SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXII
NUMBER 2130

★ NEW YORK, OCTOBER 28, 1916 ★

$5.00 A YEAR
10 CENTS A COPY

Photo from Press Illustrating Service, Inc.

An Austrian patrol scaling a mountain to make observations of the Italian forces.

FIGHTING ABOVE THE CLOUDS.—[See page 276.]

Latent Life—I*

Its Nature and Its Relations to Certain Theories of Contemporary Biology

By Paul Becquerel, Sc. D.

I.—GENERAL OBSERVATIONS.

ALTHOUGH the study of latent life holds an unimportant place in most of the standard works on biology, yet it is none the less one of the most widespread phenomena of the living kingdom. We meet it everywhere that germs exist. And since germs are continually emitted in considerable quantity, even more by plants than by animals, there is not a piece of ground on which we tread nor the smallest quantity of air that we breathe which is free from them.

Not only can the spores of fungi, bacteria, algæ, mosses, and of ferns, the myriads of grains of pollen from flowers, the seeds of phanerogams, the cysts of infusoria, the eggs of certain crustaceans and insects, pass into a state of latent life, but likewise animal tissues, and even some perfectly developed forms of life called reviviscents, as certain species of algæ, mosses, lichens, rotifers, arctisca, and nematodes.

In that condition of repose, these germs or beings may escape the harsh necessities of active life, better resist dryness, cold, or heat, are more easily carried away by the currents, winds, or other causes, finally to await for several years the return of conditions favorable to their development.

II.—THEORIES AS TO THE NATURE OF LATENT LIFE.

But what is the true nature of latent life? Is it apparent death in which all the vital functions are suspended; is it a relaxed aërobic life demanding gaseous exchanges with the atmosphere, or is it a very sluggish, intercellular anaërobic life? These are questions which since the beginning of the eighteenth century have engrossed the attention of eminent naturalists, have incited numerous experiments, and which at this moment provoke interesting controversies.

We owe to Leeuwenhoek (1701), the founder of micrography, the first observations on reviviscent animals, the arctisca or water bears, and rotifers of the roofs and gutters. That author observed with great astonishment that these little beings may remain dried up for five months amid moss and dust without showing the slightest trace of life and then, when moistened, resume their vital functions.

In 1743 Needham made analogous observations upon the nematodes from musty wheat. But the most interesting experiments upon these organisms have been chiefly those of Baker and Spallanzani.

Baker, working with nematodes (anguillula), succeeded in bringing them to life twenty-eight years after their desiccation. Since we know that the life cycle of these minute beings does not exceed ten months, it is thus proved that their life has been strikingly prolonged by this procedure.

On the other hand, Spallanzani verified the observations made by Leeuwenhoek on the rotifers. After having dried and preserved them for three years, he found that they returned to life when placed in water. All these experiments amazed the public of that period. It was at that time believed that these beings had the power of resuscitation. The extraordinary properties of these animalcules having been doubted in the nineteenth century, Doyère and Davaine, from 1840 to 1860, studied the subject very critically. Their experiments, confirmed by Gavarret, but bitterly contested by Pouchet and Pennetier, were the subject of very spirited discussions. In fact, at that time two rival theories, vitalism and organicism, were sharing the approbation of physiologists. Some, and they were in the majority, considered life as a mysterious principle of action which animates matter and sets it in motion. The others saw in life only the result of the organization of a special complex substance, merely the manifestation of the activity of organized matter.

In order to show the soundness of their conception of the question, those holding the latter view called attention to the phenomena presented by the revivified animals, notably in the experiments of Doyère and Davaine, in which they believed that they had seen a very clear example of an arrest of the functions of an organism and of their starting again under the action of a physical phenomenon, namely, the imbibition of water.

Organized matter, therefore, needed only a vital principle to resume activity. In the Société de Biologie the strife between the two factions was so earnest that to put an end to discussion it was decided to repeat the experiments before a committee of scientists, which included Balbiani, Brown-Séquard, Dareste, Guillemin, and Robin, and was presided over by Broca.

Before this committee it was then established: First, that there is no appreciable life in the inert body of reviviscent animals; second, that the bodies preserve their revivifying property in conditions incompatible with every kind of functioning life, as, for example, for eighty-two days in a dry vacuum, and in free air for thirty minutes at a temperature of 100 deg. Cent.

Some time later, Paul Bert in his researches upon the inherent vitality of tissues, corroborated this point of view by some interesting experiments. He showed that rats' tails dried for eight days, then kept for two hours in a temperature of 99 deg. Cent., and grafted four days afterward, resumed their vitality at the end of a month. About two years later, Claude Bernard, in his admirable lessons on the phenomena of life common to plants and animals, resumed the study of reviviscence and applied it to the vegetable kingdom.

In order to characterize the state of repose in which the seeds exist before germinating, he coined the term "latent life," and he gave us the following theory:

"The latent life of seeds is potential. It exists ready to manifest itself if suitable exterior conditions are supplied, but there is not the least manifestation if these conditions are lacking.

"It would be wrong to think that the seed, in this case, possesses a life so attenuated that its manifestations escape observation because of the very degree of this attenuation. That is true neither in theory nor in fact. In theory, we know that life results from the coalition of two factors—the one external, derived from a cosmic world; the other internal, derived from the organism.

"It is a co-ordination impossible to separate, and we should understand that in the absence of one of these factors the being could not live. It no more lives when they exist alone. Heat, humidity, and air do not constitute life; no more does the organism. In fact, we see some seeds preserved for years and for prolonged periods which, after such long inaction, can germinate and produce a new plant. If they had a sluggish life, that ought to exhaust it. But it is not exhausted."

From the moment that it was proposed, this conception of latent life has had many supporters who have strengthened it by the establishment of new facts. Thus the resistance of seeds, of spores of bacteria and mushrooms to the action of a vacuum, of irrespirable gases such as nitrogen, carbon dioxide, carbon monoxide, and chlorine, the conservation of the germinative power in liquids such as mercury, alcohol, ether and chloroform, as shown through numerous experiments by Giglioli, Detmer, Romane, de Candolle, Kochs, Jodin, Ewart, Kurzevelly, Maquenne, to cite only the principal authors, demonstrate in an apparently indisputable manner the reality of suspended life.

In spite of these facts, however, other physiologists have nevertheless continued to defend a theory directly opposed to it; that of the continuity of the vital phenomena, a doctrine according to which latent life is but a life relaxed.

Among the most eminent supporters of this view we may cite Van Tieghem and Gaston Bonnier, whose researches on the latent life of seeds have become classic. These scientists having allowed separate lots of seeds to remain two years in confined air and in carbon dioxide, perceived in the first medium that there had been an absorption of oxygen and a throwing off of carbon dioxide, and in the second medium asphyxiation. From this they concluded that respiration takes place in latent life, and when it is not possible, the organism perishes; consequently, life in the embryo can only be relaxed. These conclusions allayed certain doubts as to the early experiments of Doyère and Davaine. This is why Lance, in 1896, took up the study, confining his researches to arctisca.

Contrary to the claims of the committee presided over by Broca, he himself affirmed that the coming of life of these beings is not a resurrection:

"The arctisca of the roofs adapted to desiccation lose their power to revive when after desiccation they have been plunged into a gas, unsuited to support life, such as carbonic and sulphuric. When they find respiration impossible, they die; their latent life is then a relaxed life."

We have, therefore, to deal with two contradictory hypotheses, apparently based upon facts equally conclusive:

Is the relaxed life a more exact conception of the nature of latent life than the suspended life?

Must the one completely exclude the other, or is each one partly true? These are questions which I have tried to elucidate and to which we shall now turn our attention.

III.—THE IMPERMEABILITY OF THE TEGUMENT OF CERTAIN SEEDS.

When in 1904 I undertook these researches, limiting myself entirely to the latent life of seeds,[1] I asked myself if the prevailing contradictory opinions were not due to errors in interpretation of certain experimental results. For instance, were the embryos of the seeds really in contact with the media tried—confined air, irrespirable atmosphere, nitrogen, carbon dioxide, mercury, alcohol, chloroform, and ether? If their tegument had been impermeable, might it not have protected them against the various media that it was intended to subject them to? That was an important point, to which the greater part of my predecessors paid too little attention.

It was therefore very necessary to find a means for determining the permeability of the teguments of the seeds which were most used in the above-mentioned experiments. I employed a very simple apparatus: A barometric tube closed at one end by a portion of the tegument to be experimented upon, then filled with mercury with all the usual precautions, and inverted in a dish of mercury. The variations of the level of the mercury of this pseudo-barometer which terminated in a vegetable membrane, compared with the variations in the level of the mercury of another tube of the same kind, prepared in the same manner, but closed at one of its extremities, indicated under what conditions and at what rate the gas passed through the teguments.

In this way I was able to determine that the tegument of most of the seeds of Leguminosæ, such as that of the lupine and honey-locust, when it reached a certain degree of natural desiccation,[2] proved itself to be for two years impermeable to air in all its parts, even in those containing the hilum and micropyle. The teguments of these seeds do not permit gases to pass through them under the laws of diffusion except when they are moistened with water.

On the other hand, desiccated embryos of these same seeds act like porous bodies. Gases pass through them according to the laws of effusion. The tegument of the same species is equally impermeable to liquids, such as absolute alcohol, ether, and chloroform, which readily penetrate the embryos after decortication.

These results apply not only to the seeds of many species of the family Leguminosæ, but likewise to those of certain Cruciferæ, Malvaceæ, Labiatæ, Linaceaæ, and Citaceæ. They justify the reservations that I had made concerning the greater part of the experiments of my predecessors, for, in showing that the embryos protected by their impermeable teguments were not submitted to the action of the media employed, they nullify in part the deductions that had been drawn from them to explain the nature of latent life.

I was thus led to repeat on seeds with the permeable tegument either perforated or removed, the experiments of some of my predecessors. I thereupon ascertained that, contrary to their assertions, absolute alcohol, chloroform, and ether, instead of preserving the embryos of seeds, kill them when no longer protected by their teguments. On the other hand, the fact of the impermeability of their tegument rendered very improbable the interpretation that had been placed upon the gaseous exchanges of certain seeds.

With seeds of lupine, peas, castor beans, and beans, taking into account the rôle of their tegument, I repeated the experiments of Van Tieghem and Gaston Bonnier. Several comparable lots were prepared, some containing only decorticated seeds, others consisting only of the teguments of these seeds, and finally some seeds pro-

*From the last Annual Report of the Smithsonian Institution. Translated by permission from *Revue Générale des Sciences pures et appliquées*.

[1] Researches on the latent life of seeds (1904-19073. *Annals of Natural Sciences*, Botanical, 9th series.

[2] Degree of desiccation which is normally attained in the ordinary conditions of conservation of seeds.

tected by their teguments. All these lots were placed in the confined dry atmosphere of tubes inverted upon mercury, some placed in full light, others in darkness.

Six months later, having made analyses of these confined atmospheres, I found that the gaseous exchanges had been greater in the light, and that the isolated teguments of the seeds had absorbed more oxygen and given off more carbon dioxide than the embryos. Certain teguments taken from castor beans had given off in darkness 1.61 per cent of carbon dioxide and had reduced the quantity of oxygen to 15 per cent while the separated embryos from which they had been taken, placed with their endosperm in the same conditions, had not changed their atmosphere at all. If the gaseous exchanges of these seeds protected by their teguments had been interpreted as true respiration, one would have arrived at the paradoxical conclusion that the tegument composed of dead cells respired, while the embryos with their endosperm ready to germinate, having neither absorbed nor thrown off the least particle of gas, were dead.

The results obtained with several kinds of decorticated seeds, such as those of peas, beans, and lupine, in their natural state of desiccation, that is, still containing a certain quantity of water, convinced me that after a certain time in darkness they absorb traces of oxygen and throw off traces of carbon dioxide. There must, therefore, be in the embryos of those seeds which were not protected by their teguments and were in their natural state of desiccation, extremely slight gaseous exchanges.

IV.—THE NATURE OF THE GASEOUS EXCHANGES IN SEEDS.

But are these gaseous exchanges that are indicated in the case of the decorticated seeds in their state of natural desiccation really caused by a true respiration, the result of a kind of relaxed life for which the oxygen of the air is absolutely necessary? To find this out, I rendered the respiration of the embryo impossible by depriving it by means of a vacuum of its internal atmosphere confined in the intercellular spaces and the cells themselves which intercommunicate so readily through the punctures of their walls. The embryo was then placed for a greater or less time in contact with irrespirable media. Treated thus, peas with their teguments perforated, and deprived of their internal atmosphere, remained a year under the mercury and grew perfectly after the experiments. Seeds of beans, peas, castor beans, and wheat after decortication were kept in darkness in an atmosphere of nitrogen without giving off any trace of CO_2 and without losing their power of germination.

Other seeds of lupine, lucerne, peas, clover, mustard, pumpkin, buckwheat, and pine, and grains of wheat and oats, after perforation of their teguments were kept for eleven months in pure and dry carbon dioxide without suffering any injury. Finally, desiccated seeds of garden cress, lucerne and peas, and grains of wheat with the tegument perforated, were inclosed for two years in vials in which a nearly complete vacuum had been obtained, without injury to their germinative power.

These are new results, all agreeing, which are opposed to those classic experiments on which dependence is still placed to show the existence of a respiration in seeds. These results afford a proof that the gaseous exchanges demonstrated by Van Tieghem and Bonnier are not due to an attenuated respiration, but to a simple chemical oxidation of the surface of the tegument or of the embryo.

The generally accepted conception of the latent life of seeds must be modified. It is an extremely sluggish, intracellular, anaërobic, or else a suspended life. How is one to choose between these two hypotheses?

V.—LONGEVITY OF SEEDS.

If the life of seeds in nature were entirely suspended, if all the protoplasmic functions of assimilation and of disassimilation were completely arrested, as claimed by Claude Bernard, their germinative power should be unlimited. This is what many naturalists believed when they were told of the extraordinary case of the longevity of grains of wheat enclosed for more than two thousand years in the tombs of the Pharaohs, which, once sowed, would have germinated. But it is now known that the good faith of these scientists was imposed upon. Mixtures of authentic and recent grain were sold to them. This fraud, by which such botanists as Alphonse de Candolle and Decaisne were not deceived, was unmasked by M. Maspéro. This eminent Egyptologist never succeeded in germinating the grains of wheat which he himself collected in the tombs of the Pharaohs. Furthermore, the study of these grains made by Edward Gain showed that their embryos were partially destroyed; when they were moistened, they were transformed into an amorphous pulp.

On the other hand, no confidence can be placed in the story of seeds from Roman sepulchers or the granaries of Cæsar, Argau, or Herculaneum, or from Merovingian tombs or excavations. Too many flaws in the evidence, ignored by the investigators, destroy every basis for their claims. Only experiments made with specimens of which the time of harvesting the seeds and the date of their arrival in the laboratory are known can give us acceptable evidence.

Already, in 1831, Alphonse de Candolle had carried on researches with 368 kinds of seeds preserved for fourteen years in sacks. Many species of Leguminosæ and Malvaceæ had conserved their germinative faculty. I resumed the work of that learned naturalist, extending it to five hundred kinds of seeds belonging to thirty of the more important families of monocotyledons and dicotyledons. The seeds came from the seed collection of the Muséum d'Histoire Naturelle of Paris. The time of their collection, carefully verified, varied between 25 and 135 years. Four families furnished germinations: the Leguminosæ, the Nelumbonaceæ, the Malvaceæ, and the Labiatæ.

Twenty of these germinations came from seeds twenty-eight to eighty-seven years old. Among the Leguminosæ the oldest species were *Cassia bicapsularis* of 1819, *Cytisus biflorus* of 1821, *Leucæna leucocephala* of 1831, and *Trifolium arvense* of 1838. The seeds which germinated at such an age were covered with a very thick tegument, whose impermeability to gases was checked experimentally in the case of the Leguminosæ and the Nelumbonaceæ. In this way it was proved that some seeds con erved their germinative power from the epoch of the Restoration to our time without their embryo having gaseous exchanges with the atmosphere. The tegument of these seeds preventing through the years the oxidation of the substances in reserve and their hydration under the action of the humidity of the atmosphere, did much to assure them this remarkable longevity.

Nevertheless, this longevity is not unlimited. The germinative power always diminishes with time. Macrobiotic seeds, to use the picturesque expression of Ewart, who has written an excellent monograph on them,[3] do not keep their germinative power much beyond a hundred years.

The claim of Claude Bernard that the latent life of seeds, under natural conditions of their preservation, is not exhausted, rests on inexact data, and the undeniable fact of the aging of commercial seeds seems to refute it. When, however, you carefully examine the significance of this fact, it is not a positive proof against the theory of suspended life. The loss of the germinative faculty of the seed may very well be caused by physico-chemical phenomena which may not apply to those of an extremely sluggish life.

Why should not the protoplasm of the cells, when life is suspended, become decomposed in the course of time under the influence of the humidity and the oxygen accumulated in the intercellular spaces? What would prevent its comporting itself like inert substances which gradually lose their original properties, their potential energy? With time liquors are modified, a spring tends to wear out, powder ages, and yet in these substances there is no retarded life!

VI.—THE DEHYDRATION OF GERMS.

However that may be, since it is impossible to prove that a seed preserved under ordinary conditions is in a state of suspended life rather than in one of relaxed life, the problem might perhaps be solved by placing the seed under artificial conditions such that, without affecting its germinative power, its life may be temporarily arrested.

All the writers who are engaged with this subtle problem are of the opinion that the water and the gases enclosed in protoplasm are the cause of its decomposition. A seed in a state of natural desiccation always contains a quantity of water ranging from 0.5 to 20 per cent of its weight. But is it possible, without injuring its germinative faculty, to deprive it completely of this water? Relying upon experiments by numerous investigators, particularly upon those of Schröder and Ewart, it was believed until recent years to be impossible to withdraw all the water from the protoplasm of seeds without killing them. In fact, Ewart had ascertained that as a general rule the most resistant seeds lost their vitality when their percentage of water fell below from 2 to 3 per cent of their weight. This had led him to believe that the protoplasm of seeds in its state of natural desiccation must have a chemical composition very different from that of protoplasm fluid in a condition of active life. According to this new theory the chemical composition of the protoplasm in latent life would correspond with the chemical equation proposed by Loew for certain albumins. In that instance there was obtained by polymerization of aspartic aldehyde with the addition of hydrogen and sulphur, a proteid which finally gave an albuminoid, whose formula, $C_{72}H_{112}Az_{18}SO_{22}+2H_2O$, contains 2 per cent of water.

This conception of protoplasm from which you cannot draw out its 2 per cent of water without decomposition, appears to me too simplistic or one-sided, as much from the standpoint of physics as from that of chemistry. Besides, this formula does not include the greater part of the chemical elements, metals, and metalloids which are absolutely necessary for the constitution of the nuclei of cells and the formation of a protoplasm capable of life. Consequently it does not correspond to the reality of experimental facts, for though certain kinds of cells do not endure a prolonged desiccation, the result is not the same with many other cells.

Ewart was unable to ascertain this because he employed a very defective method of desiccation—that of the sulphuric-acid desiccator, a process which has the great objection of often altering the protoplasm entirely in desiccating it. Moreover, as Maquenne, the learned physiologist of the Muséum d'Histoire Naturelle, has demonstrated, for completely drying the seeds there is only one effective method and that is the employment of a vacuum for several months at a temperature of 40 degrees to 45 degrees in the presence of anhydrous BaOH[4].

This process is more efficient than that of the oven at 110 deg. Cent., which is employed in the method of dry weights. Moreover, if, as I have advocated, the precaution is taken of decorticating the seeds or of perforating the impermeable tegument, desiccation can be obtained more rapidly and more actively, so that there is no releasing of vapor in the vacuum nor loss of weight; and, besides, the germinative power of the seeds thus treated is not destroyed. Maquenne has proved this in the case of grains of wheat, seeds of parsnip, and castor bean, and myself for seeds of pumpkin, peas, and buckwheat, which lost 10 to 14 per cent of their weight of water.

Now, are seeds artificially dried more readily altered, or do they conserve longer than others their power of germination?

According to my investigations, the seeds of pumpkin, castor bean and beans, thoroughly dried, preserved in darkness in a dry atmosphere of air or nitrogen are not oxidized. I have been unable to detect by analysis the slightest indication of absorption of oxygen or release of carbon dioxide.[5] Likewise, according to Maquenne, dried parsnip seeds preserved for two years in a vacuum had suffered no loss of their germinative power, while seeds preserved in the open air as checks had been dead a long time.

These parsnip seeds, losing their power of germination at the end of six months, had, therefore, as a consequence of their dehydration and their protection from oxidation, quadrupled the duration of their latent life. Upon the basis of these results Maquenne concludes that cellular respiration is arrested in a vacuum, and that under the influence of desiccation the seed passes from a state of relaxed life to a state of suspended life in which vegetative functions cease to be performed. This conclusion, which is supported by all my above-mentioned researches, appears to agree well with the facts. But many physiologists, partisans of the theory of the continuity of vital phenomena, are unwilling to accept it.

They oppose the following objections:[6]

"In this matter of gaseous exchanges, especially if they are intracellular, how can you prove whether they are slight or negative? What leads you to believe that your methods of analyss are satisfactory evidence? There where your judgment hesitates, your theory affirms. It maintains *a priori* that the process of assimilation neither suffers, nor stops, nor begins again, but follows a continuous march."

Obviously it is very difficult to prove a complete arrest of the phenomena of life in the organism in a state of latent life. However, it must be acknowledged that the vacuum and the dehydration, carried to the extreme limit, should signally retard the exchanges of matter and energy in the protoplasm. If to these two conditions, already very influential, there be added a third, that of low temperatures, will not the suspension of life be really accomplished experimentally?

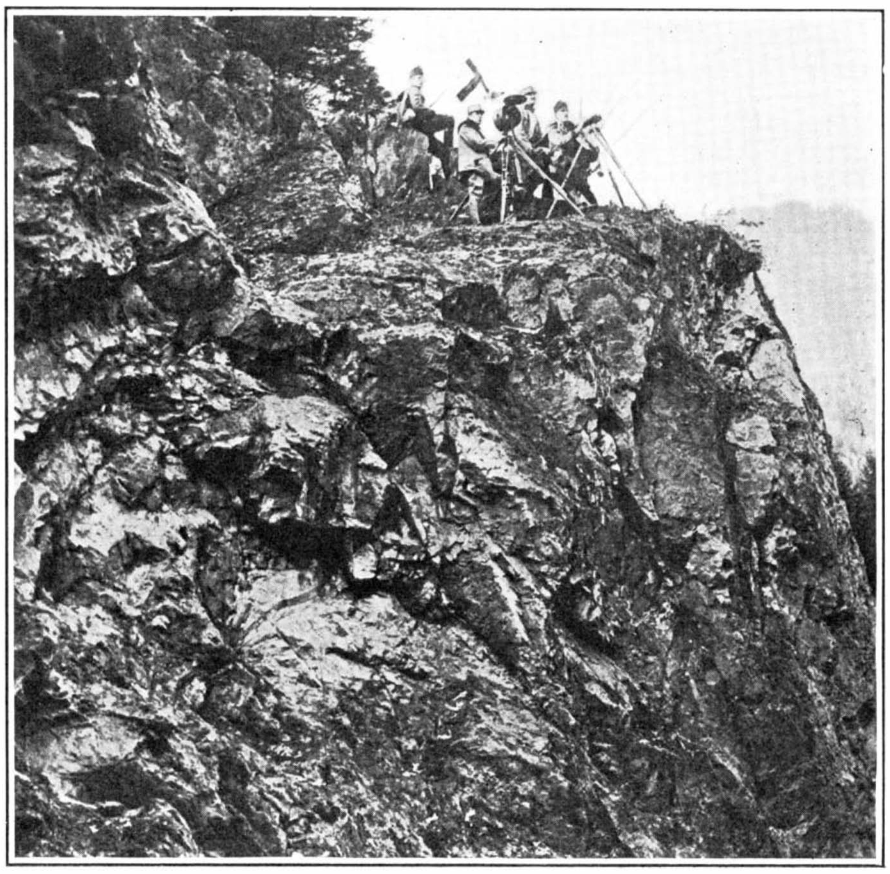
(*To be concluded.*)

[3]Ewart, on the longevity of seeds. *Proc. Roy. Soc.*, Victoria, vol. 21, 1908.

[4]Maquenne: C. R. Acad. des Sc., t. 134, p. 1234; t. 134, p. 208.

[5]Paul Becquerel: *Sur les échanges gazeux des graines.* C. R. Acad. des Sc., December 10, 1906.

[6]Dastre, *La vie et la mort*, p. 226 (Flammarion, Paris). M. Dastre, whom I have consulted on this subject, now accepts my point of view.—(Note of M. P. B.)



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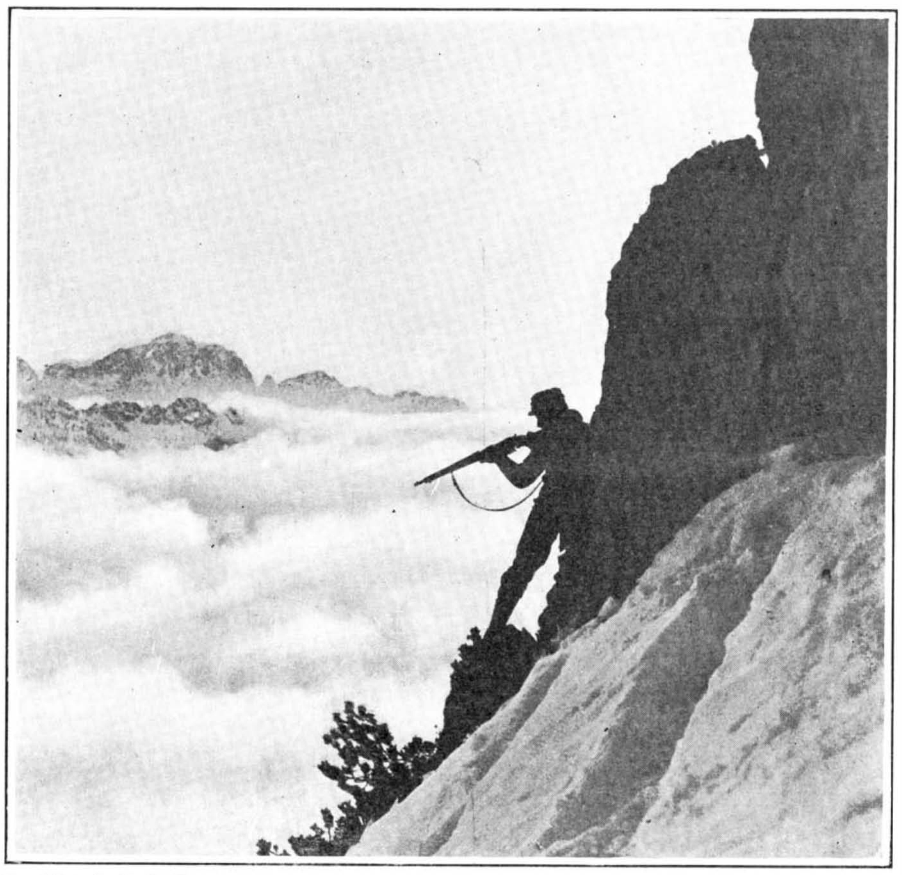
Hungarian patrol signal station on a mountain crag.



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Fighting in the clouds on the Austro-Italian front.

Fighting Above the Clouds

If public attention and interest had not been previously concentrated upon the military operations in Belgium, and in the East, and that interest stimulated by the magnitude of those operations, the campaign being conducted by Italy would be the marvel and the sensation of the world, for in difficulty and spectacular features it surpasses anything in the way of war maneuvers and military engineering that has ever been seen or dreamed of.

Owing to the extremely rugged nature of the territory involved the difficulties of the campaign have been tremendous, for in every direction there is practically a succession of high snow-clad mountains, interspersed by narrow winding valleys, which makes the concerted action of large bodies of troops impossible, and consequently, although there is an aggregate of nearly a million men engaged on each side, the number of men engaged in the various actions that have taken place has been comparatively small when compared with the immense numbers of men involved in the great battles fought in other regions.

These small engagements have, however, in many cases, been of a most desperate character, as naturally the most inaccessible cliffs are selected for defense, and the attacking party is obliged to scale the open mountain side in order to dislodge the enemy.

To establish these points of defense breastworks of stone are piled up, or, as has in some cases been necessary, trenches have been hewn out of the solid rock. Of course, it is not always difficult for troops of riflemen to establish themselves among the crags, but where artillery is also required on some high cliff it is entirely a different question, and remarkable feats of engineering have been frequently accomplished in such cases. One of the illustrations shows how a heavy field gun is being slung across a narrow mountain gorge on a cable way that has been established for the purpose, and the same means has often been employed for removing the wounded in places where it was found impossible to convey them down the steep and rugged sides of the mountains.

Much of the success in these regions has been the result of the hardiness and daring of the combatants, for a trench on a mountain face is often made untenable by a flanking fire from across the valley, or from a more elevated position on some neighboring mountain, so that, in many cases, in order to make an advance, the uttermost heights of mountains eight and ten thousand feet high must be won and held in succession.

Mining operations have been a feature of the fighting in these mountains, the same as elsewhere, and on two occasions, once by each side, tunnels were driven under a fortified mountain, and the entire top blown off by an immense charge of explosives. The fact that much of the work of the troops was done amid snow and ice, and even above the clouds, added much to the fantastic and sensational character of the campaign, and it is to be regretted that more complete reports of the military operations in these regions have not been published.

Effect of Water Upon Carbon

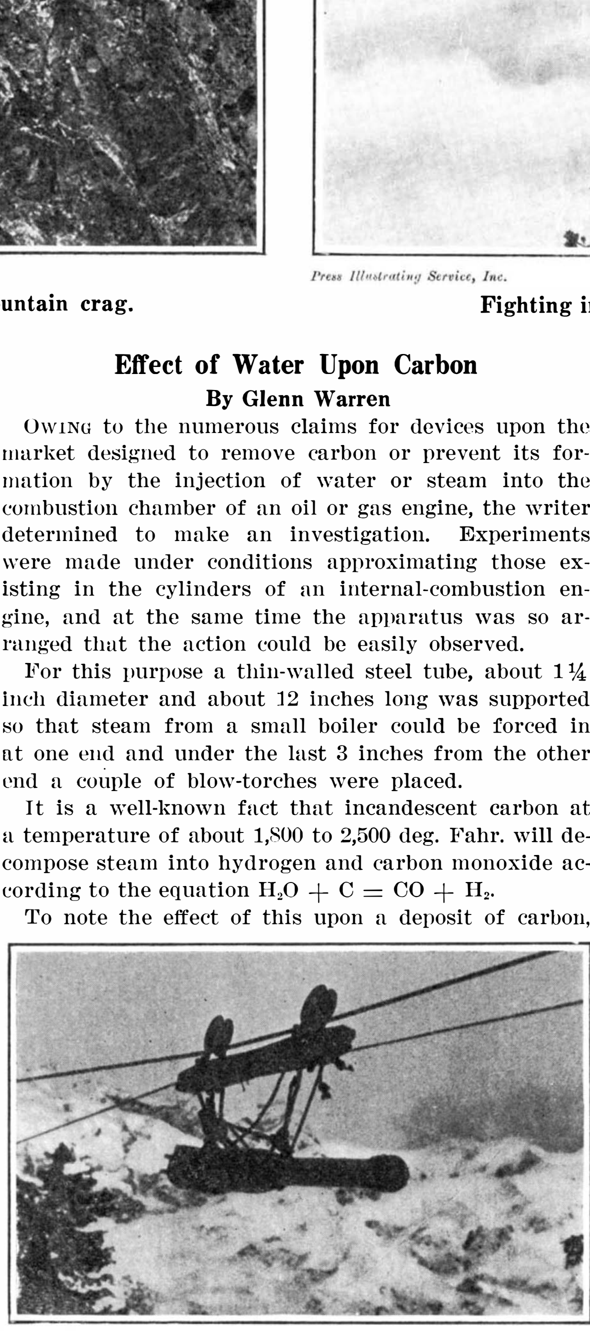
By Glenn Warren

Owing to the numerous claims for devices upon the market designed to remove carbon or prevent its formation by the injection of water or steam into the combustion chamber of an oil or gas engine, the writer determined to make an investigation. Experiments were made under conditions approximating those existing in the cylinders of an internal-combustion engine, and at the same time the apparatus was so arranged that the action could be easily observed.

For this purpose a thin-walled steel tube, about 1¼ inch diameter and about 12 inches long was supported so that steam from a small boiler could be forced in at one end and under the last 3 inches from the other end a couple of blow-torches were placed.

It is a well-known fact that incandescent carbon at a temperature of about 1,800 to 2,500 deg. Fahr. will decompose steam into hydrogen and carbon monoxide according to the equation $H_2O + C = CO + H_2$.

To note the effect of this upon a deposit of carbon,



From the Illustrated War News.

Transporting an Italian field gun to a firing position high up on a mountain, by a cradle that travels on a wire cable.

cylinder oil was placed in the steel tube and boiled until it no longer gave off inflammable vapors, and in this way a thin layer of carbon similar to the deposit on the inside of a cylinder was obtained. Upon passing steam for a short time through the tube, a small portion of which was heated to a bright-red heat with a blow-torch (about 1,800 deg. Fahr.), the carbon upon the inside of the hottest part of the tube was found to have been entirely consumed, but that on the tube that did not reach a red heat was apparently unaffected.

Upon throwing water in the liquid condition upon the heated carbon on the inside of the tube and allowing it to boil vigorously, a much larger portion of the carbon appeared to be removed or loosened to such an extent that the least breath of air would blow it away.

To verify this observation a small amount of cylinder oil was distilled to dryness upon a sheet-iron plate without access to the air and as nearly as possible realizing the conditions in the cylinder where the oil is heated in an atmosphere containing a large percentage of inert gases such as carbon dioxide and nitrogen. This sheet iron coated with carbon was then heated not quite to redness and treated with water. After the water had evaporated the carbon was in every case loosened from the plate so that it could easily be blown away with the breath.

Kerosene, reputed to be such a good carbon remover, was tried similarly and not only failed to remove any carbon, but actually left a deposit of its own, for it distilled in the same way that the cylinder oil had.

One of the chemicals now used to run through the carburetor of an auomobile motor was also tried, but gave no better results than pure water.

Thus to sum up, steam removed the carbon that had reached an incandescent temperature, but did not affect the carbon deposit at a lower temperature; while water in the liquid state applied to a hot surface coated with a deposit of carbon loosened the deposit to such an extent that it could easily be blown away.

The greater part of the carbon in an engine cylinder, however, never under normal conditions reaches a temperature high enough to become incandescent; if it did, serious trouble from preignition would ensue. The carbon must, however, be deposited from the burning charge in a finely divided condition, and this carbon before its deposit would be incandescent.

From this the conclusion must be drawn that steam in any form will not remove the greatest part of the carbon deposit in a motor, or that part which does not reach incandescence, but it would, if mixed with the charge, oxidize the finely divided particles of incandescent carbon and prevent the formation of carbon deposits. Therefore, those devices on the market designed to mix a small amount of moisture or steam with each charge as it enters the cylinder should prevent the formation of carbon, if effective in introducing a sufficient amount of steam, but would not remove the carbon already there. On the other hand, the introduction of water into the cylinders in the liquid state should loosen the carbon deposit to such an extent that it could be easily blown out the exhaust. The action of the water seems to be that it gets in between the carbon particles and, upon being suddenly vaporized by the heat, loosens the deposit.

This is nothing new. In fact, the writer saw water used in this way several years ago, but had never heard an explanation of its action or seen any experimental proof of its effectiveness. Here, as in many other things in the gas-engine industry, practical experience has gone ahead of science and theory. Many instances in practical work bear out the conclusions.

Upon examining a cylinder having removable heads in which the gasket has leaked so that upon standing idle, water from the jackets will seep in, it will be found that the carbon deposit is loose and not nearly so heavy as in the other cylinders of the same engine where the water has not entered. Again, if water alone be run through the carburetor of a hot engine, clouds of carbon will issue with the exhaust gases.—*Power.*

An Electro-Chemical Action on Glass*

An Unusual Action Not Heretofore Reported

By F. F. S. Bryson, M.A., B.Sc., Carnegie Research Fellow in Physics, University of Glasgow

DURING the course of some research work recently carried on in Prof. Gray's laboratory, in which a Wehnelt electrolytic interrupter was used in connection with an 18-inch induction coil to produce a high-tension discharge, a disintegrating effect of the interrupted current was observed on the glass electrode holders of the interrupter at the point where the wire was sealed through the glass. This effect does not seem to have been described before.

The interrupter consists of two electrodes immersed in sulphuric acid. The cathode is a large lead plate; the anode one or more platinum wires, only the points of which are exposed to the liquid. Usually the length of point so exposed can be adjusted by means of a porcelain sleeve which surrounds each wire. For efficient working, the current must lie between certain limits. If the current is too small, mere ordinary electrolysis occurs; while if it is too great, the action is irregular, the anode hisses, becomes white-hot, and disintegrates rapidly. A noticeable feature of the interruption is the violet, or in some cases pinkish, glow which surrounds the platinum point when a suitable current is passing. The interruptions are accompanied also by an explosive and almost deafening noise.

Absolute agreement as to the theory of the working of the interrupter has not yet been attained. The general statement that the effect is due to the rhythmic sealing and unsealing of the anode by the liberated gas obviously does not take account of all the circumstances. The size of the points, the current, the amount of self-inductance and capacity in the circuit, the concentration and temperature of the electrolyte, are all factors influencing the interruptions. The following explanation, as given by Ludewig,[1] is somewhat more comprehensive. Immediately after the interruption of the current the gas begins to form irregularly on elevated parts of the electrode, while the current is conducted across those parts not covered by gas. As the parts of the electrode across which the current is conducted become smaller, the current density becomes very large, and the liquid at those parts is vaporized. It is well known that high resistance is offered to the passage of electricity from a smooth metal surface to a fluid. The vaporization, then, is caused probably by the heat developed in overcoming this transitional resistance between the wire and the liquid, as well as the resistance of the electrolyte very close to the point. As this greatly increased resistance increases the amount of heat evolved for one instant, a portion of the vapor is dissociated into oxygen and hydrogen, and then the whole electrode is covered with an insulating sheath of an explosive mixture which completely interrupts the current. With the stopping of the current a high self-induced pressure is produced, which breaks down the dielectric gas layer by a spark, thus exploding the gaseous mixture. The excess of oxygen is driven off the electrode by the explosion, and the electrode again comes into contact with the liquid.

This type of interrupter was used in the research work referred to, partly on account of the fact that it needed little attention, and the discharge could be allowed to run continuously for hours, and partly because a large secondary current was required. When an adjustable sleeve is used over the anode, a perfect seal cannot be obtained between the wire and the porcelain insulation. Thus there is always a certain amount of current leakage—that is, current that passes uninterruptedly; and this tends to diminish the efficiency of the interrupter. In our case the electrode consisted of a small piece of platinum wire hermetically sealed through the end of a glass tube. Contact was made with the wire conveying the current by means of mercury covering the upper end of the platinum wire in the tube. Originally the wire was sealed into the tube by means of soft "flux" glass, and it was noticed that, after the discharge had been running for a short time, the glass round the wire became pitted out, a crater being formed with the wire projecting from its center. A similar effect was observed with different kinds of glasses surrounding the metal wire. Thus, not only were clear, ruby, and white "enamel" flux glasses tested, but also German soda, new British soda, lead, and Jena glasses. The wire was sealed directly into these latter glasses by the Burnside process.[2] This is a cooling process, by means of which electrical conductors may be hermetically sealed into glass and other vitreous substances without the aid of any flux.

In all the glasses tested, this corrosive effect was observed least of all, however, in the Jena glass. The resistive properties of Jena glass in other directions are, of course, well known. Photomicrographs are reproduced showing the platinum point projecting from the tip of the glass tube. The magnification in the various cases may be judged from the appearance of the wire, which was about 0.4 millimeter in diameter. Fig. 1 shows the disruptive effect on German soda glass. Figs. 2 and 3 are two different photographs of the same piece of British soda glass, the former showing the edge of the crater with the wire projecting, the latter showing the rough base. Fig. 4 is of a piece of the same kind of glass, in which the crater-wall has broken down at one side. Slight devitrification of this glass took place during the sealing-in of the wire by means of the blow-pipe flame. This devitrification seemed to render the glass more liable to corrosion. A glance at the photographs will show that the pitting-out is not due to any action of a mechanical nature, as, for example, a water-hammer effect. Such an action would cause radial cracks and fractures; but these do not appear. Neither is the phenomenon due to the glass having been rendered brittle by the cooling during the sealing-in process, for flux glass which had been carefully annealed after the wire had been sealed into it readily showed the same effect. In no cases do the edges or the walls of the crater show a vitreous or conchoidal fracture, but roughnesses and irregularities appear. Fig. 5 shows a piece of Jena glass with two wires sealed into it. Fracture of the layer of glass between the wires might have occurred had the corrosion been the result simply of the Joule heating effect, or of the Peltier effect; but it will be noticed that there is no such fracture. The glass between the wires is quite unbroken, the pitting-out occurring almost uniformly round each wire.

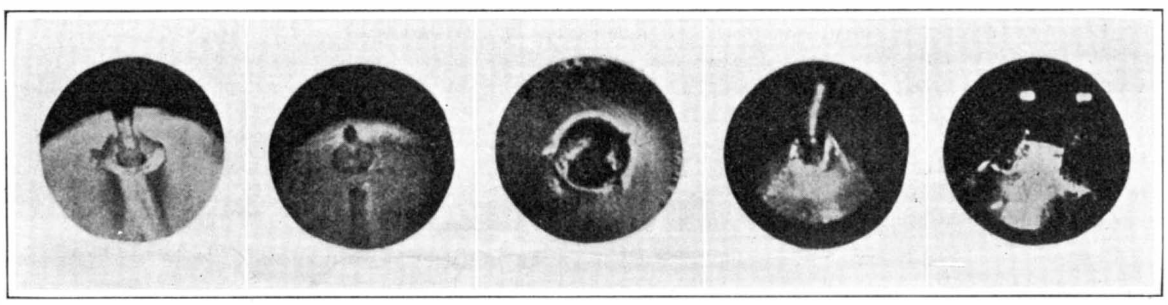


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

It may be suggested that the action is stimulated by a species of electrolysis of the glass lying between the wire and the liquid. It is well known that glass may be readily electrolyzed by quite moderate potentials if the temperature of the glass is raised. This electrolytic action consists of a transference of Na ions from the glass, SiO_2 being left behind. In certain cases the Na is replaced by the metal of the anode; but platinum cannot diffuse in this way into the glass. In the Wehnelt interrupter point electrode the corrosion takes place not only when the point is the anode, but also when it is the cathode. The formation round the wire near the point, of a layer of SiO_2, which would gradually crumble away, might explain the pitting-out action when the platinum is positive to the liquid; but this action would not take place when the current is in the reverse direction. Thus electrolysis does not account for all the facts.

The effect of changes in the temperature of the anode during the interruption must be considered. After using fusible alloys for points, McClenahan[3] stated that in the interruption stage the temperature never rose above 168 deg. Cent., and hence not high enough to produce incandescence, and that the light surrounding the point during interruption must be of the nature of a discharge of electricity through gases. This temperature seems rather a low estimate, for the interrupting action is undoubtedly caused by the intense heating due to the high current density about the small point. The spectra obtained from the light surrounding the point have been examined by Morse,[4] who used various metals in various electrolytes. His results suggest that the environment of the point passes through a great range of temperature with each interruption of the current, and that the high temperature is the cause of the luminescence. This high temperature, being local in its effect, might render the glass round the wire brittle and allow it to be disintegrated, and thus a crater would be formed. But the wide mouth of the crater and the appearance of the edges suggest that other factors also influence the action. The heat generated at the point vaporizes and then dissociates the water in its immediate vicinity into hydrogen and oxygen. Spectra like those of the oxyhydrogen flame can be obtained from the explosion of the mixed gases by the hot metal in the cooler parts of the gaseous envelope.

The presence thus evidenced of free hydrogen and oxygen at a temperature above the point of dissociation of water affords the possibility of a strong reducing or oxidizing action on the metal forming the electrode and also on the glass. That the metal is exposed to this chemical action is shown by the fact that, when the wire used as electrode is of aluminium, calcium, barium or other metal having a strong affinity for oxygen, the spectra given by the light show the bands which are usually ascribed to the oxides of these metals. The glass also will undoubtedly be affected by the reducing action and become disintegrated, the metal constituents being precipitated or going into solution in the acid.

The ultra-violet rays of the light itself will further assist the action either directly, or indirectly by acting on the atmosphere in contact with the glass. The active nature of ultra-violet radiation is well known. Thus, glass exposed in air to ultra-violet light becomes colored. This coloration is probably due to ultra-microscopic particles of reduced metal in the salt. Metals also, when covered with a thin layer of water, corrode rapidly when subjected to the action of ultra-violet rays, this effect being caused by the ozone produced by the action of the rays on the water. It is probable that a similar effect is produced on the glass, and that this, as well as the other two factors referred to, plays a part in disintegrating the glass near the exposed part of the electrode wire and so producing the cavity.

*Engineering.

[1] Ann. der Phys., vol. xxviii, page 175 (1909).

[2] Electrician, July 4, 1913; Nature, June 3, 1915.

[3] Cf. Compton, Phys. Rev., vol. xxx, page 173 (1910).

[4] Astrophysical Journal, vol. xix, page 162.

A Telephone Sound Augmenter

IN the improved type of apparatus a mica disc diaphragm is used; round this is a thin brass ring. Radiating from this, top and bottom, are a series of elastic cords fixed to adjusting screws at top and bottom of sound board. On these elastic cords are strung a number of brass discs about ½ inch diameter or square, made of rack brass (rack brass such as used for rack and pinion clock work, about ¼ inch thick), the rack edge of one piece resting on plain side of the other. Between these are placed a few carbon granules, the first and last brass discs on each elastic cord making metallic connection with the brass hing and adjusting screws. Carbon discs or squares can be also used if one of the sides of each carbon disc has a few saw-cuts made in it, so as to form a "rack" edge exactly like the brass. Of course, brass or carbon discs have to have a hole through the center to permit them to be strung on the elastic cords.—*Charles Mayfield, in the English Mechanic.*

New Archæological Lights—II*

On the Origin of Civilization in Europe

By Sir Arthur Evans, D.Litt., LL.D., P.S.A., F.R.S.

Concluded from Scientific American Supplement No. 2129, Page 259, October 21, 1916

Turning to the Nile Valley, we are again confronted with an extraordinary revolution in the whole point of view effected during recent years. Thanks mainly to the methodical researches initiated by Flinders Petrie, we are able to look back beyond the dynasties to the very beginnings of Egyptian civilization. Already by the closing phase of the Neolithic and by the days of the first incipient use of metals the indigenous population had attained an extraordinary high level. If, on the one hand, it displays Libyan connections, on the other, we already note the evidences of commercial intercourse with the Red Sea; and the constant appearance of large rowing vessels in the figured designs shows that the Nile itself was extensively used for navigation. Flint-working was carried to unrivalled perfection, and special artistic refinement was displayed in the manufacture of vessels of variegated breccia and other stones. The antecedent stages of many Egyptian hieroglyphs are already traceable, and the cult of Egyptian divinities, like Min, was already practised. Whatever ethnic change may have marked the establishment of Pharaonic rule, here, too, the salient features of the old indigeneous culture were taken over by the new regime. This early dynastic period itself has also received entirely new illustration from the same researches, and the freshness and force of its artistic works in many respects outshine anything produced in the later course of Egyptian history.

THE CONTINUITY OF HUMAN TRADITION

as a whole in areas geographically connected like Eurafrica on the one side and Eurasia on the other has been here postulated. Since, as we have seen, the Late Palæolithic culture was not violently extinguished, but shows signs of survival both north and south, we are entitled to trace elements of direct derivation from this source among the inherited acquirements that finally led up to the higher forms of ancient civilization that arose on the Nile and the Euphrates. In many directions, we may believe, the flaming torch had been carried on by the relay runners.

But what, it may be asked, of Greece itself, where human culture reached its highest pinnacle in the Ancient World, and to which we look as the principal source of our own civilization?

Till within recent years it seemed almost a point of honor for classical scholars to regard Hellenic civilization as a wonder-child, sprung, like Athena herself, fully panoplied from the head of Zeus. The indebtedness to Oriental sources was either regarded as comparatively late or confined to such definite borrowings as the alphabet or certain weights and measures. Egypt, on the other hand, at least till Alexandrine times, was looked on as something apart, and it must be said that Egyptologists on their side were only too anxious to preserve their sanctum from profane contact.

A truer perspective has now been opened out. It has been made abundantly clear that the rise of Hellenic civilization was itself part of a wider economy, and can be no longer regarded as an isolated phenomenon. Indirectly, its relation to the greater world and to the ancient centers to the South and East has been now established by its affiliation to the civilization of prehistoric Crete and by the revelation of the extraordinarily high degree of proficiency that was there attained in almost all departments of human art and industry. That Crete itself—the "Mid-Sea Land," a kind of half-way house between three continents—should have been the cradle of our European civilization was, in fact, a logical consequence of its geographical position. An outlier of mainland Greece, almost opposite the mouths of the Nile, primitive intercourse between Crete and the further shores of the Libyan Sea was still further facilitated by favorable winds and currents. In the eastern direction, on the other hand, island stepping-stones brought it into easy communication with the coast of Asia Minor, with which it was actually connected in late geological times.

But the extraneous influences that were here operative from a remote period encountered on the island itself a primitive indigenous culture that had grown up there from immemorial time. In view of some recent geological calculations, such as those of Baron De Geer, who, by counting the number of layers of mud in Lake Ragunda, has reduced the ice-free period in Sweden to 7,000 years, it will not be superfluous to emphasize the extreme antiquity that seems to be indicated for even the later Neolithic in Crete. The Hill of Knossos, upon which the remains of the brilliant Minoan civilization have found their most striking revelation, itself resembles in a large part of its composition a great mound or Tell—like those of Mesopotamia or Egypt—formed of layer after layer of human deposits. But the remains of the whole of the later Ages represented down to the earliest Minoan period (which itself goes back to a time contemporary with the early dynasties of Egypt—at a moderate estimate to 3,400 B. C.) occupy considerably less than a half—19 feet, that is, out of a total of over 45. Such calculations can have only a relative value, but, even if we assume a more rapid accumulation of debris for the Neolithic strata and deduct a third from our calculation, they would still occupy a space of over 3,400 years, giving a total antiquity of some 9,000 years from the present time.[8] No Neolithic section in Europe can compare in extent with that of Knossos, which itself can be divided by the character of its contents into an early, middle and late phase. But its earliest stratum already shows the culture in an advanced stage, with carefully ground and polished axes and finely burnished pottery. The beginnings of Cretan Neolithic must go back to a still more remote antiquity.

KNOSSOS.

The continuous history of the Neolithic Age is carried back at Knossos to an earlier epoch than is represented in the deposits of its geographically related areas on the Greek and Anatolian side. But sufficient materials for comparison exist to show that the Cretan branch belongs to a vast province of primitive culture that extended from Southern Greece and the Ægean islands throughout a wide region of Asia Minor and probably still further afield.

An interesting characteristic is the appearance in the Knossian deposits of clay images of squatting female figures of a pronouncedly steatopygous conformation and with hands on the breasts. These in turn fit on to a large family of similar images which recur throughout the above area, though elsewhere they are generally known in their somewhat developed stage, showing a tendency to be translated into stone, and finally—perhaps under extraneous influences both from the North and East—taking a more extended attitude. These clearly stand in a parallel relationship to a whole family of figures with the organs of maternity strongly developed that characterize the Semitic lands and which seem to have spread from there to Sumeria and to the seats of the Anau culture.

At the same time this steatopygous family, which in other parts of the Mediterranean basin ranges from prehistoric Egypt and Malta to the north of Mainland Greece, calls up suggestive reminiscences of the similar images of Aurignacian Man. It is especially interesting to note that in Crete, as in the Anatolian region where these primitive images occur, the worship of a Mother Goddess predominated in later times, generally associated with a divine child—a worship which later survived in a classical guise and influenced all later religion. Another interesting evidence of the underlying religious community between Crete and Asia Minor is the diffusion in both areas of the cult of the double axe. This divine symbol, indeed, or "Labrys," became the special emblem of the palace sanctuary of Knossos itself, which owes to it its traditional name of Labyrinth. I have already called attention to the fact that the absorptive and disseminating power of the Roman Empire brought the cult of a male form of the divinity of the Double Axe to the Roman Wall and to the actual site on which Newcastle stands.

The fact should never be left out of sight that the gifted indigenous stock which in Crete eventually took to itself on one hand and the other so many elements of exotic culture was still deep-rooted in its own. It had, moreover, the advantages of an insular people in taking what it wanted and no more. Thus it was stimulated by foreign influences but never dominated by them, and there is nothing here of the servility of Phœnician art. Much as it assimilated, it never lost its independent tradition.

It is interesting to note that the first quickening impulse came to Crete from the Egyptian and not from the Oriental side—the Eastern factor, indeed, is of comparatively late appearance. My own researches have led me to the definite conclusion that cultural influences were already reaching Crete from beyond the Libyan Sea before the beginning of the Egyptian Dynasties. These primitive influences are attested, amongst other evidences, by the forms of stone vessels, by the same æsthetic tradition in the selection of materials distinguished by their polychromy, by the appearance of certain symbolic signs, and the subjects of shapes and seals which go back to protoypes in use among the "Old Race" of the Nile Valley. The impression of a very active agency indeed is so strong that the possibility of some actual immigration into the island of the older Egyptian element, due to the conquests of the first Pharaohs, cannot be excluded.

The continuous influence of dynastic Egypt from its earliest period onwards is attested both by objects of import and their indigenous imitations, and an actual monument of a Middle Empire Egyptian was found in the Palace Court of Knossos. More surprising still are the cumulative proofs of the reaction of this early Cretan civilization on Egypt itself, as seen not only in the introduction there of such beautiful Minoan fabrics as the elegant polychrome vases, but in the actual impress observable on Egyptian art even on its religious side. The Egyptian griffin is fitted with Minoan wings. So, too, on the other side we see the symbols of Egyptian religion impressed into the service of the Cretan Nature Goddess, who in certain respects was partly assimilated with Hathor, the Egyptian Cow-Goddess of the Underworld.

My own most recent investigations have more and more brought home to me the all-pervading community between Minoan Crete and the land of the Pharoahs. When we realize the great indebtedness of the succeeding classical culture of Greece to its Minoan predecessor the full significance of this conclusion will be understood. Ancient Egypt itself can no longer be regarded as something apart from general human history. Its influences are seen to lie about the very cradle of our own civilization.

The high early culture, the equal rival of that of Egypt and Babylonia, which thus began to take its rise in Crete in the fourth millennium before our era, flourished for some two thousand years, eventually dominating the Ægean and a large part of the Mediterranean basin. To the civilization as a whole I ventured, from the name of the legendary king and law-giver of Crete, to apply the name of "Minoan," which has received general acceptance; and it has been possible now to divide its course into three Ages—Early, Middle, and Late, answering roughly to the successive Egyptian Kingdoms, and each in turn with a triple subdivision.

MINOAN CIVILIZATION.

It is difficult indeed in a few words to do adequate justice to this earliest of European civilizations. Its achievements are too manifold. The many-storied palaces of the Minoan priest-kings in their great days, by their ingenious planning, their successful combination of the useful with the beautiful and stately, and, last but not least, by their scientific sanitary arrangements, far outdid the similar works, on however vast a scale, of Egyptian or Babylonian builders. What is more, the same skilful and commodious construction recurs in a whole series of private mansions and smaller dwellings throughout the island. Outside "broad Knossos" itself, flourishing towns sprang up far and wide on the country sides. New and refined crafts were developed, some of them, like that of the inlaid metal-work, unsurpassed in any age or country. Artistic skill, of course, reached its acme in the great palaces themselves, the corridors, landings, and porticoes of which were decked with wall paintings and high reliefs, showing in the treatment of animal life

*From the presidential address before the annual meeting of the British Association, 1916.

[8] For a fuller statement I must refer to my forthcoming work, "The Nine Minoan Periods" (Macmillans), Vol. I.: Neolithic Section.

not only an extraordinary grasp of Nature, but a grandiose power of composition such as the world had never seen before. Such were the great bull-grappling reliefs of the Sea Gate at Knossos and the agnostic scenes of the great Palace hall.

The modernness of much of the life here revealed to us is astonishing. The elaboration of the domestic arrangements, the staircases, story above story, the front places given to the ladies at shows, their fashionable flounced robes and jackets, the gloves sometimes seem on their hands or hanging from their folding-chairs, their very mannerisms as seen on the frescoes, pointing their conversation with animated gestures—how strangely out of place would it all appear in a Classical design! Nowhere, not even at Pompeii, have more living pictures of ancient life been called up for us than in the Minoan Palace of Knossos. The touches supplied by its closing scene are singularly dramatic—the little bathroom opening out of the Queen's parlor, with its painted clay bath, the royal draught-board flung down in the court, the vessels for anointing and the oil-jar for filling there ready to hand by the throne of the Priest-King, with the benches of his Consistory round and the sacral griffins on either side. Religion, indeed, entered in at every turn. The palaces were also temples, the tomb a shrine of the Great Mother. It was, perhaps, owing to the religious control of art that among all the Minoan representations—now to be numbered by thousands—no single example of indecency has come to light.

A remarkable feature of this Minoan civilization cannot be passed over. I remember that at the Liverpool meeting of this Association in 1896—just before the first results of the new discoveries in Crete were known—a distinguished archæologist took as the subject of an evening lecture "Man Before Writing," and, as a striking example of a high culture attained by "Analfabeti," singled out that of Mycenæ—a late offshoot, as we know now, from Minoan Crete. To such a conclusion, based on negative evidence, I confess I could never subscribe—for had not even the people of the Reindeer Age attained to a considerable proficiency in expression by means of symbolic signs? To-day we are able to trace the gradual evolution on Cretan soil of a complete system of writing from its earliest pictographic shape, through a conventionalized hieroglyphic to a linear stage of great perfection. In addition to inscribed sealings and other records some two thousand clay tablets have now come to light, mostly inventories or contracts; for though the script itself is still undeciphered the pictorial figures that often appear on these documents supply a valuable clue to their contents. The numeration also is clear, with figures representing sums up to 10,000. The inscribed sealings, signed, countermarked, and countersigned by controlling officials, give a high idea of the elaborate machinery of Government and administration under the Minoan rulers.

The minutely organized legal conditions to which this points confirm the later traditions of Minos, the great lawgiver of prehistoric Crete, who, like Hammurabi and Moses, was said to have received the law from the God of the Sacred Mountain. The clay tablets themselves were certainly due to Oriental influences, which make themselves perceptible in Crete at the beginning of the Late Minoan Age, and may have been partly resultant from the reflex action of Minoan colonization in Cyprus. From this time onwards Eastern elements are more and more traceable in Cretan culture, and are evidenced by such phenomena as the introduction of chariots—themselves, perhaps, more remotely of Aryan-Iranian derivation—and by the occasional use of cylinder seals.

Simultaneously with its Eastern expansion, which affected the coast of Phœnicia and Palestine as well as Cyprus, Minoan civilization now took firm hold of Mainland Greece, while traces of its direct influence are found in the West Mediterranean basin—in Sicily, the Balearic Islands, and Spain. At the time of the actual Conquest and during the immediately succeeding period the civilization that appears at Mycenæ and Tiryns, at Thebes and Orchomenos, and at other centers of Mainland Greece, though it seems to have brought with it some already assimilated Anatolian elements, is still in the broadest sense Minoan. It is only at a later stage that more provincial offshoot came into being, to which the name Mycenæan can be properly applied. But it is clear that some vanguard at least of the Ayran Greek immigrants came into contact with this high Minoan culture at a time when it was still in its most flourishing condition. The evidence of Homer itself is conclusive. Arms and armor described in the poems are those of the Minoan prime; the fabled shield of Achilles, like that of Herakles described by Hesiod, with its elaborate scenes and variegated metal-work, reflects the masterpieces of Minoan craftsmen in the full vigor of their art; the very episodes of epic combat receive their best illustration on the signets of the great days of Mycenæ. Even the lyre to which the minstrel sang was a Minoan invention. Or, if we turn to the side of religion, the Greek temple seems to have sprung from a Minoan hall, its earliest pediment schemes are adaptations from the Minoan tympanum—such as we see in the Lions' Gate—the most archaic figures of the Hellenic goddesses, like the Spartan Orthia, have the attributes and attendant animals of the great Minoan mother.

Some elements of the old culture were taken over on the soil of Hellas. Others which had been crushed out in their old centers survived in the more Eastern shores and islands formerly dominated by Minoan civilization, and were carried back by Phœnician or Ionian intermediaries to their old homes. In spite of the overthrow which about the twelfth century before our era fell on the old Minoan dominion and the onrush of the new conquerors from the North, much of the old tradition still survived to form the base for the fabric of the later civilization of Greece. Once more through the darkness the lighted torch was carried on, the first glimmering flame of which had been painfully kindled by the old cave-dwellers in that earlier Palæolithic world.

The Roman Empire, which in turn appropriated the heritage that Greece had received from Minoan Crete, placed civilization on a broader basis by welding together heterogeneous ingredients and promoting a cosmopolitan ideal. If even the primeval culture of the Reindeer Age embraced more than one race and absorbed extraneous elements from many sides, how much more is that the case with our own, which grew out of the Greco-Roman! Civilization in its higher form to-day, though highly complex, forms essentially a unitary mass. It has no longer to be sought out in separate luminous centers, shining like planets through the surrounding night. Still less is it the property of one privileged country or people. Many as are the tongues of mortal men, its votaries, like the Immortals, speak a single language. Throughout the whole vast area illumined by its quickening rays its workers are interdependent and pledged to a common cause.

Early Maps Relating to the Search for "El Dorado."

The name "El Dorado," which dates back to the first part of the 16th century, is Spanish for "the gilded one," and an abbrevation for "the gilded man" (el hombre dorado). It was first applied to a native South American ruler or priest who, so early Spanish writers state, was gilded at a certain annual ceremony and then bathed in a lake near Santa Fe de Bogota, Colombia. The name next came to signify a legendary golden city, also called Manoa or Omoa, much sought after but never found. Later it was used to indicate a mythical country somewhere in South America where gold and precious stones were to be found in great abundance, and for which many expeditions searched in vain, among them those of Ordaz, Orellana, von Hutten, Quesada, and Sir Walter Raleigh. To-day El Dorado is used metaphorically to designate a place where wealth can be rapidly acquired.

A pamphlet issued by the Smithsonian Institution relates to the recent investigations of Dr. Rudolf Schuller, who writes on two 16th century maps which relate to the Ordaz and Dortal expeditions in search of El Dorado. The first map he attributes to Oviedo, placing the date after 1542, and the latter, which is anonymous, Dr. Schuller believes to have been made about 1560.

Diego de Ordaz, a former companion of Cortez, also credited as the first person to ascend the great volcano Popocatepetl near the City of Mexico, was granted a tract of land in South America by the Spanish Crown in 1530. His concession was for the colonization of the then every indefinite district of Maranon on the mainland. Ordaz sailed for South America, October 20, 1531, with 450 men in three vessels; he was met at the Canaries by another vessel and 150 men, but owing to severe storms the Admiral's ship was the only one to reach the coast in the neighborhood of the mouth of the Amazon. Thence he sailed northward to Paria, where he found and captured a fort built by Antonio Sedeno, justly claiming that this fort was on his concession where Sedeno had no right. Being dissatisfied with the region of the mouths of the Amazon and the coast of southern Guiana, however, Ordaz abandoned all attempts to colonize there and sailed north to the mouths of the Orinoco to explore the delta.

Two of the inscriptions on the old Spanish map refer to this exploring expedition, which set out from Paria on June 23, 1532, with 280 men, 18 horses and one mule, in seven galleys, and finally arrived at an Indian village called Huyapari or Aruacay. A translation of the legend reads: "The large village of Huyapari is situated two leagues inland from the Orinoco." According to Indian informants the source of the river was in a large lake lying in the mountains, the route to which lay through a province called Meta, where gold was abundant. This was El Dorado.

But the second legend inscribed above the mountains in the upper right-hand corner of the map, informs us that "Ordaz could not pass this chain of mountains (by the river, on account of) the bad condition of the water, and from this mountain he returned down the same river to the sea." Another inscription states that "To this side (west of the mountains), or the other end of this rock, Christians had not (yet) come," while an added note by the cartographer Oviedo mentions the accident on the return trip from the expedition in search of Meta-El Dorado—"Ordaz's large canoe remained (here) on dry (land)."

Although he later tried an overland route, Ordaz never located El Dorado; he suffered misfortune, lost his holdings in South America, and finally died on the way to Spain in 1533.

In 1533 Geronimo Dortal, treasurer of the Ordaz expedition, was granted the position formerly held by Ordaz, and also made governor of Paria. Shortly after his arrival, in 1534, Dortal equipped a new expedition to search for the famous Meta-El Dorado—under the command of Alonso de Herrera, a former lieutenant of Ordaz, and the itinerary of his ill-fated voyage is described on Oviedo's map in several legends, the last of which tells pathetically of his end: "Here they killed Alonso de Herrera, lieutenant of Governor Dortal; and to this place came afterwards the said Dortal and found true marks of the death of the aforesaid Herrera; and there were found among other things, a little bell and a tin-cup."

In 1536, about a year after Herrera's death, Dortal organized another expedition which is said to have discovered the domain of the female chief Orocomay, an independent community of Indian women, located on Oviedo's map between the Huyapari and the Barrancas rivers. This legend reads: "Here are the villages and domain of Queen Orocomay, who employs only females." Similar Amazons were also reported by Orellana in 1542, but to-day science does not credit such communities to South America.

One other legend relating to El Dorado reads: "Beyond these chains of mountains of the river Huyapari, there are vast plains which are believed to be the land of Peru, and the Indians say that beyond these chains of mountains there are great treasures and much gold." Contrary to some students of history Dr. Schuller places the date of this early map as after 1542, believing that it could not have been made until two or three years after the latest date recorded.

The second map, showing the rivers Amazon and Orinoco and the adjacent shores, is believed by Dr. Schuller to date about 1560. It includes two references to the Ordaz expedition in 1532, and much other interesting information to students of geography and history.

The region where on other maps is generally shown the legendary lake of Manoa, is here occupied by the following inscription: "This chain of mountains extends from the kingdom (of New Granada) and from Peru; in Peru it is rich in silver; and in the kingdom it is rich in gold; and this is what they call El Dorado."

The author feels that: "The influence of El Dorado and other similar traditions of genuine Indian origin, on the cartography of South America during the second half of the 16th century has not yet been studied with the care and attention which such an important historical and geographical question deserves."

Prompters Boxes for Theatres

A recent European idea relates to an arrangement of a theatre stage with several prompters' boxes of a new kind. The boxes are arranged to display the text in illuminated letters upon an endless band upon rollers, passing in front of electric lamps. Part of the roller device can lie below the stage, while the lamps are placed in the box and behind the transparent band so as to show up the part of the text that is passing. The boxes are connected with each other by any suitable driving gear and the machinist operates all the outfit from the side of the stage by a crank. A number of boxes are preferred, so that the text can be seen from all parts of the stage. An electric motor can also be used for running the device.

A class in swimming receiving their first lesson.

The Enlisted Man in the United States Navy

Advantages and Opportunities Offered by the Service

THE desirability of any particular employment may be measured, apart from its direct pecuniary remuneration, by the opportunity it affords for leisure, travel, self-improvement, hygienic living and careful medical supervision and treatment. Judged by these opportunities few employments measure up with that of an enlisted man, or as he is sometimes called a "blue jacket" of the United States Navy. And all things considered the pecuniary emoluments are not inconsiderable. Take an apprentice seaman or a landsman at $17.60 a month. On top of this he is housed, and well fed, is furnished skilled medical treatment and in the course of an enlistment is frequently carried over practically the entire civilized world. Also a free outfit of clothing valued at $60 is furnished every enlisted man of the Navy on his first enlistment. Can you think of anything in commercial or other civil life that equals it?

In entering the naval service every person must pass the physical examination prescribed and must, in addition to good health, measure up in size and weight to the regulation standard. After entering the service his physical training begins under the system based on the Swedish, modified to suit our requirements. One reason for systematic physical training is found in the changed condition of a seaman's life, sailormen of to-day being said to be not the equal, in all around physical ability, general nimbleness and lack of physical fear, of those who manned the sailing ships of former times, due probably to the fact that the life aloft strongly aided in the formation of these characteristics. The shelf exercise, one form of which is shown in the illustration, has many modifications and variations increasing its effectiveness as well as its attractions because in most of the exercises the game feature is utilized to a high degree, the participants developing individually as well as in team work, the complete illustration of the exercising and calisthenic program of the man in training showing a superior development of the gymnastic work the enthusiastic civilian pays large sums to enjoy. These exercises are carried on in perfectly-equipped halls, open air fields, and swimming tanks.

As to the inner man, that certain route to the affections of humanity, we find that applications for the cook and baker class are only received from those who have been on board a cruising ship for at least four months, and are possessed of a fair knowledge of the trade. These are given a course of six months, and the high class of the candidates and the superiority of the surroundings is shown in one of the accompanying pictures, and it will be seen that a navy kitchen is in no way inferior in equipment to that of a first class hotel on land.

Before reverting to the material advantages of the Navy we must not overlook the romantic side as well as the beneficial side, for we remember that Sidney Lanier sang,

"Oh, is it not to widen man
Stretches the sea?"

So the life of the sea may be regarded as having a widening influence on the enlisted man. This comes in the educational features, for the Navy maintains numerous schools for the instruction of its recruits, large ones being located at Newport, R. I.; Norfolk, Va.; Great Lakes, Ill., and San Francisco, Calif., where he may obtain a general education as well as an education along special lines. And then the enlisted man is never stranded away from home, for when he is enlisted he is furnished by the Government with transportation to the training-station or to the receiving ship, to which he is assigned, and if there is a night ride, he is given a berth in the sleeper, or a stateroom if sent by steamer. Meals are furnished, as are carfare and transfer across the city. When he is discharged at the expiration of his enlistment, he is furnished with a travel allowance of four cents per mile to the place of enlistment within the United States, while if he is honorably discharged or his enlistment expires because of physical inability, he is furnished with transportation and subsistence to his home, if in the United States, as men traveling under orders are always furnished with traveling expenses, and it is only when a man is traveling at his own convenience or on leave, that he is required to pay his own expenses.

There is also reasonable assurance that he will be in good company, because while a man enlisting in one of the lower ratings, is advanced one step at a time, with a corresponding raise in pay, as he becomes proficient and his conduct warrants, both of which requirements are essential to a man's advancement, as no matter how capable he may be in his duties he cannot expect to be advanced unless his conduct entitles him to consideration. This opportunity for advancement is not inconsiderable since the enlisted man may become a chief petty-officer with a monthly pay in some instances as high as $77, and he has the opportunity of advancement by appointment to the Naval Academy or by promotion to be a warrant-officer, as advancement in the Navy does not stop with chief petty-officer. The next higher grade is that of warrant-officer, which is a life position, obtainable only by promotion from enlisted grades, the pay of a warrant-officer being from $1,500 to $2,400 a year, with benefits of retirement at 62 years of age on three-quarters pay. If the enlisted man does not secure advancement to petty-officer or to warrant-officer before re-enlistment he has a special allowance for re-enlistment, this allowance being a monthly one and increasing with the number of re-enlistments. He has further opportunities in the way of allowances for special duties running all the way from coxwains of boats at $5 a month, in addition to other pay, to divers who in some instances receive $1.20 the hour for the time employed under the water, and gun pointers whose allowance ranges from $2 to $10 per month. There is also the possibility of a boatswain, gunner or machinist, or a chief boatswain, or chief gunner, or chief machinist, who has been in his grade four years and is under 35 years old, to enter the examination for appointment as ensign, which examination is held every year, and the man who wins the commission in this manner is entitled to the same pay, privileges, honors and position for further advancement as are open to officers or graduates in the Naval Academy.

There is also the opportunity open to an enlisted man in the Navy not undergoing punishment, charges or in debt to the Government, who may, in the discretion of the Secretary of the Navy when the exigencies of the service permit, to purchase his discharge from the Navy by reimbursing the Government for expenses incurred in their behalf, and for which adequate return by service has not been made, and this is regulated in accordance with the regular table prescribed in Naval regulations.'

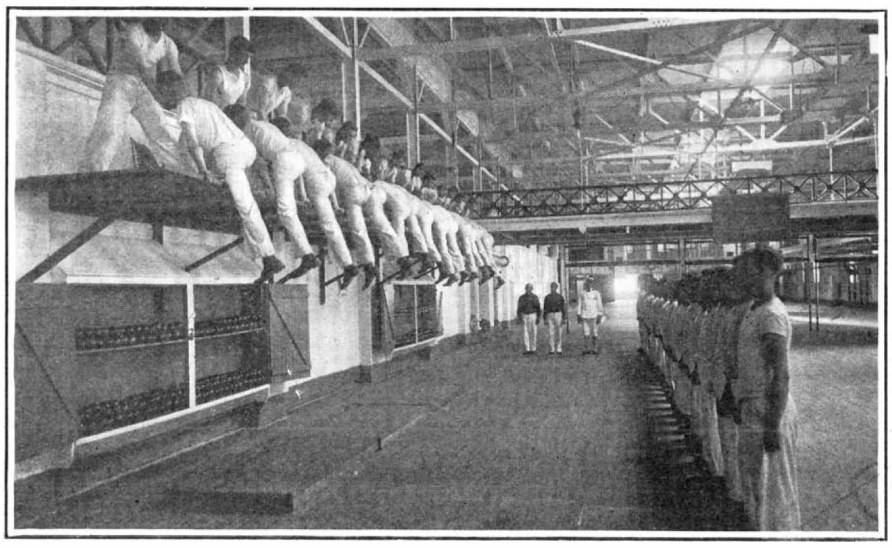
On shipboard effort is made for making life as pleasant as consistent by providing sundry amusements and opportunities for recreation and by encouraging mascots in various forms from monkeys to goats.

On top of all this there are death benefits and pensions provided by law, so that all in all the position of an enlisted man is one that might well be envied by many a skilled man in private life.

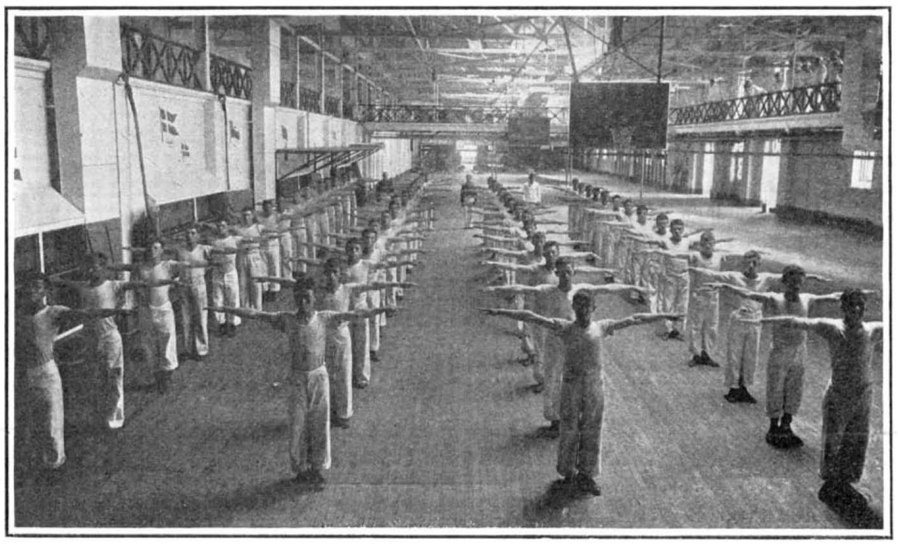
Canal and River Barges

ONE of the sections of naval architectural science about which there is little recorded information is that relating to resistance and propulsion of barges in canals and in shallow rivers, possibly because of its limited application, though it is interesting in its character, and often enough important in its results for those who make use of canals and barges. The problems associated with it differ in some ways from those of deep-water navigation, but are similar to those which are encountered where depth of water is restricted and deep-sea vessels have to run for some portion of their voyages in shallow water.

In a canal, width of water is restricted as well as depth, and the abnormalities of resistance which are exhibited in shallow water are accentuated by the double restriction, strange and almost paradoxical features are met with, and care must be taken if the highest efficiency is to be obtained. For every depth of shallow water there is a natural speed at which a



An exercise in scaling by a class at the school.



Calesthenic exercises produce supple muscles.

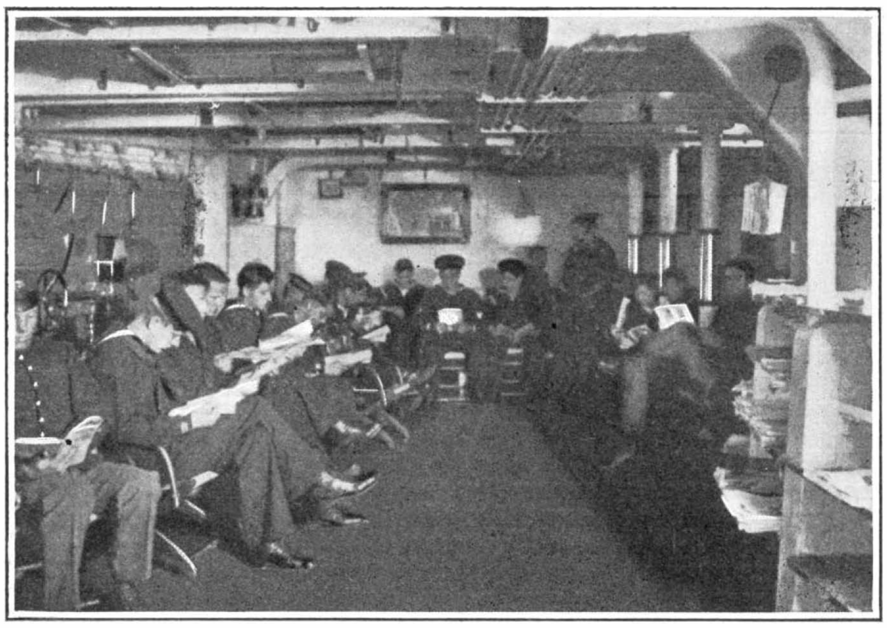
solitary wave, termed the "wave of translation," if once propagated, will travel along a canal, and if the water were a frictionless fluid, and there were no resistance, it would continue to travel indefinitely. In reality, the wave energy is soon destroyed by viscous friction in the water itself, along the sides and bottom of the canal, and in the air. This wave is called the "long wave," and its speed is expressed by $\sqrt{gd}$, where g is the acceleration due to gravity, d the depth of water in feet, and the speed is in feet per second. For a canal 6 feet from bottom to water surface this critical speed is 9½ miles per hour; for 8 feet depth of water, 11 miles per hour. It will be at once seen that these speeds are considerably higher than those usually obtained by canal boats. Scott Russel investigated this feature when making experiments on wave formation in the Forth and Clyde Canal, many years ago. He found that if a canal boat were towed at any speed less than this critical speed a procession of waves was formed and maintained behind the boat, while a corresponding high resistance was experienced; but if the vessel were towed at a speed higher than this, it was impossible to form a regular procession of waves, because the speed was greater than that of the longest possible wave for the particular depth of water, the result being that the vessel was borne along on the top of a solitary "hump," which needed little energy to maintain it, the resistance then being greatly reduced. Professor Biles stated in his book, "Design and Construction of Ships," that Scott Russel noticed this curious feature from the accident of a frightened and spirited horse running off and dragging a boat with it at such a speed that the vessel was carried along through comparatively smooth water with greatly diminished resistance. At the time that this was discovered canals were much more in use than they are now, and the result was the introduction of very light canal boats, constructed of sheet iron and drawn by a pair of horses. They were known as "fly boats," and were able to attain the requisite speed to make use of the "wave of translation." It was stated that "the boat starts at a low velocity behind the wave, and at a given signal it is pulled up with a sudden jerk on to the top of the wave, where it moves with diminished resistance at the rate of about 7 to 9 miles per hour." Obviously, the phenomenon was more curious than valuable, for the wash from such a wave had most destructive effects on the canal banks, and little more was heard of it. For nearly all inland canals the speed is restricted to three or four miles per hour, and the barges are of such full proportions that there is no serious damage caused to the banks by their passage. It is at these low speeds that the distinctive features of canal work are of importance, but there is not much reliable information available on the subject.

Beaufoy, during his investigations on resistance in 1793, tested many forms of bow and stern, applied to straight middle bodies of square section and of varying length. The experiments were not made in shallow water, but the general deductions drawn from them may be accepted as a safe guide. He found that the best form of ends was a wedge of right-angled section in elevation, the hypotenuse of this triangular section joining keel to deck, so that the underside of the wedge was a plane inclined upwards from the bottom of the boat or model. The ends were such as one would make for a vessel to run up easily on a sloping beach, and were similar to those of a Thames pleasure punt. This form was recently tried for barge design by Sadler, who found that, taken all round, it was the best whether towed singly or in groups—that is to say, the form of bow which forces the water to go under the bottom of the barge and not round the sides is better than a form triangulated at the ends in the other way to form a stern and sternpost. Baker, in his "Ship Form Resistance," gathers up nearly all the available information on barge forms, and he concludes that while any advantage which a barge may possess, when running in deep water, due to its form, is to a certain extent masked in shallow water, yet it is never obliterated. In every case of certain canal boats which were tested in the Seine, and also in a canal, that which towed best in the river also towed best in the canal, the differences being roughly the same. This is a broad generalization, and is probably not true for all conditions; but it may be accepted as justifying the use of Beaufoy's deductions for shallow-water conditions.

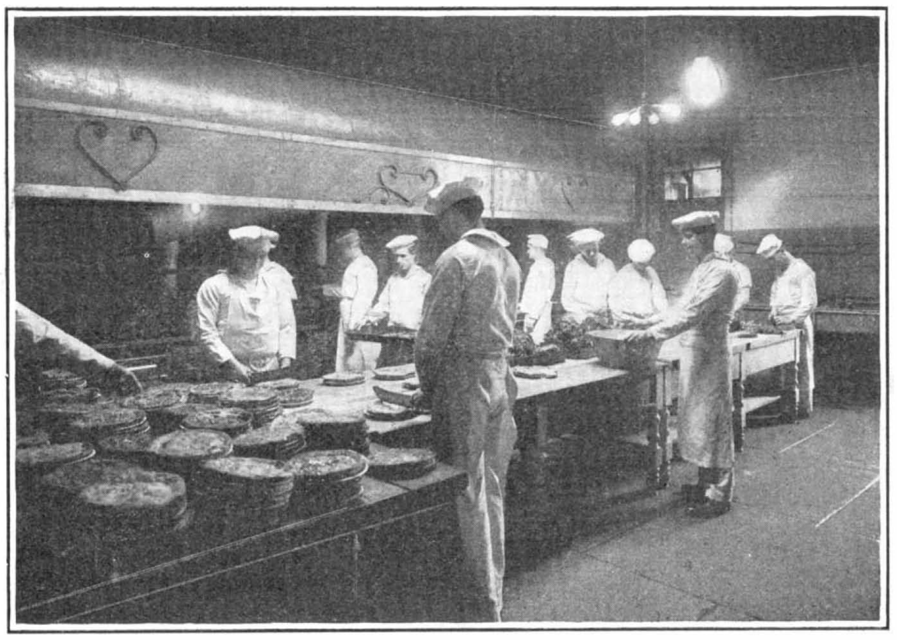
The type of barge must depend largely on the character of the service required of it, whether it is to be towed singly or as one of a group, or articulated in a long or short train with other barges. Pure resistance considerations must give way to practical necessities, but, taking an all-round view, it appears that the inclined plane entrance with a gentle slope gives a good performance in either condition. In deep water the resistance of a number of grouped barges is not largely different from the sum of their individual resistances, but in shallow water, where there is only a short distant between the bottom of the barges and the canal or river bed, it is of great advantage to use a long train of barges. The resistance of such a long train is not much greater than that of a short one, and it is easily handled if the articulation is well carried out. Where resistance is of importance it is an advantage to use steel and not wood for construction, for steel hulls keep a much smoother surface after much wear and tear. Most modern barges are of steel.

What now of the canal itself? If the waterway be very shallow, the water forced down by the bow is unable to flow steadily between the barge and the river or canal bottom. Instability is observed, the motion of the barge becomes eccentric, and there is an increase of resistance due to eddy-making. The depth of water under the keel should not be much less than 2 feet for an ordinary canal, say 6 feet or 7 feet deep. It is better to have this clearance even at the expense of width in order to get the best results, for the resistance in a canal depends very largely on the relation of the cross-sectional area of the waterway to the immersed section of the boat, and, given a constant relation between the two areas, the least resistance is obtained with a deep, narrow waterway rather than a wide, shallow one for the speeds used in canal work. It will have been noticed that the width of the canal does not affect the critical speed, which is a function of depth only, but the speeds under consideration are much below that of the wave of translation.

Slow-running deep sea vessels—say, those capable of a deep-water speed in knots less than $9\sqrt{L}$—are always subject to an increase of resistance and a loss of speed in shallow water, for the reason that they cannot be pushed at a high enough speed to take them over the last hump of the resistance curve, and in this respect the problem is similar to that of canal boats. The condition of service of deep-sea vessels, however, do not admit of the adoption of forms which can easily be used for still-water canal navigation.—*The Engineer.*



The crew's reading room on a government vessel.



A naval kitchen equals that of a hotel.

Thermometer Scales

There has been much discussion lately concerning the use of the Centigrade and the abolition of the Fahrenheit scale and it would seem as if the latter must soon be abandoned even in the most conservative countries. The British Weather Service is now using extensively Centigrade and Absolute scale; but our own weather bureau lags behind. On the current daily weather maps no effort is made to give at one end of the isotherm the equivalent Centigrade or Absolute reading. Moreover, as has been pointed out elsewhere, a most peculiar practice is followed of connecting in one continuous isotherm readings made at 8 A. M., 7 A. M., 6 A. M. and 5 A. M. Thus, if it should happen to be 300 deg. A. (20 deg. F.) this morning at New York and 277 deg. A. at Reno, Nev., because the observation is taken at 5 A. M., instead of applying a suitable correction corresponding to a temperature at 8 A. M. at the given place, the first reading is used; and the result is a conglomerate weather map, one that does not fairly represent the conditions of temperature for the given date. *Pressure* is reduced for elevation to a common base; but *temperature*, which, after all, affects us most, is not corrected even for *time* and, of course, not for elevation.

Nearly all national weather services now use the Centigrade scale and internationally no other scale has been recognized for some years. Even the few weather services retaining the Fahrenheit scale restrict its use and banish it from all investigational research work.

At Blue Hill Observatory, no less than three scales have been used and we are now considering a fourth. Beginning with 1891, the Centigrade scale displaced Fahrenheit in our published summaries. In 1914 the Absolute scale displaced the Centigrade, the first of the three figures being written once in tabular work at the head of the column. The use of minus signs for low temperatures, frequent in Winter months for surface readings, and in all months with upper air readings, is thus avoided.

The objection made, however, to the length of the Centigrade division holds also for the Absolute scale and, therefore, the writer suggested a scale based on the Absolute system but with the present 273 degrees marked 1,000 degrees.

For many reasons the freezing point is important. The new scale emphasizes this point. The boiling point is not so definitely marked but the whole system has the advantage of flexibility and consistency. For thermodynamic problems it is an ideal arrangement.

It is urged that "the common people are familiar with the Fahrenheit scale." They may be familiar with it and yet not understand it. When the temperature is 64 deg. Fahr., is it clearly understood by every one that the temperature is 32 degrees above freezing; and on the other hand when it is —32 deg. Fahr., that the temperature is 64 degrees below freezing? The scale says one thing and means another. It is true that the Centigrade scale division is nearly twice the length of the other scale division; and much has been made of this by some who insist upon accuracy to the tenth of a degree; but it may be well to remember that most air temperatures are a degree or more in error. Even with official instruments, errors of exposure or time, exceeding several degrees, go uncorrected, while instrumental errors are applied to a tenth of a degree.

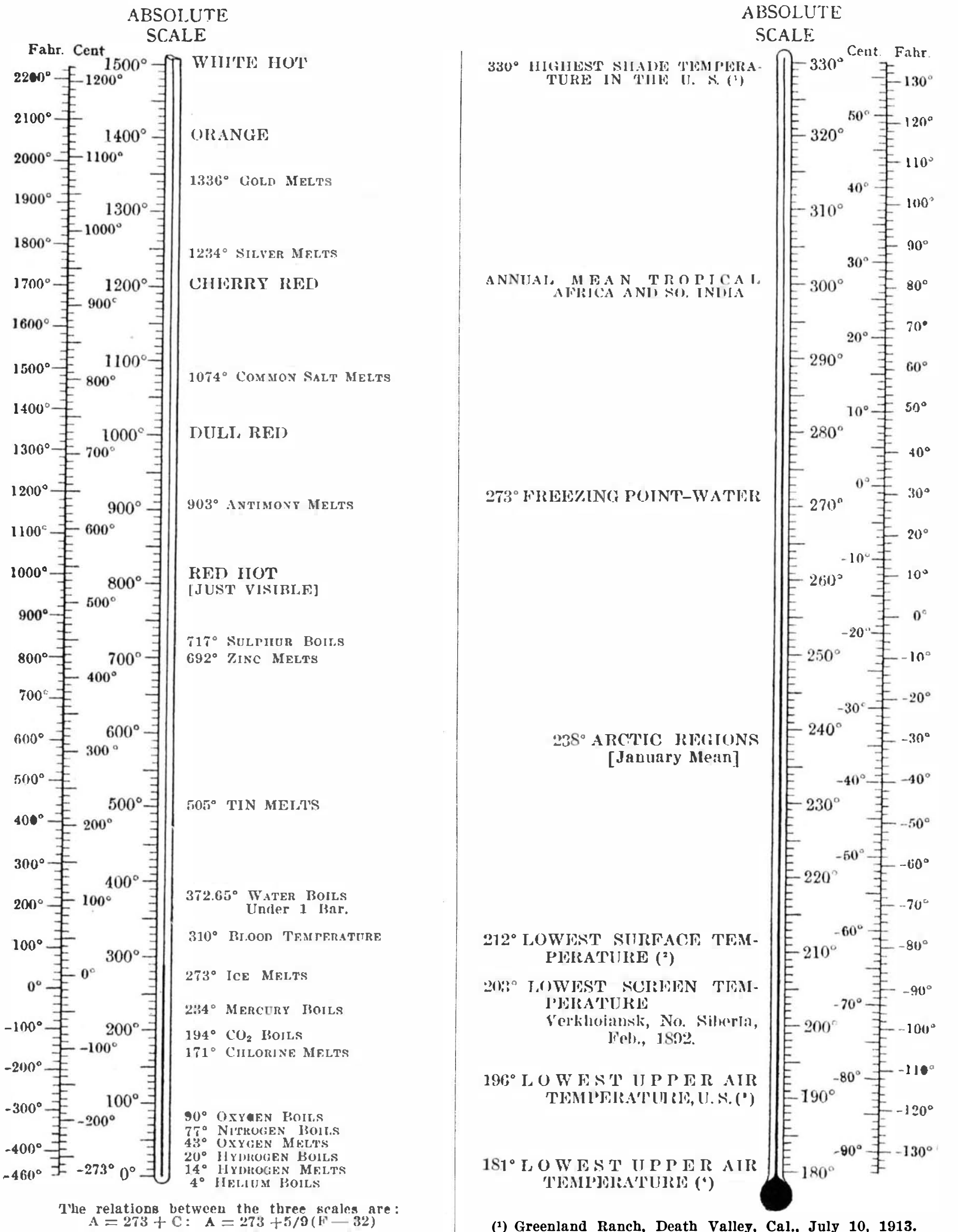
The diagrams, based upon a circular issued by the British Meteorological Office, show comparative readings on the Absolute scale from 0 degree to 1,500 degrees, the upper reading representing WHITE HOT (meaning, I presume, ordinary iron); and from 180 deg. to 330 deg. A., the latter being a shade temperature recorded at Greenland Ranch, Cal., July 10, 1913. (Parenthetically, Greenland Ranch is 4 miles from Ryan in Death Valley, and thermometers were installed there when I was director of the California section.) This is probably the highest reliable shade temperature as yet recorded at any station. The other limit, 180 deg. A. is the outcome of recent upper air work; and as stated in the diagram, a reading of 189 deg. A. was obtained over Victoria Nyanza in August, 1908. However, this is not the lowest natural temperature recorded. I am somewhat surprised at the omission of the record obtained in an ascension at Batavia, Java, December 4th, 1913, by van Bemmelen when at a height of 17,000 meters the temperature fell to 181 deg. A.

The lowest temperature obtained in the United States is 196 deg. A., obtained in the Blue Hill ascents at St. Louis. Temperatures of 204 deg. A. and slightly higher have been obtained by the weather bureau in the ascensions made at Fort Omaha. It may not be out of place to mention that the lowest temperature given by Scott is 212 deg. A.

Alexander McAdie.

TEMPERATURE SCALES.

Comparison of the Absolute Scale of Temperature with the Fahrenheit and Centigrade Scales.



(1) Greenland Ranch, Death Valley, Cal., July 10, 1913.
(2) Scott, South Pole.
(3) Blue Hill balloon, St. Louis to Iuka, Miss., January 25, 1905, at a height of 14,830 meters.
(4) At Batavia, Java, near the equator, December 4, 1913, at a height of 17,000 meters, by Van Bemmelen.

Scales based on a circular issued by the British Meteorological Office.

Cultivation and Utilization of Sunflower, Niger and Safflower Seed.

The sunflower is cultivated on a commercial scale only in Central and South Eastern Europe, but trial and experimental crops have been grown in many other parts of the world, usually with success. The stems and leaves of the plant have little nutritive value, but the ash of the former yields about 39 per cent of potash (as K_2O), whilst the seedhusks give an ash containing 56 per cent of potash. An acre of land produces 2,600 to 4,000 pounds of stalks yielding 40 to 53 pounds of potash. Sunflower seed is used largely as a poultry food, and as a source of oil. Russian seed kernels yield 18 to 24 per cent whilst Hungarian seed kernels yield 28 to 30 per cent of oil on a commercial scale. Seed grown in the Sudan contained 22 per cent of oil, the kernels containing 47.9 per cent. Sunflower seed oil has sp. gr. 0.924 to 0.926 at 15 deg./15 deg. C., saponif. value 188 to 194, iodine value 120 to 135 per cent. When cold-pressed it is almost tasteless and is suitable for edible purposes. Oil unsuitable for edible purposes is used for burning and soapmaking and as an inferior varnish oil. Sunflower cake is produced in large quantities in South Russia and is largely exported to Denmark, where it is a popular cattle food. The niger seed plant (*Guizotia abyssinia*, Cass.) is cultivated fairly generally in East Africa for local use and also on a large scale in India. The small black seeds contain 40 to 45 per cent of oil having the characters: sp. gr. at 15 deg./15 deg. C., 0.925—0.927; saponif. value, 189—192; iodine value, 127—134 per cent; it is used as an edible oil, for soapmaking, and as an inferior substitute for linseed oil. Niger seed cake is similar in feeding value to sunflower seed cake. Safflower (*Carthamus tinctorius*, Linn.) is an annual herb grown in India and Egypt chiefly as an oil-seed plant and also to a small extent for the dye which is obtained from the florets. The seeds contain 30 to 32 per cent of oil, which is very similar to sunflower seed oil and has the characters: sp. gr. at 15 deg./15 deg. C., 0.925—0.928; saponif. value, 187—194; iodine value, 130 to 150 per cent.—*Bull Imp. Inst.*

A Pallograph for the U. S. Navy Engineers

The pallograph is an instrument that simultaneously records vertical and transverse vibrations, and while primarily designed for use on ships, it may equally well be employed for tracing vibrations or oscillations of any character to their source. There are but two or three pallographs in the world, and one is the instrument recently supplied to the U. S. Navy engineers for use at the model basin at Washington.

Speech, Its Culture and Refinement*

What Is Done for It in Holland

By N. J. Poock Van Baggen

My readers, did you ever meet with that certain handsome young lady, dressed by a first-rate Paris dressmaker, smart and "*Ciln soignée*" from top to toe, who moves about so gracefully and looks so extremely distinguished and refined? Fascinated by so many charms you are only too happy to obtain an introduction and to be allowed to speak to her. When she opened her lips to respond to your modest flattery, I noticed a sort of bewildered look in your eyes, which bye and bye changed into an ironical smile. What was the matter—this outwardly distinguished and refined young person betrayed only too distinctly her low origin both by her voice and accent.

Poor young lady! She had spent so much for her general refinement and culture, and only forgot an essential matter: the culture and refinement of her speech.

Sometimes you go to church, I suppose. Going home you want to think over the beautiful words which the clergyman uttered, but it is too much for you. You got a bad headache while listening to the sermon. You overstrained yourself in the effort to understand the speaker, and you came to the conclusion that the sermon failed to make the desired impression because of the fatiguing resonance of the clergyman's voice and his want of distinct articulation.

And the clergyman himself . . . He did his utmost effort to make himself understood in the spacious church; but before he had finished half of his sermon, he had the desperate feeling that his voice was losing its clearness and became hoarse and indistinct. He came home with a sore throat and the unpleasant feeling that his audience had not come under the spell of his eloquence. Yet he had carefully meditated his subject and his sermon was well prepared. He only never thought of training and preparing his voice for its strenuous task. And this is the same case with ever so many speakers. How often does it not occur that, in the midst of an electioneering campaign, the candidate is forced to renounce speaking at a meeting because his voice has given out entirely. And no wonder! What fighter, gymnast, pianist, violinist or any other performer will go in for a performance without having thoroughly prepared and trained his muscles by appropriate and efficient exercise? They know too well that their success depends on the readiness of their muscles for the task. While in the United States, I noticed that the public speaker, as a rule, never thinks of getting his voice ready for the work.

The American speaker does not seem to realize that the voice and speech is the result of the action of a complicated and delicate set of muscles, which need more than any of our muscles to be properly trained when we demand a great exertion of them. Yet the speaker who masters the right employment of the voice will meet with the pleasant experience that his voice lasts till the end of his task. Serenely, in full possession of his faculties, he faces his audience, who follow with pleasure his intelligible and comprehensible speech.

It is a matter of course that the training of the voice includes its refinement. Vicious accents, as for instance the nasal twang, disappear altogether or are diminished sensibly when the muscles become more supple and tractable by their exercise.

How do we train the voice? I mean the fundamental training, which has in view the exercising and strengthening of the muscles used when speaking and singing and the furthering of the harmonious co-operation of the different groups of muscles.

When we observe a speaker or singer, we notice that, before he begins to produce a sound, he inhales more or less deeply. This inhalation procures him the provision of air which he uses as the motor power to put his instrument into action. We can compare this inhalation with the work which the bellows blower does for the organist. Without the necessary provision of air the organist is unable to play his instrument. Only after the bellows are put in action and he has the management over a sufficient quantity of air or, what is here the same, a sufficient quantity of motor power, he can draw sounds from his instrument.

Exhaling, the speaker or singer uses this provision of air to make the tented vocal cords vibrate. This vibration engenders the sound, which we call "the voice."

*Medical Record.

From the voice box the voice or sounding breath is driven into the pharynx, the mouth, and the nose. Those parts assume by means of the articulating muscles the different attitudes and shapes necessary for the formation of vowels and consonants, which as such leave the mouth and reach our ear.

The sonorous vibrations of the voice cause the co-vibrations or resonance from the partitions of the vocal instrument, i. e., of the thorax, the larynx, the pharynx, the mouth, and the nose with its cavities. This co-vibration or resonance gives the tone, its characteristic quality or "timbre," its brilliancy, and its fullness.

From the above results we learn to distinguish in the speaker and singer four elements: (1) A motor element (the breath); (2) a vibrating element (the voice); (3) a forming element (the articulation); (4) a resonant element (the co-vibration of the walls of the vocal instrument).

Thus for the training of the speaker and singer we consider in the first place the breathing. If the breathing is faulty and weak, it is corrected and strengthened by appropriate exercises, after which the pupil is taught how he can best use his breath on behalf of his voice and articulation.

Secondly, the articulating muscles are examined and the different vowels and consonants reformed so far as necessary. Nearly at the same time the amelioration of the action of the vocal muscles is undertaken; while finally the resonant element is developed.

Normal speech and singing depend on the faultless action and the exact harmonious co-operation of the four elements. This co-operation is so strict that even the least deviation of one of the parts is of direct influence on the other elements.

A faulty articulation, for instance, impedes the action of the vibrating element and requires a greater effort on the part of the breathing muscles; while, on the other hand, a wrong use of the breath thwarts the distinct pronunciation of the vowels and consonants as well as the voice production. And also a non-developed resonance or gaps in this element are an important impediment to the clearness and purity of the voice.

Very many times I have been asked in America if, when I speak of the training of the voice, it is elocution that I mean.

It is not. The training of the voice precedes the lessons of the elocutionist. This training is given by what we call here the "leeraar in het methodisch spreken," which means: "Specialist or expert in normal speech and voice hygienics."

The sphere of action of the expert implies not only the training of the healthy voice but also the treatment of all the voice afflictions which appear after serious diseases of the throat such as diphtheria, angina, etc., and after those affections caused by the too general misuse of the voice as well as by speakers as by singers. Most of the time the expert is also specialist for correcting speech impediments and for gymnastics of the respiratory organs.

The expert works in combination with the medical specialist in diseases of the throat and respiratory organs. No serious expert begins his work before the patient has gone through a judicious medical examination.

The studies of the student-specialist for voice hygienics include the exact anatomical knowledge of the vocal instrument, the pathology of the throat and of the voice, the diagnosis, the modes of treatment, and the application of the exercises in the different cases, tone production, acoustics, and phonetics. If he goes in for the breathing and the speech impediments, he studies also the diseases of the respiratory organs and the central and peripheral speech affections, their origin and treatment.

With regard to the treatment of the voice, affected through misuse or illness, I can say that I have found it nowhere so complete as in Holland. During my investigations regarding the care for the voice and the culture of speech in the different countries, I have been astonished to find that in some countries this special treatment is altogether unknown, as for instance in France and in the United States; while in other places, as in Berlin, it was introduced by Dutch specialists and received with general appreciation.

Since the last twenty years the culture and refinement of speech in Holland has largely improved. The conservatories for singing at Amsterdam and at the Hague, as well as the school for actors and actresses have long had their own expert specialist and every pupil is obliged to go through a severe treatment for general voice hygienics and purification of the accent.

Particular care is also given to the training of the voice and the refinement of the speech of the teachers. To every Dutch training school for teachers is attached nowadays a specialist for voice hygienics who is salaried by the government or by the municipality to which the school belongs. Moreover, in the large towns, as in the Hague and Amsterdam, the municipality has appointed a specialist for voice hygienics, who gives courses free of charge to the teachers of the municipal schools. Those courses were started to combat the throat disease (the same as clergymen's sore throat) to which the teachers, in the exercise of their profession, are so frequently subject.

When the teachers suffer from the throat the visiting physician of the school examines them and, if necessary, sends them to the courses for voice hygienics. For the teachers with a healthy voice those courses are not obligatory but on his (or her) demand, he (or she) can follow the course. Generally all the teachers of the municipal schools take a course because it gives them a better chance for an appointment and for promotion when they have a well-trained voice and refined speech.

It is a matter of course that those trained teachers exert a favorable refining influence over the speech of their pupils. I have often noticed that the young teachers who have followed the course take pleasure in correcting the speech and purifying the accent of the children, who are under their care and demand from them a faultless pronunciation.

Besides the care for the voice and for the refinement of the speech in general, the speech defects are specially attended to.

In every town of some importance there is nowadays a specialist for speech impediments, attached to the public schools and salaried by the municipality. In the large towns, as Amsterdam and the Hague, the specialist has a staff of assistants. They visit the public schools regularly and at the request of the teacher examine the pupils who suffer from any speech defect. After the diagnosis is made the children go to the municipal institution, where they receive free of charge the treatment which their case demands.

Some years ago the specialists for voice hygienics in Holland founded the Dutch association for the speech culture, which meets regularly. In those meetings special cases are discussed, and in particular the measures to be taken to further the general culture and refinement of speech are advocated.

The influence of the refinement of speech is not merely external. I have explained above how speech is produced by the action of some groups or muscles. Those muscles are stirred by the vibration of the nerves. They vibrate under the impulse of the action of the brain, which is the utterance of the soul. Thus speech comes from the soul to go to the soul.

And so the culture and refinement of speech mean the smoothing down of the obstacles which hinder the free communication of the souls.

The culture and refinement of speech mean the furthering of the better understanding between mankind; and that better understanding between mankind is what we require nowadays, essentially; there is no doubt about that.

What Causes a Fuse to Blow

Commenting on the idea held by many people that it is the voltage that causes fuses to blow *Power* calls attention to the fact that the heating of an electric circuit is caused by the current that flows through it, and not the voltage impressed upon it.

What causes a fuse to blow is excessive heating produced by a greater current than that which it was intended to carry. The heating in any circuit is proportional to the watts (I^2R) expended in the circuit, and varies as the square of the current. Thus, if the value of the current flowing in a given circuit is doubled, the temperature is not increased in the same ratio, but by the square of 2 or 4 times.

A Morse Optical Pyrometer*

An Instrument Adapted to a Wide Range of Laboratory Uses

By W. E. Forsythe, Nela Research Laboratory

THE following is a description of an optical pyrometer of the Morse type (generally known as the Holborn-Kurlbaum pyrometer) that has been constructed for use in Nela Research Laboratory. It is thought to have some advantages over existing forms. A photograph of the complete instrument is shown in Fig. 1. In Fig. 2 is shown diagrammatically the arrangement of the different parts.

The objective lens *A* is an achromatic lens 3.5 cm. in diameter. If the pyrometer were to be used only with a particular so-called monochromatic filter (e. g., red glass) before the eyepiece, there would be no need of having anything but simple lenses. However, it is quite often desirable to use different filters before the eyepiece, in which case quite a change in focus would be required if only simple lenses were used.

As may be seen from the diagram, the tube holding the objective lens is not a part of the tube to which the rack and pinion are attached. The reason for making it a separate tube was to increase the range of magnification. For the same reason this tube is made in two parts, there being a joint at the point marked *B*. Thus, with only a comparatively short rack for focusing, adjustments from magnification of little more than two times down to a focus for parallel light can be obtained. This is accomplished by moving the tube holding the objective lens backward or forward in the holder *C*. The tube can also be taken apart at the point *B* and only the short piece containing the objective lens used. The lens can also be reversed in this short tube and the tube reversed in the holder *C*. Thus the lens can be placed very near the diaphragm *D*. At this position the pyrometer is focused for parallel light. This feature has been found quite desirable. The pyrometer may be calibrated by comparison with a black body where large magnification cannot be used conveniently, and the pyrometer may also be used to measure the brightness of either distant objects or, by a slight change, to measure the brightness of a lamp filament which is only about 0.1 mm. in diameter.

The pyrometer lamp *K* has a tungsten filament somewhat of the shape shown in Fig. 3. The pointer *P* and the smaller bend in the filament indicate the point of the filament under observation. The filaments used are of three sizes (0.1 mm., 0.061 mm., and 0.037 mm. in diameter), but for the most part the second size is used, as with this the disappearance is satisfactory. The length of these filaments is approximately shown in Fig. 3. The (0.061 mm.) filament requires about 0.46 amperes at about 3.3 volts to apparently match in brightness the black body at the temperature of melting palladium. The pyrometer lamp bulb is about 5 cm. in diameter. These bulbs were selected with very great care in order to obtain bulbs as free from defects as possible.

The pyrometer lamp is so mounted that it may be moved across the field of view by a screw motion. Thus the particular part of the filament that it is desired to use may be easily brought into the center of the field of view. In addition to this the mounting is so arranged that all other possible adjustments, such as raising and lowering, turning and tipping the bulb, can be easily obtained.

As it is sometimes very desirable to have the pyrometer filament horizontal and at other times vertical, the pyrometer lamp-holder *F* and the eyepiece telescope were made so as to rotate in the collar *G*. By this means the pyrometer filament can be set at any angle. This has been found very convenient when measuring the temperature of a lamp filament. Owing to the variation from the cosine law of emission,[1] it is desirable to have the pyrometer filament parallel to the background filament. In this case it is the brightness of the central part of the filament that is measured rather than the mean brightness across the filament. This average brightness has been shown to be about 3 per cent greater than the normal brightness.

It is sometimes desirable to use two different pyrometer lamps in the same optical pyrometer. This is necessary when two different observers have to use the same pyrometer but desire to use different pyrometer lamps. It is also desirable to have a second pyrometer lamp to use occasionally to check the calibration of the pyrometer lamp that is generally used. To be sure, one pyrometer lamp can be removed and the other put in its place, but a much more accurate procedure is to have the holder large enough so that both lamps can be kept in the holder at all times. The holder for the pyrometer lamps can be brought exactly into place. This can be accomplished by turning the holder or by sliding it along guides. If the lamps are kept in the holder, they will be more likely to be used in the exact position in which they were celibrated, which is very important for accurate work.

The pyrometer lamps with tungsten filaments have a very long life as they are used in this kind of work. They are seldom operated at a brightness above that

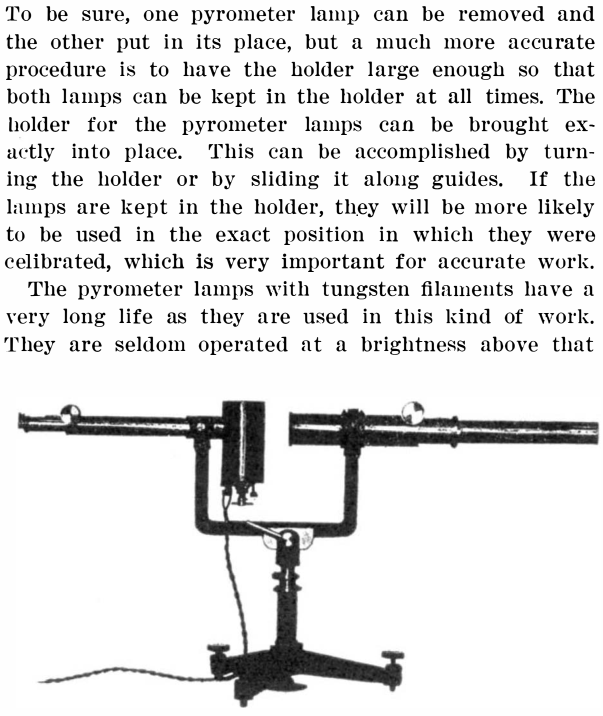


Fig. 1.—Optical Pyrometer.

necessary to match that of a black body at the temperature of melting palladium (1822° K). A particular lamp that has been in use for about two years, and has during the greater part of that time been used almost every day, shows an exceptionally good performance. When it was first calibrated two years ago it required 0.4573 ampere to apparently match the black body at the temperature of melting palladium. A recent calibration showed that it now required 0.4578 ampere to apparently match the black body at the same temperature. As this lamp has been operated for about 300 hours in all, it is seen to be very satisfactory. This pyrometer lamp has a 0.062 mm. filament.

As a ready means of checking the calibration of the

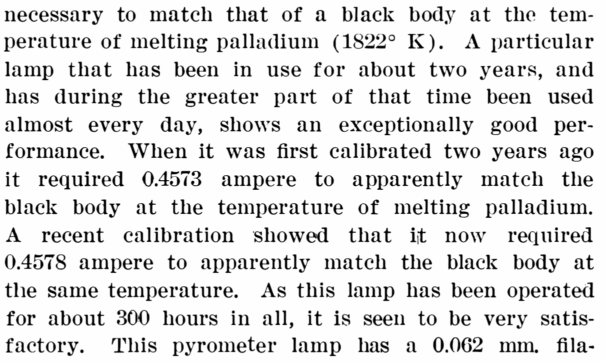


Fig. 2.—Details of the optical pyrometer.

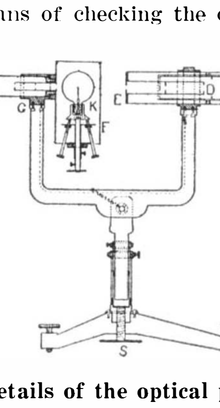


Fig. 3.—Lamp used in the instrument.

pyrometer lamp a large filament (0.25 mm.) tungsten lamp, standardized by comparison with the black body by the substitution method, is used. By using this lamp as a secondary standard the necessity of setting up and calibrating a standard black body can often be avoided. The calibration of the pyrometer lamp can be checked much more readily by means of this secondary standard than with the black body.

The opening at *E* was made for two purposes: (1) to allow the lamp-holder and eyepiece telescope to revolve, as was pointed out above; and (2) to permit the insertion of a rotating sector, since it has been shown[2] that if a rotating sector disk is used to reduce the intensity of the light incident upon the pyrometer lamp it should be placed as near the pyrometer lamp as possible. Though for the most part it is much better to use rotating sectors to reduce the intensity of the incident radiation, owing to the difficulty of securing satisfactory filters of neutral tint, it is sometimes necessary to use such filters. This is especially true when using light of the shorter wave-lengths, as the ratio of change of brightness for a given change in temperature is much greater for shorter wave-lengths. A holder for the absorbing glasses is located at *E*.

The telescope, consisting of the objective lens *J* and the eyepiece *L*, is used to observe the pyrometer filament and the projected background. This telescope is so constructed that the magnification can be altered. Thus it is possible to use the greatest magnification allowable and still have a good disappearance of the pyrometer filament against the background. One objection that has been raised against tungsten pyrometer filaments is that they disappear against the background too easily. This is due for the most part to the optical system used to observe the pyrometer filament. With an optical system of good resolving power and large magnification it is often impossible to get an apparent disappearance of the pyrometer filament against the background. It has been pointed out[3] that in order to obtain a disappearance it is sometimes necessary to use an eyepiece with less resolving power than would otherwise be convenient. It is not to be understood that the trouble with disappearance is limited to tungsten pyrometer filaments. With carbon pyrometer filaments it is often difficult to obtain a disappearance. Tungsten and carbon pyrometer filaments of the same size behave differently, owing to their difference in deviation from Lambert's cosine law.[4]

At *D* is located the diaphragm that has been shown[5] to be necessary in order to avoid an error due to diffraction at the pyrometer filament. This error is caused by changing the solid angle of the radiation incident upon the pyrometer filament, due to changing the position of the objective lens. As the solid angle is changed the diffraction around the filament will be changed. If, for example, this solid angle is increased, more light will be diffracted around the filament. The filament will thus require less current to apparently match in brightness a particular background. The size of this diaphragm is so chosen that it is completely filled by the cone of light from the objective lens and particularly even when the lens is moved to the farthest distance possible from the pyrometer filament.

Th real limiting diaphragm is located at *H*. The upper limit to the size of this diaphragm must be so chosen that it is smaller than the cross-section of the cone of rays limited by the diaphragm *D*. A limiting diaphragm is necessary, as the apparent brightness of any radiating body depends upon the solid angle through which the radiation passes before it enters the eye. Thus, with a limiting diaphragm, the brightness of any radiating solid, as observed with a telescope, is independent of its distance so long as the limiting diaphragm is filled. This same argument applies to the pyrometer filament, and the two should always have the same limiting cone. What really determines the size of this diaphragm is the resolving power of the eyepiece telescope. The size of this diaphragm must be so chosen that with the magnification necesary for use, disappearance of the pyrometer filament can be obtained. The foregoing diaphragms *D* and *H* were respectively 1 cm. and 2½ mm. The other diaphragms, shown in the eyepiece telescope and, the objective telescope, are for the purposes of lessening the stray light. The support for the pyrometer, as shown in Fig. 2, is so constructed that the instrument can be rotated, raised or lowered, or set at any angle with the horizontal. The pyrometer can also be raised a small amount by means of the screw *S*.

This pyrometer has been used in connection with the less portable forms of the Holborn-Kurlbaum optical pyrometer previously described.[6] The accuracy

*From the *Astrophysical Journal*.

[1] *Astrophysical Journal*, 36, 345, 1912.

[2] *Astrophysical Journal*, 42, 303, 1915.

[3] *Physical Review* (N.S.), 4, 163, 1914.

[4] *Astrophysical Journal*, 36, 345, 1912.

[5] *Physical Review* (N.S.), 4, 163, 1914.

[6] *Physical Review* (N.S.), 4, 163, 1914.

obtained with this pyrometer is about the same as with the larger forms.

It is interesting to note that the principle of this pyrometer (generally referred to as the Holborn-Kurlbaum pyrometer), patented by Morse in this country about 1900, was discovered and used back in 1888 in one of the lamp factories. At that time a certain furnace was operated at such a temperature that it matched the standard lamp at about 80 volts.

The author does not desire to claim originality for the above-described instrument. The pyrometer as constructed is the outgrowth of several years of use of such instruments both in this laboratory and in the University of Wisconsin. Different members of this laboratory as well as others elsewhere have given many valuable suggestions.

Some Recent Post Office Improvements

The Fourth Assistant Postmaster General, who has charge of the manufacturing enterprises of the Post Office Department, is about to introduce an office appliance in the way of an improved facing table designed in the equipment shops, for use in the larger post offices of the country, which will mark a distinct progress in such office equipment. These tables are used in facing letters before being put through a cancelling machine. Mail taken up by collectors from street letter boxes is brought to the office and dumped upon the table. Four clerks work on each side of the table arranging letters so that the stamps all face one way. The long letters are separated from the short ones and as soon as the clerk has a handful of either, he places them on a conveyor belt which runs lengthwise of the table and are then carried to a stacker at the end of the table. They are then run through the canceling machine at the rate of five or six hundred per minute. Two conveyor belts and stackers are used, the upper for long and the lower one for short letters. The four chutes at the corners of the table are for newspapers and mail which cannot be put through the canceling machine.

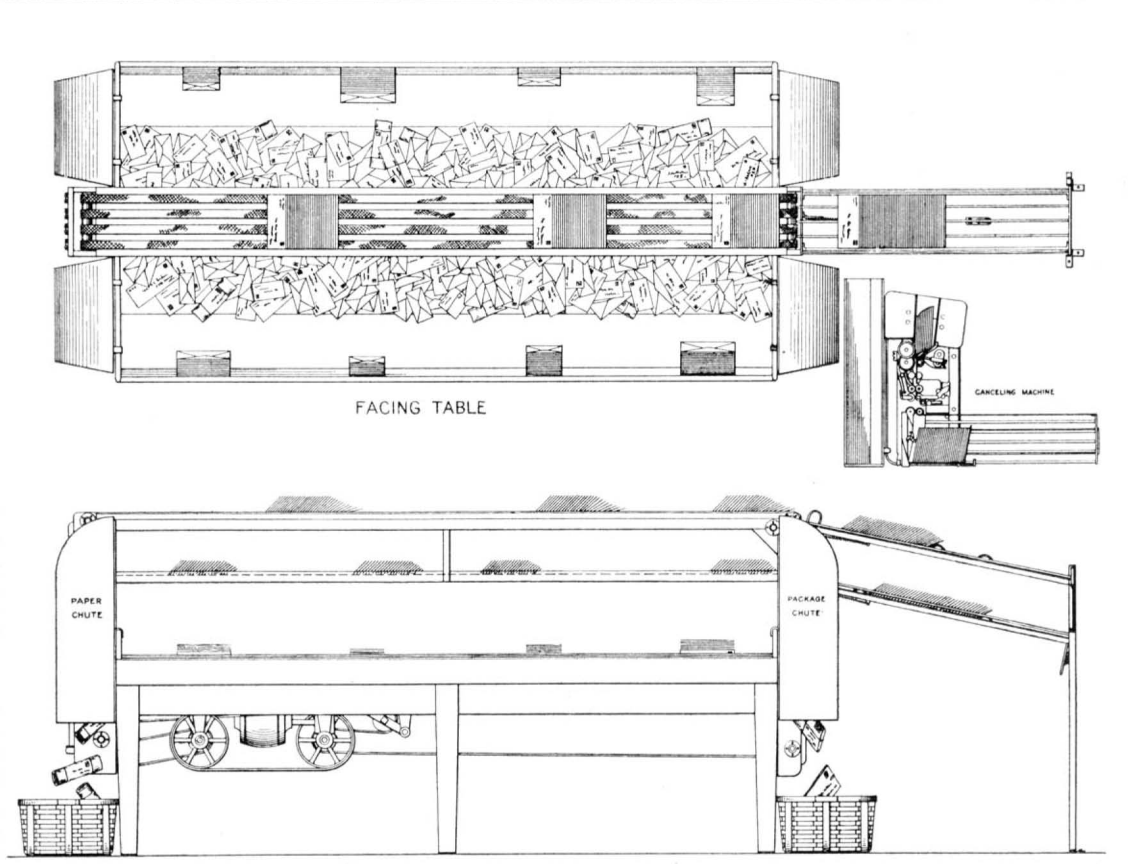


TABLE USED IN POST OFFICES FOR ASSORTING AND FACING LETTERS FOR CANCELING MACHINE

This new table is a very great improvement over the old style facing table as it can be operated with less clerical help, makes no noise, the old style table being so noisy that a special telephone receiver is necessary if located anywhere near it; there is no danger of mutilating the mail and, while the old style cost approximately $1,500, this improved table can be built for less than one-third that amount. The first one of this improved pattern has been recently set up in the Pittsburgh, Pennsylvania, post office, and others will be placed in service as rapidly as needs require.

The Department has had in contemplation and is now about to install electric trucks for transferring mail between train sheds and post offices, wherever practicable, replacing the old-fashioned two-wheel hand trucks, so commonly used but which are now being rapidly discarded by this later and more satisfactory method. These old trucks often overloaded, with the material carried falling off, while the men tugged and strained at the burden, will now give way to what will lighten labor, secure more expeditious handling and be a saving of time and expense. As these electric trucks can also be used in some cases as conveyors in post offices, their introduction for mail uses will serve a double purpose and doubtless be welcomed as a decided convenience in both directions.

Among the many recent improvements in postal facilities and accommodations is one which the public at large will doubtless note with pleasure and be of especial comfort and benefit to the army of mail collectors in the service of the Government. This is the introduction of a new and very handsome letter box to replace the old pattern with which dwellers in cities are so familiar. This new box combines convenience and elegance to an unusual degree for ordinary postal service. To an ornate design is added the very convenient feature of a full front opening, by which the collector can see at a glance the entire contents of the box and remove the mail with one sweep of the hand. Bids for the accepted model were opened at the Post Office Department the latter part of August, and as soon as the dies and necessary preparations are completed the work of manufacturing will begin and the new boxes be placed in service.

The Genetic Relations of Certain Forms in American Aboriginal Art*

By Clarke Wissler

One of the most difficult problems in anthropology has been the working out of successive steps in the origins of particular traits of culture. The most intensive effort seems to have been made in studies on the evolution of decorative designs. By arranging designs found upon prehistoric or other pottery in order of their increasing conventionality, series have resulted, showing a clearly realistic drawing at one end and an almost entirely geometrical one at the other. Such series suggested that all these forms were arrived at by first drawing from real life and then by successive conventionalizations arriving at a pure geometric form. The weak point in this interpretation is that there are no means of dating the units of the series, their arrangement being merely a matter of selection on the part of the observer. There are still other obvious objections to the interpretation, so that the tendency of the critical is to reject these conclusions. Somewhat analogous attempts have been made in the study of industrial arts and technology, but with equally unconvincing results. Consequently, as the case stands to-day, we can point to scarcely a single example in which the life history of a trait can be satisfactorily demonstrated in objective data.

In the course of some technological studies in the American Museum of Natural History, the writer observed that certain structural styles of skin clothing among the Indian tribes of the Mississippi and Great Lake areas were clearly due to the forms of the original materials. The skins of deer were used and practically always removed from the animal in the same way. Whole skins were then combined to form a garment, their natural outlines being preserved, but usually trimmed to a symmetrical form. That the cut, or style, thus resulting became a recognized feature in the native mind is shown by its survival after cloth was introduced by traders. Here the form of the material did not lend itself to the style but was cut to conform to it. Hence, we have a case in which the evidence for the genesis of a trait is satisfactory.

Next our attention was turned to the decorations upon these costumes. Here it can be shown that these same stylistic lines, determined by the contours of the material, were followed in the embroidered decorations, resulting in peculiar curved designs. Thus on the old specimens in our collections, the design follows the cut of the skin material, but upon the modern ones it is repeated upon an even unbroken surface. So without going into details we may state that satisfactory proof can be given to show that this particular design rose from the decoration following the contour of a part of the garment.

The investigation was then extended to moccasin decoration in the same geographical area. In this case satisfactory evidence can be found for the same kind of genetic relation between three different styles of decoration and as many different types of structure. For instance, north of the Great Lakes, for a considerable distance, east and west, the moccasin is made by folding a piece of skin up over the foot and joining on the top and at the heel. The shape of the foot prevents its covering the entire instep, leaving a U-shaped space. This is closed by an insert. The decoration is placed upon this insert, for which there are good technological reasons, and so has in its entirety a U-shape. Then among some of the neighbors of these tribes, particularly the Blackfoot, we find a similar decoration upon a moccasin of an entirely different pattern and one in which it bears no necessary relation to the structure. Yet these Indians are consistent enough to make a false insert upon which the decoration is placed. In short, there are very strong reasons for concluding that the Blackfoot borrowed the decoration from their northern neighbors and that these tribes arrived at it by adjusting the decoration to the structure.

Another cut of moccasin among some tribes south of the Great Lakes requires no insert on the instep, but has a long unsightly puckered seam, extending down the middle of the foot to the toe. This is usually concealed by overlaying with a long narrow band of embroidered skin. This style extends over in the tribes of the Plains to the west where we find it upon moccasins of a pattern having no seams to hide.

Again, the Apache of New Mexico and Arizona have a moccasin with a long narrow insert reaching down the top of the foot to the toe. This gives two converging seams which are concealed by fringes and very narrow embroidered bands. Then among their northern neighbors we find moccasins without any insert whatever bearing exactly the same decoration.

Thus, in moccasin decoration we find three different examples of decorative designs developed from the structure.

We may summarize this investigation as revealing several good examples of the genesis of specific decorative designs. With one possible exception, they differ from the previous genetic studies of design in that the origin was not strictly in attempts at realistic art but merely grew out of attempts to embellish surfaces of fixed contour and to conceal unsightly lines.

The data in full appear in the *Anthropological Papers of the American Museum of Natural History.*

**Proceedings* of the National Academy of Sciences.

Checking Forest Fires With Dynamite

Every one knows it is a very difficult matter to stop a forest fire after it has gotten a good start. It is also a well known fact that the trunks and foliage of the trees do not burn readily because they are green. The fire usually spreads and feeds upon the dry material upon the ground under the trees. Therefore, any method that will prevent the fire from spreading along the ground will generally effectively check it.

A plan that proved satisfactory in one case was to bore two parallel rows of holes 36 inches apart, also spacing the holes in the rows 36 inches apart. Each hole was loaded with a charge of 1 pound of gelatin dynamite and all were fired electrically. The result was a broad shallow ditch, which prevented spread of fire along the ground and served as an effective check.

The Passing of the Acid Bessemer Steel*

Phases of Its Career in the United States and Great Britain

By H. H. Campbell

THE acid Bessemer process was invented in 1856, but the first results in the hands of practical iron masters were far from successful, and it was left to Bessemer himself, not only to find the cause of failure, but actually to build a works and prove the merit of his invention. It is this complete dominance of the situation that puts him head and shoulders above other claimants for the honor of bringing about a revolution in the art of making steel.

Between 1860 and 1865 rapid progress was made in Great Britain, and converters were started in Germany, France, Belgium, Austria and the United States. By 1870 the process was firmly established and during the next ten years there was a rapid increase in the production; but the nations of Central Europe labored under a great handicap in being forced to send to Spain, Algeria and Elba to get ore which would give a suitable pig iron. So when in 1878 the basic Bessemer appeared on the scene, it was immediately put in operation in both Germany and Belgium and a few years later in France.

For a long time these three countries did not collect records showing how much metal was treated in the acid and how much in the basic vessel, so no figures can be given of the early history of acid Bessemer steel on the Continent. From a general point of view, however, it may be said that after 1880 no new acid works were built in Germany, Austria, France or Belgium, although many existing works continued to operate, while some increased their rate of production, but to-day Russia is the only large producer on the Continent. In Germany in 1913 only 1 per cent of the steel output was made in the acid converter; in France and Austria only 2 per cent. Belgium does not keep separate records for acid and basic steel, but it is known that most of the product comes from the basic converter. Great Britain and the United States lead in making acid Bessemer steel and it may be well to give a few facts about the development of the process in those two countries.

WANING OF BRITISH ORES.

In 1870 Great Britain was first in the list of steel producers, this being natural because the Bessemer process was first operated there and because England alone of all the leading European nations possessed a large supply of pure ore; for on the West Coast near Barrow-in-Furness in the counties of Cumberland and Lancashire there are several beds varying from 50 to 68 per cent in iron and giving a pig iron containing about 0.04 per cent of phosphorus. Half a century ago there was no special demand for pure ore and there was only a limited output in this district; but after the advent of the Bessemer process the mines on the West Coast became very important. The ore was shipped to southern Wales and the pig iron to Sheffield and to foreign countries, thousands of tons coming to the United States, where it formed the basis of our early steel industry. Of course, these conditions created great activity in Cumberland and Lancashire and the production of ore rapidly increased. In 1860 the output was 990,000 tons, while in 1870 it was 2,093,000 tons. The maximum was reached in 1882 when 3,136,000 tons was mined; but since then the output has decreased owing to the exhaustion of the mines, so that to-day it is only about half what it was 35 years ago.

BRITISH IMPORTS OF BESSEMER ORES.

Before 1860 no foreign ore was brought into Great Britain and in 1870 only 400,000 tons was imported, which would account for less than 4 per cent of the total output of pig iron at that time. Imports have been steadily increasing ever since and in 1913 they amounted to 7,442,000 tons, which would account for over 38 per cent of all the pig iron produced. But leaving out of consideration all material high in phosphorus, we find that in 1870 only 15 per cent of the Bessemer pig iron produced in Great Britain was made from imported ores and 85 per cent from West Coast hematites; in 1882 the proportion was just half and half; while in 1913 Cumberland and Lancashire furnished only 24 per cent of the low-phosphorus ores used in the Kingdom, the remaining 76 per cent coming from abroad, most of it from Spain.

SPANISH ORES IN GREAT BRITAIN.

As soon as the importance of the Bessemer process was realized, men turned to Spain for a supply of pure ore, because the deposits in the Province of Viscaya had been known to all the world for twenty centuries. It took a long time to develop a system of transportation and in 1870 every ton of ore was hauled from the mines in ox carts, while as late as 1881 over 700,000 tons was transported more than a mile over bad roads by this primitive conveyance. Even when tidewater was reached there were troubles, for only small vessels could cross the bar at the harbor of Bilbao, which was the chief shipping port. Political conditions were intolerable in Spain at that time and from 1872 to 1876 there was civil war, the city of Bilbao being besieged for five months.

Notwithstanding these difficulties, exports increased and in 1878 they amounted to 1,225,000 tons, three-quarters going to the British Isles. In 1913 Great Britain imported 4,714,000 tons of ore from Spain, which accounted for 60 per cent of the output of Bessemer pig iron. It should be said, however, that the greater portion of the iron made from Spanish ore is used in acid open-hearth furnaces, the West Coast hematites making a large proportion of the British acid Bessemer steel.

EARLY BESSEMER WORK IN THE UNITED STATES.

Bessemer steel was made at Wyandotte, Mich., in 1864, and at Troy, N. Y., in 1865; but operations were not carried on regularly and commercially until after the Steelton plant was built in 1868, so that as late as 1870 the whole country made only 37,000 tons of Bessemer steel. It must be remembered, however, that while Europe was building converters, we were engaged in civil war and for four years the destruction of capital and the loss of life in proportion to our wealth and population at that time were greater than the waste of money and of life in the European maelstrom to-day.

For a long time the pig iron used at Steelton was brought from the west coast of England and mixed with iron from Cornwall, Pa., but blast furnaces were built in 1872, which used a large proportion of anthracite as fuel and smelted the low-phosphorus magnetites of Cornwall, only 30 miles away, and a smaller amount from New Jersey. For many years every nook and corner of the earth was ransacked for suitable ore, and somewhere about 1884 the yard at Steelton contained at one time minerals from 26 different localities, including Pennslyvania, New Jersey, New York, Virginia, North Carolina, Spain, Algeria, Elba, Cuba, Ireland, the Grecian Archipelago, besides other places

It may not be uninteresting to put on record that the Pennsylvania Steel Company started a chemical laboratory in 1869 and that it was in regular operation in 1870, with Andrew S. McCreath, now of Harrisburg, as chemist. This probably was the first fully equipped laboratory at any iron plant in the United States.

LAKE SUPERIOR ORES.

All this time it was well known that there were vast iron deposits in Michigan, but transportation on the Lakes was crude and expensive, so that it was not until 1880 that as much as 2,000,000 tons of ore was mined on Lake Superior, while not until 1886 was 2,000,000 tons taken to Lake Erie. From that time to this the flood has been rising until in 1913 the output of Lake ores was 49,947,000 tons, which would make more pig iron than all the ore mined in Great Britain, Germany, France, Austria and Belgium combined.

Production of Bessemer Steel in the United States in Per Cent of the Total Steel Output

	Per Cent		Per Cent		Per Cent
1901........	65	1906........	52	1911........	34
1902........	61	1907........	50	1912........	33
1903........	59	1908........	44	1913........	30
1904........	57	1909........	39	1914........	26
1905........	55	1910........	36	1915........	26

Speaking roughly, about half of this ore will give a pig iron fit for the acid converter. In 1906 about 13,000,000 tons of Bessemer pig iron was made from Lake ores, which was more than half the total output of low-phosphorus iron in the whole world. In that year the United States made 12,276,000 tons of acid Bessemer steel, which is five times as much as has ever been made in one year either before or since by all the rest of the world put together.

DECREASE IN OUTPUT OF ACID BESSEMER STEEL.

The accompanying table gives the production of acid Bessemer steel in Great Britain and the United States at different periods during the last half century. In Great Britain a maximum was reached about 1890 and the output has been decreasing ever since, there being a sharp decline in the last few years.

In the United States, on the other hand, there was a steady increase in production from the beginning until 1906 when the maximum output was recorded. From that time there has been a tendency to increase the output of the open-hearth furnace and to push the converter into the background. It is not fair to draw conclusions from the record of any single year; so an average has been taken of two recent five-year periods, two abnormal years being omitted.

The first period runs from 1903 to 1907 and the second from 1909 to 1913. During this time the total steel output increased 43 per cent, but the production of Bessemer steel decreased 9 per cent. If any process is holding its own, it ought to make from year to year the same proportion of the total output, and measured by this standard the converter has been losing ground for many years, as shown by the table herewith, which gives the production of Bessemer steel in per cent of the total output during the last 15 years:

Production of Steel in the United States and Great Britain

	Total Steel, Thousand Tons		Acid Bessemer, Thousand Tons		Per Cent of Total Output	
	United States	Great Britain	United States	Great Britain	United States	Great Britain
1880.......	1,247	1,375	1,074	1,034	86	75
1890.......	4,277	3,679	3,689	1,613	86	44
1900.......	10,188	5,001	6,685	1,254	66	25
1910.......	26,094	6,374	9,413	1,138	36	18
1913.......	31,301	7,664	9,546	1,049	30	14
1914.......	23,513	7,835	6,221	797	26	10
1915.......	32,151	8,351	8,287	821	26	10
Five year averages:*						
1903 to 1907	19,036	5,572	10,267	1,286	54	23
1909 to 1913	27,256	6,635	9,313	1,033	34	16

*1908 and 1914 are omitted from these averages because these years were abnormal general financial conditions.

Both the tables here given show that as the years go by the acid converter is making a constantly decreasing proportion of our steel and this is the yardstick we unconsciously use in measuring the relative importance of different processes. We say, for instance, that the basic open-hearth has supplanted the acid furnace, because basic furnaces in 1915 turned out 16 times as much steel as the acid hearths; and we rightly ignore the fact that the acid furnaces in that year produced three times as much metal as they did in 1890 when the basic furnace was just getting under way. Thirty years ago it was firmly believed by many that the old crucible process would be displaced by the open-hearth furnace, but in 1915 this country made twice as much crucible steel as in 1880 and more than three times as much as in 1875. This sounds rather strange until we say that in 1880 crucible steel formed over 5 per cent of our total output, while in 1915 it was only one-third of 1 per cent.

SURVIVALS.

All around us are examples of what the naturalists would call "survivals." Thus, when the acid Bessemer process was developed half a century ago it was said that "the death knell of the puddling furnace had been sounded"; and a belated requiem was again sung over its grave when the basic open-hearth furnace came upon the scene. Yet the United States to-day is making twice as much wrought iron as it did in 1870.

We say that charcoal pig iron belongs to a bygone age; but the output of our charcoal blast furnaces in 1915 was nearly twice what it was at the time of our Civil War. The maximum was reached as late as 1890, when 628,000 tons was produced, this being twice as much as was made in 1854. The case, however, has a rather different aspect when we say that in 1854 the output of charcoal pig iron was 47 per cent of our total tonnage, while in 1915 only 1 per cent of our blast-furnace product was smelted with charcoal.

So in 1906 the United States produced 95,000 tons of charcoal blooms and as late as 1880 we made 36,000 tons direct from the ore in the old Catalan hearths, which possibly is as much as was made in Noricum and Catalonia in the days of Julius Caesar. Old methods die hard and no one alive to-day will see the total abandonment of the acid converter. We cannot yet write the final chapter of its history; but we can say that it made possible our modern railroads, which could never have reached their present development with wrought-iron rails. It created the Age of Steel and during the last half century has been one of the most potent factors in reconstructing our world.

*The Iron Age.

Powdered Coal as Fuel*

One of the Best Means for the Promotion of Combustion Efficiency

By Joseph Harrington

NOT only to promote combustion efficiency, but to more perfectly pulverize, the coal should be practically dry, 1 per cent of moisture being the maximum; ½ of 1 per cent is ordinarily required. Under these conditions the coal, when pulverized, remains quite fluid and will break down under the influence of the crushing rolls with much less expenditure of power than when damp. In order that the fuel may remain suspended in the carrying air in the furnace chamber during combustion, it is necessary to reduce the coal to a certain degree of fineness. After much experience this standard has been established as follows: 85 per cent must pass through a 200-mesh screen, and 95 per cent through a 100-mesh screen.

As to the quality of coal most suitable for pulverization, no arbitrary limits can be established. Broadly speaking, the greater the volatile combustible content the more readily will the coal ignite and burn and the less dependent will be this process upon the size and proportions of the combustion chamber. As the volatile content decreases, however, more dependence must be placed upon the proportions and locations of the surrounding brickwork, to maintain the temperature until ignition is complete. Anthracite has been burned in a pulverized form, but it must be finely ground and must be burned in a rather confined space, so that the ignition may be prompt and aid rendered by nearby brickwork during the period of early combustion.

Several types of machinery that are commercially marketed will satisfactory pulverize coal. They are divided broadly into air separation machines and screen machines. In the former class there is an upward current of air produced by a fan that has a carrying capacity sufficient to take with it the finest particles, but which will not lift the coarser ones. As soon, therefore, as the coal is reduced to the required degree of fineness, this air current will lift the particles and take them away and will then deposit them in a receiving tank by means of a cyclone separator, which is usually vented in some manner to prevent the loss of dust.

In the screen mill the coal is continually thrown against a screen that permits the fine particles to pass through but causes the coarser particles to fall back under the rolls. Pulverization can be effected in a tube mill or ball mill, with an expenditure of power and cost not greatly different from that of the other types.

The pulverized fuel, being collected in a hopper, is conveyed either by screws or pneumatic means to the burner, which is situated at the furnace to be served. At this particular point there is a difference of opinion and a variety of apparatus is used. It is now generally conceded that the most efficient results are obtained when the coal dust is carried into the furnace in a stream of air the volume of which is just sufficient to supply the oxygen necessary for its complete combustion.

This mixture of coal and air must be made in fairly close proximity to the furnace, the reasons being that when this mixing is done, there is produced an explosive compound which must not be allowed to accumulate. The velocity of the entering jet must be greater than the rate of flame propagation to prevent burning back into the pipe.

Another reason for making the explosive mixture close to the furnace is that there is a tendency for the coal to separate and lose its uniformity of mixture, under which condition it is obvious that part of the jet would be over-supplied with coal and the other part over-supplied with air. Various devices have been provided for producing and maintaining the required uniformity of mixture.

In the existing commercial installations the fuel is removed from the storage hopper by means of a screw of special design which is placed at the bottom of the hopper and is usually driven by some form of variable speed device, thereby securing control over the amount of coal extracted per unit of time. It is well known that the delivery from such a screw is not uniform, the coal being delivered in little masses and producing a distinct pulsation in the furnace. To reduce this effect these screws have been made of double and triple thread, in which case there are two or three discharges per revolution in place of one. This is an improvement, but even under these conditions a noticeable pulsating effect is observed. Devices have been developed for passing this discharged material over a perforated screen or over a moving disk operated at high speed, the idea being to smooth out the inequalities and produce a continuous flow of dust. Some of these devices have proved their ability to secure this effect. Once established, this uniformity must be maintained, and if it is necessary to have the mixer at a considerable distance from the furnace, means must be provided for continual agitation of the air current that the fuel cloud may remain of constant density. This is not a particularly difficult matter, but is one which must not be overlooked.

Like all new things, the early history of powdered coal is full of accounts of failure. This has left on the minds of the engineering public an impression which it will take years of successful application to eradicate. The early experimenters did not understand the necessity of fine grinding, and it would seem that they did not appreciate the influence of furnace design upon the temperature of the resulting gases. The coal was powdered sufficiently fine, however, to develop intense temperatures, even though part of the fuel was lost by falling to the bottom of the furnace and being extracted with the slag and ash.

Insufficient combustion space and the ease with which this fuel can be mixed with the minimum amount of air combined to produce abnormal temperatures and a direct contact of flame and brickwork. The blowpipe effect of the high velocity jet acted to melt out the brickwork upon which it impinged. A layer of melted lava formed by the fusing of both ash and brickwork formed in the bottom of the combustion chamber and naturally discouraged the people who depended upon this fuel for continuous service.

Later, difficulty was encountered by reason of the minute particles of liquid slag being carried in suspension, and deposited upon the tube sheet or water tubes of the boiler, thereby closing up the flame space, sometimes putting the boiler out of action. These effects are particularly conspicuous with certain grades of coal, but noticeably absent with other grades of coal. Only recently has the research work been carried to a point where any knowledge has been obtained of what causes this trouble and what coals are most suitable for this work.

From the viewpoint of the theorist powdered coal forms one of the best means ever advocated for the promotion of combustion efficiency and commercial economics. There is in all transformations of energy unavoidable loss, and there is no apparatus that will gasify coal with 100 per cent efficiency. In the producer there are many losses that reduce the available heat in the gas, and in the mechanical stoker there are unavoidable losses due to various forms of incomplete combustion. Only in the case of powdered coal is the actual solid fuel both gasified and completely consumed directly within the chamber desired to be heated. With thorough pulverization all the coal is burned in suspension, and in practice but a fraction of 1 per cent is lost in the flue dust or slag pan.

On account of the fuel being conveyed into the furnace by the air which is afterward to be used in its combustion and on account of the diffusing of the coal throughout the air in cloudlike formation, there is a possibility of a mixture that can be secured by no other means. Each particle of coal is surrounded by air, and on account of the extreme fineness of the particle instantaneous oxidation occurs.

The result is efficient combustion, and it is necessary to deal only with the effects of the high temperature thereby obtained. That it is now possible to control this temperature while not sacrificing any material gain due to it is definitely established. Moreover, the definite control of the amount of air per unit of coal permits of the most perfect variation in the results obtained.

Steam generation by the use of powdered coal as a fuel is still in the experimental stage, and herein, if anywhere, powdered coal will meet severe competition. That steam can be efficiently produced in this way is unquestioned if the mere matter of combustion and evaporation is considered. Whether it can be done more economically than at present done by the best mechanical stokers still remains to be commercially proven, and even with powdered coal, gas analyses better than 16 per cent. of CO_2 are not developed. With the mechanical stoker the CO_2 can be maintained around 14 per cent.

With powdered coal the loss in the ashpit and in the flue does not exceed 1 per cent and in the best mechanical stokers will not exceed 2 per cent of the coal fired. A possible advantage in favor of powdered coal of 2 or 3 per cent in combustion efficiency is offset by the cost of fuel preparation. It is not reasonably to be anticipated that better than 90 per cent efficiency can be obtained, and this is a figure possible with the mechanical stoker.

It is in cases such as the locomotive that powdered coal shows most favorably. Here there is not only the single problem of combustion efficiency, but a long list of related conditions that are effected thereby. A summary of the advantages incorporated in the report of the standing committee on powdered coal of the American Railway Fuel Association was presented. The committee was of the opinion that the effectiveness and utility of the use of fuel in pulverized form has been demonstrated from the past year's development and that the progress in the use of this method of stoking and burning bituminous and anthracite coals and lignites for generating power, heat and light on railways will be quite marked from now on.

The constantly increasing cost of railway fuel at the mine, the scarcity of fuel oil, the domestic and export demand for the larger sizes of coal, the prohibitive cost for briquetting the smaller sizes of coal and of lignite for railway use, the payment of labor on the run-of-mine basis for mining bituminous coals and the necessity for eliminating smoke, sparks and cinders will all tend toward the inauguration of this practical means and method for increasing the efficiency of steam-boiler operation, which today affords the greatest opportunity for improving locomotive and power-plant costs and performance and for changing public sentiment by smoke abatement.

A phase of the combustion problem, both in connection with powdered coal and mechanical stokers, which is but now receiving adequate attention is the study of the temperatures and conditions under which ash will melt. Engineers have always recognized the fact that certain coals were greater clinker producers than others, and this was laid at the door of the sulphur content. Recent experiments have shown that the sulphur is not the controlling element, although the exact causes are not yet sufficiently well known to be definitely stated.

Coal ash will melt at temperatures between 2,300 and 2,700 deg. Fahr. Furnace temperatures in commercial practice run between 1,800 and 2,800 degrees, so that it is possible to secure coals the ash from which will pass through the furnace without fusing. Under these conditions no clinker formation is encountered and the coal is rated as satisfactory from this standpoint. In the same furnace another coal will clinker badly and give trouble. There is no hard-and-fast rule, therefore, which can be stated for the selection of a coal.

The temperature obtained in service, which is a function of the rate of combustion, the amount of excess air and the proportions of the furnace chamber, must be determined and analyses of the fuel made to determine whether it will be suitable under the given conditions. Like many other scientific investigations, the value of a few dollars spent in this manner is not always appreciated, and the user will tolerate the formation of clinkers for months before he turns to another source of coal supply. When he does so, he may or may not solve his problem, and it becomes necessary to purchase and consume a variety of coals before one is found which is suitable to his needs.

In powdered-coal work with the more scientific combustion process, the necessity for proper knowledge of the point of ash fusibility is greatly increased. The day is rapidly approaching when the burning of coal will be considered a scientific chemical reaction in which the elements are supplied with exactness and understanding, and the result obtained, corresponding in definiteness to the precision of the mixing process, will be made to conform to the requirements of the particular service.

*From a paper read before the Chicago section of the American Society of Mechanical Engineers.

Valuable Magnetic Method for Steel Testing

"One of the most important problems of the day" is how the International Association for Testing Materials has designated the corelation of the magnetic and mechanical properties of steel.

Work already done on this subject during the past few years shows that the prospects are very bright that a magnetic examination of steel will furnish information of practical value as to its fitness for mechanical uses, without at the same time injuring or destroying the specimen under test.

Among the mechanical properties that have been studied in connection with the magnetic characteristics are hardness, toughness, elasticity, tensile strength and resistance to repeated stresses. The well known fact that not only do these various properties depend upon the chemical composition and the heat treatment, but that frequently very slight changes in the chemical composition or the heat treatment produce very appreciable effects on the magnetic and mechanical properties, complicates the problem considerably.

There are at least three phases of this subject that warrant consideration. Of first importance is the comparison of the magnetic properties with the other physical properties of the material. If it can be shown that every variation in composition and method of preparation brings with it a corresponding variation in magnetic characteristics, and, further, that variations in magnetic conditions are always accompanied by other physical variations, then it is obvious that the general physical characteristics may be defined in terms of the magnetic constants. Whether such a procedure is feasible depends upon the fullness of our knowledge of the simultaneous magnetic and mechanical data, and also upon the facility with which the necessary magnetic data are obtainable.

A second important phase of this subject is the variation in magnetic behavior, as the test piece is subjected to the influence of stress. The correlation here is so close that the strains set up in a stressed bar are accompanied by simultaneous variations in the magnetic behavior, which change in character as the magnitude of the strain with respect to the elastic limit changes.

Finally, mechanical inhomogeneities of whatever origin are mirrored by corresponding magnetic inhomogeneities. A magnetic test may therefore be of assistance in detecting flaws in material where the vital characteristic is reliability, e. g., a mine cable.

TESTING A MINE ROPE.

In this connection quite an ingenious application of the fact that mechanical inhomogeneities are accompanied by corresponding magnetic variations was made by McCann and Colson in 1908.

The apparatus consists essentially of a solenoid surrounding the mine hoist cable to be tested, and connected in series with a suitable current source and measuring instrument. Any variation in the magnetic constants of the cable, due either to the breaking of individual strands or hardening caused by excessive strains, is indicated as soon as the defective portion passes through the apparatus. Suitable recording apparatus is provided so that a test of the entire cable is made every time the cage travels the length of the shaft.

More recently experimental evidence on this important and fascinating subject has been put forward by Mr. Charles W. Burrows, of the Washington Bureau of Standards. His evidence seems to point to the conclusion that there is one, and only one, set of mechanical characteristics corresponding to a given set of magnetic characteristics, and conversely there is one, and only one, set of magnetic characteristics corresponding to a given set of mechanical characteristics.

Although there is no evidence to refute the preceding rather broad statement, the utility of this generalization is decidedly limited by the complexity of the relations due to the large number of variables and the lack of sufficient quantitative data. Quantitative data, however, are gradually being obtained by Mr. Burrows and others, who are working on this problem. The application of the magnetic tests is further limited by practical difficulties in testing irregular shapes. Even with these limitations, magnetic testing in conjunction with mechanical testing may be expected to be of considerable value in determining mechanical properties.

UNIFORMITY INDICATIONS.

It has been shown that magnetic observations taken during the course of a tensile test indicate the time when the true elastic limit, the yield point, the necking down point, and the ultimate strength are reached. In addition the magnetic data give some idea of the uniformity of the material.

If it is once determined what treatment is requisite for a given steel, a magnetic test may be used to determine whether or not the material has been brought into the desired condition.

It is quite possible that the magnetic data may be used to define a bar of steel. In no other manner than by a magnetic examination is it possible without doing violence to the specimens to determine whether two steel bars are identical in properties. A determination of the magnetic uniformity of a piece of steel may be used as an index of the mechanical homogeneity.

A magnetic test indicates the character of the entire cross section of the metal, rather than merely a surface phenomenon, as in the case of certain hardness tests.

Notwithstanding the possibilities of the magnetic test, it must be remembered that at present they are possibilities only. Before the magnetic characteristics can be of much practical importance a great deal of investigation is necessary, and a large number of accurate measurements on specimens of known chemical composition and heat treatment must be made.

Before a magnetic test can be of service as an indicator of the mechanical characteristics in any particular case, preliminary work must be done to determine the most suitable magnetic data and also the minimum amount which will give the desired information. Among the magnetic characteristics which may be used are permeability, residual induction, coercive force, hysteresis energy, etc., and each of these may be taken in connection with any one of a great number of magnetizing forces.

A CONCRETE CASE.

To take a concrete case, we may suppose that the problem is to devise a magnetic test for a steel spring or a crank axle. The preliminary investigation would take some such course as the following:

1. Determination of magnetic normal induction curves and hysteresis data for test pieces made of the materials to be tested and submitted to the various heat and mechanical treatments that may be expected in practice.

2. Comparison of the above magnetic data with the corresponding mechanical data and the determination of the most suitable magnetic data to use.

3. Working out the experimental details so that the required magnetic measurements may be made on the full-size commercial specimen.

4. Checking of the magnetic and mechanical data on the full-size specimens to be sure that the same conditions are as in the case of the original test pieces.

Operations 1, 2 and 4 are time consuming, but do not offer any great difficulties that can not be overcome by patient, intelligent experimenting. The third operation may offer practical difficulties due to irregularities in the shape of the material to be tested. Relatively long objects uniform in diameter, such as rails, steel rims, band screws, drills and steel cables, present no difficulty. Relatively long objects whose cross section changes gradually from section to section, such as spring leaves, straight axles and files, present comparatively little difficulty. Relatively long objects of irregular section, such as crank axles, present great, but not insuperable, difficulty. Short, thick castings present difficulties which for the present seem insuperable.—*London Daily Telegraph.*

The Avoidance of Industrial Diseases

The slogan "safety first" should be extended from its original application as a safeguard against accidents to safeguard against disease. There is, for instance, a tremendous economic loss going on yearly which might be largely prevented by hygienic measures. Dr. Schereschewsky, in a recent public health report, has outlined a plan for the prevention of industrial diseases which is worthy of note. Estimating that there are from 25 to 30 million industrial workers in the United States and that each one loses from 8 to 9 days' work a year from illness, that would make the annual loss 600,000 years, or an economic loss of $360,000,000, supposing the workman's average pay was $50 a month. A great part of this loss is undoubtedly preventable and Schereschewsky calls attention to several ways to prevent it. He believes that more attention should be given in medical schools to the interrelations of occupation and disease —in fact, he would give a chair to this subject. Death certificates, too, should be filled out with greater exactness and should indicate correctly and exactly the occupation of the decedent. Also information regarding industrial hygiene should be disseminated as industriously as crusades against tuberculosis and alcohol are being carried on now. He suggests six main parts of such an educational campaign: permanent exhibits, popular lectures, bulletins, popular articles in the lay press, and instruction in the public schools. In a great many cases investigated among industrial workers it has been found that disease has been the result of neglect of personal hygiene rather than from inattention to any sanitary precautions connected with the particular occupation. These fundamentals of hygiene should, of course, be taught in the home and, that failing, in the schools, but it does not seem that the instruction there has hitherto been sufficiently convincing to bear much fruit. When we consider that about one-third of our school children later become industrial workers the importance of including personal hygiene in every public school curriculum becomes evident.—*Medical Record.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 28th, 1916.

Published weekly by Munn & Company, incorporated.
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 4.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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