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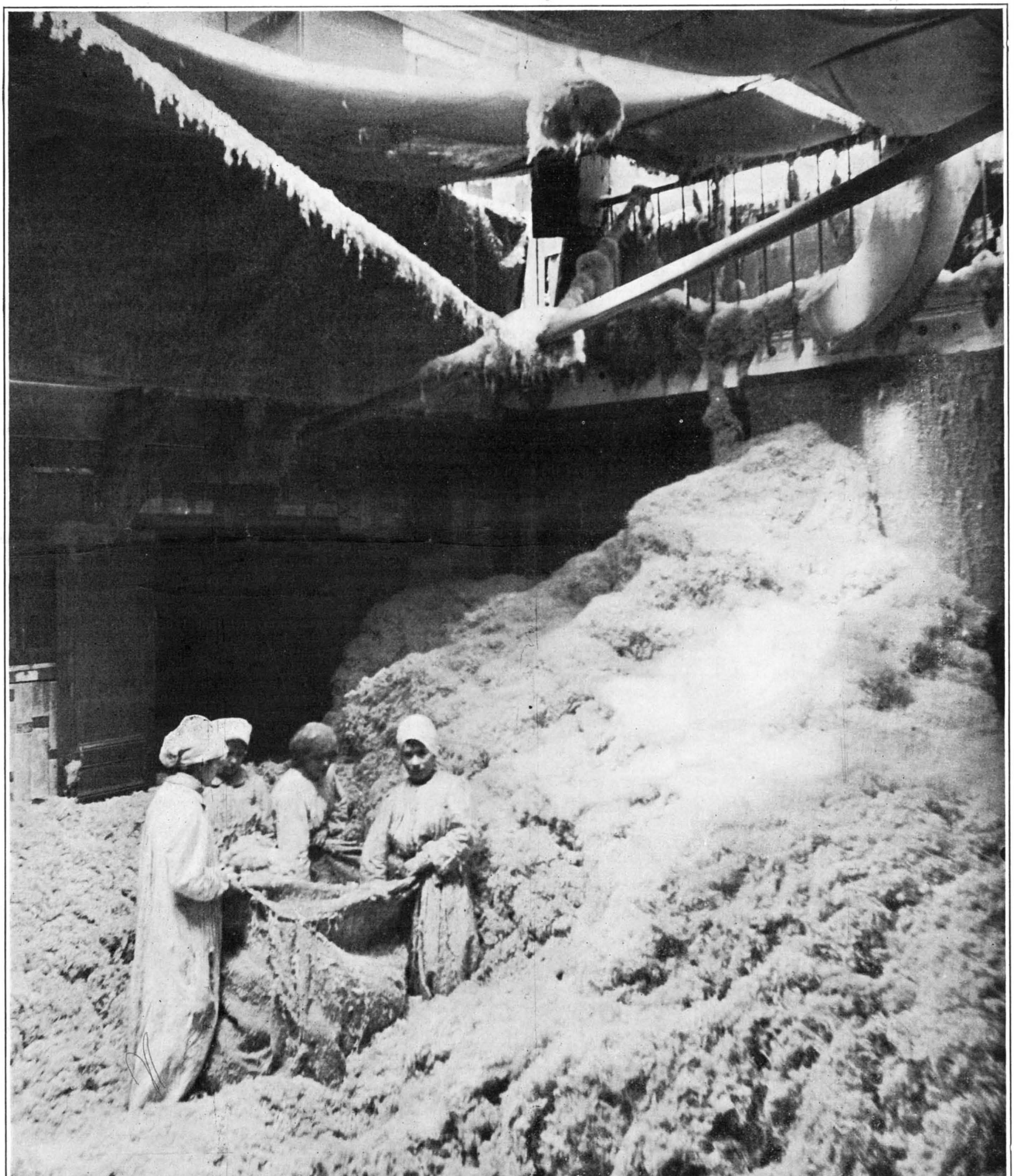


Packing kapok fiber after ginning.

KAPOK: A NEW TEXTILE FIBER.—[See page 120.]

Mysteries of Matter*

Some of the Marvels of the Properties and Constitution of the Atom

By John Candee Dean

In the study of the vast, or of the minute, the imagination is incapable of comprehending the spaces involved. When we say that the sun is more than a million times larger than the earth, the statement does not present a mental picture of the sun's magnitude. A better conception of the sun's immensity can be obtained by saying that if the earth were placed in the center of a spherical shell, with a diameter equal to that of the sun, the moon's orbit would be a little more than half way between the earth and the shell of the sphere. But sizes of all things are relative. The magnitude of the sun is insignificant compared with some of the fixed stars. Prof. Kapteyn estimates that the red star Antares, in the heart of the Scorpion, is 3,400 times as brilliant as the sun. The diameter of Antares is estimated to be 160 million miles, or nearly as great as the orbit of the earth.

We meet with the same difficulties in attempting to comprehend the spaces occupied by molecules, atoms and electrons. Lord Kelvin said that if we could magnify a drop of water to the size of the earth, the atoms then might appear to be somewhat smaller than cricket balls. The average atom has been estimated to be 100,000 times as large as the electron. Now to bring the electron up to the size of Kelvin's magnified atoms, it would be necessary to magnify a drop of water to 100,000 times the size of the earth.

For nearly one hundred years Dalton's atom kept its place in the theory of the structure of matter. This atom was supposed to be the ultimate particle of matter, and stability was believed to be an essential characteristic of all the elements. At the beginning of the present century, the old theory of the indivisible atom, and of the stability of the elements, was upset by the discovery that certain rare elements were disintegrating, and changing, by throwing off particles much smaller than atoms. It must not be assumed that this discovery demolishes the atom. It does not. The atom continues to be the unit that enters into all chemical combinations. The hydrogen atom was formerly the smallest particle known to science. Now the smallest particle known to science is the electron, whose weight is one seventeen hundredth part of the hydrogen atom.

Herbert Spencer said, in substance, that organic progress consists in a change from the homogeneous to the heterogeneous, and this law of progress is the law of all progress. He said, "From the earliest traceable cosmical changes, down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which progress consists." No two elements have atoms of the same size or weight, and each of the different elements has strong individual characteristics. Atoms are therefore heterogeneous, and according to Spencer's law they must have been evolved from a lower stage of matter. Now electrons appear to be absolutely homogeneous, since all electrons are of the same weight or mass, carry the same electric charge, and always turn out to be the same thing, regardless of the metal that forms the negative electrode, or the gas from which they are derived. Hence, according to the Spencerian law, they should be the primal substance from which matter is evolved.

Stability is no longer regarded as an essential characteristic of the elements. The element radium disintegrates by the explosion of its atoms. The primary elements subject to disintegration by atomic explosions are uranium, actinium, and thorium. Radium is derived from uranium in consequence of its throwing off three atoms of helium. Hydrogen (1.008) is the lightest of the elements. Uranium is the heaviest. Its atom is 238.5 times as heavy as hydrogen. The atomic weight of helium is 4. Three atoms of helium would be 12, hence uranium (238.5) — helium (12) = radium (226.5). The atomic weight of radium is 226.4. The small difference is probably due to the loss of electrons during the change. Radium disintegrates by the breaking up of its atoms, each radium atom hurling off one atom of helium, and one of niton. The change is as follows: Radium (226.4) — helium (4) = niton (222.4). Therefore, the atomic weight of niton is 222.4.

The explosion of the atoms of radium appears to be as complete as that of a steam boiler; the whole of the atom bursts into gases. The light atoms of helium, that form, are shot into space with a velocity of more than 10,000 miles a second and the heavy residual atoms of niton acquire sufficient velocity, in consequence of the ejection of the helium, to escape and be deposited on bodies in the neighborhood. The expelled helium atoms are called Alpha rays. There is an inexpensive little instrument, called the Spinthariscope, which is arranged with a minute particle of radium in front of a zinc sulphide screen. On looking into this interesting instrument one can see the helium atoms bombarding the screen, each atom producing a minute scintillation, the hundreds of points of light making the screen sparkle like the stars in the Milky Way. The helium atoms are so minute that the bombardment of the screen could go on for hundreds of years without any sensible diminution of the particle of radium.

Radium also emits powerful Beta rays, which consist of electrons flying out with a velocity of 100,000 miles a second, capable of penetrating thin plates of metal. A third radiation, called Gamma rays, originate in the impact of the Beta rays. They are really X-rays of such strength that shadow-graphs can be made with them through eight inches of solid lead. This radiating power is an automatic property which cannot be produced artificially. Radium is a very heavy metal; heavier than gold, mercury, lead, or any material with which we are familiar. It disintegrates very slowly. Its half period of decay is 1,760 years. If a gramme of radium were put away for 1,760 years, only half a gramme would remain at the end of that time; in 3,500 years one fourth gramme, and in 7,000 years one eighth gramme would remain. The half period of uranium is roughly estimated at seven billion years, while that of thorium, another radio-active element, at ten billion years. An attempt has been made to estimate the age of the earth from these slowly decaying elements.

As already stated the emanation of radium is niton, an inert substance which forms no salts. Niton's half period of decay is only four days, and its emanation is changed to a new type of matter called Radium A. Each second a definite fraction of the number of atoms present break up, and the process of degeneration continues through a number of distinct unstable forms called Radium A, B, C, D, E, F. Radium F is also called Polonium, an intensely radio-active substance with an atomic weight of 210.4. By throwing off one atom of helium its weight changes to a substance with an atomic weight of 206.4, which is close to that of lead, hence it is probable that lead is the final product of the radium series. Twenty-six so-called elements are derived from the automatic breaking up of uranium, thorium and actinium; sixteen of which are formed by throwing off of helium atoms, and are therefore real elements. Ten are formed by the emission of electrons and therefore are allotropes or pseudo-elements. It is by the ejection of full-sized atoms that substances of different chemical properties and valency result. We frequently have our attention drawn to the enormous energy stored in radium and its emanations. Sir William Ramsay states that the heat which niton parts with during its disintegration is equal to 3,500,000 times the energy available by the explosion of an equal volume of detonating gas. The principal part of this energy comes from the expulsion of helium atoms. He also says: "If radium were to evolve its stored-up energy at the same rate that gun-cotton does, we would have an undreamed of explosive, provided always that a sufficient supply of radium were forthcoming," and Sir J. J. Thomson startles us with the statement that the atomic energy stored in an ounce of chlorine, "Is about the amount of work required to keep the 'Mauretania' going at full speed for a week." He further tells us that to split up an atom of one element into different kinds of atoms, would involve enormous transformations of energy, "In fact the explosion of the atoms in a few pounds of material, might be sufficient to shatter a continent."

The electromagnetic unit is an electric current of one ampere flowing for ten seconds. A sixteen candle-power, 110-volt, carbon-filament, electric lamp requires a current of one half ampere. Therefore, such a lamp consumes one electromagnetic unit in 20 seconds. The agitation produced by the crowding together of millions of swiftly passing electrons gives rise to the brilliant light of the filament. The electric energy is so concentrated in the electrons that a mass of them equivalent to a mass of *one ounce* would suffice to light 300 of these lamps to their full candle-power, night and day for a year.

In spite of the minuteness of atoms Rutherford has been able to detect the presence of a single atom of helium. He employed a partially exhausted vessel having a tiny hole, through which, by ingenious apparatus, single atoms of helium were shot. These atoms are expelled from radium with a velocity of more than 10,000 miles a second, striking and breaking up the gaseous molecules in the vessel, producing positively and negatively charged ions, which for an instant permit a current of electricity to pass. A current measuring instrument in the line records the entrance of the atom, enabling the observer to count each one as it enters.

We appear to be getting back to Franklin's single fluid theory of electricity. The electric current is believed to be a movement of negative electrons through a conductor, from the negative to the positive, instead of flowing from the positive to the negative, as was formerly supposed. Many scientists believe that negative electricity is the only kind. Positive electricity arises from a lack of electrons. For example, a positively charged helium atom is merely a helium atom that has temporarily lost two of its electrons. In theory the negative electron is not a particle negatively charged, but is in itself a negative charge. This is equivalent to saying that matter is wholly electrical. The electron enters into the structure of the atom, but is the weight of the atom due entirely to the mass of the electron? It is claimed that the electron has no mass in itself. Its apparent weight is due to the adhering ether which it drags along, as it shoots through space. It is like stirring a bucket of water with a cane, a small quantity of the fluid will temporarily adhere to the cane and be carried along with it.

Nature is more marvelous, more interesting, and more beautiful than anything that the imagination can produce. The great French astronomer and scientist Henri Poincaré tells us that the scientist does not study nature because it is useful. He studies it because it pleases him, and it pleases him because it is beautiful. He says, "Were nature not beautiful, she would not be worth knowing, life would not be worth living. I do not mean here, of course, that beauty which impresses the senses, the beauty of qualities and appearances; not that I despise it—far from it; but that has naught to do with science; I mean that subtler beauty of the harmonious order of the parts which pure intellect appreciates."

It is a mistake to suppose that knowledge of breaking up of atoms into smaller particles originated with the discovery of radium. As far back as 1873 Sir Norman Lockyer suggested that many difficulties of the laboratory would vanish if we conceded that atoms could be broken up into much smaller particles. In 1890 he published "Inorganic Evolution as Studied by Spectral Analysis," in which he says, "Science now has to consider masses much smaller than the atom of hydrogen." In the study of the hottest stars he found himself in the presence of furnaces of transcendental temperature shielded by their vastness from the distracting phenomena which were present in the laboratory.

He classified the fixed stars in the order of their temperatures. Stars of the hottest class he called Argonian from the star Gamma of the constellation of Argo Navis, which has a temperature estimated by him at 50,000 deg. Fahr. Gamma Argus contained a set of spectral lines not before recognized and he concluded that they indicated a new element connected with hydrogen. He called the new element proto-hydrogen, because of the relation of its lines to those of the proto-metallic lines. The Argonian stars are now called helium stars; they shows but few elements. Proto-hydrogen, helium, asterium, and proto-calcium are conspicuous.

Lockyer tells us that the high temperature at which proto-hydrogen appears, is not the end of the simplification of stellar transcendental temperature. "The work of the dissociation of the atom carried on under our eyes in the hottest stars, is quite impossible in our laboratories." He says, "At higher temperatures the chemical units with which we work, at low temperatures, are broken up into smaller masses, explains the spectral phenomena observed, not only in our laboratories, but in the sun and stars." "The final breaking up by heat must be the earliest chemical forms."

Heat is a motion of the atoms of matter, and a fall of temperature slows down this motion, but man's ingenuity has not yet brought a single atom to a state of rest. **The temperature of a body varies as the square**

* From *Popular Astronomy.*

of the amplitude of vibration of its atoms. If all the heat of a body could be abstracted its atoms would cease to vibrate. Increase of heat accelerates atomic motion until a critical velocity is attained that overthrows the affinities which hold the atoms in chemical combinations. At a temperature of 4,000 deg. Fahr. the existence of water is no longer possible, not even in the form of steam. Its molecules no longer cohere, because of their energetic motion, and they dissociate into hydrogen and oxygen gases.

The heat of the sun is probably sufficient to dissociate all chemical combinations, consequently interior solar matter is in its monatomic, or elementary condition, and much of it may be in the electronic state. Perhaps there is a critical, or maximum temperature for all matter, where the violence of the motion of clashing atoms causes them to break up into electrons. In stars of the highest temperature like Gamma Argus, or Zeta Puppis, the critical state has probably been reached and the greater part of their matter is in the form of electrons. When matter is in its hottest state, it is at its lowest point in the scale of evolution, and progress depends on a fall of temperature by radiation. Lockyer's inorganic evolution, joined to the nebular hypothesis, and this to geological and biological evolution, completes the evolutionary cycle of matter to its present terrestrial stage.

We now come to the most interesting, most marvelous mystery of matter. There has been collected a wealth of evidence which proves that the atom is an organized planetary system of dazzling complexity, in which electrons simulate the movements of the planets of our solar system. The negative electrons of the atom swing around the positive nucleus, like planets around the sun. The planet Neptune requires one hundred and sixty-five years for a single revolution around the sun, but it has not made a half revolution since its discovery, while the electrons of the atom complete their revolutions around their central nucleus in a millionth or a billionth of a second. The electrons revolve in a series of concentric orbits all in the same plane. While the larger part of the mass appears to reside in the nucleus, the nucleus is relatively minute, with a diameter of probably less than 1/5,000 of that of an atom. It is thought that the simpler atoms, such as hydrogen, nebulium, and protofluorine, where the electrons are few, all revolve in one ring, but in the heavier and more complex atoms, their orbits lie in three to five, or more rings. The atom is as much a machine as an electric motor and both are electro-magnetic engines.

Nearly the whole mass of the atom resides in the nucleus, but the nucleus is relatively very minute. It is quite impossible to imagine the extreme density of the nuclei. If an oxygen nucleus could be enlarged to a diameter of one inch, its mass would probably be more than 500 tons. If oxygen gas, at atmosphere pressure, could be magnified until the nuclei were each equal to the mass of the sun, we would have the sidereal universe reproduced in which the mean distance between atoms would approximate the mean distance between the fixed stars of the universe. Since the atomic weight of oxygen is sixteen, the atom is supposed to have eight electrons revolving around its nucleus. If we apply the same analogy of magnification to the structure of the oxygen atom, we would have a system of eight satellites in which the relative distances between the revolving electrons and the central nucleus would approximate the distances of the eight planets from the sun. Thus, in oxygen gas, the sidereal universe, with its stars and revolving planets, is reproduced in miniature.

It will be seen that the structure of gases counterfeits on a very small scale, the structure of the great sidereal universe. Since all the forces acting in the nuclear atom are electrical, may not the forces acting in the stellar universe be electrical? Is not the force of universal gravitation electrical? Should not the universality of law lead us to infer that the force of gravitation is an electro-magnetic force?

It will be seen from the preceding description that the form of the atom is that of a flat disk, which probably possesses elasticity. It was formerly supposed that atoms were spheres of infinite hardness, and of course without elasticity. The atom, and in fact all matter, is immersed in a medium called ether, which is continuous, frictionless, and pervades all space. Ether is the universal carrier of the energy of light, heat, electricity and X-rays. Hydrogen has been called the smallest and lightest of the elements, but the sun, stars and nebulas yield still smaller atoms, called protohydrogen, asterium and nebulium. The atoms of these very primitive forms of matter are simpler in their arrangement, and easier to calculate than most terrestrial elements. Working in the dark, the alchemist of the Middle Ages attempted the transmutation of metals, without even knowing the nature of his problem. Science has now unveiled the secret of transmutation, by observing nature's process of changing the heaviest element into a series of different products. The alchemist vainly sought to change mercury into gold. We now know that mercury might be changed into gold, if we could expel from its atoms, one alpha particle, and a beta particle; or if the metal thallium could be made to expel an alpha particle, it would become like atoms of gold. This has not yet been done, but it is possible that it might be done by the application of an electric current of some million volts.

The principal weight of the atom lies in its nucleus, but the nucleus is very small compared with the size of the atom. It contains so-called "sub-atoms" and electrons, in association with positive electricity. The electric charge of the nucleus is therefore overwhelmingly positive. In the breaking up of atoms by radioactivity, the alpha particles (helium atoms) and the beta particles (electrons) are thrown off from the nucleus. In the outer region of the atom there is a sufficient number of negative electrons to balance the central positive charge. It is this outer region that controls the chemical, and much of the physical influence of the atom. It will thus be seen that the radioactive charge is connected with the nucleus, while chemical and electro-chemical properties are controlled by the outer rings of electrons. It is now known that there are relatively few electrons revolving around the nucleus, probably not more than half of the number representing its atomic weight, in which hydrogen is the unit.

The period of revolution around the nucleus, by the electrons, appears to be identical with Kepler's harmonic law of planetary motion, in which electrical force, varying inversely as the square of the distance, takes the place of the force of gravitation. The lightest atom is supposed to have but one revolving electron. This limits the smallness of the atom, because you could not have an atom with no revolving electron. The smallest atom resembles the earth with its one satellite. The heavy atoms have far greater numbers; an atom of mercury would possess a hundred electrons, which is ten times as many satellites as Saturn has.

Lockyer has shown that the younger and hotter stars contain elements fewer in number, and simpler in structure, than the older and cooler stars. In this fact we face the gigantic evolution of matter from the primitive source of the universal ether, to the complexity of terrestrial organic matter. The mighty machinery of the cosmos is immortal in its operation. Ceaseless change is the only constant thing in nature. The complete cycle of change leads matter through all its phases from the simplicity of the hottest star to the complexity of matter in the planets and in our cool earth.

A recent article by O. Lehmann, on the discovery of the formation of liquid crystals, incidentally confirms the theory, that atoms are flat and not spherical. He assumes that the molecules of these crystals are tiny flat plates whose surfaces are perpendicular to the optical axis. He says, "The molecules easily glide over one another in a direction parallel to their flat surfaces," and concludes that the crystals are combinations of plate-like molecules. Since molecules are small groups of atoms, and some molecules consist of single atoms, it follows that disk-shaped atoms would lend themselves to the formation of flat molecules.

It is probable that the atom is elastic; not perhaps by the pressure that could be secured artificially in the laboratory, but by the gigantic gravitational pressure of the interior of the planets and stars. The earth's interior is so hot that if its pressure were released it would explode into gases of very high temperature. The pressure of gravitation near the earth's center amounts to millions of pounds to the square inch, and there matter is reduced to the density of platinum. Under this force liquids yield like a sponge. Owing to the enormous pressure that gravitation imposes on the earth it is compacted into a dense mass as rigid as that of a ball made from nickel steel armor plate.

We now appear to be on the verge of further discoveries in the nature of matter which may lead to a knowledge of the mysterious, unknown, ether. All intelligent people are interested in new information regarding the swift electrons, that light our cities, propel our street cars, operate factories, transmit speech, carry wireless messages and serve man in hundreds of ways. A host of eminent scientists have framed a science of radio-activity which has changed the entire theory of matter, involving conceptions that are difficult to explain to those who have not specialized in physical science. Even the accomplished physicist, Sir William Crookes says that the conceptions of atomic physics are often hard to understand. We are unfortunately lacking in gifted interpreters of physical science, such as the nineteenth century furnished. Darwin, Huxley, Spencer, and Tyndall could clearly explain to the unitiated, in simple words, the most intricate scientific discoveries of their period.

The Distortion of Iron Casting

An iron casting cooled in the mold usually—not always—comes out practically true to pattern, and left in the state in which it leaves the mold it will not alter much in form. If partially planed or if subjected to heat, alterations in form will almost inevitably occur; in the first case, owing to the release of casting stresses, and, in the second, through the "growth" of the metal. In both cases inconvenience is caused and there is no easily applied remedy. Such remedies as are known to be reasonably effective should, however, be applied in the necessary cases.

Where casting stresses have to be counteracted, the castings should be made red-hot for some hours, and then gradually cooled. The heating to the critical point (about 750 deg. Cent.) which varies somewhat with different grades of iron, and the cooling afterward must be done slowly and without exposure to the air, while the full heat should be kept up for from two to ten hours, according to the bulk of the metal. This treatment will usually be sufficient where castings have not necessarily to remain dead true, but where absolute truth of outline has to be maintained, other methods are necessary, whether or not the heat treatment has been given. To secure permanency of outline, the castings must be planed all over, a cut of not less than ⅛ inch being taken, and then laid aside for at least three months, when the final roughing machining can be done. Before finishing, however, another three months must elapse, and then the articles will probably not alter in shape unless heavy or deep cuts be made. It is safer, in very important work, to give another month's rest, and again test for distortion, if absolute precision is necessary. The release of casting stress occupies a long period, and as the alloy known as cast iron often varies greatly in content, the stresses do not at all times disappear so rapidly as might be expected, or in any uniform period.

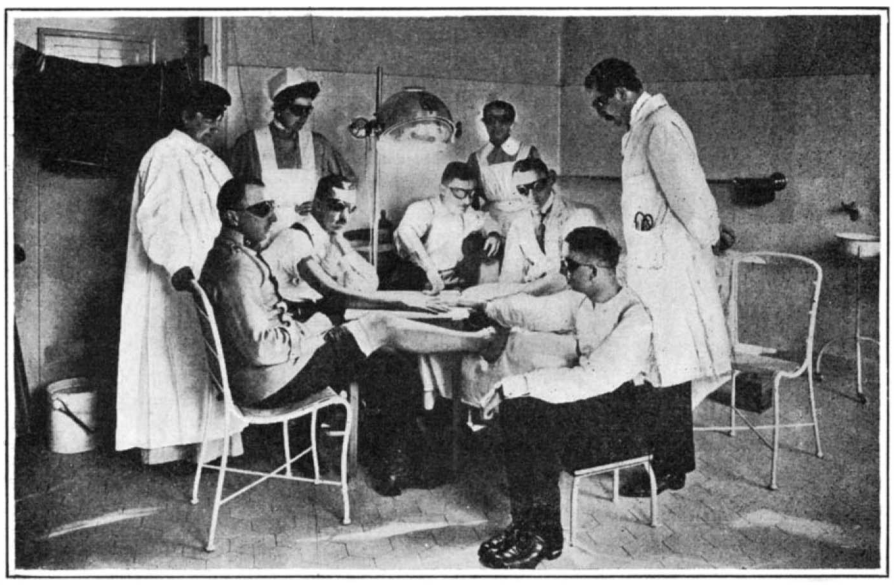
Where the distortion is caused by the growth of the iron in bulk (owing to chemical changes chiefly), heat will be found to be the cause of the distortion, and this will be seen in fire-bars, the sides of domestic stoves and ovens and in mechanical parts subject to heating to a high temperature, intermittent heating and cooling probably producing the worst effects. To get over this trouble as far as is possible, plates should be cast with thin gills at fairly close intervals, and in use a plentiful supply of air should pass over the gilled sides to remove heat as rapidly as possible. In many cases the actual fire can also be kept from actual contact with the plates by fire-clay linings, which do not actually touch the iron, and where this is possible there is seldom any local heating sufficient to cause the iron to grow appreciably or to become seriously distorted.

With fire-bars the growth is usually caused by having thick and shallow bars widely spaced, these absorbing and holding heat very largely. Also by using fuel containing a lot of dirt which fuses into clinker, the heat of the fused mass closely approaching the melting point of iron. To get over this trouble, the better plan is to use deep, thin bars, which will part with the heat freely, and have them somewhat narrowly spaced to more evenly spread the air through the fuel and so avoid local heating in parts of the furnace. This not only prolongs the working life of the fire-bars, but it also leads to economy in fuel, as, there being less clinker to remove, the fire has not to be pulled about so much. Obviously, the cleaner the fuel the better it is for both the fire-bars and the obtaining of economy in the generation of steam.

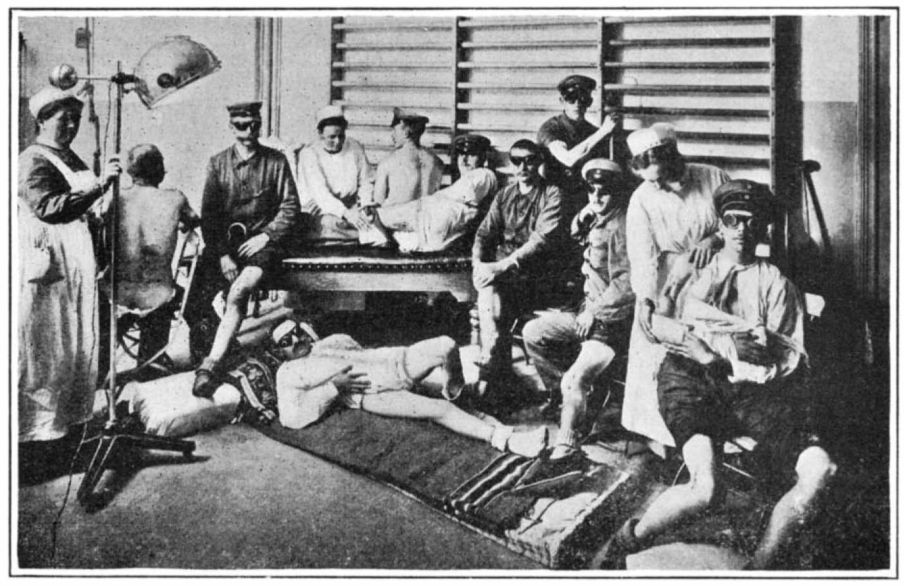
Of course, it is presupposed that grades of iron suited for the work to be done are being used, as otherwise the best results would not be obtained. It is always best to allow the foundry to deal with this point, unless the engineer knows the actual content of the metals or alloys be uses. With some irons it is possible to get quite 100 per cent increase in bulk by repeated heating and cooling, while with others a bulk increase of 25 per cent would be the limit. For this reason it is always better to use a good make of fire-bar and leave it to the maker as to what is the content of the iron he uses. It is quite certain that the analysis of a burnt fire-bar will not show what the original content was, nor will it indicate the grades of iron originally placed in the cupola.—*W. J. May, in the Practical Engineer.*

Golden-Rod

Most people are familiar with golden-rod, the unpretentious but attractive flower that is so common in waste places along the road, but it will be a surprise to many to learn that there are twenty-five or more varieties of the species to be found in New England. These vary in height from a few inches to 5 or 6 feet, and some of these would not be recognized as belonging to the species except by a botanist.



Under the ultra-violet rays in the "Landesbad," Baden-Baden.



Treatment with artificial mountain sun by means of a quartz lamp.

Modern Science and War Surgery

Artificial Sun Baths and Electric Heating of the Body

DURING the present war, when thousands upon thousands of brave soldiers are received in field hospitals, nothing is, of course, left untried in order to re-establish them as promptly as possible, so that they may, if feasible, return to the front at the earliest possible moment. Modern science is therefore resorted to and expected to press into service all its valuable achievements. Even the most recent discoveries and inventions, those not yet adopted by ordinary medical practice, are made use of and are doing excellent work. Some typical instances are discussed in the following:

Just a few words on Artificial Sun Baths to begin with. There is hardly any curative agent that has had so prominent a part in the history of medicine as sunlight. Man at all times instinctively sought recovery from his ailments on mountain tops, where the beams of the sun are allowed to act more freely than down below; common experience shows man, animals and plants to languish in the thick atmosphere of cities, impenetrable to sunlight. Modern medicine therefore counts sun baths and mountain cures among its most efficient curative agents. Dr. Rollier, of Leysin, for instance, has long treated tuberculosis, especially of the bones, by exposure to sunlight at high altitudes, the result being that even the most emaciated and sickly patients would, after a relatively short treatment, be converted into healthy individuals, endowed with a powerful frame and fully capable of enjoying life and yielding useful work. Dr. Bernhard, of St. Moritz, obtains the most striking results in the case of infected wounds, superficial tumors, extensive wounds produced by contusion, explosion, freezing, combustion, purulent inflammations of the bones, etc., exposed to the beneficial action of sunshine.

What benefit could be derived of a similar treatment if only sunlight were always within easy reach of the military surgeon! Sunlight, of course, is not always available, but what there is valuable in it can at any time and any place be produced artificially.

In fact, the lamp designed on plans by Dr. Hugo Bach, of Elster, Germany, by the Quartz Lamp Company, Ltd., of Hanau-on-Main, gives out in abundance the chemically—and medically—effective rays of the spectrum, those rays which are absorbed by the lowland atmosphere, and most of all by the atmosphere of large cities. In an evacuated quartz tube an electric arc of peculiar bluish-green color passes between two small mercury vessels. Inasmuch as its light has no warmth, this lamp is combined with a wreath of small glow lamps.

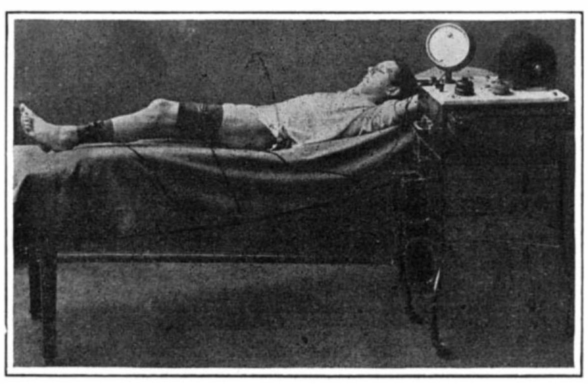
Comprehensive tests have been made with this lamp ("Artificial Mountain Sun," as it is termed by its inventor) in German military hospitals, the results being so encouraging that artificial sun baths are now employed in a great number of field hospitals, both in Germany and Austria-Hungary. The beams from the lamp act absolutely like sunshine, to the extent that even sunburn is produced, an unmistakable symptom, by the way, of a successful cure.

Even the most serious and extensive wounds, when exposed to the Artificial Mountain Sun, will heal much more rapidly and safely than otherwise; wound fever is counteracted efficiently, and gangrenous, fetid wounds soon become inodorous. Extensive wounds due to contusion, freezing or burning, as well as purulent inflammations of the bones, lend themselves especially for this treatment. Some success is already noted after the second or third application.

Exposure to the Artificial Mountain Sun produces a particular well-being, accompanied by a fall in the temperature of the blood and rapid recovery of bodily strength. Moreover, the wound is disinfected automatically. Excellent results have also been obtained in connection with tetanus, and intensive sun baths of the whole body have been resorted to as an efficient cure in cases of general exhaustion.

However, electricity supplies not only light, but heat, and this results in a number of other applications of great value to military hospitals. One of our pictures shows how electrically heated fabrics—networks of fine metal wire heated by the passage of an electric current—are used in the place of hot compresses, thermophores, etc., which affords a number of advantages.

Incomparably stronger effects are obtained by using, in the place of ordinary electric currents, high-tension alternate currents, changing direction with extraordinary rapidity, say, one million times per second. On account of this rapid change in direction these currents are unable to exert their ordinary physiological effects—the well-known prickling and uncomfortable feeling—while their heat effects are all the more marked. In fact, the heating of the tissues produced by them could well be likened to an artificial fever, and the same as fever, the spontaneous reaction of the body against any morbid agent assists in expelling the latter; this internal heating greatly facilitates the healing process.



Curing wounded by applying electric heat.

Treating frozen feet by electricity.

This method—*diathermy*, as it is termed in medical language—is, in German military hospitals, used, e. g., in treating stiffness of the joints; it allays the pain and restores the limbs much more quickly than without its aid to their normal mobility. In the after-treatment of fracture, possibly in conjunction with gymnastic exercise, it has been found to render good services.

Among other affections lending themselves for this treatment should be mentioned rheumatism and traumatic lesions of the muscles, sciatica, neuralgia, etc. Excellent results have also been obtained in cases of heart disease, lung disease and general exhaustion.

In the Siemensstadt Military Hospital, from which our pictures were derived, frozen limbs and other "trench diseases" are likewise treated by the new method.

Latent Heat of Fusion of Ice

IN an investigation by the Bureau of Standards at Washington the heat of fusion of 92 samples of ice from various sources was determined by two methods.

The result of these determinations indicates that for commercial can ice, commercial plate ice, natural ice, ice frozen in the laboratory from air-free double-distilled water and from double-distilled water containing air, all of which were very pure, as indicated by electrical conductivity tests, the heat of fusion is the same to within the limits of accuracy of the earlier determinations, i. e., about one part in one thousand. Further experiments on the three commercial forms of ice fail to show differences greater than about one part in five thousand.

Five observations on ice contaminated with a mixture of ammonia, sodium chloride, and calcium chloride to the extent of about one part in one thousand give results about 1.4 per cent lower than for pure ice.

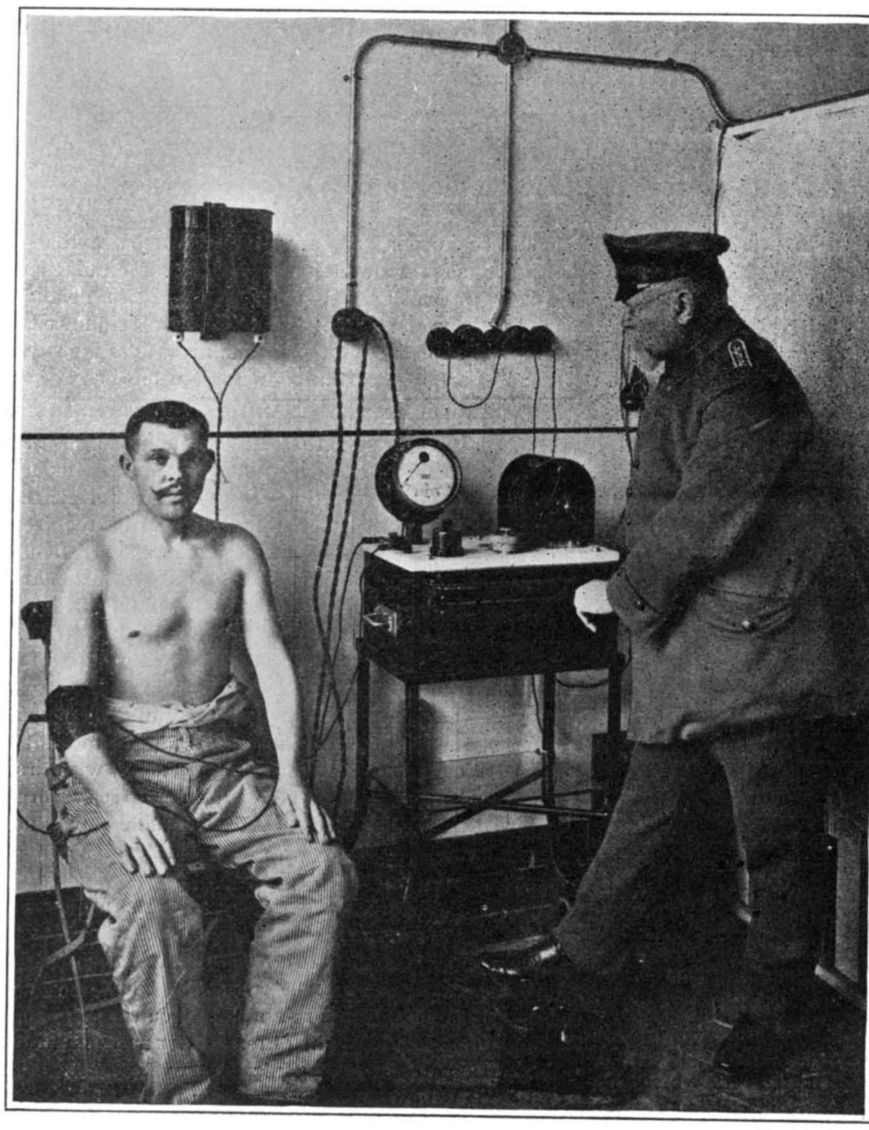
The mean of the final 21 determinations on samples of plate, can, and natural ice give for the heat of fusion:

79.63 cal_{15} per gramme mass,
or 143.3_3 Btu per pound mass,

or 143.5 Btu per pound weighed in air against brass or iron weights.

Stellite

THE alloy known as stellite, which has been found useful for many purposes, is composed of cobalt and chromium, and if tungsten or molybdenum is added, or both, a very hard material results that is capable of scratching any steel. Tools for machining iron and steel made from this material will maintain their edge at cutting speeds and temperatures that would ruin any known tools containing a notable proportion of iron.



Treating the wounded by application of electric heat.

Engineering Education Faults*

ENGINEERS feel that they are not receiving the recognition they deserve. Engineering as a profession apparently does not stand as high in the eyes of the public as do the law and medical professions. Public affairs are in the hands of lawyers, doctors and business men. Commissions, even when called upon to consider questions involving engineering problems, are seldom controlled by engineers.

Although engineers may feel that they are not getting a square deal, as evidenced by the discussions in the engineering periodicals, it is well to remember that men are appointed to commissions, not because they are doctors, lawyers, business men or engineers, but because they have seen the need of society for this thing for which the commission stands, because they are men of ability and reputation and are willing to sacrifice their time and money for the public welfare, qualities which are essential in one who would serve on a public commission.

ARE ENGINEERS AT FAULT?

In view of this fact, does it not seem that the fault may be with the engineer rather than with the public or the ones in power? Since engineering education, as distinguished from other kinds of education, has been in vogue about half a century, if engineers are failing to meet the standards of a learned profession, may not the fault be in their professional training?

Engineering has been defined as the utilization of the resources of nature for the benefit of mankind. In considering the education of an engineer it is this comprehensive view of his work which the writer has in mind rather than the more popular view that an engineer is a person who surveys a railroad, designs a generator, runs an engine or does any other one thing which requires a highly specialized technical training. It is the failure to understand the function of an engineer that is responsible for so many poorly planned courses of study in our schools and that is also responsible for men being classified as poorly paid engineers who are really well-paid mechanics.

University courses of study have changed rapidly. During the early part of the last century they included only the study of pure science, philosophy and literature. About the middle of the century a few schools introduced courses in applied sciences. These met with but little encouragement at first, but finally grew in popularity, until near the close of the century a huge wave of popular engineering education flooded the country.

Though this, on the whole, was a good thing, it carried with it some undesirable features. Chief among these was an irresistible demand for what were spoken of with pride as practical courses. It seemed to be the prevailing opinion that in some mysterious manner a student could attain a greater proficiency in certain highly specialized mechanical processes after a few hours' practice each week for a few months than a mechanic could acquire working day after day for years.

Although trade-school training is recognized as valuable to a man who expects to spend his life as a mechanic the better engineering schools soon realized that such work could not take the place of scientific training for the man who expected to be, not a technical expert, but an engineer in the broader sense of the word. Manual training has therefore lost its standing as a part of a university course of study, and though shop work is still given in most first-class engineering schools, it is used more to illustrate the principles of scientific shop management than to train expert mechanics.

OVER-SPECIALIZATION A MENACE.

Although the danger from over-emphasis of manual training has been largely done away with, the engineering schools of to-day are facing in over-specialization an even more serious menace. All engineering work was originally classed as either military or civil engineering. Civil engineering was later divided into four major divisions known as civil, mechanical, electrical and mining engineering. At the present time some of our schools, at least, are apparently vying with one another in their endeavor to subdivide each of these major divisions into the largest number of attractively named subdivisions. Some of the schools frankly admit that this is done for advertising purposes. Manufacturers, however, recognize that any advertising scheme that injures the product is poor business policy.

Schools which recognize the folly of trying to train expert mechanics are, nevertheless, now trying to do for office work what a few years ago they tried to do for shop work. A man who does the technical work in a specialized line of engineering uses certain scientific facts over and over, day after day, and becomes expert at his particular process just as a mechanic does. In a sense he is a mechanic. Although a higher order of mentality is required, it is a difference in degree rather than in kind. Given sufficient training, it is something that almost anyone can do. It would seem, therefore, as illogical for universities to train expert draftsmen and calculators as it is admitted to be for them to train expert mechanics.

It is true that special training in college will help a draftsman or a calculator just as a trade school will help a mechanic. But although special training is helpful, a greater benefit can be obtained by devoting to other things the time required for training in a specialized line.

All the sciences have developed rapidly during the evolution in education. The pure sciences on which our engineering work is based have increased in scope many times in the last half century. The principles of economics which play such an important part in engineering in its broader sense are just beginning to be understood. Practically all successful engineers in addressing young men emphasize the value of expertness in self-expression, but practically none dwell upon the necessity for technical training. With all of the wealth of knowledge useful in all human activities that is available it would seem to be the height of folly to spend any part of a student's time on a special line of work. The routine duties of specialized industries can best be learned in commercial life. But if science and literature are neglected in college they are not likely to be courted in after life in a busy world.

HOW TO PRODUCE BROAD-MINDED MEN.

If after half a century of engineering education the most severe and insistent criticism of our engineers is narrowness, then the training of engineers should be changed so as to produce broader-minded men. If our engineers can build good railroads, but fall short of the highest success because they fail to see the relation between a railroad and the development of a new territory, then let us teach less of bridge design and railroad surveying and more of economics. If our engineers can design and construct an efficient sewer system, but cannot induce a community to install it, then let us teach less of sewer systems and more of sociology. If our engineers are intensely interested in equipment for factories, but are indifferent to the happiness of their families and the health of their employees, then let us teach less of machine design and more literature, philosophy and sociology. A man cannot lightly claim membership in a learned profession if he cannot see beyond the technique of his work.

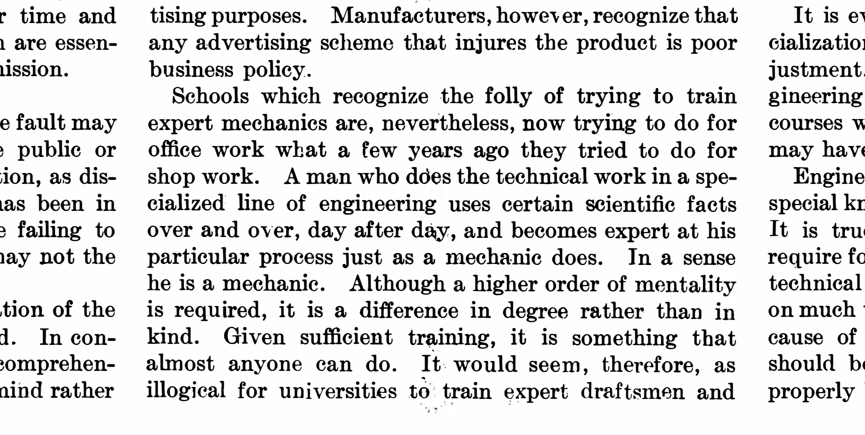
The argument that a specialized course fits one for his lifework does not hold. In most cases boys do not know what line of work they want to follow. The selection of a university course is often based upon a mere whim, and seldom is the choice made on a basis of solid facts and sound reasoning. A special course is as likely to cause a student to persist in a line of work for which he is not fitted as it is to fit him specially for his career.

Some men may be so fortunate as to be able to pick their job upon graduation, but more often the line of work one enters is determined by the kind of job he can get. Nearly all men have to shift a few times before they find the line of work for which they are best suited. There is a striking illustration of this fact at the University of Illinois. Of six men in the Civil Engineering Department having professorial rank, only two have taken a course in civil engineering.

It is evident that all advantage to be gained by specialization in an undergraduate course is lost in this adjustment. Moveover, observations show that where engineering graduates and graduates of science or literary courses work together, any advantage which the former may have immediately upon graduation is soon lost.

Engineering covers a broad field and requires, not a special knowledge, but a broad view and sound judgment. It is true that many parts of an engineering project require for their execution men having highly specialized technical training. But all of these processes are based on much the same fundamental scientific principles. Because of their universal applicability, these principles should be known by all engineers and therefore may properly be a part of a university course. Each of the highly specialized processes, on the other hand, is used by comparatively few, and can best be learned by daily repetition in commercial work. Training in these processes should therefore form no part of a university course. An engineer in the broader sense is a man who can conceive a project, have it financed and then organize an army of workmen to carry it out. One of these three functions is as important as another. The graduate who will develop into this type of man is what our engineering schools should produce. He is more likely to be produced by a broad training in science, art and literature than by a narrow specialized training in technical subjects.

A school should be interested in the career of its alumni fifteen or twenty years after graduation rather than in a meteoric success during the first year or two. This fact is becoming more and more realized; eventually it will predominate.



The Tatterman bath at the "Landesbad," Baden-Baden.

*By W. M. Wilson, Assistant Professor of Structural Engineerng, University of Illinois, Urbana, Ill., in *Engineering News*.

Co-Operation in Foreign Trade*

Existing Commercial Conditions, and Problems That Confront the American Exporter

By Hon. Joseph E. Davies, Chairman of the Federal Trade Commission

EPOCHAL opportunity confronts American business today in foreign trade. Conditions have never been so favorable to trade expansion on a permanent basis. It is probable that never again will so propitious an opportunity knock at the door of American enterprise.

Questions concerning the value of foreign trade and problems of its development have recently, therefore, become emphasized in the public mind. The analysis of our own economic conditions which world events have precipitated has brought to us the realization that the economic character of our national life has changed. We are no longer an agricultural country of undeveloped resources alone, but have become one of the great industrial and financial nations of the world, and have become subject to the trade and industrial fluctuations which such conditions breed. In addition to the contribution to national wealth which foreign trade brings, its substantial value has become recognized because of the stabilizing influence it has upon production as a back log for industrial energy. The desirability of foreign trade has become a large factor in national outlook.

GENERAL PROBLEMS OF FOREIGN TRADE.

The problems connected with the development of foreign trade are manifest. The goods must be produced. They must be carried in ships to foreign countries. Banking and credit facilities must be provided. Markets must sometimes be created, and international competition must be met.

That portion of the problem which has to do with competitive conditions is peculiarly germane to the functions of the Federal Trade Commission; and it was because of its judgment that no more opportune time than the present could be had to exercise the power conferred upon it by Congress in respect thereto, that it has been engaged upon an investigation for the last several months of conditions in foreign trade, and the competitive conditions in international markets which will have to be met in the successful projection of American trade abroad. It was for this reason, I presume, that you have asked me to discuss upon this occasion the question of "Co-operation in Foreign Trade."

PROBLEMS DISCLOSED BY ANALYSIS OF CONDITIONS.

Any consideration of the problem of co-operation in foreign trade must be based upon an analysis and correct understanding of the conditions affecting our foreign exports; their character, the condition of their marketing, and the character of foreign competition they are required to meet.

Our exports consist of two general classes. Two thirds of the total is made up, approximately, of foodstuffs and materials to be used in manufacture abroad. The remaining one third is made up of manufactured articles.

CONDITIONS WITH REFERENCE TO EXPORT OF RAW MATERIALS.

The first class of exports—the raw materials, foodstuffs and the like—presents, so far as developing a market is concerned, little or no need for co-operative effort. The market is there. The goods sell themselves. If there were need, the foreigner would come and extract the goods from the earth, for his necessities require that he have them to live and to translate his labor into value. In this situation the problem is rather that of conserving our natural resources. Investigation discloses that American sellers of lumber in Australia and elsewhere, that in some instances American sellers of coal, minerals and metals in foreign markets, are forced into the severest competition with each other at the hands of a combination of buyers who thus secure the lowest possible prices. There is reason to believe that, in consequence, our raw resources are frequently sold abroad at lower prices than at home, and not merely at no profit, but at a loss. This economic waste in raw resources accrues, under such conditions, not to the benefit and advantage of consumers in this country (wherein some possible justification might be alleged), but to the benefit and advantage of consumers abroad. The requirements of an intelligent and provident people would certainly seem to demand that some system should be devised to prevent this economic waste and preference of the foreign consumer, and at the same time a method that would protect the domestic market and the domestic consumer, consistently and fully, from any ill effects that might possibly arise as a result of such system.

CONDITIONS AFFECTING EXPORT OF MANUFACTURES.

The remaining one third of our exports are manufactured articles, and consist generally of two classes—specialties and staples. These do not sell themselves. A demand must be created, and foreign competition must be met. In specialties the demand is largely created and the competition met through the popular character of the product. In staples, which constitute the large bulk of international trade in manufactured goods, the condition differs. The development of the demand is difficult, and the competition to be met most severe. The demand for co-operation comes especially from the manufacturer of staples.

ANALYSIS OF THE DEMAND FOR CO-OPERATION.

Inquiries have been addressed to business concerns of all classes in the United States, and the replies indicate some interesting facts in connection with this subject. Relatively few of the larger organizations of the country manifest a desire to enter into extensive co-operation in foreign trade. They do not seem to feel the need of co-operative effort because of their ability and capacity to project their own enterprises. In that connection it may be said, with some reservation, that a very substantial part of our foreign trade has been developed through large organizations of this character. This development of our foreign trade is characterized by the fact that the ownership and management of plants reside in a single corporation, and is in distinct contrast to the manner in which the foreign trade of some European countries has been developed, where similar results have been obtained through the syndicated relations of smaller manufacturers who retain the individual ownership and individual control of their respective plants. This form of organization is peculiar to some of the selling cartels of Germany, as well as to some of the comptoirs of France.

The demand for co-operative action in foreign trade comes largely, our investigations disclose, from the smaller concerns engaged in the production of staple manufactured articles. They see through this agency a means of securing business which otherwise their size, or lack of size, prevents them from obtaining. Some reasons alleged are as follows:

"The selling cost on our goods, if handled alone, would consume all the profit."

"We are too small to do it alone."

"It would be a better medium of presenting my product to a foreign market at less expense."

And these are fairly typical.

A *résumé* of the general reasons advanced would seem to be that in many lines of manufacture it is impossible for a small man to engage directly in foreign enterprise; that cost is prohibitive; that risk is too great; that warehousing and credit facilities are individually impossible; that co-operative effort would enable such manufacturers to procure markets otherwise unavailable, and would enable other small producers to extend and increase foreign trade which they now have. Moreover, in some degree, concerted action would serve to protect them against combinations of foreign buyers.

THE SMALL MANUFACTURER AND STABILIZATION IN INDUSTRY.

To the extent that foreign trade serves a tendency to equalize production and to sustain industrial organization during periods of local stress, it is obvious that its advantage accrues most advantageously to smaller manufacturers. Large aggregations of capital engaged in foreign markets, it is apparent, have relatively less need for such a factor in production, for they have both organizations to sustain and reserves to finance them during periods of depression. In periods of domestic stress stabilization is most needed, both in the interest of the employer and the employee, in the zone of smaller manufacturers and producers. They are less able to withstand periods of lessened demand and are the first to feel the stringency.

EXTENT OF THE DEMAND AND THE PROTECTION OF PUBLIC INTEREST.

Eighty-five per cent of the thousands of replies that we have received from the business men of the United States disclose a demand for permission to co-operate in foreign trade. It is of serious and great interest to note that a very substantial part of these who declare that such co-operation should not only be permitted, but should be encouraged, are equally emphatic that this situation should develop under Federal regulation, so as to assure not only that the domestic market and the domestic consumer shall not thereby be prejudiced, but also that all American manufacturers shall have fair play and equal opportunity in foreign business.

FOREIGN COMPETITION IN INTERNATIONAL MARKETS.

Equally important with domestic considerations in connection with foreign trade—perhaps even more important to its successful projection—is the kind and character of competition that American trade will be required to meet in foreign fields. These conditions, which our investigations disclose existed in the world's markets prior to the war, will undoubtedly be intensified in the foreign trade of the future. Typical illustrations of the effectiveness and comprehensive character of foreign methods might be illuminating.

A combination of non-competing manufacturing plants of Great Britain, for instance, are equipped to establish, and have established, joint selling agencies, with branch offices and warehouses, and with such effective organizations that they are equipped to handle any kind of service within their lines, from the sale of a handsaw to the building of a railroad.

Much of the Oriental business of Germany is alleged to have been acquired through so-called "rings," which include representatives of every kind of industry whose goods or services might be required. The markets are scientifically studied and assiduously cultivated. In one of these rings forty-eight different German manufacturers participated. Its organization with the local bank and home bank connections was complete. It had within its organization facilities for selling to a Chinaman a five-cent file, or for planning, financing and completing the industrial development of an entire province, opening harbors, building railways and telegraph lines, sinking mines, erecting factories, installing light and power plants, and even to clothing the people and marketing of their products.

But still more significant than these isolated instances are the suggestive activities which a survey of international commerce will disclose. Some of these facts are, briefly, these:

Prior to the war, in Germany approximately six hundred cartels or manufacturing and selling syndicates, of a high degree of integration in industry and capacity, were projecting their activities into foreign markets. It is generally recognized that at the same time there were approximately one hundred and thirty international cartels of a similar character; and it may occasion surprise to know that the control of a smelting and refining plant in Colorado was owned by such a little known international organization.

At the University of Kiel there has existed, and does now exist, an institute for the study of world trade, subsidized by the Imperial Government of Germany, and organized with a corps of highly trained economists.

In Turkey during the last several years a German trade paper has been published daily in both French and German.

The Imperial Government of Japan has projected its enterprise into foreign countries, with its government monopolies of salt, camphor and tobacco.

In Chosen, which is the new name for Korea, it is significant that there has been established an institute for the development of native Japanese chemical and industrial engineers. It is generally recognized that exporting and marketing Japanese firms threaten the complete domination of the Chinese trade.

These manifestations of activity in Europe and in the Orient are indicative of the kind and character of competition that will be met in foreign trade in the future.

Subsequent to the war these conditions will be emphasized, and activities will be intensified by the spur of economic necessity in some of the nations of Europe.

Under conditions such as these the embarkation of American enterprise into foreign trade and the maintenance of its rightful place there will require the strongest initiative and the highest order of business intelligence.

COMBINATION IN FOREIGN TRADE AND THE LAW.

There is much misapprehension as to the application of the anti-trust laws to foreign commerce. Of course, as a matter of fact, there is no greater restriction upon American business in the foreign fields than the law imposes as to domestic. Nor does the law forbid co-operation in either domestic or foreign commerce ex-

* An address before the National Foreign Trade Council at New Orleans, La., Friday, January 28th, 1916.

cept where it amounts to a restraint of trade or a monopoly or a tendency to create a monopoly. The census taken by the Federal Trade Commission, directed to a very large number of business men of all classes, discloses that the great body of opinion in such circles is that co-operative effort in export trade is prohibited by the law. Our investigation discloses that more than half of the men who answered our inquiry stated it as their understanding of the law that co-operative enterprise in export trade is prohibited even as to non-competing articles—a situation where ordinarily there would be no competition to be restrained. It is a fair statement of the fact that our investigations disclose that doubt as to the legality of such enterprise in the foreign fields amounted in many instances to a prohibition of any action in the foreign market. This belief is undoubtedly one of the factors in the situation which hinder the development of foreign trade at this time.

It is the opinion of the Federal Trade Commission that enterprise in foreign trade should not be impeded by conditions of this kind. In the absence of injury to any American interest a greater degree of co-operation in export trade than is allowed in domestic trade may be beneficial to the country. If this is not now permitted by law, new legislation to that end, properly safeguarding the public interest, should be enacted.

BASIC PRINCIPLES.

This position is in entire consonance with the public policy of this nation with reference to government's relation to industry. Competitive conditions in foreign markets are assured by the international conflict of interests. Opportunity is afforded, through co-operative effort in this field, to those who otherwise, by reason of their limitation in size, would be denied such opportunity.

The objection which is urged with greatest force against co-operation for foreign business is that the combinations effected for export trade may be used to oppress competitors here at home and to exploit consumers in the home market. There is plainly a serious danger here, and it must be met frankly and guarded against effectually. But abuses of this kind, and the possible abuse of an extension of a monopolistic condition into the foreign field to the disadvantage of the smaller manufacturer in such activity, can be prevented, we believe, by Federal regulation. Other nations having policies similar to ours have found it possible within the law, and it is equally possible for us. It is not consonant with the spirit of our people to fail to grasp a great opportunity because of possibilities of evil which can be guarded against and prevented.

DANGER TO FOREIGN TRADE NOT FROM LAW, BUT FROM CONDITIONS WITHIN BUSINESS ITSELF.

The danger which is most imminent to the development of our foreign trade at this moment does not lie within any limitation of law. It comes from business itself and the imminence of unprecedented domestic prosperity, The conquest of the foreign market is a slow, laborious and painstaking project. The convenience of the home market, its greater demand, and the large profits of great domestic prosperity may seriously impede the development of the foreign field. The remedy for that condition lies solely with the good judgment, the farsightedness, and the longheadedness of American business, which will place the wisdom of building upon a strong, secure foundation before large profits and temporary prosperity.

FUNDAMENTAL PRINCIPLES OF FOREIGN TRADE.

The same considerations of fairness which we demand in domestic conditions should be preserved in foreign fields. Co-operation in foreign trade does not contemplate doing that abroad which we hold to be improper if done here to us. If the process of unfair dumping, or selling for the purpose of destroying competition in this country at a price substantially below the fair price in the country of production, is wrong, and if it should be prohibited by law, the same principle applies when the shoe is on the other foot and trade is being projected by us into foreign fields.

THE UNITED STATES AND FAIR PRINCIPLES OF TRADE.

At no time in our history has it been more incumbent upon us as a people to project into our relations with other nations, whether it be in trade or otherwise, those principles of fairness, justice and law upon which civilization is supposed to be based. Civilization is today withstanding the shock of internal assault, if civilization means the development of men and peoples to the highest point of efficiency through peaceful methods. There is a conflict between two concepts of civilization. The tendency of warring nations is to substitute force for the rule of justice. Victorious Germany demands that it shall be self-sufficient as an economic unit from Belgium to Bagdad. Runciman declares that victory to the Allies must mean destruction of Germany's economic efficiency and dominance in foreign trade. To the west, an Oriental nationalism proclaims the same doctrine. Such attitudes are predicated upon the power of force, and are a denial of the application of those fundamental conceptions of natural development of trade controlled and directed by large conceptions of what constitutes equity and justice, upon which civilization has been founded. Economic self-sufficiency has been generally held to exist for people, when within the sphere of their dominion all the products of the zones, from the Arctic to the Torrid, are available for their uses, and "Southward—not westward" has been proclaimed to be the course of empire.

In the Western Hemisphere alone there seems to be that combination of economic self-sufficiency which diversity of geographical position gives, with the coincidence of and belief in the principles of justice and law was a governing force between independent nations seeking to serve men under common ideals of government, and under a common belief that the rule of justice and law will obtain, as the ruling force of civilization, long after the warring nations have passed from memory.

The European war has accentuated the trade of the Americas. In contrast to the self-sufficient nationalism of the East and the West that seeks to impose its will by force, we have here an internationalism economically self-sufficient, protected by two oceans, and consisting of nations who still hold that justice and rules of fair dealing enforced by law of their own making shall serve to sustain and proclaim a Christian civilization.

Herein may lie the destiny of the Americas in the development of civilization.

Emulsions and Emulsification

EMULSIONS do not usually concern the engineer very much, though he has a troublesome emulsion of oil and water to deal with in the condenser water. Scientifically they are of the highest importance. When fine particles of a solid are suspended in a liquid, physicists speak of a suspension; when the particles are themselves liquid, they speak of an emulsion; and when the particles are very fine, they are described as colloidal. Whether we are to imagine the ultimate particles of colloids as solid or as fluid is as difficult as to say whether or not the ultimate particles of gases—those particles which produce the kinetic gas pressure—are to be regarded as solid.

Discoursing upon "Emulsions and Emulsification" at the Royal Institution, Professor F. G. Donnan, F.R.S., Sir W. Ramsay's successor at University College, W.C., emphasized especially the biological and physiological importance of the phenomena, which, he pointed out, should be studied by cooks. He defined an emulsion as a distribution of one liquid in another. A little oil shaken with much water gave an emulsion in which the oil particles had a dameter of about a thousandth of a millimetre; in an emulsion of a little water with much oil, the water particles were smaller; the former emulsion was of the milk type, the latter of the butter type; to demonstrate their different appearances, the water or oil was stained with some dye, Good emulsions, the lecturer said, were very stable and settled very slowly; the oil emulsion would turn creamy and the particles might conglomerate; they would not coalesce under ordinary conditions, however. The chief factor preventing their coalescing was that all small particles carried electric charges. That could be shown by placing the emulsion in an electric field, in which the particles would migrate to the one or the other pole, according to their charges, or by neutralizing the charges. Thus an oil emulsion settled like the fog of magnesium oxide (produced by burning magnesium wire) settled under a glass bell when electrodes were immersed into the fog or the emulsion, and an emulsion could also be made to coalesce by adding solutions of acids, alkalies and salts to them. In the latter case, the ions neutralized the charges on the particles, and it had been found that the positive ions of elements of high valency (in aluminium or thorium chloride, *e.g.*) were particularly powerful in coalescing oil emulsions, the particles of which generally had a negative charge. By charge was understood the inner charge, the drops being assumed to be covered with an electric double layer, after Helmholtz. The charges were of the order of about 0.05 volt. The particles of some dyes carried a positive charge, and when such an emulsion was mixed with an emulsion of oil or gum mastic (negative charge), the particles coalesced (rose or settled according to their density); but when an excess of the one emulsion was used, the mixture became stable again. That proved that an emulsion remained stable or turbid as long as its particles carried an electric charge (either positive or negative), but became unstable and settled when the charge was neutralized.

In order to prepare a fine emulsion, Professor Donnan continued, it was advisable to add a little soap or alkali to the water with which the oil was shaken; otherwise the oil would not break up into fine particles. Here surface tension came in. Water had a very high surface tension, and the addition of all other substances lowered this tension. To demonstrate this, lycopodium powder was sprinkled on the centre of a surface of water, on which it settled like a film of snow; but when the powder was touched with a glass rod dipped into caustic soda, the whole film was instantaneously swept off, being pulled away by the greater surface tension of the clean water outside the film. That the alkali acted so readily on oils was partly due to the fact that most oils contained a little oleic or other acid, and the alkali formed a soap with this acid. This action on oil was further exemplified by a pretty experiment due to Professor Donnan. From a pipette, which was bent upward, oil was allowed to escape under water; owing to the high surface tension of the water the oil rose in drops to the surface of the water. When alkali was stirred into the water, the phenomena became momentarily indistinct; but when the agitation had quieted down again, the oil was seen to rise in a steady thread, no longer in drops. Certain therapeutically important colloids, Professor Donnan explained, had similar effects as soap, and these "protective colloids" resembled emulsifying agents. They lowered the surface tension, and surrounding the particles, allowed them to coalesce. Such colloids appeared frothy, like soap solutions, and the appearance of a froth in general indicated the presence of a substance lowering the surface tension. Methyl violet was one of these substances. It gave with water a frothy solution; when the solution was separated from the froth, with the aid of a big funnel, and a little ether was poured into the froth (which in itself looked lighter in color than the solution), the clarified froth immediately appeared darker in color than the solution. This and other experiments proved that the substance which lowered the surface tension became concentrated in the layer surrounding the particles of the emulsion. The addition of acid to the emulsion destroyed this protective action again, just as the addition of acid to the alkaline water in the Donnan experiment, above described, destroyed the oil-thread and made the oil rise in drops again.

Having further elucidated these phenomena by means of slides, Professor Donnan drew attention to another experiment due to Dr. Patrick, who assisted him in the demonstrations. Mercury was forced in a very fine spray through the pores of wood, and the spray fell down a glass tube into which a red dye solution was introduced; the spray of very small mercury particles bleached the color. Professor Donnan remarked that he did not suggest the de-colorization of impure solutions of sugar and other products in this way instead of by charcoal. Our readers may remember a similar experiment: removing the color from solutions by filtering them through fine sand. We are not quite sure whether Professor Donnan merely desires to intensify this effect of absorption by making use of very fine particles, or whether he would suggest some additional electric cause for the effect. The energy in the surface layer depends upon the product of the area and of the surface tension per unit linear dimension; the smaller the drops, the greater would be the relative area, and the greater, consequently, the diminution of the surface tension.—*Engineering.*

Protective Coating for Small Articles

SMALL articles of metal may be conveniently protected against corrosion as follows: The apparatus necessary may be improvised from two tin cans, one larger than the other. The larger can is partially filled with a mixture of one part of a cheap varnish and two to three parts of wood alcohol. The articles to be treated are put into the smaller can, which has a number of holes punched in it to convert it into a dipping basket. Lowering the small can into the varnish mixture, and agitating it up and down a few times, will thoroughly coat the articles, when the small can is withdrawn and allowed to drain for a few moments to get rid of most of the superfluous liquid, and the pieces are thrown out onto a tray of wire mesh to complete the draining and to dry. They will be ready to pack in a few minutes.

A Novel Construction for Gas Holders

THE floating bell form of gas holder, with its telescoping sections, water tank seal for the lower edge and elaborate framing for guiding the cylinder, is a very expensive structure, and it has not been evident how it could be improved. A new principle has, however, been devised that greatly simplifies the construction and reduces the cost. Instead of being movable the tank is fixed, and its roof is movable, sliding up and down within. This roof is fitted as closely as possible, and to prevent the gas escaping water is pumped onto it, thus forming a water seal. Of course some water passes through the joint, but this is withdrawn and returned to the roof by a pump regulated to compensate for the leakage.

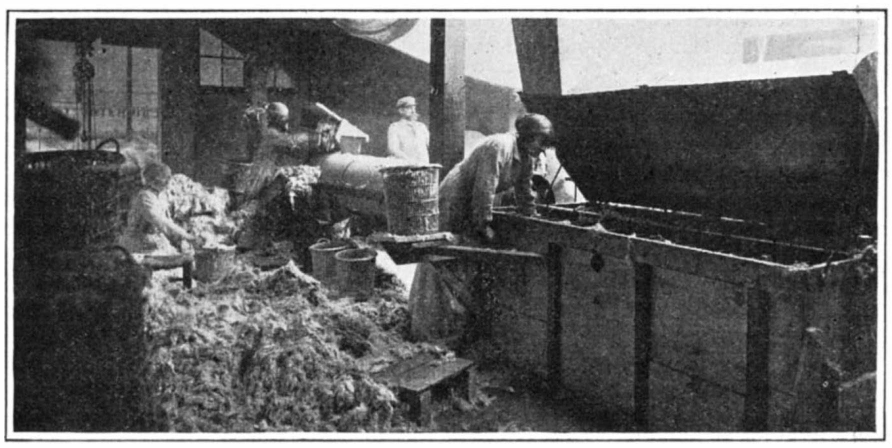


Fig. 3.—A gin for separating the fibre from the seeds.

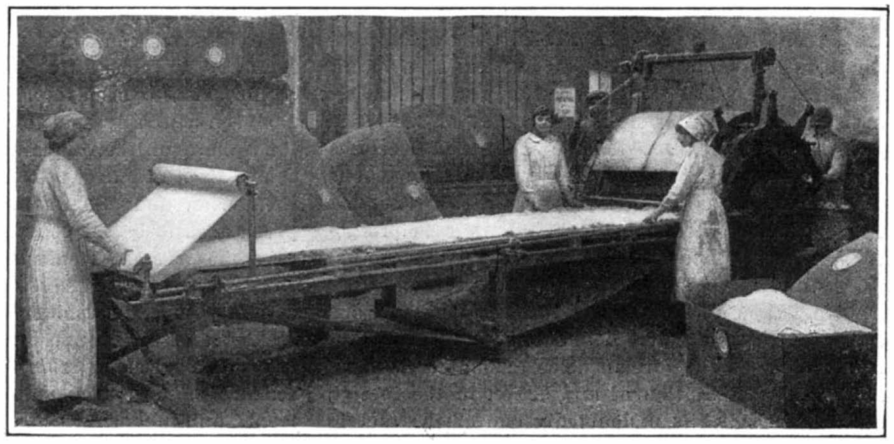


Fig. 6.—Film from carder running onto supporting slips.

Kapok—A New Textile Fibre

Its Manufacture and Industrial Applications

By Jacques Boyer

A French inventor, M. Jean Mondamert de Saint-René, has just created a new industry in textiles by discovering a method of carding, spinning and weaving Kapok. This is a silky down from the *Bombax ceiba* or *Eriodendron anfractuosum* (silk cotton trees), which are well distributed in the tropics, especially in the West Indies, South America and the Soudan.

At the moment there are fifty establishments in Java collecting this vegetable wool, while five men have been at work with it alone for about a dozen years. Javanese Kapok is composed of threads of a clear yellow, somewhat silky in texture and half to three quarters of an inch in length, and is contained in the long capasudal fruit of the tree. In the midst of the mass of threads constituting a floss there are to be found, previous to working it, seeds of from an inch to an inch and a quarter in diameter of dark-brown color (Figs. 1 and 2). On examining the floss with the microscope it is seen to be composed of unicellular fibers of the length above given, cylindrical throughout most of the length, and with thin walls and a light skin near the base. The central tube filled with air gives to the fiber its very valuable lightness.

Aside from their lightness the fibers of Kapok possess absolute impermeability to water, due, according to Dr. Clavel, to the presence of a wax with which the filaments are coated. This is described by M. de Saint-René as a "solidified oil," and he it is who calls attention to the membraneous nature of the covering. However this may be, Kapok, through its inaptitude to accept water and the quickness with which it dries, does not rot. It will support from thirty to thirty-five times its weight in water, while ordinary cork will float only about five times its weight. Experiments have shown that a packet of Kapok which sustained thirty-two times its weight when first immersed would still hold up twenty-six times its own weight at the end of a month in the water. No other vegetable substance known has this extraordinary ratio of flotation power and impermeability; it is an attribute of down of Bombax alone.

On account of its elasticity and its lightness Kapok is admirable for the stuffing of cushions or mattresses, replacing advantageously feathers, wool or hair. Again, its conduct in the water makes it superior for life-preservers, "cork" jackets and other items for life-saving in rivers or the sea.

In general, the Kapok trees are set out along the roads at three, four, five or six yards apart, oftentimes in plantations of coffee or cocoanut palms or even in the fields, where they are spaced some 30 feet apart, about fifty to the acre. Although they can be propagated from slips it is customary to plant the seeds, since the growth is then more regular. They yield their fruit in three to four years in Java and take about a year longer in Indo-China. At Cambodia a Kapok tree at five years bears annually about 400 fruits each of four to the ounce when the fiber is weighed. The harvest is in April or May. It is customary for the natives to wait till the fruit ripens and falls, sometimes they knock them down with bamboo poles, and again they may climb the trees to pick them. It is the work of the women and children to extract the down and to put it to dry in the sun on cement floors where wire nettings are placed to prevent the fibers from floating away on the breezes.

To separate the silk or wool from the seeds there is a process of primitive ginning. In Java this is done by means of little iron mills worked by hand. Four workmen are needed to run one of these mills which will gin on an average about 275 pounds. The seed is not a negligible waste, for it contains to about one fifth of its weight an oily substance used in Java to adulterate other commercial vegetable oils.

The down thus obtained is packed in bags of jute or straw matting. The packing must not be too strenuous, otherwise there is risk of robbing the fiber of some of its elasticity.

In the European establishments the ginning is accomplished in a cylinder machine of sheet iron (Fig. 3), five feet long by two and one half in diameter. In the interior there are fixed arms mounted on the cylinder while in the center is a revolving shaft—400 to the minute—carrying arms that are alternate to the others. After the Kapok has been subjected to the action of the arms, the seeds fall to the bottom while a current of air catches the down, carries it out of the cylinder and by a winnowing process relieves it of all foreign matter.

The next process is to convert the fiber mass into sheets of different widths and thicknesses like cotton batting, or into rovings for making threads. Till now no one has succeeded in this because the carding machines employed were too severe for Kapok and broke the delicate fibers literally into dust.

After unsuccessful trials lasting over several years M. de Saint-René has succeeded in overcoming the difficulties. The essential principle of his procedure lies in the process whereby the fibers, disentangled and blown up, are straightened out between the teeth of this card by means of brushes, which while maintaining the parallelism of the threads does not break them up and takes nothing away from their qualities. In addition it produces artificially a felting of the fibers which do not carry a series of little natural hooks, as does the staple or wool. The strength of the roving or sheet is obtained by subjecting the carded material to a proper heating which curls the fibers a little and ensures their subsequent enmeshing.

Fig. 4 presents a section of the Kapok carding machine, which converts the silky floss into a sheet of batting. It consists of a feeding device, the drum, carder and the finisher. The Kapok already ginned is turned into a hopper (1). Compressed air from the injectors (2) blows the Kapok across the points (3), disposed checkerwise, and disentangles and straightens the fibers ready for the carder. This machine consists of a carding drum (4), furnished with teeth on its entire surface, and it is surrounded by revolving brushes (5) which serve to direct the filaments between the teeth of the cylinder and to lay them out parallel. The cylinder turns in the direction of the arrow *f*, and the brushes in the contrary direction. The brushes may be detached and can be taken away from the card for the removal of the sheet of Kapok. On account of the weakness of the fibers the brushes must be of comparatively soft substances, like vegetable hair or metallic threads of great flexibility.

The vibrating comb detacher (6) receives an oscillatory motion from a cam and detaches the sheet from the card, to do which the drum is reversed in motion and revolves in the direction indicated by the arrow f^2, that is, in the direction opposite to that when the sheet is formed. The detached sheet is carried to the finisher (7), actuated by a pulley (8). This finisher apron comes into contact with a heated surface (9) to submit the sheet to the action of the heat. This is about 158 deg. Fahr. (70 deg. Cent.), and has the effect of so curling the ends of the fibers that they hook into one another. The sheet has now acquired a tenacity and it is next pressed between the rolls (8 and 10), and finally wound on the reel (11).

The operation requires from eight to ten minutes for a carder 13 feet in circumference and 3 feet in length. When finished the carder is stopped, the brushes thrown out of contact with the teeth of the card, the carder is reversed in its motion, and the detaching comb and the finisher are set in motion.

In order that the film of Kapok be properly supported and to preserve the continuity of what is at the moment a very delicate fabric, slips of paper or of cloth on one or both sides of it will serve to carry it forward to the finisher. How this is done is represented in Fig. 6.

There is shown in Fig. 5 a variation in arrangement of M. de Saint-René's carding machine. In this difference in treatment the fact is utilized that Kapok swells considerably under the influence of heat and it is an advantage to use this peculiarity in treating the floss when it is more matted and cannot readily be carded by one passage through the carder. In this machine (Fig. 5) the Kapok receives a preliminary carding and arranging on an endless carding band or apron furnished with teeth between which fixed brushes dispose and parallelize the fibers as they come to the table. Sheets of fiber are thus formed of whatever thickness may be desired and portions of this sheet are fed to the rotary carder. This reworks the material, completes the parallelizing of the staple, and the film is detached as before described and passed on to the finisher.

As is shown in Fig. 5, the feeding is accomplished by means of a metal box (21) furnished with a hopper or tube (22) that can be filled with Kapok and hermetically sealed by means of a cover or valve. The box (21) has tubes leading out from its top (23) in number sufficient to command the whole surface of the carding apron (25) placed immediately above it. These tubes may be controlled by valves (24). The carding band is set in motion by means of pulleys (26 and 27), and treats the Kapok delivered by the tubes in the proportions in which it arrives.

To effect the forcing of the fibers into the tubes

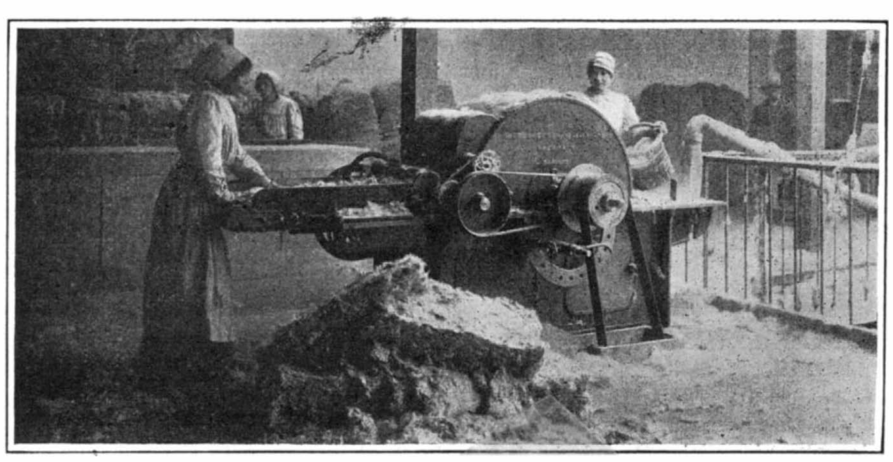


Fig. 7.—De Saint-René's cylinder carding machine.

Fig. 1.—Kapok pods.

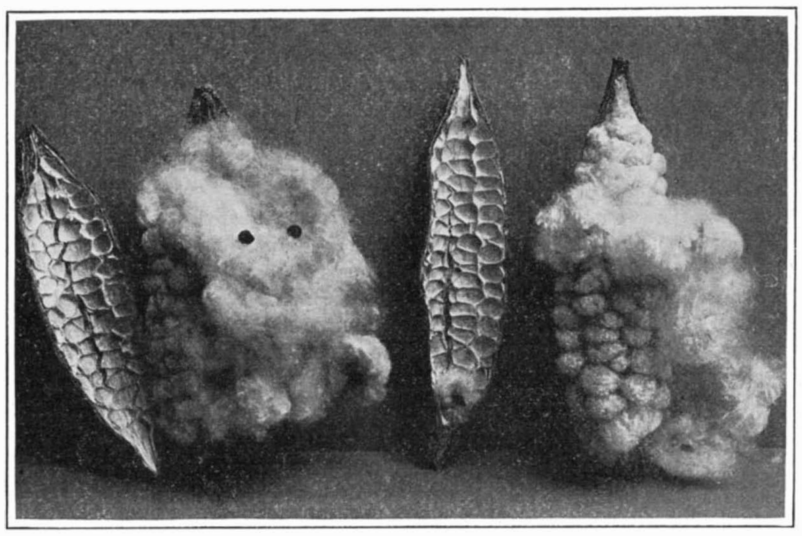


Fig. 2.—The pods opened, showing fiber and seed.

which are in the top of the box, mechanical means would serve, but experience has shown that it is better to use heat seconded by a light upward draft of air. While within the box the Kapok is heated and swells considerably, the filaments tend to separate, this tendency being continued and emphasized during the passage up the tube. They are therefore pretty well disengaged on reaching the carding band (25) which brings them under the influence of the fixed brushes (28). In addition to these there are revolving brushes (33) in gear with the carding drum. When this is sufficiently charged with Kapok to have a sheet of the desired thickness the valves (24) of the tubes from the box are closed and the carding band is brought up toward the cylinder carder so that its contents may be fed progressively to the cylinder. This (29) is then given a motion in the direction of the arrow *f* (opposite to that of the carding table), and in this way seizes the filaments and finishes their treatment. The revolving cylinder is surrounded by brushes (31) which force the filaments between the teeth of the card, crowding them here so as to obtain a compact sheet. The card is revolved a longer or shorter time according to experience to make more certain the parallelization of the filaments, the brushes are thrown back and the sheet removed by the detaching comb. It then glides along the flexible band (34) which is actuated by the pulleys (35). This band is of thin metal and is warmed by electricity or in some other manner to the desired temperature (158 deg. Fahr.), and here the filaments catch one on another as already described. To give the sheet a brilliant appearance advantage is taken of its position on the metal to pass it between this and another metallic band (36), the latter being by preference of aluminium. This is not heated. The two bands of metal with the Kapok between them are run between pressing rollers (37 and 38). On cooling the tissue preserves the tenacity acquired and is ready for futher operations in accordance with its intended use. It may remain as Kapok batting, or it may be cut into rovings for spinning.

The spinning depends first on the carding, without which it would not be possible, and it is here that the inventions of M. de Saint-René give the advantage over previous ones that could not parallelize the fibers. He has furthermore been able to develop a liquid which without robbing Kapok of any of its advantages, serves admirably to gum the fibers together, and through the use of this it becomes possible to spin fine or coarse threads of the substance with great facility. With such threads weaving becomes easy. Exhibitions of knitting and of the manufacture of floating garments of Kapok cloth have been given before the French ministers of the navy and of war, who have awarded testimonials of appreciation to the inventor. The industrial future of the fiber of the silk cotton tree of the tropics, Kapok, seems well assured.

Imitation as Pioneer of the Genuine

Is THE copy or imitation of an original or genuine object to be regarded as spurious, as rubbish, as a makeshift, or should the imitation be defended as a pioneer of the genuine, or regarded as a method of spreading modern culture? This question is asked in an animated, brief article in a late number of the German journal *Prometheus*. The author in his defense of imitation claims that without it there would be fewer genuine objects, that only a very small portion of the human race would be able to possess these genuine objects, and that there would be little comprehension of them.

One difficulty in discussing the theme is that in all ages the conception of genuine and spurious has varied greatly. In antiquity dyed fabrics were very costly and could only be owned by the few. The art of dyeing developed very slowly, and the introduction of each new dye was violently opposed, even when it was technically genuine, that is, unsensitive to light and a fast color. Thus, in many countries at first the use of indigo was punishable with death, although the genuineness of this dye is unquestionable. Each new dyestuff enriched the scale of colors, until the coal-tar substances produced a series of shades before undreamed of.

These new dyestuffs, however, with a few exceptions were correctly regarded as not genuine. They either faded gradually when exposed to the light or they could not bear washing. They were in reality substitutes, even though the fabrics colored by them had a much more brilliant appearance than those that were considered genuine in their dyeing. With the increase of knowledge, however, artificial dyestuffs were produced which did not fall below the natural dyes, that formerly were alone held to be genuine. The latter were imitated by synthesis in fully equal quality, and now we have an unlimited number of dyestuffs that are genuine in every regard. The battle has been won by the equivalent imitation. To gain this victory, the pioneer work of the imperfect substitute was necessary. It was only because the first products of doubtful value found a market that factories grew to a size enabling them to meet the huge cost of the experiments which brought the final success.

The time is not so far distant, to refer to another example, when the plain man ate his soup from a coarse earthen pot with a wooden spoon, and cut his meat on a wooden plate. It was only the few who could afford the luxury of porcelain and silver forks and spoons. The wooden spoon was followed by the tinned iron spoon and the pewter spoon, but neither of these could claim to be on a level with silver ones. Then came various metal alloys plated with silver, yet even this method of copying could not supplant the massive silver spoon. On the contrary, silver knives, forks, and spoons are now owned by people of very moderate means, as is also genuine porcelain, for which stoneware prepared the way and did pioneer service. The coarse stoneware awakened in its owners the desire for the genuine porcelain and forced the porcelain manufacturers to cheapen their methods so as to meet competition. Thus, what was originally a costly article and the privilege of the few became the possession of all.

Development of this kind can be found on every side. The precious stone is copied in the cheaper imitation, which can only present the external appearance of the genuine one, and the end of the development is the synthetic stone that equals the work of nature. It was sought to replace silk, which is costly, by cotton treated in a special manner. These experiments were followed by artificial silk that cannot be distinguished from the genuine by the ordinary person. In the end the artificial product will probably equal in value the genuine.

In not every case, however, can imitation develop into a copy that becomes genuine of its kind. This difficulty is always present in the imitation of furs. The spread of civilization makes fine skins constantly more scarce. It is impossible to produce a substitute of equal value, for plush and velvet, however beautiful, are not properly imitations of fur. The imitation of valuable furs by the skillful treatment of ordinary ones only increases the demand for fine skins, and thus will probably lead to the breeding of fur-bearing animals.

It is not merely the material that is copied; the work itself is also at times imitated. Genuine lace is often imitated by machine so successfully that only an expert can tell the difference which, curiously enough, is shown by the greater regularity of machine work, this being technically more perfect than hand-made lace. Most of the products of weaving are better made by machine, imitation having in this case completely conquered both as to appearance and durability.

The course has been the same with many of the products of art industry. After the first imperfect experiments, that often yielded imitations which rightly could be called rubbish, persistent effort produced substitutes that could be pronounced genuine of their kind. The material is genuine, although only a small amount of it is used, and the work is genuine, but owing to the aid of machinery, a dozen or more copies can be turned out at the same cost as the original hand-made article.

So it seems, in some cases, merely a fad when a much higher price is paid for hand work, when the inequalities of the hand-made article, which in a factory would be regarded as failures, are considered merits.

Opinions differ the most when the question is one of pure art. If it is already difficult to bring about agreement as to what is and what is not art, how much less chance is there of agreement as to the value of its reproduction in an imitation?

Artists regard reproductions with mixed feelings. The copy is a competitor of the original, yet at the same time the payment to the artist for the right to make the copy often exceeds the value of the original picture. Horrible as the chromolithograph often was, still it was the means of arousing in the general public a sense of the worth of pictures, and now there are methods of reproduction which turn out copies the artistic value of which is undeniable, provided that this value exists in the original.

Thus, it is evident that caution should be observed in pronouncing judgment upon imitation. Above all, hasty talk about the decay of the sense of the genuine and complaints as to the mere varnish of culture in the present day should be avoided.

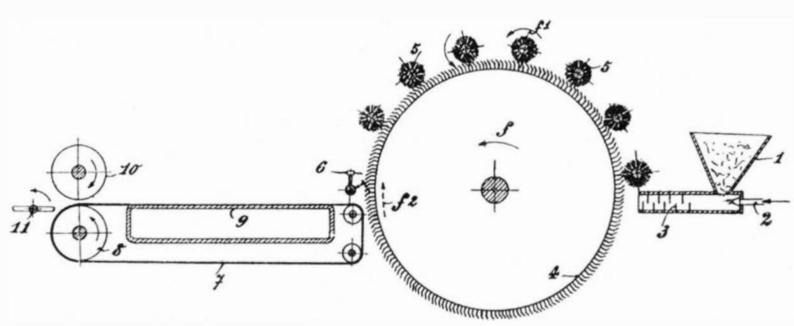


Fig. 4.—Diagram of cylinder carding machine.

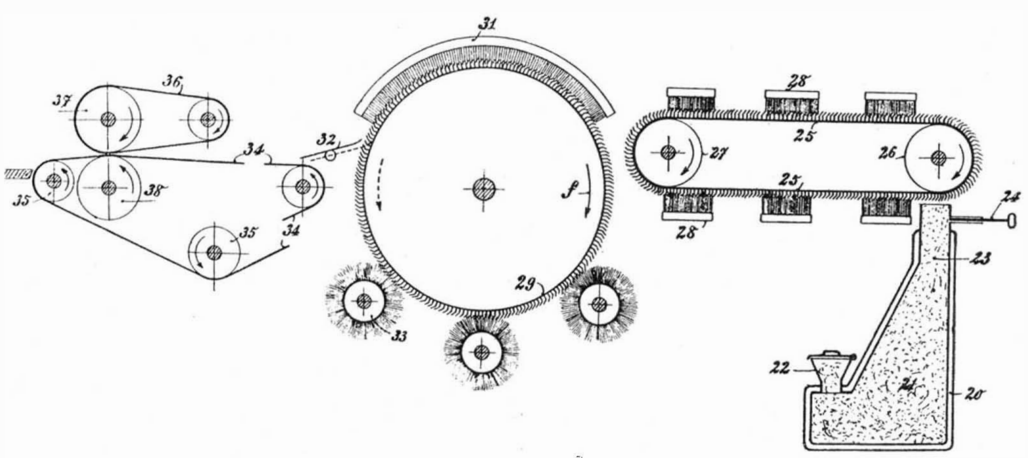


Fig. 5.—Diagram of double carding machine.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Simplex Calendar

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

MY attention has been called to the two perpetual calendars which appeared in your issues of December 19th, 1914, and February 27th, 1915, both of which extend over the Christian era, the former being by Mr. S. F. Kennedy, and the latter by Mr. W. J. Spillman.

Mr. Kennedy's table is simple and accurate, in so far as it deals with the Gregorian or "New Style" of calendar—which, by the way, only began in 1582—but it is fundamentally wrong in regard to Julian or "Old Style" dates. The New Style repeats itself every fourth century, and Mr. Kennedy has evidently presumed that the Old Style does the same. The Julian calendar repeats itself every 28 years, and, as a sequence, every seventh century, but not every fourth century; and any table based on a repetition every 400 years is bound to be hopelessly in error.

Mr. Spillman ingeniously deals with Julian dates by means of a "conversion table," but this indirect means of reaching the desired end involves too much care and calculation to keep one free from error. This liability to error is exemplified by the fact that Mr. Spillman, in using his own tables, makes four slips out of the thirteen examples he gives, i. e., October 12th, 393 (O. S.), Tuesday should be Wednesday; October 11th, 1492 (O. S.), Friday should be Thursday; January 10th, 872 (O. S.), Friday should be Thursday; September 14th, 1752 (O. S.), Thursday should be Monday.

His "conversion table" is correct in principle, but he makes an error in detail by ending his centennial periods with the 23rd and 28th of February, respectively; those periods he should have ended all through with the 29th of February.

Mr. Spillman does not deal clearly with, nor is he accurate in his statement regarding the double day of bissextile years. He also omits to note the important fact that past years did not all begin with the first day of January.

The "Simplex" calendar, herewith appended, embraces both the old and the new styles of reckoning. The writer trusts it will prove an easy and accurate means of finding the relative week-day or days of any date or dates in the Christian era. It may be mentioned that a similar table, supplied by the writer, appeared in "Whitaker's Almanack" for 1912.

The historical notes subjoined to the "Simplex" calendar will doubtless be interesting. In many cases, a reference to these notes will be found essential to a true reading of the "Simplex" tables.

The Christian Era.—The Christian era was not instituted as a basis of reference until a Scythian monk, Dionysius Exiguus, resident in Rome, had computed and suggested it about 532 or 534 A. D. The computation made by Dionysius is now generally regarded as having placed the beginning of the era too late by three or four years.

New Year's Day.—Much confusion exists regarding the dates of past events because of the changes of positions of New Year's Day. The most common positions for it have been Christmas, Ladyday, Easter and the first of January.

In the Julian calendar, as founded by Julius Cæsar in 45 B. C., the year began with the first of January. For the simplification of references to past events, it is generally assumed by historians that the first of January has continuously been the first day of the year, and January 1st to December 31st is recognized as the historical year.

In England, between the sixth century and 1066, Christmas and Ladyday contested for priority as the first day of the year, and thereafter the first of January took precedence till 1155, when Ladyday (i. e., 25th of March) was again recognized, first ecclesiastically, then generally, and so remained in legal usage until 1751. But for many years prior to 1751, common usage in England had held the first of January to be the first day of the year, and it became customary to combine the year date of both usages; e. g., 29th of February, $164\frac{7}{8}$, or 24th of March, $16\frac{79}{80}$, or 1st of January, $1\frac{699}{700}$. This method of indicating the year was the more necessary, seeing that Scottish legal usage differed from English. The first of January became legally the first day of the year in England in 1752.

Scotland made the retraction from Ladyday to 1st of January in 1600, so as to be in better agreement with the practice of continental Europe, with some countries of which it had more intimate commercial and friendly relations than it had with England.

France, under Charlemagne, observed Christmas as New Year's Day; then it afterward recognized both Easter and Ladyday till 1562. The 1st of January became the 1st day of the year with the advent of 1563. The Autumnal Equinox was observed as the beginning of the year under the Revolutionary calendar from 1793 to 1805. By decree of Napoleon, the 1st of January was again restored as the first day of the year in 1806, with the resumption then of the Gregorian calendar.

Germany in 1544, Spain and Portugal in 1556, and Prussia, Sweden and Denmark in 1559, each substituted the 1st of January in place of 25th of December as the first day of the year. In the Netherlands, the first of January as New Year's Day was adopted by the Roman Catholic provinces in 1556, and by the Protestant provinces in 1583, and in Russia in 1725.

Change of Style.—Sixteen centuries after the establishment of the Julian calendar, a correction was made by Pope Gregory XIII in October, 1582. Ten days were excised from that month and Thursday, October 4th, was immediately succeeded by Friday, October 15th, 1582. This change became immediately operative in most of the Italian States and also in Spain and Portugal.

In France and Lorraine the New Style became operative with Monday, December 20th, 1582. In Prussia, the Gregorian calendar (or New Style) was adopted in 1583, and in Hungary in 1587. In the German Roman Catholic States, in most of the Netherland provinces, in Savoy and Switzerland, the New Style began with Saturday, January 1st, 1583; in Poland with Wednesday, January 1st, 1586; and in Strasburg with Sunday, March 1st, 1682. In Denmark, in some of the Protestant States of the Netherlands, and in the German Protestant States, the New Style came into vogue with Monday, March 1st, 1700.

The Gregorian calendar became operative in Great Britain and colonies with Thursday, September 14th, 1752. Seeing that this occurred about 24 years before America's Declaration of Independence, it follows that North American dates will coincide with those of the mother country.

Japan and China, until recently, both used lunar calendars, but the Gregorian calendar was adopted by the former in 1872, and by China in 1912.

Sweden, in the re-setting of her calendar, followed the precedent set by Augustus Cæsar, who, for a number of years, dropped from the calendar the extra day of leap years. By this means, Sweden in a gradual way departed from the Old Style and merged into the New. She departed from the Julian calendar with the close of Wednesday, February 28th, 1700, and began her correspondence with the Gregorian calendar with the advent of March 1st, 1740. Thus, after "40 years in the wilderness," Sweden attained uniformity with the west of continental Europe.

Leap Day, or Bissextile Day.—It will thus be seen that there are numerous pitfalls for the student who, in the tracing of past events, seeks to re-establish the relationship of the days of the week with those of the month. It may be here mentioned that the Romans did not have a seven-day week. They regulated their affairs by references to the Calends, the Nones and the Ides of the months. The 24th of February was, for instance, styled by the Romans as the "sixth day before the Calends of March." We should, in our method of counting, say

THE SIMPLEX CALENDAR.

Giving, by means of two Key Tables and seven Monthly Tables, *all* the days of the week in the Christian Era. Arranged by John C. Robertson, Kirkcaldy, Scotland.

KEY TABLE NO. 1.

The Centennial Figures of the Years.						The Individual Years, or Section C.																												
Section A. Julian or Old Style.			Section B. Gregorian or New Style.			01 29 57 85	02 30 58 86	03 31 59 87	04 32 60 88	05 33 61 89	06 34 62 90	07 35 63 91	08 36 64 92	09 37 65 93	10 38 66 94	11 39 67 95	12 40 68 96	13 41 69 97	14 42 70 98	15 43 71 99	16 44 72	17 45 73	18 46 74	19 47 75	20 48 76	21 49 77 Ol	22 50 78 d	23 51 79 St	24 52 80 yl	25 53 81 e	26 54 82	27 55 83 =	28 56 84 CO	New Style = 00
0	7	14		17	21	6	0	1	**3**	4	5	6	**1**	2	3	4	**6**	0	1	2	**4**	5	6	0	**2**	3	4	5	**0**	1	2	3		5
1	8	15				5	6	0	**2**	3	4	5	**0**	1	2	3	**5**	6	0	1	**3**	4	5	6	**1**	2	3	4	**6**	0	1	2	**5** **4**	
2	9	16		18	22	4	5	6	**1**	2	3	4	**6**	0	1	2	**4**	5	6	0	**2**	3	4	5	**0**	1	2	3	**5**	6	0	1	**3**	3
3	10	17				3	4	5	**0**	1	2	3	**5**	6	0	1	**3**	4	5	6	**1**	2	3	4	**6**	0	1	2	**4**	5	6	0	**2**	
4	11	18	15	19	23	2	3	4	**6**	0	1	2	**4**	5	6	0	**2**	3	4	5	**0**	1	2	3	**5**	6	0	1	**3**	4	5	6	**1**	1
5	12	19	16	20	24	1	2	3	**5**	6	0	1	**3**	4	5	6	**1**	2	3	4	**6**	0	1	2	**4**	5	6	0	**2**	3	4	5	**0**	**0**
6	13	20				0	1	2	**4**	5	6	0	**2**	3	4	5	**0**	1	2	3	**5**	6	0	1	**3**	4	5	6	**1**	2	3	4	**6**	
These two sections can be indefinitely extended.																																		

Factors for the years.

KEY TABLE NO. 2.

Days in the Months.	Factors for the Months.		Monthly factors in leap years =
31	January	1	**7**
28–29	February	4	**3**
31	March	4	
30	April	7	
31	May	2	
30	June	5	
31	July	7	
31	August	3	
30	September	6	
31	October	1	
30	November	4	
31	December	6	

INSTRUCTIONS.

Leap years are indicated by the factors being in heavy type.
The factor for any desired year occupies the square in line with the Centennial section, and under the Individual section, of the year's number.
For Old Style dates use sections A and C. For New Style dates use sections B and C.
By adding the year factor to the month factor the number of the table of any desired month will be given.

MONTHLY TABLES.

1 or 8.					
S	1	8	15	22	29
M	2	9	16	23	30
T	3	10	17	24	31
W	4	11	18	25	
T	5	12	19	26	
F	6	13	20	27	
S	7	14	21	28	

2 or 9.					
S		7	14	21	28
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	
F	5	12	19	26	
S	6	13	20	27	

3 or 10					
S		6	13	20	27
M		7	14	21	28
T	1	8	15	22	29
W	2	9	16	23	30
T	3	10	17	24	31
F	4	11	18	25	
S	5	12	19	26	

4 or 11.					
S		5	12	19	26
M		6	13	20	27
T		7	14	21	28
W	1	8	15	22	29
T	2	9	16	23	30
F	3	10	17	24	31
S	4	11	18	25	

5 or 12.					
S		4	11	18	25
M		5	12	19	26
T		6	13	20	27
W		7	14	21	28
T	1	8	15	22	29
F	2	9	16	23	30
S	3	10	17	24	31

6 or 13.						
S		3	10	17	24	31
M		4	11	18	25	
T		5	12	19	26	
W		6	13	20	27	
T		7	14	21	28	
F	1	8	15	22	29	
S	2	9	16	23	30	

7 or 14.						
S		2	9	16	23	30
M		3	10	17	24	31
T		4	11	18	25	
W		5	12	19	26	
T		6	13	20	27	
F		7	14	21	28	
S	1	8	15	22	29	

EXAMPLES.

With what day of the week will the year 1921 begin?

In Key Table No. 1, the horizontal line in section B containing the figures 19, and the column in section C containing the figures 21, converge on factor 6. In Key Table No. 2, the factor for January, in common years, is seen to be 1. The sum of these factors is 7, which is the number of the Monthly Table for January, 1921, in which it will be seen that that year will begin with a Saturday.

In Russia, Greece, Serbia, or any of the Balkan States, where the Julian Calendar, or "Old Style" of reckoning the year, is still in use, the answer would be different. In these countries, although the week days coincide with ours, the monthly dates are now 13 days behind. The proper combination to use, for these countries, is section A with C (not B with C). Thus it will be seen that the year factor for 1921 is 5. This added to 1, the factor for January, produces 6, and in Monthly Table No. 6 it is seen that in Russia and these other countries the year 1921 will begin with a Friday. This same Friday with us will be 14, January, 1921.

On what day of the week did America make its Declaration of Independence, the date being 4th of July, 1776, New Style?

In Key Table No. 1, the co-mergent square, for figures 17 in section B, and figures 76 in section C, is seen to contain factor 2. This, added to 7, which is the factor for July, makes 9. In Monthly Table No. 9 it is seen that the 4th was a Thursday.

that the 24th of February was the fifth day before the Calends of March, but the Romans counted inclusively, so that the 24th, 25th, 26th, 27th and 28th of February, and the 1st of March, by this inclusive method, amounted to six days. In leap years, or, to use the Roman term, "Bissextile" years, the 24th of February or the sixth day before the Calends of March, represented two solar days —hence, the term "Bissextile," or "Twice the Sixth." For many centuries, the extra day of each fourth year was included with the 24th day of February, and the 29th of February, therefore, did not exist.

The present practice of inserting the extra day at the end of February appears to have come into use gradually, and we find it officially recognized in the sixteenth century. In English State papers, the following dates may be seen: February 29th, 1571, February 29th, 1619, February 29th, 1647. These three years (which began with Ladyday) would, if written according to the historical year, read 1572, 1620 and 1648.

Bond's "Handy-book for Verifying Dates" (G. Bell & Son, London) first published in 1866, gives much interesting minutiæ in regard to these and other calendar matters.

Adjusting Rules.—In the "Simplex" calendar it is presumed that all years have begun with the first day of January; also that the month of February in leap years has always contained 29 monthly dates. The following special rules, which apply to former and differing standards of reckoning, will, if the style of calendar and the first day of the year be known, enable the correct days of the week to be found, from the monthly dates, by means of the "Simplex" calendar.

SPECIAL RULE NO. 1.—FOR ANY YEAR THAT BEGAN WITH CHRISTMAS.

The monthly factor for dates between the 25th and 31st December, inclusive, instead of being 6, as shown in Key Table No. 2, should be 5.

SPECIAL RULE NO. 2.—FOR ANY YEAR THAT BEGAN WITH LADYDAY.

For dates between the 1st of January and the 24th of March, inclusive, excepting sometimes 24th, 25th, 26th, 27th, and 28th of February, increase the monthly factor by 1. This rule applies also to years that began with Easter, but is variable in range according to the date of Easter.

SPECIAL RULE NO. 3.—FOR THE BISSEXTILE AND LATER DAYS OF FEBRUARY.

In leap years or "Bissextile" years, for many centuries, the monthly date known by the Romans as "Bissextile" day, and by us as the 24th of February, accounted for two solar days, and it thus included two days of the week. The "Simplex" calendar monthly table which indicates the 24th of February should be used for the first "Bissextile" day. The second 24th day, and the remaining dates of the month, are to be taken from the next succeeding monthly table; so that if the first 24th be in Table 3, the second 24th will be in Table 4.

NOTE.

The dates that may be affected by these three special rules range from the 25th of December to the 25th of April. Dates from the 26th of April to the 24th of December need no such rules; nor are such rules needed for dates based on the "historical" year, nor for any date whatever after 1751.

DOMINICAL LETTER TABLES.

0	1	2	3	4	5	6	0
A	G	F	E	D	C	B	A

This table gives, at a glance, the Dominical letter, or letters, of any year in the Christian era.

RULE.

Find the factor for the given year, either Julian or Gregorian, by means of Key Table No. 1. This factor indicates in the above table the required Dominical letter, but in leap years, which always have two Dominical letters, the preceding letter must be taken for January and February.

EXAMPLES.

Required the Dominical Letter for 1915, N. S.—The factor for 1915, Gregorian or "New Style," is seen in Key Table No. 1 to be 5. In the above table, the letter under 5 is seen to be C, which is the Dominical letter required.

Required the Dominical Letter for 1872, O. S.—This is a leap year, and the factor is 0. Therefore, we find that the Dominical letters are B and A.

JOHN C. ROBERTSON.

The Locomotive and the Revolutionist

A Discussion of Some Suggested Improvements

WE recently received from a correspondent a communication on the improvement of locomotive design. It was not sent to us for publication, and we have returned it with our comments. It was a carefully compiled summary of all the arguments against the present form of steam locomotive, coupled with a scheme of the writer's for a radical departure in design. The case against the Stephenson locomotive, as we may conveniently call the type with which we are all familiar, was clearly stated on well-known grounds, while the plan brought forward followed, in its main aspects, several designs of recent years. It called for the use of a high-speed engine, either steam or internal combustion, or, by preference, a steam turbine; an electric generator; motors on many axles; a water-tube boiler, with automatic stoker, and other items. We must not pry into it too closely, but from this bare outline it will be understood that the writer has little or nothing really new to offer and that his study of the subject, which has clearly been very careful, has led him to the same conclusion that his predecessors have reached. We may, then, presume that the line of thought is fairly common, and it may be of some service to others who are spending their time upon the problem if we consider the subject in a little detail.

There is a certain type of mind which concludes from the fact that something has not changed materially for a long time that it must be defective. The revolutionist of the locomotive starts, on the perfectly correct basis, that there has been no inherent alteration of the steam locomotive for eighty-five years or so. He sees that it is still driven by cylinders acting directly on cranks on the driving axle and fed with steam raised in a smoke-tube boiler by a fire urged by the draught caused by an exhaust blast pipe. From these fundamentals we have never departed, and while other engines and boilers have changed in the course of time the boiler and engine of the locomotive remain the same. This is anathema to the reformer. He sees high-speed engines or turbines, water-tube boilers, internal combustion engines, dynamos and motors on shore and on ships, and he asks why these things, with their admittedly higher efficiency, cannot be used on the railway engine. It is not a conclusive answer to him that they have been tried and found wanting. He is convinced that if the Heilman, the Reid-Ramsay, the Sulzer-Diesel locomotive and others have not been perpetuated it is because the locomotive superintendent is so prejudiced that he will not persist in the experiments and carry them forward to success. As a rule the reformer is blind to and ignorant of the fact that the tests made with such engines have revealed inherent difficulties, and have shown that the designs failed in the very direction where they were most expcted to succeed. He is not wholly to blame for this attitude. Unfortunately, we hear too little about failures. The general public is rarely allowed to profit by them, and in nine hundred and ninety-nine cases out of a thousand can only judge that things have not succeeded because they are not repeated. Why they failed, and where, is only learnt, if at all, by hearsay. This is much to be regretted. On this very subject a most valuable lesson in mechanical railway engineering could be derived from a full report of the trials of novel types of locomotives. But we are not likely to get it, and we have to deduct from what we do know things that we do not know. It is some satisfaction to recall that Wellington, applying that observation to warfare, said it was the chief business in life. On this ground, then, let us examine one or two suggestions. Take, for example, the water-tube boiler for locomotives. It has been tried in France and elsewhere. In the exhibition at Nancy Messrs. Schneider showed a large engine, 1,600 square feet of heating surface, so fitted. It was illustrated in *The Engineer* on October 22nd, 1909. If the engine had been a success we may take it that more would have been heard about the design. The *Chemin de Fer du Nord* has gone part way in the same direction. M. Bosquet built several engines of large size with water-tube fire-boxes. Not cross tubes like those Mr. Drummond used, but regular walls of tubes like a small water-tube boiler. The engines work well up to a point, but rumor has it that they are very wet steamers. Several other forms of water-tube, or pseudo water-tube, fire-boxes have been tried, but the object is generally to get over fire-box troubles rather than to increase boiler efficiency. The Nord boxes were designed with the latter object and did not attain the former, for their joints gave trouble—to begin with, at least. The loading gage restrictions have practically settled the type of water-tube generator for locomotives. It must be of the upright tube type. To get a boiler of the kind into the standard gages, which are rigidly fixed by platforms, tunnels, etc., is no easy matter. The problem is impossible of solution if the boiler must be kept between the driving wheels, and the usual method of inventors is to carry it above small wheels. Even then the outside dimension in this country is only 9 feet, and by the time a very large engine—and no one would consider these changes for small engines—is reached the generator reaches a great length. A Yarrow boiler, for example, with 3,000 square feet of heating surface, would have a grate of about 60 square feet. It would have to be 12 feet to 15 feet long—not an easy length to deal with on a locomotive. If still greater power is required the boiler gets still longer, for it cannot get any wider, and a ridiculous position is soon attained. Hand firing is practically out of the question, and the mechanical stoker in one form or another has to be introduced. Mechanical stoking of locomotives is making considerable progress in America, but the problem to be solved is very different from that met in land installations. The same kind of stoker will not do, and it is very doubtful, to say the least of it, that a moving grate suitable for a land boiler of the Yarrow type would be serviceable on a boiler swaying and jerking as a locomotive boiler does. In the Reid-Ramsay engine—the most ambitious attempt to revolutionize the steam locomotive yet made—the ordinary boiler was retained; acute engine builders like Mr. Reid's firm preferred to adhere to the common form. So much for the boiler; let us now turn to the engine itself. The innovators desire to see a high-speed motor of some kind employed. Whether it be of the ordinary reciprocating type driven by steam, gas or oil, or a turbine, does not affect the problem appreciably. In any case, reduction gear of some kind must be employed between the engine and the wheels. To maintain economy superior to that of a slow-speed engine, the high-speed motor or turbine must run all the time at something approaching its limit.

There is no advantage to be gained from the high-speed engine if speed be reduced. We find ourselves immediately in the midst of a whole host of complications, into which it would be merely wearisome to enter. Mechanical, hydraulic or electric means have to be employed to convert the high speed of the engine into sufficient torque for starting a heavy train or for keeping it in motion when started. Worse still, there must be an infinite range of speeds between the highest and the lowest. The internal combustion engine can be regulated for speed to a certain extent without great loss of economy; not so the turbine. Hence reduction gear like that of a motor car will not serve for the latter, and electric reduction is generally favored. This means a generator, several motors, a switchboard and those numerous accessories which always accumulate round everything electrical. The multiplicity of separate parts and items becomes enormous, and the cost of the engine goes up with leaps and bounds. The reformer generally turns a blind eye to this drawback to his schemes, as well as to the high upkeep charges that his designs involve. On this rock, if it could pass the mechanical test, the revolutionized locomotive would split. The economy gained by turning the locomotive into a traveling power station and distribution system is swept away in capital cost and depreciation and upkeep charges.

There are many more points on which we might touch, the excessive length of these reformed locomotives for one, but enough has been said to show that, for the present at least, there is not the least likelihood of any revolution in locomotive design spreading. This is not due to prejudice on the part of locomotive superintendents or builders. It is due to reasoned conviction. The Stephenson locomotive has triumphed by reason of its simplicity. It does what it has to do in the most direct way possible, and where there are no great countervailing advantages associated with complication, simplicity and directness are always the best in mechanical engineering—and in most other things. We have not yet reached the time when the ordinary type of engine is unable to meet the requirements of the traffic superintendent, and till we do we shall not see the general introduction of a type which, against far greater cost to build and far greater cost to keep in repair, has nothing to set but a problematical small economy.—*The Engineer.*

Aiming With the Rifle*

Some of the Difficulties Encountered, and How They May Be Overcome

By Edwin Edser

So many people are now learning to shoot with the rifle that it is profitable to consider some of the difficulties they are likely to meet with. These difficulties become greater as the age of the learner increases, and they may be minimized or accenuated by the lighting of a range at which the learner practices. A discussion of the lighting of rifle ranges, which took place at the monthly meeting of the Illuminating Engineering Society on May 18, shows very clearly that the existing conditions place artificial obstacles in the way of the learner; and it may fairly be contended that these obstacles never would have arisen, and the path of the learner would have been considerably smoothed, if certain optical principles had been recognized and utilized. Mr. A. P. Trotter, who opened the dscussion, gave a very clear account of the difficulties encountered by a man of middle age when he attempts to shoot at one of the many indoor ranges which have recently been opened; it has appeared to me to be worth while to attempt to explain some of these difficulties, in order that those which are avoidable may be eliminated.

An experimental arrangement which can be used to illustrate the essential difficulties to be met with in aiming with the rifle, is represented in perspective in Fig. 1. *A* is a rough model of the eye. It comprises

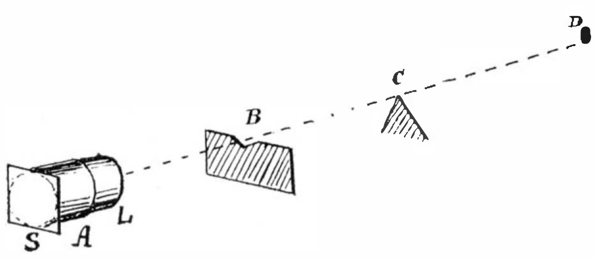


Fig. 1.

a tube about 1½ inches in diameter and 3 inches long, closed in front with a lens *L* of about 3 inches focal length; into the back of this tube fits another tube, which carries a screen of ground glass *S*. *B* is a sheet of cardboard, with a notch in the upper edge, to represent the rear-sight of the rifle. *C* is a piece of card cut to a point, to represent the fore-sight of the rifle. *D* is a circular opaque disk which, for convenience, may be attached to the glass of a window of the room in which the experiment is conducted; this disk represents the "bull's-eye" of the target. By sliding the screen *S* in or out, either *B*, *C*, or *D* may be focussed; but all cannot be focussed at the same time. If, however, the lens is covered with a piece of card provided with a circular aperture of about ½ inch diameter, *A*, *B*, and *C* can all be focussed simultaneously; and the screen *S* can be moved in or out through some distance without impairing the clearness of the image on the ground glass. The brightness of the image is, however, much diminished. This illustrates the advantage and disadvantage due to the use of "pin-hole" spectacles. If the card is arranged so that its circular aperture lies over the middle of the lens, and the images of *B*, *C*, and *D* are formed at the middle of the ground-glass screen, the position of the image of either *B*, *C*, or *D* is identical with that of the corresponding image produced, with the card removed, by adjusting the position of the ground-glass screen; but if the aperture of the card is displaced toward the edge of the lens *L*, the various images are displaced both relatively and absolutely.

Further, let the perforated card be removed, and let the screen *S* be adjusted so that the "bull's-eye" is focussed; then on covering the lens from below by a piece of unperforated card, it will be seen that as the card rises, the image of the "bull's-eye" sinks, while the images of the sights rise. A similar effect can be observed with regard to the eye. If the model eye *A* is removed, and replaced by the eye of the observer, adjusted so that *B*, *C*, and *D* are in alignment, while *D* is focussed, it will be found that if the pupil of the eye is gradually covered from below by a piece of card, the "bull's-eye" appears to rise above the sights.[1] To understand this result, it must be remembered that the image produced on the retina is inverted, and that an absolute depression of the image is interpreted as an apparent rise of the object viewed. The apparent motion referred to is very marked when the light is dim and the pupil is expanded; it can only be noticed with some difficulty in bright daylight.

Returning to the arrangement represented in Fig. 1, it will be found that when the "bull's-eye" is focussed by the unstopped lens *L*, raising the card *B* causes the image *D* to sink. Similarly, in a dim light, on bringing the rifle into position so that the rear-sight intercepts light from the lower part of the pupil, the "bull's-eye" appears to rise. In a greater number of cases, when the fore-sight is brought too high, so as partially to cover the "bull's-eye," the latter appears to swell at its upper left-hand edge (at about "half-past ten"), and sometimes this swelling develops into a second "bull's-eye" detached from the first one.

The following important phenomena can also be noticed:

(1) On focussing the bull's-eye with the lens *L* unstopped, the image of the fore-sight *C* is surrounded by a narrow penumbra; a similar but wider penumbra borders the image of the rear-sight *B*. If the lens is now stopped down, the circular aperture of the card being over the middle of the lens, the images of *B* and *C* become sharp, and it will be noticed that *the images of the edges of the sights now have the same positions as the edges of the corresponding penumbras produced by the unstopped lens.* Thus it appears that in aiming with the rifle, when the bull's-eye is focussed, the top of the narrow penumbra surrounding the fore-sight should be brought level with the top of the wider penumbra bounding the shoulders of the *V* or *U* rear-sight. I have found that this procedure leads to consistent and good shooting. A peculiarity of the penumbra surrounding the ocular image of the fore-sight will be mentioned later.

(2) On focussing the fore-sight *C* with the lens *L* unstopped, the image of the bull's-eye *D* becomes much smaller, and may even disappear. The image of the rear-sight is slightly improved. Similarly, when aiming with the rifle, the image of the bull's-eye is diminished in size when the fore-sight is focussed by the eye.

(3) On focussing the rear-sight *B* with the lens *L* unstopped, the bull's-eye *D* disappears, and the fore-sight *B* becomes smaller and less distinct.

Now, young people can alter the focus of their eyes without effort; they see the bull's-eye, the fore-sight, and the rear-sight in rapid succession, so that sometimes they appear to see all three at the same time. In this case sighting is easy. But with advancing age comes the necessity for effort in focussing the eye to different distances, even if this capacity is not lost altogether. For myself, I can read print (even small print) at 10 inches from my eye, but a perceptible effort is required to alter the focus of my eyes; and from the result of my own experience, together with that of several men in a condition similar to my own, I strongly advise that the bull's-eye only should be focussed, the tip of the fore-sight being brought just below the bottom of the bull's-eye and level with the top of the penumbra which bounds the shoulders of the rear-sight.

A peculiarity of the image of the fore-sight, when the bull's-eye is focussed by the eye in a dim light, must now be mentioned. At first sight the appearance presented is that of three images[2] standing side by side, the central image being the darkest. On careful scrutiny, however, two overlapping images only are seen, the portion common to both being darker and giving the appearance of a third image (Fig. 2, *A*).

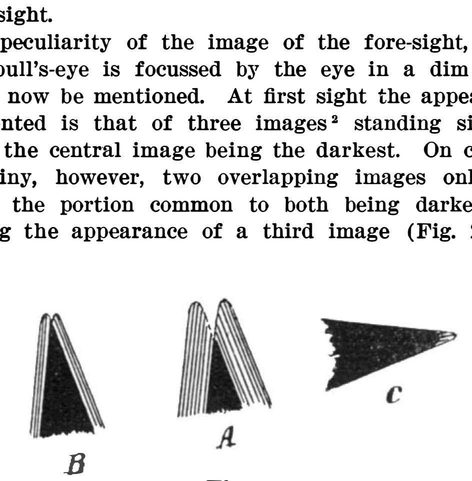


Fig. 2.

No such appearance can be obtained with the model represented in Fig. 1; we must therefore seek for its explanation in some defect peculiar to the eye. With a little care a somewhat similar double image can be seen even in fairly bright daylight. Let the pointed tip of a lead pencil be placed (for steadiness) upright against the glass of a window, and then, with one eye closed, look with the other eye past the pencil at some distant object; a narrow penumbra will be seen round the tip of the pencil, and on observing this carefully it will become evident that there are really two overlapping images of the pencil tip standing side by side, the portion common to the two being dark (Fig. 2, *B*). The nearer the eye is to the pencil, the greater is the separation of the images; in daylight, separation is just visible (to me) at a distance of about 3 feet. If the *right* half of the pupil is now covered by a card, the *left* image disappears; on covering only the *left* half of the pupil, the *right* image disappears. If the pencil is placed in a horizontal position, the appearance is quite different; the pencil now appears sharply defined laterally, but its tip ends in a penumbra (Fig. 2, *C*).

It appears to me that these phenomena may be ascribed to the peculiar shape of the cornea. It has long been known that the cornea is not spherical, and Sulzer has found that its form does not agree with any

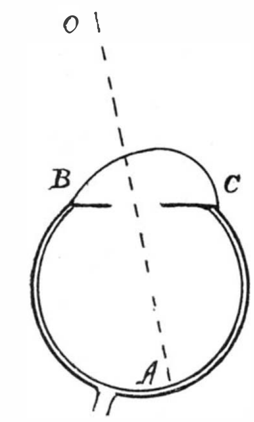


Fig. 3.

known simple surface, and that it has no axis of symmetry. In the majority of cases the nasal side of the cornea is flatter than the temporal side, so that the section of the cornea of the right eye, when viewed from above, resembles *BC*, Fig. 3. The visual line *OA* (i. e., the line along which the most direct ray travels from the object *O* to the most sensitive portion of the retina *A*) passes through the flatter portion of the cornea; and the center of the pupil is also behind the flatter portion of the cornea. Thus when the light is good, and therefore the pupil is small, the rays which form the image on the retina pass through the flatter portion of the cornea; and under these conditions we obtain the best occular images.

Now, in aiming with the rifle in a dim light, the bull's-eye being focussed, if the cornea were spherical, there would be a number of overlapping images of the fore-sight, thus giving rise to the appearance of a single dark image surrounded by a penumbra. The peculiar shape of the cornea, however, appears to cause a segregation of these images into two groups, giving rise to two overlapping images side by side. The light which enters the right eye through the left part of the cornea (i. e., the flatter portion) gives rise to the right-hand image; that which enters through the right (more strongly curved) portion of the cornea gives rise to the left image. So far as my experience goes, the right image is the darker and better defined of the two; and we might expect this to be the case, since it is formed by the rays which traverse that part of the cornea which is utilized when vision is at its best. It therefore appears that *the right-hand image of the fore-sight should be aligned with the middle of the notch of the rear sight, its tip being just below the bull's-eye at "six o'clock," and just level with the top of the penumbra that bounds the shoulders of the V or U rear-sight* (Fig. 4). In a dim light it is well to allow for the fact that the bull's-eye is apparently raised, by leaving a distinct white line between the tip of the fore-sight and the lower side of the bull's-eye. In all cases the fore-sight should at first be aligned some distance below the bull's-eye, and raised to its final position just before firing.

When the rifle is aimed in daylight *with a bright sky overhead*, light is reflected from the upper rim of the rear-sight into the eye. When the bull's-eye is focussed, this light forms three bright linear images in the eye. The lowest bright line occupies the position of the upper boundary of the black portion of Fig. 4; the middle bright line occupies the position of the upper boundary of the penumbra shown in

* From *Nature*.

[1] See "Spherical Aberration of the Eye," by E. Edser (*Nature*, April 16, 1903). Also "Light for Students," by E. Edser (Macmillan & Co.), p. r65.

[2] These appear to be the three images mentioned by Mr. Trotter.

Fig. 4; while the upper bright line bounds a faint secondary penumbra which is scarcely visible in a dim light. Similarly, if a diaphragm with a narrow horizontal slit is placed in front of an eye focussed to see distant objects, three bright images of the slit are seen. These multiple images, which vary somewhat in position for different observers, and even for the two eyes of a single observer, are presumably due to variations of curvature of the cornea in a vertical plane. Correct shooting can be obtained by aligning the top of the fore-sight with the *central* bright line which bounds the lower penumbra; as this line is clearly seen, it can be utilized as easily as the focussed image of the rear-sight. The advantage of a good overhead light thus becomes apparent.

So far as the lighting of indoor ranges is concerned, it may be inferred that we shall see best under those conditions which approximate most closely to ordinary

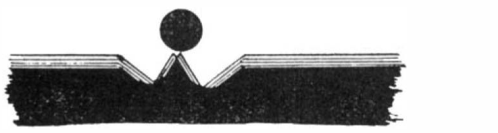


Fig. 4.

diffused daylight. The use of a small, bright illuminated target, in a room with black walls and ceiling, could be defended only if it were desired to train people to shoot at a distant searchlight. In such conditions the pupil is distended, all of the troubles discussed above are intensified, with the addition that the glare of the target tires the eyes. Similarly, the glowing filament of an incandescent lamp tires the eye more when it is viewed in a dark room than when it is viewed in daylight. I believe that the best thing to do in connection with indoor rifle ranges would be to whitewash the walls and ceiling, and have a good illumination either with electric glow lamps or incandescent gas mantles, merely taking the precaution that the lamps are shielded (say, by paper shades) from the direct view of the shooters.

So far as the utility of miniature rifle ranges is concerned, it appears to me that this may be easily overrated. It is possible, of course, at one of these ranges to learn to hold the rifle correctly, to become accustomed to accurate sighting, and to press the trigger without moving the rifle. Difficulty, however, arises from the fact that accurate shooting entails compliance with *all three* of these requirements, and bad shooting may be due to a failure in one only. The position of the bullet-hole in the target gives only the net result of all the actions involved; and I have known men to ascribe their failure to get near the bull's-eye to the defective sights of the rifle, or (more rarely) to their own defective sighting, when in reality their bad shooting was due to *pulling* the trigger instead of *pressing* it. It is clear that more rapid progress can be made if the learner can discover the particular defect to which his failures are due. Various devices have been used for this purpose.

In the sub-target, the rifle is mounted on a universal joint, and on pressing the trigger a hole is punched in a card, thus indicating the direction in which the rifle is pointed at the instant. This appliance is expensive, and since the rifle is not free, defects due to trigger-pulling are not made evident.

The aim-corrector is a piece of plain smoked glass mounted behind the rear-sight so that its surface is inclined at 45 degrees to the sighting line. The learner takes his sight through this glass in the usual way; the instructor watches the sights from the side, as they are seen reflected in the glass. Obviously, the instructor must possess considerable skill in order to use this appliance with advantage.

The aiming disk is a perforated metal disk which is placed in the observer's eye like a monocle. The learner aims at the perforation, and any *considerable* motion of the rifle during trigger-pressing can be seen by the observer. This appliance can only be used with advantage at short distances from the learner, and anyone accustomed to the use of firearms can scarcely avoid an uncomfortable feeling on watching a gun that is pointed at his eye.

I have devised a simple appliance by means of which most (if not all) of the benefits usually derived from a miniature range can be obtained without the use of ammunition. This appliance is represented diagrammatically in Fig. 5. A metal tube T, which can be fitted to the bayonet standards of a rifle, is provided with a lens L at the front end, and a small electric glow-lamp G at the rear end. The lens L can slide in or out, so that the image of the glowing filament of the lamp can be focussed on a white screen placed near the target. The current for the lamp can be supplied by three or four Leclanché cells; or a battery of dry cells, similar to that used for an electric torch, can be fixed to the tube T, thus obviating the inconvenience of the leads from the lamp to the cells. It is best to aim at a target about 10 yards away; an observer, who need possess no qualifications other than general intelligence and quickness of perception, stands or sits by the target and watches the image of the filaments formed on the screen. I have obtained small electric glow-lamps which produce an image approximating in shape to a V. The position of the point of the V, at the instant when the trigger is pressed, can be marked on the screen; and if the rifle

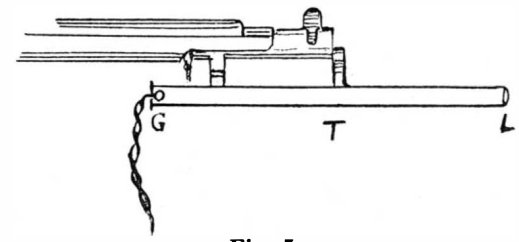


Fig. 5.

is moved during the act of trigger-pressing, the direction of motion, and its extent, can be marked by an arrow. If the position of the point of the V has previously been marked when the rifle was aimed by an expert, the correctness or otherwise of the learner's sighting is seen at a glance. I have found that most learners aim better than they shoot; that is, they sight the rifle on the bull's-eye with some approach to correctness, and then pull it away while they are actuating the trigger. If the learner is particularly bad at sighting, the rifle may be supported on a sand-bag or tripod stand, and sighting can be practiced until a satisfactory "triangle of error" is obtained.

I have found, by the aid of the appliance just described, that different people can aim a rifle with perfect consistency according to the rules given earlier in this article.

English Measures of Length*

The History of Their Origin and Development

By Colonel Sir Charles M. Watson

ALTHOUGH there is considerable variety in the measures of length used by the different nations of the world, there can be no doubt that they are, for the most part, derived from a common origin, and that their ancestors, if the expression may be used, existed in times so remote that the date of their invention has been completely lost. But the study of what the original measures were is a matter of considerable historical importance, and the question can be investigated by an examination of the changes made in the course of generations by the people who have adopted them—changes, in some cases, apparently due to accident rather than design.

For the sake of clearness, it is convenient to divide the measures of length into four categories which are, to a certain extent, independent of one another, and may be defined as follows:

(1) The shorter measures of length, used for building and manufacturing purposes, of which the more important in ancient times were the cubit, the palm, and the digit, or finger breadth, and the English representatives are the yard, the foot, and the inch.

(2) The shorter measures of distance, such as the foot, the yard, and the pace.

(3) The longer measures of distance, including the stadium, the mile, the parasang, the schoenos, the league, the hour's march, and the day's march.

(4) Measures of length used in connection with the calculation of land areas, of which the English representatives are the perch, the chain, and the furlong.

As regards the first of these classes of measures, it is generally accepted that they were, from the earliest times, based on the proportions of the human body, so that every man had his own scale to which he could work. As, however, men are not all of the same size, there is considerable variety in the length of the different units, but, with some exceptions, they may be included within the following limits:

The digit, or finger breadth,	from	0.72	to	0.75	English inch.
The palm,	"	2.88	to	3.00	" inches.
The cubit,	"	17.28	to	18.00	" "
The fathom,	"	5.50	to	6.00	English feet.

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

The palm is the width across the open hand at the base of the fingers; the cubit is the length of the arm from the elbow to the end of the middle finger; and the fathom the length of the outstretched arms. There is no fixed relationship between these units.

There is no record as to when an attempt was first made to combine the measures in a standard scale, but it was probably at an early period, as it must have been found inconvenient for workers on the same building, for example, to use different lengths of palms and cubits, and, when a standard was fixed, it may have been some such scale as the following:

	1 digit	=	0.7375	English inch.
4 digits	= 1 palm	=	2.95	" inches.
6 palms	= 1 cubit	=	17.70	" "

The cubit of this scale may be called the "cubit of a man," to distinguish it from other cubits, which will be described hereafter.

In process of time it was found desirable to have a smaller unit than the digit, and this was made by taking it as equal to six grains of barley placed side by side. In the English scale, barleycorns were also used as the smallest measure of length, but in this case they were placed end to end, three barleycorns so placed being taken as equal to one inch.

There is no evidence that the foot was included originally among the units of the hand worker given above, and it may, perhaps, more properly be regarded as belonging to the second class of measures, derived from the distance covered by a man walking, and as a subdivision of the important unit, the pace. The pace is of two kinds, the first being the single pace, or distance covered by the step of one foot, and the second, the double pace, the distance covered by both feet one after the other.

In the case of the Roman double pace, a very important measure, the pace was taken as equal to five feet, but this was an artificial connection, as there is no fixed proportion between the length of a man's foot and the length of his pace.

There is nothing to show when the foot was added to the units of the mechanic's scale, but when this was done it was assumed to be equal to four palms, or two thirds of a cubit.

The third class of measures of length is the most important, and the history of these is of particular interest, as they appear to have started in a state of perfection, and to have been first used by a people who possessed a high degree of astronomical and mathematical knowledge, who were acquainted with the form of the earth, and were able to carry out accurate geodetical measurements. It is also remarkable that the changes made as regards these measures in the course of time have been changes for the worse, in consequence, apparently, of the origin of the measures having been forgotten. There can be no doubt that they are based on the angular division of the circle, and on the application of this division to terrestrial measurements.

The unit of angular measurement is the angle of an equilateral triangle, and this angle was divided by the ancient geometricians, for purposes of calculation, into 60 degrees, the best number possible, as $60 = 3 \times 4 \times 5$. Following the same principle, each degree was divided into 60 minutes, and each minute into 60 seconds. As the circle contains six times the angle of an equilateral triangle, the circle was divided into 360 degrees. This division of the circle, although so ancient that its origin is unknown, has never been improved upon, and is still in use by all nations. An attempt on the part of certain French mathematicians to substitute a division of the circle into 400 degrees, on account of the supposed advantages of the decimal system, has proved a failure.

The manner in which the division of the circle into 360 degrees was used by the ancients to determine the unit for terrestrial measures of distance was as follows: If a circle be described cutting the equator of the earth at right angles, and passing through the north and south poles, its circumference in angular measurement is equal to 360 degrees $\times$ 60 minutes = 21,600 minutes, and the length of 1 minute, measured on the surface of the globe, was taken as the unit, which is called a geographical mile at the present time. If the earth was a perfect sphere, every geographical mile would be of the same length, but, as the polar diameter is less than the equatorial diameter in the proportion of 7,900 to 7,926, the length of the geographical mile, measured on the meridian, is not the same in all latitudes, but increases in length from

6,046 English feet at the equator to 6,108 English feet at the poles. Whether the ancient astronomers were acquainted with this irregularity in the figure of the earth is not possible to say, but it is certain that the value at which they fixed it must have been close to the actual mean value as determined by modern astronomers, which may be taken as about 6,075 English feet. The Greek stadion (the same as the Roman stadium), which was one tenth of the geographical mile, was 600 Greek feet in length, and the Greek foot was about 12.15 of our present English inches.

The next step taken appears to have been with the view of assimilating the subdivisions of the geographical mile with the cubit, and it was not easy to do this, as the cubit of a man has no necessary connection with a geographical mile. The difficulty appears to have been solved by the invention of two new cubits, of which the smaller was very nearly equal to the cubit of a man and was contained 4,000 times in the geographical mile. This, for the sake of distinction, may be called the geographical cubit. The second cubit, afterward known as the Babylonian Royal cubit, was longer, and was contained 3,600 times in the geographical mile. According to Herodotus this second cubit was three digits longer than the other cubit. On these two cubits there appear to have been based two different divisions of the geographical mile, one in accordance with a decimal, and the other with a sexagesimal system of calculation, but there is, so far as I know, no ancient record of these scales, and the following attempt to compose them is founded on inferences, drawn from the Babylonian, Greek and Roman measures, all of which, there can be little doubt, came from the same origin.

The first, based on the geographical cubit, which was rather longer than the average cubit of a man, is as follows:

		1 digit	= 0.729	English	inch.
25 digits	=	1 geographical cubit	= 18.225	"	inches.
100 "	=	1 fathom	= 6.075	English	feet.
100 fathoms	=	1 stadion	= 607.5	"	"
10 stadia	=	1 geographical mile	= 6075	"	"

The second, or sexagesimal scale, based on the Babylonian Royal cubit, appears to have been as follows;

		1 digit	= 0.723	English	inch.
28 digits	=	1 Royal cubit	= 20.25	"	inches.
60 cubits	=	1 plethron	= 101.25	English	feet.
60 plethra	=	1 geographical mile	= 6075	"	"

Some writers are of opinion that the Babylonian Royal cubit was composed of 30 instead of 28 digits, but this appears to be improbable, because it would make the digit too small, and, if Herodotus is correct, it would make the cubit in the decimal scale consist of 27 digits, an inconvenient number. Nor is there any evidence to prove that a cubit was ever divided into 27 digits, while Prof. Petrie has shown, in "Inductive Metrology," that the division of the cubit into 25 digits, and of the fathom into 100 digits, is very probable. There was another Babylonian measure of length called the gar, used for land measurements, which appears to have been composed of 12 Royal cubits. It was the ancestor of the English land measure, the perch, which is 11 English cubits in length.

The ancient Egyptian measures of length, although evidently derived from the same origin as the Babylonian, differ from these in some respects. The most important smaller unit was a cubit usually known as the Egyptian Royal cubit, which was divided into seven palms, each palm of four digits. The approximate length of the Egyptian Royal cubit is well known, as a number of cubit scales have been found which give a mean length of 20.65 inches, and an examination of the monuments of Egypt shows that this cubit was used for building purposes from ancient times.

Prof. Petrie, in "Inductive Metrology," has given a large number of samples of the Egyptian cubit derived from the measurements of buildings, which vary from 20.42 to 20.84 English inches, and yield a mean value of 20.64 English inches, or almost exactly the same as the mean length of the cubit scales.

As is generally the case with regard to measures of length in all countries, the Egyptian cubit appears to have grown longer in course of time, and there is a good instance of this shown by a comparison of the three nilometers on the island of Philæ, above Assuan, of which the first gives a mean value for the cubit of 20.47 English inches, the second of 20.81, and the third of 21.05 English inches.

The best results given by Petrie are based on his measurements of the Great Pyramid of Gizeh, the great chamber of which, having a length of 20 cubits and a width of 10 cubits, yields a cubit of 20.627 English inches, while the height of 78 palms gives a cubit of 20.65 English inches. The length of the side of the base of this pyramid is of particular interest, as it appears to have been designed as one eighth of a geographical mile. This length is not easy to measure, as the lower part of the pyramid is covered with sand and rubbish, and the stones which cased it have been removed. Petrie, after very careful measurement, arrived at the conclusion that it was 755.7 English feet. There are reasons for thinking it may have been a little more than this, but less than 760 feet. The length of a geographical mile at the latitude of the pyramid is 6,060 feet, and one eighth of this is 757.5 feet, or so nearly equal to the length of the side of the base that it is difficult to believe that the architect had not this in view when he designed the pyramid. The side of the base was therefore equal to 500 geographical cubits, and very nearly equal to 440 Egyptian Royal cubits—a remarkable coincidence, if it is only a coincidence. It is interesting to note that there are 440 English cubits in the English furlong, but whether this has any connection with the measure of the pyramid there is no evidence to show.

There was a good reason for making the side of the base 440 cubits, as the height is equal to the radius of a circle, of which the perimeter of the base is the circumference, so that the height was 40 × 7 cubits, and the length of the side 40 × 11 cubits. It would be interesting to know how the ancient Egyptian geometrician arrived at so close an approximation to the value of π as $\frac{22}{7}$.

It is matter of controversy from whence the Greeks derived their measures of length, whether from Egypt or Babylonia; but the latter appears more probable, as their principal measure of distance, the stadion, was equal to one tenth of a geographical mile of 6,075 English feet, and this was divided into 6 plethra, each of 100 Greek feet. The Greek scale appears to have been as follows:

		1 Greek foot	= 12.15	English	inches.
1½ Greek ft.	=	1 cubit	= 18.225	"	"
10 " "	=	1 reed	= 10.125	English	feet.
10 reeds	=	1 plethron	= 101.25	"	"
6 plethra	=	1 stadion	= 607.50	"	"
10 stadia	=	1 geographical mile	= 6,075	"	"

There was another foot used in Greece, of which Petrie gives a number of instances, derived from old buildings, varying from 11.43 to 11.74, with a mean value of 11.60 English inches. This would appear to be a foot of 16 digits, used for building and manufactures, but not connected with measures of distance.

The Roman system of measures was based on the Greek, but while adopting the stadion—called by them stadium—as the fundamental measure of distance, they used the shorter Greek foot, and introduced another measure, the double pace. They also made the land mile to consist of 8 instead of 10 stadia, while retaining the geographical mile of 10 stadia for use at sea. As they had an affection for a duodecimal system of calculation, they also divided the foot into 12 inches in addition to the old division into 16 digits. The Roman scale, which showed considerable ingenuity in assimilating a number of different measures which had no real relationship to one another, appears to have been as follows:

		1 digit	= 0.729	English	inch.
		1 inch	= 0.972	"	"
4 digits or 3 inches	=	1 palm	= 2.916	"	inches.
4 palms	=	1 foot	= 11.664	"	"
6 "	=	1 cubit	= 17.496	"	"
5 feet	=	1 pace	= 4.86	English	feet.
125 paces	=	1 stadion	= 607.5	"	"
8 stadia	=	1 land mile	= 4,860	"	"
10 "	=	1 geographical, or sea mile	= 6,075	"	"

The land mile was probably made up of 8 stadia in order to have it exactly 1,000 paces in length, or it may have been considered that eight was a more convenient number for dividing than ten; but it was necessary to retain the mile of 10 stadia for navigation.

The above remarks deal with the measures of distance used by the principal nations of antiquity up to and including the geographical mile, upon which they seem to have been based, but in addition to these there are certain longer measures of distance which must be referred to, such as the parasang, the schoenos, and the league. The fundamental idea of these measures was that they represented the distance which could be marched in a given time, such as one hour, and as the rate of marching naturally varied with the nature of the country, it was not easy to have a fixed length, and when there was made a theoretical unit it did not always agree with the actual distance.

There is a good example of this in the "Anabasis" of Xenophon, in which the writer recorded the distance traveled by the Greek force, day by day, on their way across Asia Minor from Ephesus to the Euphrates, and, after the battle of Cunaxa, from the Euphrates to the Black Sea. Xenophon gives the distance from Ephesus to the battlefield as 535 parasangs, or 16,050 stadia, thus making the parasang equal to 30 stadia, or 3 geographical miles. But Col. Chesney has pointed out that the actual parasang, or hour's march, was less than this, and that it averaged 26 stadia from Sardis to Thapsacus, and about 20 stadia from Thapsacus to the battlefield of Cunaxa. A fair average hour's march for an army would be 25 stadia, equal to 3 Roman miles, and a day's march of eight hours to 20 geographical or 24 Roman miles. In the Antonine Itineraries the distance between important stations is, in a number of cases, given as 24 and 25 Roman miles, which looks as if the stations were fixed at distances apart suitable for a day's march.

In Egypt the measure of distance corresponding to the parasang was the "alter," called "schoenos" by the Greeks, and stated by different writers to have been equal to 30, 32, 40, and 60 stadia in various parts of Egypt. It is evident that it was based on the geographical mile as a rule, while 32 stadia is equal to four Roman miles. There is some doubt whether the Egyptians had a fixed length for the schoenos, and a good deal has been written with regard to it, notably a paper entitled "Der Schoinos bei den Aegyptern, Griechen und Römern," by Wilhelm Schwarz, published at Berlin, 1894.

Another longer measure of distance, which was largely used in the western parts of Europe under the Roman Empire, was the Gallic league, equal to 12 stadia or one and a half Roman miles. In the Antonine Itineraries the distances in Gaul are in some cases given in leagues, and in others in both leagues and Roman miles, while in the "Bordeaux Pilgrim," a work dating from the early part of the fourth century, the distances in the west of France are given in leagues, and afterward in Roman miles.

An important application of measures of distance from the earliest times was for the calculation of areas of land, but there is considerable doubt as to what was the original unit, and whether this was a square, or in the form of a rectangle one stadium in length and one tenth of a stadium in width. In the latter case there would have been ten measures in a square stadium, and 1,000 measures in a square geographical mile, and such a measure would seem quite in accord with the ancient system of measures of distance. Its area would have been 40 × 400 geographical cubits (36 × 360 Babylonian Royal cubits), or 0.847 English statute acre. There is a very widely distributed type of land measures based on a rectangle of this form, of which the English acre is an instance, as it measures 44 × 440 English cubits.

The Egyptian unit of land area appears to have been the "set," called "arura" by the Greeks, which was a square having a side of 100 Egyptian Royal cubits. A cubit of land was the one hundredth part of this, and was the area of a rectangle 1 × 100 cubits.

In the Greek system the unit of area was the square of a plethron or 100 Greek feet, equal to 0.235 English acre, of which there were 36 in a square stadion and 3,600 in a square geographical mile.

The Roman unit of land area, called the "jugerum," was a rectangle, 120 × 240 Roman feet, or 0.624 English acre, which was subdivided duodecimally, the uncia of land being the twelfth part of a jugerum, or the area of a rectangle measuring 10 × 240 Roman feet. The relative proportions of these different units of land area were as given below.

Area of Unit.	Number Contained in Geographical Miles.	Area in English Statute Acres.
36 × 360 Babylonian Royal cubits.	1,000	0.847
100 × 100 Greek feet.............	3,600	0.235
120 × 240 Roman feet...........	1,356	0.624
100 × 100 Egyptian Royal cubits...	1,240	0.683
Geographical square mile.	1	847.238
English square mile.....	1.324	640

It will be seen from the above descriptions that from the earliest times the shorter measures of length were based on the proportions of the human body, and the longer on the geographical mile, and that at some remote period an attempt was made to combine them into a continuous scale, from the digit to the geographical mile. When the digit was made the point of departure the decimal system of calculation appears to have been preferred, and when the scale was worked downward from the mile the sexagesimal system was the most convenient, while in the Roman scale the duodecimal system was introduced. But it is to be regretted that the more ancient system was not retained, by which the geographical mile was the unit, and was divided into 10 stadia, each of 400 cubits, or 600 feet, as it is doubtful whether the changes made by succeeding generations can be regarded as improvements.

The modern measures of the civilized world are, with few exceptions, based on the ancient units, of which they may be regarded as the direct descendants. Of these exceptions the most important are the measures of the metric system, which were designed with the object of breaking away from the records of the past by the adoption of a new geographical mile, equal to 54/100 of the true geographical mile.

The English measures of length are a good example of the modern representatives of the old units, and are worthy of study from this point of view. How the measures originally came to England it is not easy to say, but there can be no doubt that they were in use before the Roman invasion, having possibly been introduced by

Phœnician traders, and were afterward modified by the Romans, the Saxons, the Scandinavians, and the Normans, each of whom had measures, based on the old units, but altered in course of time. It was not until the thirteenth century that they were molded by law into one uniform system.

The English scale, as authorized by statute, may be summarized as follows:

		1 inch.
12 inches	=	1 foot.
3 feet	=	1 yard.
5½ yards	=	1 rod, pole, or perch.
4 perches	=	1 chain.
10 chains	=	1 furlong.
8 furlongs	=	1 English statute mile.

Of these units the inch is derived from the Roman system, being one twelfth of the foot, but the foot, on the other hand, is equal approximately to the Greek foot, while the yard, which is simply a double cubit, comes from the Babylonian system, being approximately a double geographical cubit. The perch is the English representative of the Babylonian gar, and the furlong occupies a similar place to the stadium, while the mile is composed of eight stadia, apparently in imitation of the division of the Roman mile. For use at sea, however, the geographical mile, divided into ten stadia, or, as we call them, cable lengths, has been retained, as no other mile can be used for purposes of navigation.

In order to fully understand the connection between the English measures and the ancient measures of length, it is necessary to write the scale in a somewhat different manner, and to introduce some other units which are no longer used. The revised scale is as follows:

		1 barleycorn.
3 barleycorns	=	1 inch.
3 inches	=	1 palm.
4 palms	=	1 foot.
6 palms	=	1 cubit.
12 palms	=	1 double cubit or yard.
11 cubits	=	1 perch.
405 cubits	=	1 cable's length.
4 perches	=	1 acre's breadth or chain.
10 chains	=	1 acre's length or furlong.
8 furlongs	=	1 English mile.
10 cables	=	geographical, or sea mile.

The English inch is equal in length to 3 barleycorns set end to end, or to the width of 8 barleycorns set side by side. The barleycorn, as a measure, is forgotten, but the inch on carpenters' rulers is still divided into eight parts, while on a shoemaker's tape the sizes of boots and shoes increase by a barleycorn or ⅓ inch, for every size. For example: size No. 8 of a man's boot measures 11 inches; size No. 9, 11⅓ inches; size No. 10, 11⅔ inches; and so on. One would have thought that the sizes would increase by one quarter of an inch at a time, but the barleycorn has held its place to the present day.

The palm, which was originally composed of 4 digits or finger breadths, and, since the time of the Romans, of 3 inches or thumb breadths, is no longer used in England, and its place has to a certain extent been taken by a measure called the hand, composed of 4 inches and employed in measuring the height of horses. The change may have been due to the fact that the number 4 was more convenient for division than 3, and that when the digit gave way to the inch the palm of 4 digits was replaced by the hand of 4 inches.

Prior to the thirteenth century, the length of the foot in England was uncertain, and there appear to have been several measures in use, varying from the Roman foot of 11.66 English inches to the Belgic foot of 13.12 English inches; but, by the ordinance known as the Statute for Measuring Land, enacted in the reign of King Henry III., the relations of the inch, the foot, and the cubit to one another were definitely fixed, and have never since been altered. The cubit of this statute is the double cubit, afterward called the yard. A translation of the Latin words of the statute, describing the different measures, is as follows:

"It is ordained that 3 grains of barley, dry and round, make an inch; 12 inches make a foot; 3 feet make a cubit; 5½ cubits make a perch; 40 perches in length and 4 perches in breadth make an acre.

"And it is to be remembered that the iron cubit of our Lord the King contains 3 feet and no more; and the foot must contain 12 inches, measured by the correct measure of this kind of cubit; that is to say, one thirty-sixth part of the said cubit makes one inch, neither more nor less. And 5½ cubits, or 16½ feet, make one perch, in accordance with the above-described iron cubit of our Lord the King."

It is interesting that, in this statute, the double cubit, thus accurately described, should have been called the cubit of the King, just as the longer cubits of Babylon and of Egypt were called Royal cubits to distinguish them from the shorter cubits of those countries. In the Latin original of the ordinance the word used is "ulna," the usual word for cubit. The word "yard," to signify the English double cubit, occurs for the first time in the laws of England in a statute of 1483, written in French.

The perch, equal to 11 single or 5½ double cubits, is a very ancient measure, but I cannot find at what period it was first used in England. It was employed principally in connection with the measurement of land, and I have already pointed out its likeness to the Babylonian measure the gar, composed of 12 Babylonian cubits.

The two measures, the acre's breadth, afterward called the chain, and the acre's length or furlong, have also been used from a very early period. The former is equal to 44 single cubits, 22 yards, or 66 English feet, while the latter is exactly ten times this, 440 cubits, 220 yards, or 660 feet. The furlong is the modern representative in our system of the ancient stadium, which had a length of 600 Greek feet, or 607.5 English feet, but the reason for its being longer than the stadium has so far as I know not been satisfactorily explained. But the change may have been due to the fact that other measures of distance were in use in England prior to the present statute mile, which varied in different parts of the country, and the mean of these was approximately equal to the Gallic league of 12 stadia or 7,290 English feet. One-eleventh of this, 663 English feet, is approximately equal to the English furlong, and eight of these measures, following the Roman system, were combined to form the English statute mile.

But whether this is the origin or not, there appears little doubt that the mile, furlong, and chain, or acre's breadth, were in use in England in Anglo-Saxon times, as there is a law of King Athelstane, who reigned A. D. 925-940, in which it is enacted:

"Thus far shall be the King's grith from his burgh gate where he is dwelling, on its four sides; that is three miles, and three furlongs, and three acre's breadth, and nine feet, and nine palms, and nine barleycorns.

The length of the measure called the King's grith, or King's peace, was the distance from his house within which peace was to be maintained, and it is evident that in this law an attempt was made to express the distance in terms of ordinary measures. Converting these terms into feet we have:

3 miles	= 3 ×	5,280 feet	=	15,840	feet.
3 furlongs	= 3 ×	660 "	=	1,980	"
3 acre's breadth	= 3 ×	66 "	=	198	"
9 feet	=	9 "	=	9	"
9 palms	=	2¼ "	=	2¼	"
9 barleycorns	=	¼ foot	=	¼	foot.
		Total		18,029½	feet.

18,029½ = 601 × 30 very nearly, so that it would appear that the length of the King's grith was 30 stadia, the same measure as that known in the East as the parasang, and in Egypt as the schoenos. It is remarkable that this measure should thus appear to have found its way to England, and there be regarded as a Royal measure.

There was another measure of distance used in England, known as the leuga, composed of 12 furlongs, which corresponded to the Gallic league of 12 stadia already described. In the Chronicles of Battle Abbey, which extend over the period A. D. 1066-1176, in the account of the lands belonging to the abbey, the following statement occurs: "The English leuga contains 12 roods (furlongs), and 40 perches make one rood; the perch is 16 feet in length; the acre is 40 perches in length and 4 in breadth; but if it is 20 perches in length, it shall be 8 in breadth." The acre's length, here called rood, and the acre's breadth appear to have been the same as in the time of King Athlestane, and the foot is the Saxon foot, equal to 12.375 of our present inches. The measurement of the acre, 4 × 40 perches, is the same as that given in the Statute for Measuring Land enacted in the reign of King Henry III., which has already been referred to.

The terms acre's length and rood are no longer used, and this measure is now known as the furlong, while the acre's breadth has been called the chain since the beginning of the seventeenth century, when it was divided into 100 links instead of 66 feet. The chain, which was the invention of Prof. Gunter, has proved very convenient for the measurement of land acres, and is always used.

Since the introduction of the chain, the perch or rod has been less employed in connection with land measures, but is still used by builders for the measurement of brickwork. The common English stock brick is half a cubit in length, one quarter of a cubit in width, and one sixth of a cubit in thickness, or rather less than these dimensions, to allow for the thickness of the mortar joints, while a rod of brickwork, which is the unit for builders' work, is a mass of brickwork, one rod or 22 bricks in length, one rod or 66 bricks in height, and three bricks in thickness. The perch or rod of brickwork contains 4,356 bricks.

The English sea mile is exactly the same as the geographical mile of the Babylonian system, and its tenth part, the cable length, is identical with the stadium. In these measures there has been no change, and the only difference is that the cable length is 405 English cubits, whereas the stadium was 400 original cubits. This is due to the fact that the English cubit is a little shorter than the latter in consequence of the English foot, as fixed by law, being rather less than 1/6,000 part of the geographical mile.

The Medical Needs of Modern Armies

INTERESTING side lights on the need for a sufficient supply of medical officers in war are shed by correspondence to the London *Lancet* of November 20, 1915. The secretaries of the Harveian Society called a meeting of that society to discuss the organization of the British medical profession for war service, and in their official announcement said: "This topic is assuming very great proportions, for the actual personnel of the Army Medical Service already be approaching 10,000 in place of the peace establishment of 1,000." And on the same page another communication says: "The authorities at the War Office are very uneasy about the supply of doctors to the Army. At their request a War Emergency Committee in connection with the British Medical Association has been established, and a committee is working with all its power to see if they can find by the middle of January some 2,000 odd medical men which the War Office deem necessary."

It appears, then, that the British army will shortly include no less than 12,000 physicians with the colors, in order to satisfy present immediate needs in the medical service. This despite the fact that the main bulk of the fighting is in Flanders, where the conditions of trench warfare and short haul permit of great economies in medical personnel through the ability to eliminate many of the intermediate sanitary formations which are ordinarily required to bridge the gap between the firing line and the base.

Clearly the situation as to medical officers in which Great Britain finds itself has many morals for us. We must appreciate that in the United States, too, the day of little things is over and that no question of national preparedness is complete without the inclusion of the medical profession in civil life in terms of many thousands. Such immense numbers of troops will be necessary that any regular medical personnel which could be maintained in peace will scarcely suffice to leaven the mass in war. Efficient administrative machinery must be created and maintained to secure and instruct in the elements of their medico-military duties the vast mass of medical men whose services will be required. This additional work will chiefly fall upon the Medical Corps of the army, now both actually and relatively too small to do its routine work in time of peace. Efficiency demands that not only must the Medical Corps be given enough officers in the coming defense plans to do the peace work of the standing army, but it must share proportionately in the large extra and unassigned list of officer instructors which all schemes for defense agree upon as being absolutely necessary for the education and training of the second line forces.

An army is a many-sided and very complex structure, every part of which has a definite relation, usefulness and proportion to the rest. This is a fact of which many of the civilians upon which we have to depend for service legislation are ignorant, and one which a certain few line officers who are better informed seem to choose to ignore. To attempt to pile up fighting men without sufficient medical personnel to maintain physical efficiency defeats any expectation of securing maximum fighting strength. The Medical Department wants only what is necessary. It must insist on having enough officers in peace time to make it feel a reasonable competence to perform satisfactorily the tasks which devolve upon it in peace. It will expect in time of war a personnel adequate to perform war duties. With anything less than this reasonable provision it will not be satisfied.—From the *Military Surgeon.*

[See "The Medical Reserve Corps, U. S. Army," in SCIENTIFIC AMERICAN SUPPLEMENT No. 2075, October 9, 1915.]

Planting Trees With Dynamite

So much is now being written about the use of high explosives in war that many are apt to lose sight of the fact that this same agent is an exceedingly useful servant for peaceful operations, and that new and ingenious methods of applying are constantly being devised. A recent novel application of the powers of dynamite was for planting trees. There was an apple orchard of four thousand trees to be planted, and as winter was approaching, no time could be lost, lest a sudden turn in temperature should freeze the ground. The man who undertook the work first mounted a 2½ horse-power gasoline engine on the running-gear of a light farm wagon, and arranged it to operate a soil-auger, and with this outfit two men were able to put down as many holes in a day as thirty men could have punched with a bar and sledge. In these holes light charges of dynamite were exploded to form an excavation in which to plant the trees, a number of holes being fired at a time. By this method the entire orchard was planted in less than 15 days of 9 hours each.

Battery Versus Magneto Ignition*

By Frank Conrad[1]

The mechanism for igniting the charge in the cylinder of an explosive engine is one of the foremost problems of design with which the automobile engineer has to contend. Its general development is one of evolution, a condition which is true of all new problems in engineering.

The ignition mechanism on the early automobile engines was copied from the system as used on stationary engines of that day. This was the so-called make-and-break system in which an electric circuit was mechanically closed and opened through contact points placed inside the cylinder. The electric circuit usually consisted of a simple reactance coil in series with a few cells of primary battery. The inductive discharge from the coil produced a spark on separation of the contacts which ignited the charge in the cylinder. Under limited conditions this system leaves little to be desired. The electrical apparatus is simple and easily understood. The ignition spark is very hot and if the mechanical part is well made its operation is practically perfect.

ADVANTAGE OF JUMP-SPARK SYSTEM.

The next scheme to be proposed was the jump-spark or high-tension system in which the spark electrodes in the cylinder are fixed with a small separation between which the spark is produced at the proper instant by applying a voltage sufficiently high to jump the gap. This arrangement has the advantage that there are no working parts in the combustion space and therefore the parts are mechanically much more simple than the low-tension system. This system had the apparent disadvantage of giving a much weaker spark, and owing to the high voltage this spark might be further weakened by leakage between the parts forming the terminal supports and the connecting wires. These problems were more readily solved than the ones connected with the make-and-break mechanism. In fact, it can be stated that the modern high-speed gasoline engine would be impracticable with make-and-break ignition. For the slow-speed stationary engine, especially where, due to a low-grade fuel being used, compression is carried to a high value, the low-tension system has, however, held its own.

In the high-tension system the mechanism connected with the sparking points has been simple and the problem of insulation of these points has been solved to a satisfactory degree. It is, therefore, upon the mechanism which furnishes the high-tension current at these points that our attention is now centered. The first and most obvious solution of this problem was to use an ordinary vibrating contact induction coil, the primary circuit of which was supplied from a primary battery, and in the secondary circuit of which was induced a voltage sufficient to jump the space between the electrodes in the cylinder, these electrodes and their mounting forming the now well-known spark plug. The primary circuit of the induction coil was controlled by a contact device which served to close this circuit at the proper instant. The shortcomings of this system were mainly in the battery which supplied the electric energy to the coil, and in order to obtain a reasonable life from the type of batteries available for this service, it was necessary to reduce the energy consumption to the minimum that would give satisfactory ignition. To overcome this defect, designers turned their attention to the matter of supplying this energy from a mechanical generator which would obtain its power from the gasoline engine. As the only object of this generator was to supply energy to the induction coil, it was evident that this coil and its contact mechanism would be combined in one piece of apparatus with the generator.

IGNITION BY SINGLE SPARK.

As a simple alternating current generator which gave a comparatively low frequency was used, it was found necessary to abandon the magnetically operated vibrator and substitute a mechanically operated one which would open and close the primary circuit of the induction coil at definite points on the voltage wave induced in the windings of the generator armature. This, of course, gave but one spark in the cylinder instead of the series of sparks induced by the vibrating coil, but as it is necessary to obtain proper timing of the explosion that the first spark ignite the mixture, the succeeding sparks are superfluous, although it is possible that should the first spark, owing to unfavorable conditions, fail to ignite the explosive mixture, a succeeding spark may do so. This condition can be practically overcome by supplying more energy to the single initial spark, which is permissible when this energy is generated by a mechanical device.

As a generator with permanent magnet field gives the simplest arrangement and has the advantage of overcoming the time element necessary for any electromagnet field to be built up, the permanent type is universally used and the name magneto has by usage in automobile engineering circles been taken to cover generating and spark producing mechanism as a whole.

The advent of electric lighting, and later of electric starting of the gasoline engine, produced demands for electric energy on the automobile which could only be met by the use of a much more efficient type of generator than that which served for the supply of ignition energy. As it is necessary to have power when the engine is not running, a storage battery is required. This condition is being met by the variable-speed battery-charging generators now on the market. The presence on the automobile of a supply of electrical energy much greater than required for simple ignition seems, therefore, to render superfluous the use of a separate generator for the ignition system. Naturally, in view of this, the first impulse would be to go back to the original vibrating coil system with its primary battery energy being supplied from the lighting and starting system instead. This system, however, has certain disadvantages which have been in large measure corrected in the development of the magneto generator, the principal ones being the time which elapses between the closing of the primary circuit and the production of the spark at the plug and the limitation which the vibrating contact mechanism places on the amount of energy it is possible to deliver to the spark plug. As this time is constant and independent of engine speed, it is obvious that the spark would occur progressively later as the engine speed increased. To overcome these defects it has been necessary to design a mechanism in which the primary contact points are operated mechanically the same as in the case of the magneto. As the spark is produced at the opening of these contacts, and this opening occurs at a definite angular position of the engine crankshaft, the spark is not regarded as the speed increases, thereby necessitating only the amount of angular advance required for the complete combustion of the exploding charge, and the type of contact device also permits of increasing the amount of energy which may be delivered to the spark plugs. The remaining distinction between the operation of a magneto and a battery system lies in a difference in the action which takes place in the induction coil.

ENERGY CONDITIONS IN BATTERY SYSTEM.

In the battery system the total energy to be supplied to the spark plug is delivered through the primary winding of the induction coil and stored as magnetic energy in the magnetic circuit of this coil. On opening the primary circuit this energy, minus the incidental losses, is delivered through the secondary winding to the spark plug. An oscillograph curve of the current in the spark plug circuit shows that this current rises instantaneously to a definite value from which value it gradually falls off to zero. The amount to which the circuit rises is determined by the value of the primary current and ratio of primary to secondary turns; while the time required for this current to fall to zero is determined by the energy stored in the magnetic circuit of the induction coil and by the resistance of the secondary or spark plug circuit.

In the case of the magneto the inital current value through the spark plug is, as in the case of the coil operated from a battery, determined by the primary current and ratio of turns. Its subsequent value, however, may be modified by the fact that energy can be delivered directly to this secondary through the mechanical motion of the generator armature itself. The time required for the current in the spark-plug circuit to reach zero may, therefore, be prolonged over that which would be possible in the case of the simple induction coil system. So far as performing its function of igniting the explosion charge is concerned, this prolonged spark can be of no value as, in order to properly develop the power in the cylinder, the combustion of the charge which is started at the spark plug points must take place through the whole volume of charge in an extremely limited time as compared to one complete engine cycle. No increase of power could, therefore, be obtained by maintaining the spark at the spark-plug points after the explosive mixture in the vicinity of these points has been burned. This effect of prolonging the duration of spark may be very deceptive in comparing the relative intensities of the spark produced by different systems by observations. Thus, a greatly prolonged spark of comparatively low current value may appear much hotter than one of short duration but higher current value, although this latter would be the more efficient igniting spark.

LIMITATIONS IN MAGNETO VOLTAGE.

A further distinction between magneto and battery ignition lies in the limitations on possible secondary voltage it is practical to generate in the magneto equipment, especially at the lower engine speeds. In the battery system it is possible to wind the secondary coil for any required voltage. In the case of the magneto there are limitations of design, due particularly to the limited space in which it is possible to place a secondary winding and the difficulty of obtaining clearances necessary for effective insulation. This condition can be observed by noting the size of the magneto required to give efficient ignition when the jump-spark system is used on the comparatively slow-speed high-compression stationary engine.

I have not gone into any details of the construction or operation of either the magneto or the battery system, as it can be seen from the foregoing that there is no fundamental difference between the two systems, and the method used to work out the problem of any particular design would have no bearing on the question under discussion. That the ignition system in which the primary source of electrical energy is the generator, which can supply in common all electrical demands of the automobile, is the most rational solution, is evidenced by a study of changes in the type of equipment used within the last few years.

* Read before the Society of Automobile Engineers.

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