withdrawing a portion of the solution for testing completion of oxidation. At the top it is fitted with a three-inch cork (*c*) sealed with paraffin having two holes to accommodate the glass tubes (*b* and *e*). One of these tubes (*b*) extends to the bottom of the cylinder and is blown at the end to distribute the gas well. It is connected by a short piece of rubber tubing to the pipe attached to the chlorine cylinder. The other tube (*e*) which does not touch the surface of the solution in cylinder *B* is connected by a rubber tube to a glass tube (*f*) running to the bottom of the acid bottle and blown to distribute any gas which may not be absorbed in *B*. Bottle *C* is fitted at the top with a cork (*g*) sealed with paraffin and having two holes through which pass tubes. One of these tubes (*f*) runs to the bottom of the bottle, the other (*h*) starting from above the liquid is so connected as to carry unabsorbed chlorine out of doors. The chlorine gas is regulated by a valve (*a*) in the head of the chlorine cylinder. The glass tubing used should be ⅛ inch inside diameter.

Operation.—Dissolve 1.33 pounds of potassium ferrocyanide in about 2½ quarts of distilled water and pour into cylinder *B*. Nearly fill bottle *C* with a 10 per cent solution of caustic soda. Connect the chlorine cylinder with tube (*b*) by means of a short piece of rubber tubing and tube (*e*) with tube (*f*) and finally run a tube (*h*) from bottle *C* out of doors. Turn on the chlorine gas and allow it slowly to bubble through the solution of potassium ferrocyanide. Shut off the chlorine at intervals of a half hour or so and to aid the absorption of the gas shake or agitate the container. Do not allow the caustic soda solution to suck back when the gas is shut off. This can be prevented by breaking the connection between *B* and *C* immediately after shutting off the chlorine. Continue passing the chlorine into the potassium ferrocyanide solution for some time after the color has darkened considerably. After which frequent tests are necessary to determine when the oxidation has been completed To test for complete conversion to the ferricyanide, draw off a little of the solution through the petcock (*d*), dilute with distilled water and test with a solution of ferric chloride. If a blue precipitate is formed potassium ferrocyanide is still present and the process must be continued. If a brownish or amber coi red solution results, the oxidation is complete. After tests show the oxidation to be complete, turn off the chlorine gas, disconnect the chlorine cylinder and connect (*b*) with an air pressure line. Bubble air through the solution until no odor of chlorine is noticeable. In case air pressure is not available and suction can be obtained, break the rubber connection between tubes (*e* and *f*) and connect (*e*) with the suction and draw air through the solution until free of chlorine.

Great care must be exercised that no chlorine escapes into the room and comes in contact with the flesh as it is a powerful irritant and serious injury may result to the throat, nose, eyes and hands from exposure to the fumes or contact with the liquid.—*U. S. Department of Agriculture, Office of Information.*

Explosibility of Gases From Mine Fires

Although the methane that makes a mine gaseous is largely responsible for explosions that take place when ventilation is stopped during a mine fire, inflammable gases—carbon monoxide, methane, and hydrogen —produced by the fire itself are also responsible.

Methane is the most dangerous gas as regards low limit of explosibility, whereas carbon monoxide and hydrogen are especially dangerous because of their wide explosive ranges.

Heat reactions between coal and air may be studied by comparing mine-fire combustion processes with those in gas producers, gas retorts, and boiler furnaces.

In the destructive distillation of coal large amounts of hydrogen, carbon monoxide, and the paraffin hydrocarbons (principally methane) are formed. At temperatures between 339° and 1,100° C. the proportions may vary—for methane, between 2.50 and 71 per cent; for carbon monoxide, between 2.0 and 16.0 per cent; and for hydrogen, between 0 and 73.0 per cent. At low temperatures the proportions of hydrogen and carbon monoxide formed are lower than the proportion of methane, hence in low-temperature distillation in mine fires the principal danger is from methane. As regards a mine fire that has been burning for some time, it is probable that when the oxygen of the air has been so depleted that products of destructive distillation appear, the embers will have cooled to a point where the low-temperature products are given off in largest quantity.

Carbon monoxide formed by the reducing action of hot carbon on carbon dioxide is a highly important agent in some mine-fire explosions.

It is probable that water gas (carbon monoxide and hydrogen), produced by the action of steam on hot carbon, plays a relatively unimportant rôle in causing mne-fire explosions.—*Technical Paper, No. 134, Bureau of Mines.*

Removing Paint from Wood

As examples of the numerous preparations of the kind in question the following are on record: (1) Potassium hydroxide, 1 pound; acetone, 2 pints; methylated spirit, 1 pint; oil of turpentine, 1 pint; petroleum spirit, 1 pint; castor oil, 10 fluid ounces. Mix. It is used by spreading thinly over the old paint. After a few minutes a second application is made, when the softened paint can generally be easily removed with a blunt spatula. (2) The following is an example of a patented preparation: Lime water, ½ gallon; soda, 1 pound; soft soap, ¾ pound; ammonia, 2 ounces; paraffin oil, ¼ pint. A well-known book on painters' materials states that "some of the most satisfactory paint removers are prepared by mixing in various proportions such substances as acetone, amyl alcohol (fusel oil), carbon bisulphide, ethane tetrachloride. These solvents can either be used alone and put on with a brush or made up into a paste with pumice powder and used with a pad." Some seem to be little more than a solution of hard paraffin in benzine prepared with heat, excess of paraffin crystallizing out on cooling and being left in the liquid. In nearly all preparations of the kind, however, there is something present to retard evaporation of the solvent, usually castor oil or cocoanut oil. A small addition of ether to a solution of hard paraffin in benzine or petroleum spirit prepared as above would answer very well.—*The Spatula.*

How to Value Gems*

A Description of the Natural and Artificial Features That Determine the Quality

Gems have always been to man, whether savage or civilized, objects of the liveliest interest and attraction. Their sparkle and play of colors, their untarnished beauty and durability, have ever made them the coveted ornaments alike of the troglodyte of the cave and the prince of the palace. The most gorgeous wreath of flowers scarcely survives the day it is worn, the most brilliant head-dress of feathers is soon sullied and worn, but the necklace or amulet of gems retains its glitter and freshness for generations. No wonder, then, that they have been so universally prized, so long the essential adjuncts of barbarian splendor, and still the most esteemed and precious ornaments of refinement and civilization. As minerals they bulk very slenderly in the crust of the earth, being druses in veins and fissures, segregated as geodes in the pyrogenous rocks, or developed as accidental or accessory crystals in the older metamorphic strata. In whatever formation or position they occur, they are never found in masses; and when found, comparatively few have sufficient purity and brilliancy to render them especially attractive. For this reason most of them retain a wonderful uniformity in value; and though fashion may occasionally enhance or diminish the demand for certain sorts, yet in the long run the finer gems and precious stones can ever secure a ready and remunerative market.

It is true, of course, that most jewelers have some knowledge of diamonds, and the terms Jagers, Crystals, Rivers, Wesseltons, Capes, Bywaters, etc., have more or less definite meaning for them. Yet there is much more in reference to diamonds that is extremely interesting—the production of the rough in olden and modern times, the prejudice against Brazilian diamonds and in favor of the Indian stones, and, later, the feeling against South African diamonds, based on the theory that these stones were not as good as the Brazilian. The history of celebrated diamonds, the cutting of diamonds—all these and many other things will serve to interest your customers in diamonds and to impress them with the feeling that they are dealing with men who understand their business.

The value of polished diamonds depends on the following conditions:

First—The color: The limpid diamonds command the highest price, and twice as much as those that are colored; the blackish, brownish, yellowish, brown, steel-gray, and impure bluish ones, stand in no value, and are often rejected for working.

Second—The purity, faultlessness and transparency. The diamonds ought to be, according to the technical terms of the jewelers, free from ashes, gray spots, rusty or knotty places, veins, fissures, scratches, feathers, flaws, sand, grains, and faint yellow or vitreous spots.

The transparency and clearness of the diamond are divided into three degrees, viz.:

A, of the first water, as in those diamonds which are free from even the slightest faults, and stand highest in price.

B, of the second water, as in those diamonds which, although clear and limpid, are marred by some dark spots, clouds or flaws.

C, of the third water, as in those diamonds having a gray, brown, yellow, green, blue or blackish color; or those that are limpid, but are injured by several material faults.

In order to determine accurately the nature of diamonds, it is well to breathe on them; then they lose for a moment their lustre, and the eye is then better enabled to examine them and distinguish their faults. The real diamond becomes clear much sooner than the false.

Third—The cut: The perfect and regular cut of the diamond increases its value considerably; a Brilliant, for instance, of one carat, is worth twice as much as a rough diamond of equal weight. It depends upon the proportions of the height to the circumference of the diamond, and that the planes and facets stand in a regular proportion, for should this not be the case, the diamond would lose much of its fire.

A properly cut diamond has 58 facets, including the table and culet; the 32 facets above the girdle should be 40 per cent of the girdle and the angle from the girdle to the table should be 35 degrees and from the girdle to the culet 40 degrees. A perpendicular line drawn from the center of the table to the center of the culet will be one-third above the girdle and two-thirds below.

The brilliant is the finest form of cutting. It is not always exactly the same, but all the forms of it have certain main features in common.

The front or top of a brilliant consists of an eight-sided facet, called the table, which is surrounded by 32 smaller facets. These reach to what is known as the girdle, the thin edge separating the upper part, called the crown or the bizet, from the lower part or pavilion.

The pavilion has 24 facets terminating in a small flat facet called the culet. This makes 58 facets, counting the table and the culet. Sometimes there are added 8 extra facets around the culet.

Of late years it has been discovered that a stone should be cut with a good deal of what is termed "spread." It used to be thought that a stone should have one-third above the girdle and two-thirds below. Now the best are cut with less than a third above and the change makes for greater brilliancy.

A properly proportioned stone will show as much light and color in the very center, under the table, as at the edge where it is cut thin to receive the light. If a diamond is too deep it has a dead center, a black well without light or color. If it is too shallow it has a glassy look and is technically known as a "fish-eye."

Diamonds are grouped under different names according to their color. Old mine diamonds were originally Brazilian, from the old diggings, but it is the term now applied to most old cut diamonds of good color.

Jagers (pronounced Yahgars) is the trade term for blue-white stones. It comes from the fact that the Jagersfontein mine produced a great many of these bluish diamonds.

Rivers are the purest white stones, so called because the diggings on the River Vaal yielded this type. It is said that in general stones from wet diggings are better than those from dry.

Next to Rivers come crystals and top crystals, which finish up the pure white and blue-white goods. From them on the grades become more and more off color in shades of yellow, brown and green.

The stones which have the faintest tinge of yellow are called Silver Capes. Next come the Capes and then Bywaters, which are decidedly yellowish.

Mackle is the name given the diamonds suitable for rose cutting. Naats is another name for thin, flat crystals.

Melee is the term for a lot of small diamonds; melange, for diamonds of mixed sizes; chips, for pieces of less than three-fourths of a caret when taken by cleavage from a larger stone. Bahias are Brazilian diamonds from the Bahia district. Golcondas are diamonds from India.

Two of the most common expressions in the trade are interesting in the light they throw on the history of precious stones: The word Oriental has come to be applied to all gems of the finest quality, no matter where they come from. Less frequently the word Occidental is used to designate inferior stones.

The actual value of the gem is, of course, determined by its color, brilliancy, freedom from discernible imperfections or conspicuous flaws and size.

For examining gems the optical test is best. A glass magnifying about 20 times suffices.

Every expert knows that almost all precious stones have little flaws or inclosures.

It is impossible to see a diamond at its best in some stores. One must know the light, the surroundings, to judge the stone properly.

In buying or valuing diamonds the following have to be considered:

Brilliancy, proportion, cutting, perfection.

Brilliancy is the chief quality. Color is important. Perfection is largely a matter of sentiment.

Fire is the term applied to the luster, life and brilliancy of the gem.

Diamonds are classified according to the colors in the following order:

Blue, fine blue-white, blue-white, white, silver cape, fine cape, second cape, fine bywater, second bywater, off color, light yellow, yellow, fine light brown, brown, dark brown, darkest brown, grey.

Sometimes they are classified according to mines and we then find mentioned: Rivers, jagers, wesseltons, etc. Also there are some fine stones called crystals.

Fancy colors are:

Emerald green, red, sapphire blue, pink, orange tint, tints of violet-blue and blue, canary, black, brown, golden brown, apple green, deep blue, mahogany brown.

Fancy shapes: Drop shape, navettes, marquise shape, heart shape, square cut, emerald cut, square cut with steps, oval, pear shape.

Jagers: Are white stones with a bluish tint.

Rivers: White stones of extreme purity, extraordinary hardness, found in the riverbeds.

The brilliancy is sharp and color a snow-white.

Wesselton: Color is nearly equal to Rivers, only it lacks the purity and snow-whiteness of the latter and the brilliancy is not so sharp.

Crystals which are divided in top crystals are white stones with a trace of yellow when compared with higher grades.

Silver Capes is called a general white stone; there are grades as silver capes, and top silver capes. Capes are again divided in the same way; they are tinted still deeper and are sold often as "Commercial White."

Bywaters are tinted yellow, though the color is not deep enough to place them among the fancies and is sufficiently lost to the eye when mounted to warrant their retention in the list of white stones.

Yellow white stones vary from a clean bright yellow to a dark and somewhat muddy shade. The more clean the yellow tint the better it is.

Browns are all included under one classification. Brown white ranges from ashen to red brown and are all undesirable, as they look dark when mounted.

About 30 per cent of the diamonds found at the present time are perfect, making 70 per cent of imperfects. The colorless perfect stones run only about 5 per cent of the entire production. A diamond is considered perfect in formation when no flaw or imperfection can be detected under an ordinary eyeglass, such as used in the jewelry business. Flaws are carbon spots, feathers, bubbles, hairs, and flaky formations, similar in appearance to a piece of clear ice after having hit it with a hammer. A diamond to be sold as an absolute perfect stone must be cut in the proper proportions as heretofore mentioned, as well as free from any flaws in the formation.

Clean means free from interior flaws and inclosures, which are hard to find.

Flaws consist mainly of so-called carbon spots, and fissures or "glasses," glesson, as they are sometimes termed.

There are comparatively few stones which are absolutely flawless, though many of the faults are almost imperceptible to the naked eye and are of such a character that they do not hurt the brilliancy or beauty of the stone.

Imperfection: Rough edges on the girdle of the diamond will cast a shadow through the center of the stone, causing loss of brilliancy. Rough edges most of the time can be covered with a prong or bezel of the setting and cannot be seen in a mounted diamond.

Scratch: A scratch on top of a stone is liable to be formed in any stone; this scratch can come from rough handling, two stones rubbed against each other, or any other object. Sometimes a stone can be scratched on the side of the crown. A scratch can be removed—polished out—if it is not too deep.

A small nick in the girdle. This also can be covered by the mounting. A stone is often nicked by a careless setter or two stones having rubbed each other, of falling on iron; this happens on account of the girdle being brittle or fine finished.

Thick Edges: A thick edge will cast a shadow through the facets and easily can confuse the color.

A Feather: A feather is really a milky flake in the stone, formed in the crystallization, and cannot be removed.

The flaws vary in size from a small speck to one which may be seen with the naked eye. This will give the diamond a hazy, lifeless appearance.

Feathers are also white subtransparent lines in the body of the stone.

A Fracture: They are generally found near the edge of the diamond. Fractures are found in the natural stone and will give the stone a dead and hazy appearance and diminish the value of the stone. A fracture is a diamond which has been shivered either by a blow or carelessness in setting.

Carbon Spots: Black spots, specks in the diamond, generally are found in the top and lower half of the stone. Some of the specks may be cut out in shaping the stone. The size varies from a very fine spot to one readily seen with the naked eye. It is peculiar that these carbon spots appear in pairs.

Bubble: A diamond may contain a bubble, caused by air formation in the carbon in crystallizing. Streaks color from gray to dark brown. Bubbles are small, hollow specks in the body of the gem.

Clouds: Muddy or cloudy patches of any color or flat, subtransparent blotches along the grain of a stone.

Knots: Conditions found in a diamond as in wood and troublesome to cut.

Off Color: Having but a tint of desirable color.

Lumpy: A stone cut too thick.

*By Emil Freund in *The American Jeweler.*

Deep and Shallow Diamonds: In buying a diamond see to it that your stone is neither too deep nor too shallow. If it is too deep the "table" at the top of the stone will have a dead look instead of showing as much color and light as at the edge, where the diamond is cut thin to receive the light. You are simply paying for extra weight that adds nothing to, but rather detracts from, the appearance of the gem. The shallow stone, on the other hand—which is technically known as a fish eye—has a glassy look.

Many persons buy these fish eyes because the stone looks as if it were larger than it really is. As a matter of fact their lack of brilliancy is so much more conspicuous than any detail of size that a fishy stone is a bad bargain at almost any price. As for the thick stones, called lumpy by dealers, a person simply pays for that much extra weight and after all gets a dead centered stone.

The American cut brilliant has the same number of facets as the regular brilliant, 58, but the proportions are different. The twentieth century is a comparatively new form of the brilliant cut.

At first it had 88 facets, and instead of having the table it was carried to a low point in the center. Later it was cut with 80 facets, the central ones being almost flat. Opinions vary as to this cutting, but it is probably best suited to shallow stones, whose defects it would help to conceal.

The rose cut is used only for thin stones. It is circular; the front is covered with triangular facets and the back is quite flat.

The Dutch rose has 24 facets, the Brabant rose 24, 12 or 6 facets, the rose recoupe has 36, the marquise and the pendeloque have 24 each, and the double rose has 24 above and instead of a flat back 24 below.

Briolettes are pear-shaped or oval stones covered with triangular facets. They are generally drilled through the narrow end so that they may be worn as pendants.

"Indian cut" is a clumsy form in which most stones from that country reach Europe. They are cut by the natives with the sole idea of retaining as much weight as possible without regard to the brilliance secured. They always have to be re-cut for Europe and America.

Testing Doubtful Diamonds: Marvelously beautiful as are the imitation diamonds of to-day, an experienced eye never mistakes them for the genuine article.

The average person, however, can easily be deceived, and the following simple tests should assist him when striking a bargain. The facets on a real diamond are rarely so regular as those of really good imitations. With the latter the greatest care has to be taken in grinding and polishing, so that there shall be no irregularity in the reflections of the light.

A file cannot scratch a real diamond, but quickly injures an imitation. A sapphire is the next hardest stone to a diamond, and is an even better test than the file.

Thrust a diamond ring into a bowl of water and the stones will glitter through the liquid, but an imitation stone loses all its brilliancy under water. If you look through a diamond at a black dot on a piece of white paper you will see one black speck quite clearly. If the dot is blurred or multiplied the stone is probably not genuine.

Place one drop of water upon the face of a diamond, touch it with a point of a pencil—the drop will keep its globule form and the stone remain dry. If the brilliant is an imitation the water at once spreads out.

Keep in mind a diamond is very seldom absolutely perfect. The European buyer is not as strict about "perfect" as the American, because he knows that most of the diamonds have inclosures by nature.

Before I close my remarks on valuing gems, I call your attention to Prof. Frank B. Wade's article in *Jeweler's Circular Weekly*, August 4, 1915, with which I fully agree and quote as follows:

"Another essential is to have by you for comparison stones whose color you are sure of. One cannot 'carry color' in one's eye, although some people seem to think it possible. Rough distinctions may doubtless be made by those who are experienced, without the aid of a comparison, but when it comes to deciding between two very fine stones or lots of stones without seeing them side by side, it is almost impossible to do so.

A good lens is also an essential aid in studying the color of diamonds. By means of it one may still see clearly when the object is within an inch or less of the eye. Hence the true color of a diamond is more apparent when viewed under a lens, as the light from the stone is caught before it has had a chance to scatter widely. A lens of 1-inch focal distance is best for all-around work. A higher power is neither necessary nor satisfactory, and a much lower one is not as efficient as the 1-inch.

While most diamond dealers use—as they did in the past—simple lenses, uncorrected for chromatic aberration or for spherical aberration, better results may be had from the new triplets, which consist of three lenses, balsamed together as one, and having 6 polished curved surfaces so arranged as to correct all color defects so that pure white light passes the lens untinted. They are also corrected for spherical aberration, so that instead of being sharply defined only in the center the field of view is clear from edge to edge. These triplets, while costing a little more (about $4 list), are so much more satisfactory that no one who has used one would ever wish to depend on one of the old-style glasses. The new lenses are seldom sold mounted like a watchmaker's glass, but they can be so mounted by anyone with a little ingenuity, if it is thought desirable. As pocket lenses they are unsurpassed. The optical houses usually call the type referred to "aplanatic triplets."

The value of many precious stones is increased by engraving them. The common gems have, for several centuries, been used in heraldry. In Italy, Germany and England we find the coats of arms of distinguished or noble families engraved on stone. The machine used for such purposes is like that of the glass cutters, with this difference, that finer and harder instruments, and sometimes diamond splinters, are required for this work. Before the stone can be cut or engraved, its surface, after having received the proper shape and form required, is rubbed with emery, glass or leaden wheels; the artist now makes his drawing with a brass pin, and executes it afterwards with his tools. On hard stones he uses diamond powder; on soft, emery and oil.

The engraving of armorial bearings, single figures, devices, etc., on any gem is performed by means of a small iron wheel, the ends of the axis of which are received within 2 pieces of iron in a perpendicular position, that may or may not be closed as the operation requires; the tools are fixed to one end of the axis, and screwed firm; the stone to be engraved is then held to the tool, the wheel set in motion, by the foot, and the figure or device gradually formed.

Difficult works are executed after models of plaster of paris, of clay or other substances; the polish is afterward given on wheels provided with brushes or with rotten stone. The semi-transparent and opaque stones are more used for engraving than the transparent gems, because the drawing will not show distinctly through them, on account of the great refraction of light; the same is the case with iridescent or shining stones. The engravings are generally bas-relief or raised; those having layers are most preferred for cameos; for instance, the onyx, sardonyx, and chalcedony; also, Wood-opal, which is constantly exported from Germany for the Italian artists in Rome.

Cameo cutting, or the engraving of gems in relief, is effected with the same apparatus and by the same general methods as those employed in engraving corresponding forms in intaglio, and both arts are occasionally practiced by the same individuals. The principal differences in the manipulation of the seal engraver and the cameo cutter arise from the design being in the former case wrought concave, and in the latter convex. The tools with which the former are produced, being themselves convex, they may in most cases be selected of counterpart curvatures to the concave details required in intaglio engraving; but the convex forms in cameo cutting have to be produced with convex tools, which cannot, therefore, be selected of counterpart forms, but the convex surfaces have to be produced by twisting the stone about at all angles beneath the rounded edge of the tool. For this reason, the engraving of gems in relief is usually considered to be more difficult than engraving in intaglio. On the other hand, however, the deep recesses in cameos are generally more accessible than those in intaglio, and the principal source of difficulty in gem engraving is therefore in some measure avoided.

The stones selected for engraving in cameo are generally those called onyxes, consisting of 2 layers of different colors forming a strong contrast, as the black and white layers of the agate or the red and white layers of the carnelian. The design is almost always engraved exclusively in the white layer, and the dark-colored layer forms the background, the contrast of the two colors serving to render the design more distinct. Sometimes onyx stones having 3 or more layers of colors are employed for cameos; these are selected when, either from the great amount of relief desired in the engraving, the thickness of the white layer would be insufficient to allow the entire design being engraved in it, or that it is desired to make the most prominent parts of the design of different colors in order to improve the effect.

Mineralogists generally restrict the name onyx to a variety of chalcedony, consisting of alternate layers of brown and opaque white; but those artists who work in precious stones usually attach a much more extended signification to the same.

All the stones in different colored layers employed for cameos are known to practical men by the general name of onyxes; but some confusion has arisen with regard to the nomenclature of stones of this class, in consequence of the imperfect information of those authors who have undertaken to describe them. It is a remarkable fact, that no author who has undertaken to describe the onyx has given this simple and to all practical persons intelligible description of it, namely, a stratified stone, occurring in any of the semi-transparent or opaque varieties; thus there is the onyx of the sard, called the sardonyx; that of the carnelian, called the carnelian-onyx; and so on through the whole variety of stones.

The stones to be cut into cameos are prepared by the lapidary; and, to avoid wasting the material, each stone is left as large as possible. The cameo cutter has, therefore, to select a stone as nearly as he can in accordance with his intended design, which must be afterward modified in some degree to suit the stone.

As a preliminary step to cutting the cameo, it is most important that the artist should have a clear conception both of the design and the capabilities of the stone. To assist in this, he first makes a sketch of the design on an enlarged scale, and then, having considered the degree of relief that will be adapted to the thickness of the white layer, he makes a model in wax of the exact size of the stone.

With unimportant works this is frequently omitted by practical artists, who depend upon their skill for overcoming any difficulties that may arise; but it is at all times a great assistance in elaborate works, especially to those who have not great practice. The model and stone are carefully compared, and any alterations that may be demanded by the formation of the stone are first made in the model.

When the stone is in 3 layers, additional care is required to adapt the design to the stone. It is at all times desirable that the line of division between the colors of the 2 layers forming the ground and figure should be distinctly defined, but it is sometimes an advantage when the transition between the 2 colors in the upper layers is more gradual. For instance, in cutting the head of a Medusa, in a carnelian having 1 layer of white between 2 of red, if the lines of division between both of the layers of red and the white are sharply defined, the features must be cut entirely out of the white layer, and the upper layer of red must be reserved for the snakes; but if the transition between the upper layer of red and the white were gradual, faint tinge of color might be left on the cheek with great advantage to the effect, and the skilled engraver of cameos will thus avail himself of every opportunity for heightening the effect that is offered by the formation of the stone. When the stone consists of several layers of color, considerable scope is afforded for the exercise of the judgment, in selecting a design in which the whole of the colors can be rendered available.

When the design has been accommodated to the stone as nearly as possible, the outline is sketched on the surface, and cut in with a knife-edged tool, and the superabundant portions of the white layer beyond the outline are removed down to the dark layer forming the background. The general contour of the figure is next formed and this is followed by the principal details, which are sketched and cut in succession, care being taken to preserve sufficient material at the most prominent parts, and to advance the engraving uniformly, so that the general effect may be compared from time to time with that of the wax model.

The surface of the background is conveniently flattened with the broad, flat surface of a tool, and the difficulty of removing the little irregularities on the rounded surface of the figure, with the convex edge of a revolving tool, may be entirely avoided by the use of a tool called a spade, consisting of a piece of soft iron about 3 or 4 inches long, the end of which is filed at an angle of 45 degrees, and charged with diamond powder. The spade is held in the fingers, like a pencil, and rubbed with short strokes, either straight or circular, to reduce the irregularities of the surface. The last delicate touches are executed with very small tools, and the cameo is finally smoothed and polished in the same manner as the best works in intaglio.

Engraving on glass is executed in much the same manner as seal engraving, and with tools of similar forms; but the designs on glass works are usually of larger sizes than those on gems, and the tools are therefore made of proportionately greater diameter. In order to permit large objects, such as decanters or squares of glass, to be applied to the wheels, the latter are fixed on stems that project from 6 to 10 inches from the front of the lathe-head, or, as it is generally called, the tool.

The wheels employed for engraving are made of copper and charged with fine flour emery and oil. When the engraved surfaces are required to be polished similar wheels made of lead, charged with pumice-stone powder and water, are used.

The engraver watches his work during the cutting through a lens of from 1 to 2 inches focus, which is mounted in an adjustable stand directly over the tool.

The work is removed from time to time to allow of its being seen directly; but the engraver depends very much on the sense of feeling for placing the work in the proper position with respect to the tool, and upon that of hearing for judging of the progress of the tool. He occasionally takes a proof of his work in blue modeling clay or in a black wax made by mixing fine charcoal powder with beeswax.

It is of great importance that the artist should have his hands perfectly steady and placed so as to be moved about in all directions with freedom.

Chalcedony and agate are, however, not unfrequently colored artificially. The layers vary much in their structure, some being absorbent and others not. Such stones, if it is desired to have black and white layers, are boiled in a solution of sugar or honey, and then in sulphuric acid. The sugar or honey is, in the first place, absorbed by the more porous layers, and then decomposed by the acid. Red or brownish-red layers are produced by occasioning the stone to absorb a solution of sulphate of iron and then, by exposure to heat, effecting the oxidation of the metal. This being done, layers very strongly contrasted in color are the result, and very fine cameos have been cut upon stones so prepared. In Italy and in France, the art of producing the "cameo dur" has been, to some extent, revived; but the immense labor which such hard materials require renders them so expensive that these cameos have not come into general use. Other materials used are translucent rock crystal, amethyst (purple) emerald, carbuncle, chrysolite, beryl, semi-translucent crystals (agates), or cloudy quartz and their varieties, such as the orange-red, sardius, sardonyx, opaque crystals, various jaspers, turquoise and chrysoprase, certain metallic oxides and bituminous substances are also used. Hematite, malachite and amber, corals and the inner layers of certain mollusc shells; lastly, and largely for purposes of imitation of the antique cameos, vitreous pastes.

Porcelain and glass have been employed as substitutes for the natural stones; but the results are so inferior that these materials have of late been entirely neglected for this purpose.

The art of imitating cameos in shells, which has now attained such perfection as to rival the cutting and finish even of antique workmen, and which is a process quite as artistic as their production from gems, is of modern invention.

The shells, like the stones chosen for this purpose, are such as possess layers of different colors. The most useful are the "bull's mouth," the inner layer of which is red, resembling the sardonyx; "the black helmet," which has a dark onyx ground, and the "queen's couch," of which the ground is of pinkish hue.

Certain descriptions of these shells are well adapted for cameo cutting on account of their substance being made up of differently colored layers, and also on account of a difference of hardness and texture in the different layers, some approaching more nearly to the nature of nacreous than of porcelaneous material.

Experience has taught the cameo cutter to choose the kinds known as the "bull's mouth," the "black helmet," and the horned helmet, and the queen's couch, of which the first two are the best. The art of cameo cutting was confined to Rome for upwards of 40 years, and to Italy until the last 26 years, at which time an Italian began cutting cameos in Paris.

The "black helmet," on account of the advantageous contrast of color in the layers, produces very effective cameos, the carved figure of the white upper layer being strongly relieved by the dark, almost black, ground supplied by the second layer. The shell is first cut into pieces the size of the required cameos by means of diamond dust and the slitting mill, or by a blade of iron or steel fed with emery and water. It is then carefully shaped into a square, oval or other shape on the grindstone and the edges are finished with oilstone. It is next cemented to a block of wood, which serves as a handle to be grasped by the artist while tracing out with a pencil the figure to be cut on the shell. The pencil mark is followed by a sharp point, which scratches the desired outline, and this again by delicate tools of steel wire flattened at the end and hardened and by files and gravers for the removal of the superfluous portions of the white shell. A common darning-needle, fixed in a wooden handle, forms a useful tool in this very minute and delicate species of carving. The careful manipulation necessary in this work can only be acquired by experience, but there are general rules which the learner would do well to remember: "As in all other processes of producing form by reduction, the general shape should be first wrought, with care to leave every projection rather in excess, to be gradually reduced as the details and finish of the work are approached. To render the high parts more distinct during the process of carving, it will be found convenient to mark them slightly with a black lead pencil. Throughout the cutting great caution should be observed that in removing the white thickness the dark ground is not damaged, as the natural surface of the dark layer is far superior to any that can be given artificially; indeed, should the ground be broken up at one part, it would be requisite from its lamellar structure to remove the entire scale or lamina from the whole surface, a process that will be found very tedious and much more difficult than the separation of the white from the black thickness. In order that the finished cameo may possess a distinct outline at all points of view, it is desirable to adopt the system followed in antique cameos, namely, to leave all the edges of the figure quite square from the ground and not gradually rounded down to the dark surface; should this latter method be followed, it will be found that the outline is in many places undefined owing to the color of the white raised figure of the cameo gradually merging into that of the dark ground; this evil is entirely avoided by leaving the edge of the figure quite square, for the thickness of about one-fiftieth of an inch. The surface of the cameo should be finished as nearly as possible with the cutting tools, as all polishing with abrasive powders is liable to remove the sharp angles of the figures and deteriorate the cameo by leaving the form undefined. When, however, the work has been finished as smooth as possible with the cutting tools, the final polish may be given by a little putty-powder used dry upon a moderately stiff toothbrush, applied with care, and rather to the dark ground than to the carved surface; this is the concluding process, after which the cameo is ready for removing from the block prior to mounting."

Intaglios are much more abundant than cameos; the stone in which they are engraved is more easily obtained, being of but one color; and, besides, the tools employed by the ancients were less efficient for cutting away this stone, a much larger quantity of which has to be removed in forming a cameo than an intaglio.

Many of the intaglio and cameo gems are executed in stones much harder than marble, and they are highly valued, both for the beauty of the workmanship and the quality of the carnelian, sardonyx, sard, amethyst, emerald or other stones upon which they are engraved, and which are often of high price. These gem stones are all so hard as to require diamonds to cut them—hence, the Italian epithet, pietra dura (hard stone).

The scarabs are of all sizes, from that of a small beetle to that of a turtle, or larger, as may be seen in the British Museum. They are made of every description of stone; the largest of granite, basalt, etc.; the small ones of every kind of gem stone, chalcedony, sardonyx, etc., and of baked clay.

The beetle was an emblem venerated by the Egyptians as the cross is with the Christians; so that it should seem that every individual possessed one, the poorer classes having them made of such a simple material as baked clay. The small scarabs, being of convenient shape and size, were converted into seals and were engraved on the under side with a device of some kind of figure, or a cipher or legend, either in letters or symbols, such as are engraved on the obelisks, pyramids and monuments; and these scarabs are bored with a small hole lengthwise, so as to be worn strung on a thread or wire.

For many years the jewelers' shops have been and are still deluged with temporary cheap cameos, both in pietra dura and shell, mounted for brooches, and sold to the million; but no connoisseur has his taste affected by such rubbish any more than a lover of paintings would be diverted from his estimation of the art by seeing the ill-colored prints or paintings in a country inn, or elsewhere.

The studio of the gem engraver, as well as of the sculptor and painter on the Continent, is frequently the rendezvous of persons of taste among the rich and noble; while in England his studio is known only to his commercial employers.

Electric Railway Operation Successful

From every direction the reports of the results of the application of electric power on steam railways are most satisfactory, and they have in all cases exceeded expectations. The latest large enterprise, the St. Paul, has now been in operation long enough to demonstrate the advantages of the new equipment, and it has been found that the big electric locomotives can easily handle a considerably greater load than their contract capacity. On a one per cent grade these engines are rated for a load of 2,500 tons, at a speed of approximately 15 miles an hour, but it has been found that they can take 3,000 tons over the mountains, and larger loads up to 4,500 tons on the easier sections of the division, if a helper is used over some of the short grades. The mileage of the electric trains figures out, in actual practice, at about 200 miles for 24 hours, as against 114 miles for the steam locomotives. With only one-fourth of the electrification in operation twenty-four heavy steam locomotives have been released, and the work is being done faster and cheaper with only nine electric locomotives. One of the most appreciated features of the system is the ease with which heavy trains can be taken down the long mountain grades. With steam locomotives constant and skillful use of the air brakes is necessary, which means that all the potential energy stored in the train at the top of the mountain must be dissipated as heat in the brake shoes and wheels during the descent. This results not only in great wear on the brake shoes, but also on the wheels and the track, and a direct waste of power. With the electric braking employed on this line, in which the motors are driven mechanically as the train pushes the locomotive down the grade, not only is all of this wear eliminated, but a large portion of the potential energy of the train returned to the trolley system to assist in hauling other trains up the grade. The same latitude in speed variation is available as when operating up grade under power, and the air brakes never have to be used except for making a stop. It has been found that heavier trains can in this way be taken down long grades, and with greater safety, than by the use of air brakes.

Strength of Zinc-Bronze Alloys

One of the conclusions arrived at in Technological Paper No. 59 of the Bureau of Standards on Standard Test Specimens of Zinc-Bronze is that the presence of oxides is one of the most potent sources of weakness in these alloys in their cast condition.

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