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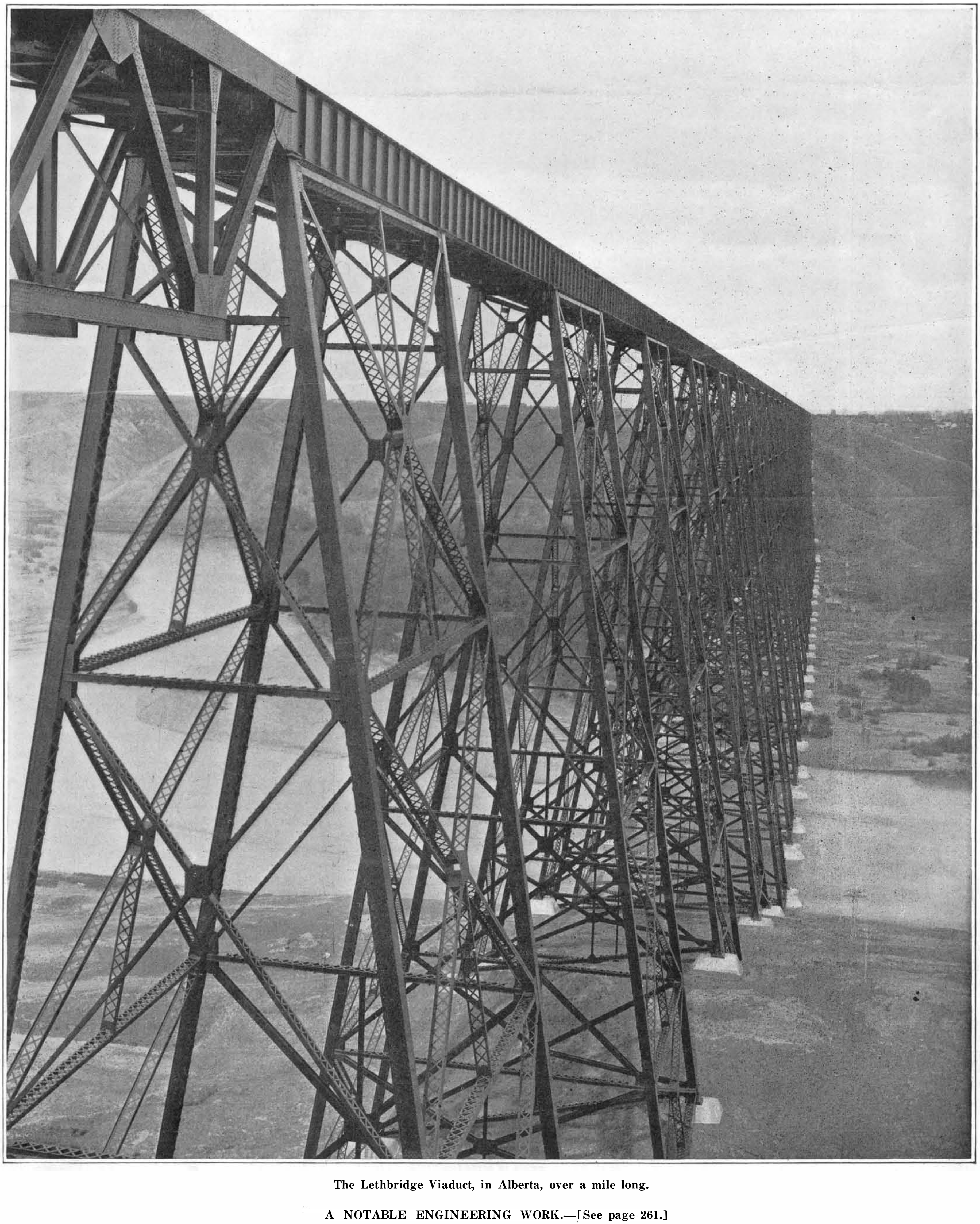


The Lethbridge Viaduct, in Alberta, over a mile long.

A NOTABLE ENGINEERING WORK.—[See page 261.]

The Earth*

From the Geophysical Standpoint

By John F. Hayford†

THE size of the earth, as well as its shape, is now known with such a high degree of accuracy that the errors are negligible in comparison with the errors in other parts of our knowledge of the earth. The probable error of the equatorial radius is less than 1/300,000 part, and of the polar semi-diameter is about the same.

The three physical constants of the earth, and of its different parts, on which you are now asked to concentrate your attention are the density, the modulus of elasticity, and the strength.

It is important to know as much as possible about the density. The more one knows about the density in all parts of the earth the more surely and safely one may proceed in learning other things about the earth.

The modulus of elasticity at each point in the earth controls the behavior of the earth under relatively small applied forces.

The strength of the earth, at each point, as measured by the stress-difference at that point necessary to produce either slow continuous change of shape or rupture, decides the behavior of the earth under the greater forces applied to it.

As to the density we know that the earth's surface density is about 2.7, that the density probably increases continuously with increase of depth, that the density at the center is probably about 11, that the mean density is about 5.6, and that within a film at the surface of a thickness of about one fiftieth of the radius of the earth there is isostatic compensation which is nearly complete and perfect as between areas of large extent.

The manner of distribution of the isostatic compensation with respect to depth and the limiting depth to which it extends are but imperfectly known. Nevertheless it appears that above the depth, 122 kilometers, the compensation is nearly complete even though there may be some compensation extending beyond that depth.

Two general lines of evidence are available in determining the modulus of elasticity of the earth, that from earthquake waves, and that from earth tides.

There are many inherent and extreme difficulties in the way of securing reliable evidence as to the modulus of elasticity from earthquake waves.

To 1913 the accuracy of available observations of tides in the solid earth was insufficient to furnish a basis for reliable conclusions. Nevertheless the estimates of the modulus derived from these early observations were a fair approximation to that given by the very recent and much more accurate observations.

Dr. Michelson and those associated with him in the observation of earth tides at the Yerkes Observatory since 1913 have developed a method of observing which is of a new order of accuracy such that the minute changes of inclination at a given point due to earth tides may be determined with an error of less than 1 per cent.

These observations make the modulus of elasticity of the earth as a whole about like that of solid steel, namely, (8.6) (10^{11} C.G.S.).

It is the modulus of elasticity of the earth as a whole which is measured in this case.

It is eminently desirable to determine if possible whether the modulus of elasticity varies with increase of depth. The Michelson apparatus possibly opens the way to such a determination. Suppose that the apparatus is used on the shore of the Bay of Fundy. Twice a day a large excess load of water is placed in the bay by the tidal oscillation and as frequently the water load is reduced below normal. The stresses produced in the body of the earth by these changes of load applied over an area only about 30 miles wide are probably confined almost entirely to the first 100 miles of depth. The magnitude of changes of inclination produced at an observing station on the shore by the changing water load would, therefore, be dependent primarily on the modulus of elasticity of the material below and around the bay to a depth of less than 100 miles. The observations might serve, therefore, to determine a modulus of elasticity of the surface portion of the earth rather than of the whole earth.

Turn now to the third of the physical constants which it was proposed to examine, namely, the strength.

Among the forces which we may consider as furnishing tests of strength are: (1) the forces involved in earthquakes, (2) the weight of continents, and (3) the weight of mountains.

The forces which produce the more intense earthquake evidently cause stress-differences locally which are beyond the breaking strength of the material. However, from earthquakes we may obtain but little information as to the strength of the earth material because the intensity of the stress-differences cannot be reliably determined. We know simply that the intensity exceeds the breaking strength of the material at the point of rupture.

It is uncertain how great are the maximum stress-differences produced by the weight of continents. One great difficulty in computing these stress-differences arises from the fact that the isostatic compensation of continents, now known to exist, reduces the stress-differences much below what they would otherwise be. Love computed the maximum stress-differences thus reduced as 0.07 ton per square inch. Darwin computed the greatest stress-difference due to the weight of the continents, without isostatic compensation, as 4 tons per square inch. If each of these computations were based upon assumptions which correspond closely with the facts one should be warranted in drawing the conclusion that the maximum stress-difference caused by the actual continents supported in part by the actual isostatic compensation is between 0.07 and 4 tons per square inch and that it is much nearer to the smaller than to the larger value. But a close examination of either of these computations shows that it is based upon assumptions made to simplify and shorten the computations, which assumptions depart widely from the facts and tend strongly to make the computed stress-differences much smaller than the actual. For example, both Darwin and Love used in their computations hypothetical continents represented by regular mathematical forms in the place of the actual continents with their many irregularities. The maximum stress-difference caused by the actual continents is necessarily much greater than would be produced by the assumed smoothed out, regular, symmetrical continents.

Similarly, no adequate computations have been made to determine the maximum stress-difference due to the mountains. Darwin computed the maximum stress-difference produced by two parallel mountain ranges, of density 2.8, rising 13,000 feet above the intermediate valley bottom, to be 2.6 tons per square inch. Love, for the same mountain ranges, but with isostatic compensation taken into account, computed the maximum stress-difference to be 1.6 tons per square inch. In this case the computation indicates that the isostatic compensation reduced the maximum stress-difference to but little more than one half what it would otherwise be. Here again both the computed maximum stress-differences have been greatly reduced by substituting hypothetical smoothed-out mountains in the place of the actual irregular unsymmetrical mountains.

To the person who is trying to get a true picture of the present state of stress in the earth, two very important facts are made evident by a comparison of the Love and the Darwin computations. First, the existence of isostatic computation greatly reduces the stress-differences which would otherwise be produced by the weight of the continents and mountains. Second, the depth at which the maximum stress-difference tends to occur is evidently very much less with isostatic compensation than without it. These two conclusions, based on the differences between the two computations, are apparently reasonably safe even in spite of the same wild assumptions on which both the computations were based.

Note that even a little information as to the distribution of densities—a little information about isostatic compensation—profoundly modifies the conclusions as to the state of stress in the earth. It should, therefore, be clear why it was so emphatically stated in an earlier part of this address that information as to the distribution of density in the earth is necessary in order to make safe progress in learning other things about the earth.

Is the earth competent to withstand without slow yielding the stress-differences due to the weight of continents and mountains, the isostatic compensations being considered? From the computations by Darwin and Love, considered in the light of the assumptions made by them to simplify the computations, I estimate that it is probable that the actual mountains and continents with all their irregularities of shape and elevation possibly produce stress-differences in some few places as great as 4 tons per square inch, and certainly produce stress-differences at many places as great as 0.2 of a ton per square inch. The material would certainly yield slowly under such stress-differences especially when they persist continuously over long periods of time and throughout large regions. Four tons per inch is the breaking or rupture load for good granite, one of the strongest materials existing in the earth in large quantities. Two tenths of a ton per square inch is the safe working load used by engineers for good granite. There is abundant evidence from laboratory tests that the so-called yield point on which the engineer bases his estimate of safe working load for a given material is a function of the length of time the load is applied and the delicacy of the test. The longer the time of application and the more refined the test to determine the permanent yield the lower the observed yield point. In the case of the test in progress in the earth the time of application is indefinitely long and the test is extremely refined inasmuch as the minimum rate of yielding which may be detected is exceedingly small.

If an engineer wishes to know whether a bridge, or foundation, or building, or railroad rail is yielding under stress-differences which have been brought to bear upon it he looks for evidence of distress, for rivet heads popped off, scaling from the surface, settling, cracks, or even changes in microscopic structure. The geologists have made very extensive corresponding examinations of the earth. Everywhere they find evidence that the earth has yielded. On the one fourth of the earth's surface exposed to examination, the land, there is no part for which the evidence does not indicate past uplift, or subsidence, or horizontal thrust, or cracking under tension, or cracking produced by shear, or microscopic yielding in detail, such as produces schistosity, for example, or some other form of past yielding to stress-differences. The physicist studying the earth must take this overwhelming mass of evidence into account and must conclude that the earth habitually yields slowly to the stress-differences brought to bear upon it. Please note that I do not assert that the stress-differences are all due to gravity.

I propose now to state what are, in my opinion, probably the lines of least resistance to future progress in studying the earth from the physical standpoint. I propose to outline what I believe to be the most effective methods of attack, and to indicate some of the conclusions which will probably be reached. I am led to this procedure by two considerations. First, I find it possible to state certain of my opinions as to the net outcome of past investigations most clearly in that form—and time presses. Second, I indulge the hope that such an outline, which is frankly an expression of judgment based on evidence much too weak and conflicting to be proof, may possibly kindle the imagination of some man or men, and so lead to vigorous attacks upon the problem and to future progress.

In attacking the problems of the earth one should assume at the outset that the phenomena exhibited are very complicated, that they are probably due to various simultaneous actions, and that the various actions are probably closely interlocked, modifying each other, though some are probably primary in importance and others secondary. Hence the most effective method of attack is probably one which includes a general correlation of apparently widely separated ideas and facts gathered from physicists, engineers, geologists, chemists, etc., and at the same time includes intensive attacks in detail on one after the other of single features of the problems which arise and an intensive working out of the possible consequences of said features.

It should be recognized at the outset that no observed behavior of the earth clearly warrants the assumption that the material of which it is composed differs radically in any way from that accessible at the surface. It should be assumed, therefore, that throughout the earth the materials are a mixture differing from the mixture found at the surface only as the extreme pressure and temperature conditions at great depths directly and indirectly produce differences.

It should be kept clearly in mind that the geodetic evidence from observations of the direction and intensity of gravity indicates simply the present location of attracting masses, the present distribution of density. It furnishes no direct evidence whatever as to past distributions of density, or as to changes in density now in progress. But an understanding of the present distribution of density within the earth, especially near the surface, is so necessary to a true understanding of the present state of stress and of viscous flow in the earth that an understanding of the geodetic evidence is fundamental to progress.

Computations should be made in extension of those

* From *Proceedings* American Philosophical Society, vol. liv., 1915.

† College of Engineering, Northwestern University, Evansville, Ill.

which have been made by Darwin and Love. The new computations should, however, deal with the actual irregular continents and mountains, not with regular substitutes. The computations should also take into account the bulk modulus of the materials composing the earth, that is, these materials should be assumed to be compressible. Such computations will no doubt be both difficult and long. I believe that even a moderately vigorous attack along this line will show conclusively that the earth does not behave as an elastic body under the large loads superimposed upon it by the continents and mountains. I believe that the computed stress-differences will be found to be so large that the computation will be essentially a proof of viscous yielding.

Next make the contrasting assumption that the material composing the earth is competent to withstand but little shearing stress, and that the pressure at any point is that due to gravitation acting on the mass in the column extending from the point vertically to the surface. Let it be assumed that isostatic compensation exists, is uniformly distributed with respect to depth, and is complete at depth 122 kilometers. Consider the actual topography and form a mental picture as accurately as possible of the viscous flows which would take place on the assumption that at each level the material would flow horizontally from regions of greater pressure to regions of less pressure along lines of maximum rate of change of pressure, and that the time rate of such viscous flows would tend to be proportional to the space rate of change of pressure. The flows would all be found to be away from beneath high regions toward low regions, from continents toward oceans, from mountains toward valleys.

After such a picture has been clearly formed assume that the isostatic condition is disturbed by long-continued erosion and deposition producing changes in the surface elevations and surface loads. On the same assumptions as to the nature of the viscous flows as before, form a new picture of the viscous flows which would now be in progress. It will be found that under the new conditions the viscous flows near the surface would still be away from high areas and toward low areas, but in general they would be slower than before. At greater depths, however, it will be found that the viscous flows would be undertows from regions of recent deposition toward regions of recent erosion. These undertow flows would in general tend to be in the direction opposite to recent surface transportation of material. This picture would serve as a first approximation to an understanding of the mechanism of isostatic readjustment. The undertows would be found on these assumptions to extend to a considerable depth, certainly more than 122 kilometers.

Next one should picture the changes in density which would be produced by the viscous flows. The density should be pictured as decreasing in regions from which material is being carried away by the flow and increasing in regions to which the material is being carried. It will be noticed as soon as such a picture is formed that every undertow flow at any level tends to equalize pressures at lower levels. This will have a strong tendency to make the prevailing undertows occur at much higher levels than they otherwise would.

Let it be assumed that the viscous material offers some small resistance to shear and still has elastic properties to a slight degree. The condition assumed originally that the pressure at a point depends simply upon the weight of the material above that point will be disturbed thereby. Form as clear a conception as possible of these disturbances and the modifications of the flows produced by them. I believe the modifications will be found to be important, and that they will be found to be such as tend to confine the effects of surface changes of load to a depth which is a small fraction of the radius.

So much for the direct effects of gravity which it seems important to picture clearly. Next study other effects, some of which are indirectly produced by gravity.

First study the modifying effects of changes of temperature. Wherever viscous flow takes place in the quasi-solid portions of the earth there heat is necessarily developed in amount equivalent to the mechanical energy expended in overcoming the resistance to flow. This will tend to increase the volume of the material, to increase the pressure, and to raise the surface above the region of viscous flow. It is probable also that the increase of temperature will tend to weaken the material, thus emphasizing the weakening produced by the damaging mechanical effects of the flow.

This temperature effect is probably locally important. Beneath areas of recent deposition the temperature of a given part of the buried material will slowly increase for long periods of time, on account of heat conducted up from below and prevented by the new blanket of deposited material from rising to the surface so freely as before. Conversely, beneath the areas of recent erosion the temperature of a given portion of material will decrease. The ultimate limit of change will tend to be in each case not greater than about 1 deg. Cent. for each 32 meters of depth of erosion or deposition. These temperature changes tend ultimately to lower areas of recent erosion and to raise areas of recent deposition, possibly as much as one thirtieth of the thickness of the erosion or deposition—the temperature effect taking place much later than the erosion or deposition which initiated it.

Study next the effects which may be computed from the bulk modulus of elasticity. Beneath areas of erosion a given particle of matter tends to rise by an amount which may be computed from the bulk modulus of material, and similarly a particle tends to fall beneath an area of deposition. If the depth to which the elastic phenomena extend is as great as 122 kilometers and the bulk modulus is 500,000 kilogrammes per square centimeter (corresponding to granite) the rise or fall of a particle near the surface will tend to be at least one fiftieth part as great as the thickness of the material eroded or deposited. This is a change so large as to have considerable effects in modifying or magnifying the actions which would otherwise occur. Possibly this elastic change is much larger than the estimate here given. Of course, if the erosion or deposition takes place in a small area only, such elastic response will be largely inhibited by surrounding material on which the load has not been directly changed. But under large areas of erosion or deposition such action must take place and extend to depths possibly as great as 122 kilometers.

Study next the modifying effects, on the phenomena already pictured, of chemical changes which are probably produced in the earth by changes of pressure. The expression "chemical changes" is here used in the broadest possible sense. A relief of pressure at any given point in the earth necessarily favors such chemical changes as are accompanied by increase in volume and reduction of density. Increase of pressure tends to have the reverse effect. Such changes tend to reinforce and extend in time the effects just referred to which may be computed from the bulk modulus of elasticity. It is important to estimate such changes as well as possible from all available evidence, such, for example, as that furnished by chemists, by geologists, and by such investigations of rock formation as have been conducted at the geophysical laboratory in Washington. I believe the possible effects of this kind will be found to be so large as to be of primary importance.

Evidence has accumulated during the past few years which makes it reasonably certain that with increased pressure, as at the great depths in the earth, the rigidity and the viscosity of the material also necessarily increase. This tends to cause the viscous flows to take place at higher levels than they otherwise would. This should be taken into account.

Next a re-examination of the conceptions so far formed should be made to ascertain to what extent and how they would be modified if one started with some other reasonable assumption as to the limiting depth of present isostatic compensation or some other reasonable assumption as to the law of distribution of the compensation with regard to depth.

Next full and extensive comparisons should be made between the hypothetical phenomena on the one hand pictured as made up primarily of viscous flows, modified by some elastic effects, initiated in part by surface transfers of load, modified by changes of temperature, modified by chemical changes and in the other ways, and on the other hand the facts of the past as to the behavior of the earth recorded in the rocks and read by geologists and others. This comparison should be used to the fullest possible extent to evaluate the relative importance of the various elements in the actions.

In making this comparison of various hypothetical phenomena with the great accumulated mass of geological facts it should be recognized at once that it is false logic to reason that if a given hypothesis does not account for all the observed facts the hypothesis is necessarily erroneous. On the contrary it is true logic in dealing with such a problem as the earth seen from a physical standpoint to reason that the more facts are accounted for by a given hypothesis the more certain it is that said hypothesis is a statement of a controlling element in the complex phenomena and then to study the facts which appear neutral, or conflicting, with reference to the hypothesis, considering them as indicators of other elements of the phenomena which one should attempt to embody in other supplementary hypotheses.

I admit that in studying the earth it is a mistake to think that there is any necessary conflict between the idea that the earth behaves as an elastic body and the idea that it is yielding in a viscous manner. A body may behave in both ways at once. The earth is probably acting largely as an elastic body under small forces which change rapidly and at the same time is yielding in a viscous manner to forces of larger intensity which are applied in one sense continuously for long periods.

The object of this address will have been accomplished if it serves in time to arouse the imagination and interest of some one, and to guide him to greater effectiveness in attacking the problems presented by the earth as seen from the geophysical standpoint.

Garlic Juice in Wound Treatment

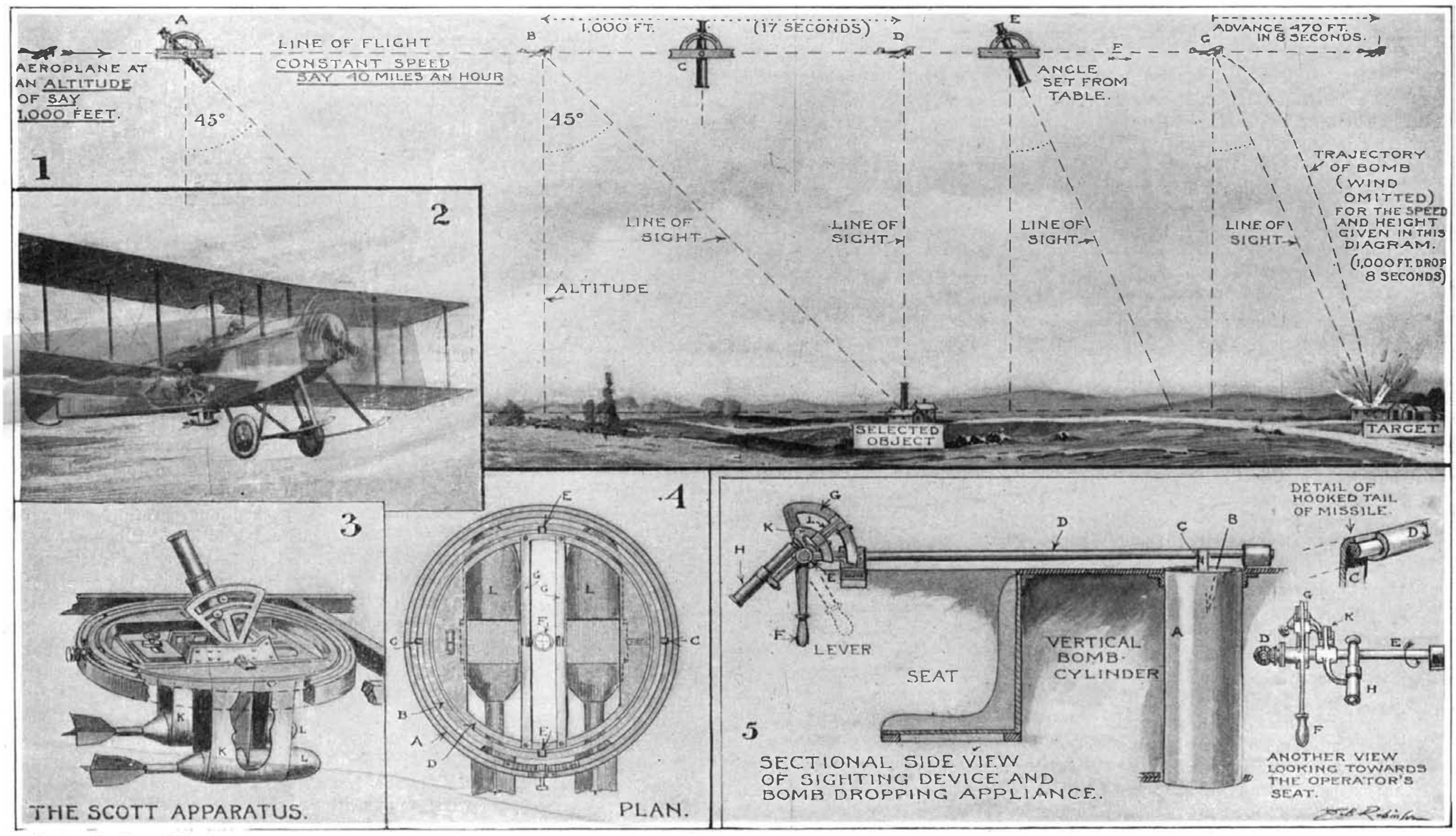
Since the great European war commenced many and various modes of treating wounds have been tested and more have been discussed. At the beginning of the campaign the antiseptic treatment of wounds and injuries in civil life had fallen into disfavor—almost into disrepute—and some authorities had openly stated that the antiseptic method was practically dead. However, after the war had progressed somewhat, it was found that not only were antiseptic principles not dead, but that under the conditions which prevailed in the most modern warfare the carrying out of aseptic methods was, generally speaking, impossible and that recourse must be had to Lister's principles. Many measures have been suggested and tried, and among these not the least successful has been the employment of hydrogen peroxide. Another substance which seems to have proved its worth is garlic juice. In the *Medical Press and Circular*, November 17th, 1915, Dr. A. D. Serrell Cooke writes concerning this method. The way in which the juice was used is stated to be as follows: After efficient drainage had been established the infected wound was washed out carefully twice daily with a lotion of garlic juice and distilled water, in a strength of 1 to 3 or 1 to 4. After this treatment in a large number of cases a noticeable improvement occurred in 24 hours and a decided improvement within 48 hours. During this period the purulent discharge not only became markedly diminished, but also the pain and surrounding inflammation were either very much relieved or disappeared. The kind of wounds treated were recent dirty wounds, in which suppuration had not yet occurred; foul, lacerated suppurating wounds of the face, scalp, thigh, etc.; extensive superficial burns of the face, scalp, chest, limbs, and abdomen in children; suppurating bursæ about the knee; cases of empyema; foul ulcers of the leg; infected and suppurating wounds in connection with compound fractures; carbuncle; one particularly interesting case of moist spreading gangrene of the leg in an old woman 71 years, etc.

The good effects of garlic juice have been ascribed to the active principles contained in the essential oil derived from it; and oleum allii is stated to contain allyl sulphide, in addition to certain volatile terebenes. As the red-skinned varieties of *Allium sativum* are said to contain more of the essential oil than the white-skinned, the juice derived from the former has been chiefly employed.

As a matter of fact, although stress has been laid upon the regeneration, so to speak, of antiseptic principles in the treatment of wounds, the antiseptic value of garlic juice according to the Rideal-Walker tests is but small. Cooke is of the opinion that as the result of the work carried out in Paddington Infirmary with garlic juice, it would seem that in this substance we have at hand a powerful remedy for the treatment of infected wounds. It would appear to possess properties which are cleansing, sedative, deodorant, penetrative, lymphagogic, and possibly also antiseptic. To its action as a lymphagogue probably most of its good results are due, and the results in wound treatment so far achieved by it would appear to confirm in practice, without injury to the tissues, the recently expressed theory of Sir Almroth Wright as to the value of drainage combined with lymph lavage in wound treatment.—*The Medical Record.*

Chemistry of Grape Ripening

Physico-chemical analysis on a modern basis has been very successfully applied in this case by Messrs. Baragiola and Godet, two Swiss scientists, and their method is valuable in determining the equilibrium of acids and alkalis in a complex medium. The authors followed out their experiments at the vine-growing station near Zürich which is well suited for this class of work, and they observed the evolution of the different products during the ripening of the grape, taking eight samples at one week intervals. Grapes of an Alsatian variety were strongly pressed each time to obtain the juice, which was thereupon analyzed. Specific gravity of the juice was seen to increase during the ripening from 1.028 to 1.053, and the percentage of sugar quadrupled in this two months time. Nitrogen was doubled, i. e., from 47 to 92 grammes per liter, this increase bearing exclusively on albuminoid nitrogen. Ash increased but slightly, from 2.8 to 3.2 grammes per liter, the increase bearing somewhat upon the potash, but especially on the phosphoric acid, which is found to be doubled. Sulphur increases during the ripening. As to acids, the proportions are as follows, in grammes per liter: tartaric acid decreases from 13.9 to 9.4; tannic, 0.89 to 0.34; malic, 20.9 to 11.1, showing a marked decrease in acids. These results are given mainly in order to show the character of the present researches, and the authors' method allows of following the elements of the grape during the ripening, as well as during fermentation.



Courtesy of the *Illustrated War News*

Scientific Bomb Dropping*

Sighting Devices for Aircraft Bombs

THE comparatively limited number of missiles carried by aircraft, and the impossibility of replenishing the supply without coming to earth, make accuracy of aim of high importance, and numerous devices have been invented to assist the airman. One such device (Figs. 1, 2, 3, 4), to be fixed in the floor of an aeroplane fuselage (as in Fig. 2), consists of a circular ring or frame (*A*—Fig. 4) which supports a smaller ring (*B*) on gimbals or trunnions (*CC*), the ring (*B*) in its turn carrying a still smaller ring (*D*) in gimbals (*EE*) at right angles to the gimbals (*CC*). A telescope (*F*) is mounted at the center of the ring (*D*) between two cross-bars (*GG*) which support a pair of graduated quadrants (seen in Fig. 3). Two straps or slings (*KK*—seen in Fig. 3) hang below the frames and hold the two bombs (*LL*), the outer end of the slings being hooked to pegs attached to the armature of two electric magnets.

Some time before the target comes within range, the telescope is set at an angle of 45 degrees (*A* in Fig. 1). The observer, seeing his object through the telescope (*B*—Fig. 1), starts his chronometer, and, moving the telescope to a vertical position (*C*—Fig. 1), looks through it until over the object (*D*—Fig. 1). So he ascertains his speed, his aneroid showing his altitude, which is equal to the distance traveled in the time noted. The 45-degree angle of the telescope gives him a perpendicular equal to his base. By a table the airman gets at the correct angle at which to set his telescope (*E*—Fig. 1) so as to hit the target on which the telescope bears when he drops his bomb.

The telescope having been fixed at the required angle, the airman flies directly toward the target (*F*—Fig. 1), and the observer, watching through the instrument, presses a switch button as the target appears in the line of sight (*G*—Fig. 1), which withdraws one of the pegs and releases its bomb.

In another contrivance (Fig. 5) a vertical cylinder (*A*—Fig. 5) built into the aeroplane accommodates the bomb (*B*), which has a hooked tail (*C*—Fig. 5: detail) by which it hangs on the shaft (*D*—Fig. 5). A partial revolution of the shaft (*D*) lets the hook slip over and releases the bomb. The shaft (*D*) passes forward along the center line of the machine between pilot and observer, and is geared by bevel pinions to a cross shaft (*E*) in front of the observer which has, mounted on it, a lever (*F*) fixed to a quadrant (*G*). It also carries a telescope (*H*), fixed to a quadrant (*K*), but free to revolve on the shaft (*E*). The quadrants (*G* and *K*) are coupled by a link (*L*). The speed of the machine and its altitude being known, the telescope quadrant (*K*) is fixed to the lever quadrant (*G*), so that the tooth in the shaft (*D*) is engaged by the backward movement of the lever (*F*) when the telescope is at such an angle with the horizontal that the bomb will fall on the spot at which the instrument points. Approaching the target, the observer keeps it within the field of the instrument by steadily pulling toward himself the lever (*F*), and with it the forward end of the telescope, until the required angle is attained. Now the shaft (*D*) becomes engaged by the lever (*F*), and the continued movement of *F* revolves shaft *D* and releases the bomb. The observer keeps the target in sight throughout, and drops the bomb at the right moment by merely following the target with the telescope. A device for releasing aeroplane bombs consists of a number of vertical cylinders each carrying a missile held by a sliding fork, released by a pedal in front of the observer's seat. If the avaitor dives (Fig. 7) toward his target, accuracy of aim becomes easier, and effective work can be done without scientific instruments; but risk from hostile fire becomes greater. The Scott apparatus shown on this page is well known in Germany. It was fully described in a work (W. Hahn's "Für Mein Vaterland") published in Berlin in 1913. No. 5 is a German Krupp apparatus, patented in England in 1914, a short while before the war.

*From *The Illustrated War News.*

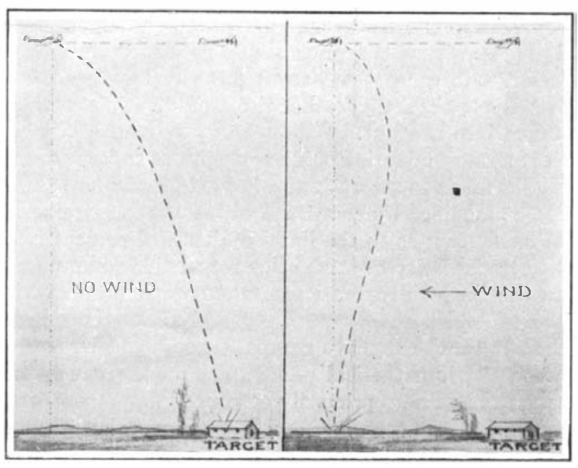


Fig. 6.—The effect of wind on trajectory.

In the left-hand diagram the conditions are those in Fig. 1. The aviator, moving at forty miles an hour at an altitude of 1,000 feet, has advanced 470 feet when his bomb strikes the target. With an adverse wind (as in the right-hand diagram) to hit his mark the airman would require a similar advance, so as to be directly over his target on letting go his bomb. In the right-hand diagram the airman, having failed to allow for the adverse wind, has missed the target.

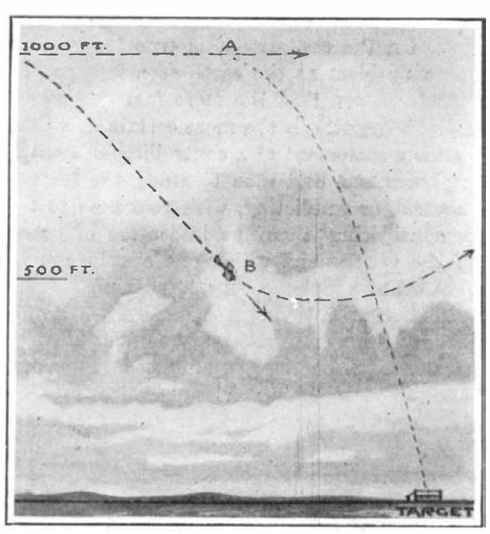


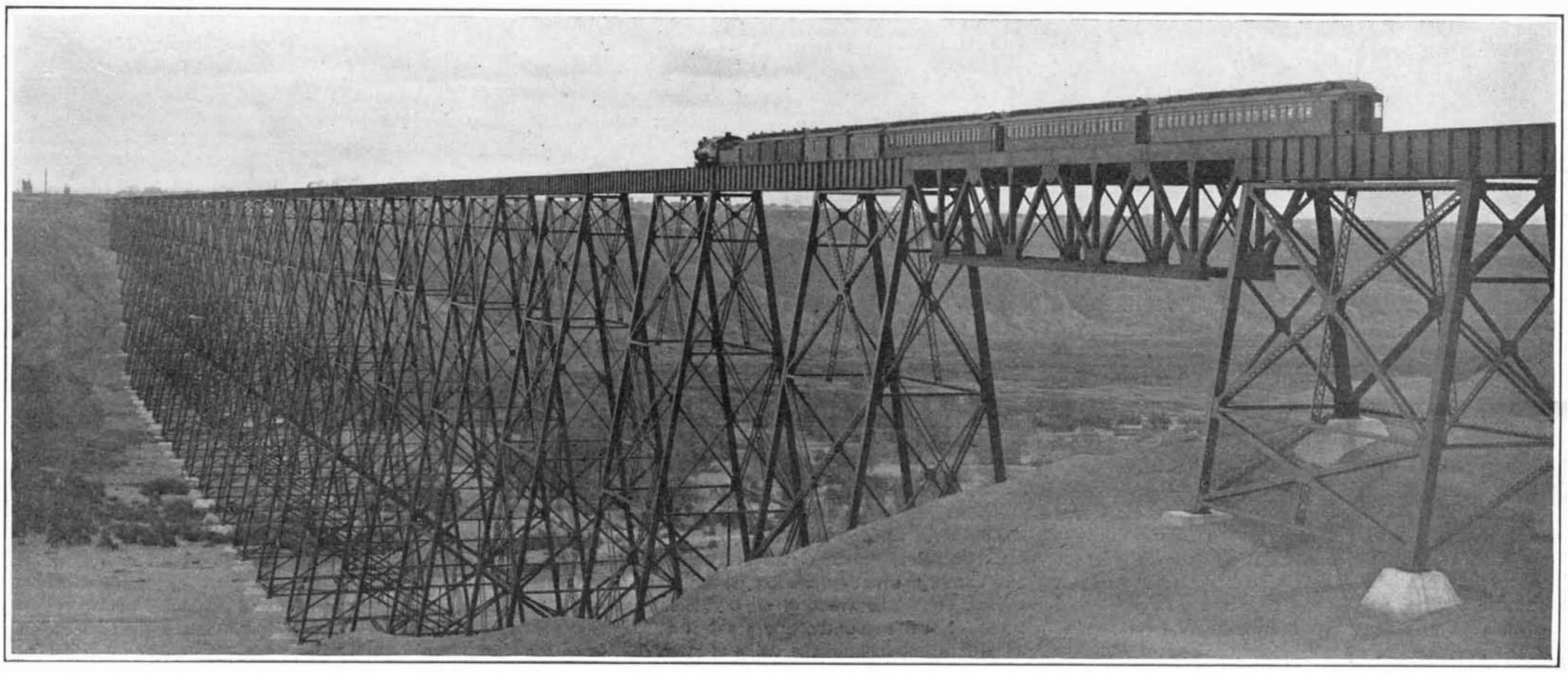
Fig. 7.—Making a dive toward the target.

Leaving out wind-pressure, *A* would be the airman's point of release to hit the target, while going forty miles an hour. If, as shown also, he preferred to nose-dive to half-altitude, *B* would be his effective point for letting go his bomb.

Protecting Metals by Aluminium

To protect heated metals from the action of the air it has been recently proposed by Van Aller, according to *La Nature* (Paris), to plunge them into a heated receptacle filled with a solution containing, among other constituents, a quantity of powdered aluminium. A protective layer of an aluminium alloy will be formed on the surface of the objects. This process, whose inventor has given it the name of calorization, is very efficacious and is advantageous in protecting wires of the resistances utilized in electric heating, pieces of iron which must resist temperatures above that of red heat, the tubes of condensers, pieces in contact with electric interrupters, etc.

The thickness of the protective alloy increases, of course, in proportion to the duration of the treatment, and the percentage of aluminium in the alloy is greater on the exterior surface of the coating than next to the metal. For low temperatures this process is not superior to galvanizing or tinning, but it is very efficacious for temperatures between that of the fusion of tin or zinc and that of aluminium (1100 deg. Cent.), The protective action is due to the formation of a layer of aluminium.



A wonderful cobweb of steel work that carries a railroad across a wide valley.

A Notable Engineering Work

How a Big Railroad Problem Was Solved

AMONG the many problems in railway building that tax the skill and ingenuity of the engineer few are of more general interest than the bridges, for the conditions to be met differ in every case, requiring different treatment and design. An important structure that has attracted much attention is the great viaduct at Lethbridge, on the Canadian Pacific Railway, which is notable not only on account of its length and height, but also for the details of its construction, and two excellent pictures of it are presented, from which the system of construction can be easily understood.

Lethbridge, 759 miles west of Winnipeg, is a divisional point on the Crow's Nest Branch of the Canadian Pacific Railway. It is the center of an important coal mining district as well as of a large irrigation tract on the eve of springing into greater prominence. The old Crow's Nest line in its 38½-mile course from Lethbridge Junction to Macleod, had twenty bridges, aggregating nearly three miles of length, a number of them being over 100 feet high. It had a curve, with no compensation, for every mile and to spare, and was burdened with a 1.2 per cent grade (63.4 feet per mile). The rapidly increasing traffic of ten years ago, coupled with the demands of rolling stock for heavier structures, combined forces with the company's desire for lower grades and better alignment, and resulted in an entirely new line between Lethbridge and Macleod. This, compared with the old, effected a 5.26-mile reduction in length, a saving of 1,735 degrees of curvature (eliminating 37 curves) and a reduction of grade from 1.2 per cent to 0.4 per cent. The number of bridges was reduced from twenty to two. One is a 1,900-foot structure over the Old Man River valley, and the other is the famous Lethbridge viaduct, 5,327 feet long, with a maximum difference in elevation between river bed and base of rail of 314 feet.

The viaduct consists of 44 plate girder spans 67 feet 1 inch long, 22 plate girder spans 98 feet 10 inches long, and a riveted deck lattice truss span 167 feet long. It is carried on 33 riveted steel towers, rigidly braced. Its general design is clearly illustrated in the accompanying view and elevation photograph. The substructure consists of concrete piles supporting concrete pedestals, the length of the piles under the land piers varying from 12 to 20 feet. The alignment is a tangent throughout. A 3-degree curve exists at the western approach and a 1-degree curve at the eastern approach. There is a grade of 0.4 per cent rising toward the west for the entire length.

The 33 high bents in the center of the bridge have four anchor bolts 2½ inches in diameter in the foot of each column; the remaining bents have two anchor bolts per column. The taper of the towers is 1:6. This, with the girders of the spans spaced at 16-foot centers, gives ample spread at the base of the towers. The tower spans were made 67 feet long in order to give longitudinal stiffness to the towers and to reduce the traction stress in the lower legs.

The diagonal bracings, both transverse and longitudinal, are stiff riveted members composed of angles and channels. Latticed and long members, as the illustrations show, are supported at the center.

Meerschaum

MEERSCHAUM has been extensively used for over a century in the manufacture of pipes and other articles for the use of smokers, as cigar holders, mouthpieces, etc. The principal source of supply has been, for many years, the deposits in the plains of Eskishehr, in Anatolia, Asia Minor, about 120 miles southeast of Constantinople. Deposits of the mineral are also reported to occur in Greece, on the Island of Euboea; in Moravia, Austria, near Hrubschitz; in Spain near Vallecas, Madrid, and Toledo; and in Morocco. The meerschaum deposits of Eskishehr have been briefly described by J. Lawrence Smith[1] as occurring in a valley filled with drift material from the surrounding mountains that has been consolidated by lime. The meerschaum is scattered through the drift in rounded nodular masses, with pebbles and fragments of magnesian and hornblende rocks.

The mineral sepiolite, or meerschaum, as it is commonly called, is a hydrous silicate of magnesia with the probable composition $H_4Mg_2Si_3O_{10}$ or $2H_2O+2MgO+3SiO_2$.[2] Many analyses of meerschaum only roughly approximate the formula given above. This is probably due largely to the uncertain relation of the water to the other elements of the mineral. A large amount of hygroscopic moisture is driven off below 110 degrees, sometimes amounting to nearly half of the total lost at a red heat.

Pure meerschaum is a white, porous mineral, with a specific gravity of about 2. In much of it, however, the porosity is so great that blocks of the mineral will readily float on water. This property, along with its snow-white color, gives rise to the name, meerschaum, from the German for sea foam. In a similar way the French often call it "ecume de mer." It absorbs water strongly and becomes somewhat plastic, but returns to its original condition on drying. When saturated it will not, of course, float on water. The hardness of meerschaum is from 2 to 2.5. It is very tough, breaking with a conchoidal to earthy fracture. Some forms have a leathery or fibrous texture, and in these the toughness is very pronounced. The luster is dull and earthy, somewhat like that of plaster.

The ease with which meerschaum can be carved, its whiteness, and the fine polish it takes with wax render it especially suitable for elaborate carving and artistic treatment in the manufacture of pipes. Meerschaum pipes are prized for the rich cream-brown or brown color which the bowl assumes after being smoked a while. This color is caused by the mixture of the nicotine from the tobacco with the wax used in polishing the pipe, permeating through the mineral. As long as there is absorbed wax in the meerschaum the color of a pipe will grow darker and nearly black with continued smoking. It is, therefore, necessary to "fix the color" of the pipe when the proper shade is obtained. Though the principle employed is the removal of the wax and boiling in linseed oil to harden the mineral and render it less porous, there are trade secrets in the process which the writer is not at liberty to divulge.

The manufacture of meerschaum, together with clay, amber, horn, wood, metals, etc, into pipes and similar articles is a thriving industry in parts of Germany and Austria. The headquarters of the industry in Germany is at the town of Ruhla, in the Thuringian Forest. According to Consul George N. Ifft,[3] of Annaberg, there are between 3,000 and 4,000 workmen employed at this industry, which was started in 1767. It is said that the supply of meerschaum is becoming low and that the manufacturers experience great difficulty in obtaining the necessary material to keep their factories going. This scarcity is said to be caused partly by failure of the mines in Asia Minor to meet the demands of the trade and partly because American and English agents have gained control of the Asia Minor production. Consul U. J. Ledoux, of Prague, reports similar difficulties in the Austrian meerschaum industry.

The treatment that meerschaum receives before reaching the consumer is varied. At Eskishehr the crude mineral is mined by systematic pits and galleries.[4] The nodular masses are first roughly scraped to remove the earthy matrix; then dried, scraped again, and polished with wax. The roughly polished nodules, in almost every conceivable peculiarity of form, are then shipped to the manufacturers. Pipe bowls are first turned out on lathes or carved by hand. The bowls are then smoothed down with glass paper and Dutch rushes, and after being boiled in wax, spermaceti, or stearin, are carefully polished with bone ash or chalk.

Artificial and imitation meerschaum are also manufactured for the trade. Artificial meerschaum is made by consolidating waste chips and fragments by pressure. Imitation meerschaum is sometimes prepared by treating hardened plaster of Paris with wax and coloring with gamboge and other suitable materials. Many of these imitations are nearly perfect.

Two deposits of meerschaum have been located in Grant County, N. M.—*U. S. Geological Survey.*

[1] *Am. Jour. Sci.*, 2d ser., vol. 7, 1849, p. 285.

[2] Dana, J. D., "System of Mineralogy," 6th ed., p. 680.

[3] Daily Cons. Report., April 25th, 1907.

[4] "Encyclopædia Brittanica," vol. 15, p. 825.

The Collapse of Cylindrical Rods

THIN rods frequently collapse when flexed, although the stress is well within the elastic limit, and it has been usually assumed that this resulted from some defect. It is now believed that such is not always the case, but is caused by the existence of a state of unstable equilibrium in the rod.

The Industrial Development of Japan

What Intelligent Co-operation Has Done for the Country

By Charles Richards Dodge

Few people have any knowledge of the tremendous advancement in manufactures and world trade that has been made by Japan in the past two or three decades—a material progress of which any nation might be proud. While the "awakening" may be said to date from about 1854, at which time Com. Perry visited the islands, and sought to establish friendly relations on behalf of the United States, the real beginning of the new movement was in 1867 when the Emperor Meiji came to the throne and brought about the restoration of the Imperial Government.

In the new order of things there was an immediate seeking after world knowledge, through the opening of intercourse with the people of occidental countries, through the employment of foreign specialists as advisers and teachers, and especially through the sending of technically educated young men to Europe and America to study modern methods and processes. Experimental factories for promising new industries were established by the government, which, before the end of the first decade—when the students sent abroad had returned—were disposed of to be conducted as private enterprises, and from this time on the progress was rapid and substantial.

At the beginning of the Meiji *régime* the country was importing all of its textiles but silk, this product and tea being its chief exports. Naturally there were many native industries and some of them were very old. In a few of these the products had been brought to a high degree of excellence at a very early period, though not by modern machinery and methods. Among these may be named the weaving of silk fabrics, by slow manual labor. The manufacture of ceramics is a very old industry, many of its productions veritable works of art. Pottery was manufactured from a remote age. Another old national industry was lacquer work, the products of which are famous. The Japanese early learned to work in metals, and as far back as the twelfth century, sword making and the manufacture of weapons and armor was carried to a high degree of perfection. As the tea ceremony became fashionable, about the beginning of the fourteenth century, the manufacture of cast-iron tea-kettles and other utensils became an industry—some of the designs being highly elaborate. All of these products were largely manufactured for home consumption.

After the restoration many new manufactures were established, and varied industries began to increase under the influence of government direction and encouragement. By the close of the second decade, or 1887, there were 880 private establishments, employing 6,300 workmen. But as no factory was listed that employed less than ten men, these figures do not tell the whole story. The most prominent industries at this time were the spinning and weaving of cotton and other textiles, silk filature by machinery, paper milling, the manufacture of glass and cement, machine construction and shipbuilding. In 1897 the number of factories had increased to 7,287 with 430,000 work people, the official figures showing a threefold increase in the last five years of the third decade. At this time such new industries are recorded as tanning, tobacco manufacture, brewing, sugar refining, rubber manufacture, the making of paint, matches, brick, artificial fertilizers, metal refining, electrical materials, etc., with car construction and shipbuilding. The China-Japanese War, and the later war with Russia, checked for a time industrial progress, and many small establishments went under. After peace with Russia had been declared, however, there was a revival, and by the end of 1912 there were 10,519 factories employing 863,447 operatives, of whom 515,217 were women. The number of industrial companies had reached a total of 4,403, with paid up capital amounting to 670,000,000 yen against 173,000,000 yen in 1903—a fourfold increase in ten years. (The yen is equivalent to about 50 cents in United States money.) At the same time there were 13,887 companies at large with paid up capital of 1,756,000,000 yen. It would not be possible to review the entire list of Japan's industries, and the reader's attention can only be directed to a few conspicuous examples where extraordinary progress has been made.

The textile industries are probably the most important, cotton spinning especially taking front rank, raw and ginned cotton being imported to the value of 233,000,000 yen in a single year in addition to what the country produces. This was one of the first industries to be fostered by the government, two experimental factories having been early established with machinery purchased in England. Cotton weaving, with power looms, embraces a large line of products, such as white goods, cotton flannel, crapes, towels, etc., besides a line of mixed silk and cotton goods. The silk weaving industry, which is one of the old industries, is in a transition stage. In former times all weaving was done by manual labor, but now mechanical weaving is rapidly superseding old methods, and the Jacquard loom has been introduced and is used throughout the empire. The woolen industry was founded in 1878, when the government established a factory, which ten years later became a private enterprise. Since that time the industry has shown a steady growth, with an increasing home demand for woolen goods, such as muslins, serges and woolen cloth. The linen industry was established about the same time, with private capital, and the company is now producing all of its flax by European methods, with 25,000 acres under cultivation. The products include duck, sail-cloth, linen cloths and shirting, table linen and napkins, toweling, sewing thread, shoe thread, fine twines, etc. The value of all textile fabrics manufactured for 1912 amounted to a total of 337,000,000 yen. This does not include the value of spun silk, or cotton yarn, which cannot be stated, the cotton manufactured into yarn alone in a year footing up 554,800,000 pounds, or 277,400 short tons. Silk yarn spinning was established in 1878, the government having purchased machinery in Switzerland with which to start a model factory. Hemp yarn spinning began in 1883.

Paper making is another important industry, the manufacture of "Japanese" paper going back to the Middle Ages. The raw material used in this form of paper is rice-straw, the barks of the willow and mulberry trees, the gampi, mitsumata, and kauzu. After the restoration when, through intercourse with occidental countries, new ideas and a more modern civilization had been introduced, a demand arose for foreign forms of paper, and in 1872 machinery having been purchased in England, the first paper by European process was manufactured. The industry is now firmly established, and in 1912 the value of production—largely from wood—amounted to 28,000,000 yen, while "Japanese" paper in the same year was valued at 20,000,000 yen.

The manufacture of lacquer wares, which likewise has come down from past ages, is another important industry. In the present age, through the wide dissemination of a knowledge of applied chemistry, new processes, especially for color lacquering, have been invented and the production is steadily increasing. All kinds of wares in lacquer are now produced, such as household furniture and ornamental articles—even dinner services, etc. Skilled artists are engaged in the production of raised lacquer in many beautiful designs. The value of these productions in 1912 amounted to 9,000,000 yen.

The manufacture of pottery and earthen ware, which had made some progress as early as the seventeenth century, is now a very flourishing industry. Western methods have been introduced into the manufacture, with the employment of plaster types, copper plates, and gas and coal furnaces. The products include not only household pottery, toys and ornamental goods, but building materials, scientific and medical apparatus and electrical appliances. The value of the output for 1912 was 16,000,000 yen.

The small item matches makes a good showing among new industries. There are many factories and a large export trade has been built up, besides supplying the home demand. The manufacture amounts to 10,000,000 yen annually. Another small industry is the manufacture of straw plait, formerly used only in toy making, but now employed in a large variety of goods. Chip plait, from soft wood shavings, is also manufactured to a considerable extent. Both industries are carried on by farmers as secondary employment. These two industries foot up a value of 8,000,000 yen annually. The manufacture of figured rush matting was introduced from China in the seventeenth century, and is a distinctively Japanese industry. A great impetus has been given the industry by government aid since the restoration. New forms have been invented, and at the present time mattings are woven in thousands of houses. The annual production has reached a value of 10,000,000 yen.

Tea production is an agricultural industry, six kinds being recognized, as the Hikicha, Gyokuro, Sencha, Kocha, Oolong and Bancha. As the government prohibits by law the artificial coloring of teas, as well as all other forms of manipulation, the product has a high reputation for purity and flavor, and it is worth noting that the United States is the largest purchaser. The value of the tea crop is nearly 9,000,000 yen. Rice is the most important agricultural product, and an area of 73,000,000 acres is devoted to its cultivation. As it is the principal food stuff of the Japanese people, considerable attention is paid to the improvement in methods of culture, this work being carried on largely by the government through the agricultural experiment stations, and the Department of Agriculture and Commerce. An annual yield of 245,000,000 bushels is recorded. Over forty rice exchanges have been established to afford facilities for marketing the product, which is a leading commerical commodity. Wheat, barley and rye are also grown to an extent of nearly 120,000,000 bushels. Among fruits the mandarin orange takes precedence, the crop being valued at 3,000,000 yen. Other fruits are the apple, pear, and the Kaki, or Japanese persimmon, of which latter there are many varieties. This crop is worth 780,000 yen annually. The product is largely eaten in the dried form.

The income from forest products in 1912 was nearly 104,000,000 yen. In addition to the lumber trade there is a large business in chemical products from wood among which may be named calcium acetate, pine soot, charcoal, wood pulp, camphor and camphor oil. The camphor industry is a government monopoly, which yields an annual income of four and a half million yen, three fourths of which is derived from the forests of Formosa. The total value of chemical products is nearly 30,000,000 yen.

Japan's rapid industrial advancement during the past forty years is conspicuously shown by glancing at the statistics of the mining industry, which goes back to the Middle Ages. After the restoration the government gave particular encouragement to the industry through the employment of European experts—even miners—and by enacting laws for its regulation, and establishing governernment management of important mines. Combining Japanese experience with western methods, and by utilizing modern machinery, the industry has undergone a complete change, and its development has been very rapid. The principal products are gold, silver, copper, iron, coal, sulphur and petroleum, the latter occupying third place among mineral products, with an output of over 1,600,000 barrels in 1913. Coal occupies the first place with an output of 21,300,000 tons valued at 70,000,000 yen. Copper comes next in importance with a value of 41,700,000 yen. Gold occupies fourth place, valued at 7,000,000 yen, and silver fifth, totaling 5,700,000 yen. The income from mineral products in 1903 was 57,475,000 yen; in 1908, 105,393,000 yen, and in 1913, 146,660,000 yen. In 1875, five years after the restoration, the value was not more than 2,500,000 yen, increasing in the next five years to 6,700,000 yen. There are no available figures to show the amount of capital invested by individuals, but the paid-up capital of corporations, in 1913 was 232,000,000 yen.

Japan, with her 14,000 miles of coast, has an enormous fisheries industry, the claim being made that the number of fishermen finds no parallel in any country of the world. About 1,800,000 men are engaged in the fisheries, with 419,000 fishing boats, and the total value of the catch—including the income from new territorial possessions—amounted in 1912 to 114,800,000 yen. Among the species caught in largest numbers are herring, bonito, bream, mackerel, tunny, flounder and cuttle-fish. The cod fishing is the least important, as the industry is new, and the catch not easily marketed. Fish culture is given considerable prominence, there being over sixty hatcheries for salmon alone. Trout and other species are also cultivated. The value of such marine products as iodine, shell buttons, and isinglass amounts to a total of 4,500,000 yen annually, and the fish cannery 2,500,000 more. In the whaling industry steam whaling boats are used, these being limited to thirty as a matter of protection of the species. The number of whales caught in 1911 was 1330, valued at 1,270,000 yen. Steam trawling has greatly developed in recent years, and there is a government inspection for the regulation of the industry. In 1912 there were 153 vessels and the total value of the catch was 3,820,000 yen.

Japan's extraordinary industrial development is shown to a marked degree by viewing the figures of her export trade. From an importing country at the beginning of the Meiji *régimé*, through the activities of government and people, the limit of the home demand in many products was soon reached, and her wares began to be known—first in Eastern countries, and later in the markets of the world. In 1868, when silk and tea were the chief exports, these two items represented one third of the total value of exports. The articles exported at the present time cover a wide range of products, many of which come into direct competition with similar goods produced in other countries. Of raw silk alone, the exports amount to about 190,000,000 yen in a year, and

waste and spun silk 12,000,000 more. Exports of cotton yarn amount to 70,000,000; cotton cloth, cotton crape and flannel, twilled goods, shirtings, bath towels and cotton knit goods, foot up 40,000,000, and silk fabrics and silk handkerchiefs another 40,000,000.

The item matches is a conspicuous example of Japanese thoroughness in the establishment of a new industry. This industry was begun in 1875. Two years later a trial shipment was sent to Shanghai, and three years after, the importation of foreign matches was wholly stopped. In 1912 the exports of this product to British India and the East, to Australia and to America, amounted to 14,000,000 yen. The exports of coal amount to 23,000,000; refined sugar, 15,000,000; straw, chip and hemp plait, 15,000,000; tea, 10,000,000. Other exports are rice, wines, vegetable oils, vegetable wax, dried cuttle-fish, figured mattings, fans, toys, brushes, patent medicines, glass and glass goods, imitation Panama hats, paper, lacquer wares, porcelain and pottery, soaps, shell buttons, oranges and vegetables, dried mushrooms, canned and bottled foods, timber, railway sleepers, bamboo, machinery, ships, sailing vessels, etc. The total value of exports foot up 632,460,213 yen for the year ended 1913. The imports for the same year amounted to 729,431,644 yen, the most important items being raw and ginned cotton, jute and other raw fibers, wool and woolen cloth, iron ore, pig iron, rails, bars and rods, iron plate, wire, tin plate, petroleum oil, sulphate of antimony, caustic soda and other chemicals, indigo, dye stuffs, nickel and other metals, cotton spinning and wood and metal working machinery, bicycles and automobiles, locomotives and railway cars, steam vessels, gas and caloric engines, building materials and plate glass, wood pulp, electrical instruments, wheat, rice, beans and other agricultural products, fertilizers, and many other articles. The rapid growth of Japan's commerce, and the development of trade, is shown in the following table of export and import values, by decades, since 1868:

Year.	Exports.	Imports.
	Yen.	Yen.
1868	15,553,473	10,693,073
1877	23,348,522	27,420,903
1887	52,407,681	44,304,252
1897	163,135,077	219.300,772
1907	432,412,873	444,467,346
1913	632,460,213	729,431,644

In trade with other countries the United States holds the first place, the exports amounting to 184,475,000 yen and the imports 122,408,000 yen, the balance of trade being with Japan. China, England, France, Kwantung, Dutch India, Italy, Hongkong and British India follow in the order of their importance, the list including twenty-four other countries. The bankers' clearing house returns for 1912 showed a business of nearly 10,000,000,000 yen, which is almost three times that of ten years before. At the present time business is done on a very much larger scale than a few years ago, and there is a tendency to adopt the latter day system of trusts or combines, especially in the conduct of such industries as cotton spinning, linen manufacture, paper making and beer brewing.

Japan appreciates the value of advertising, and in her participation at international expositions her displays have always been superb, and her hospitality lavish. Her representation at the Panama-Pacific Exposition in San Francisco was no exception, for her many industries were represented by a thousand and more interesting exhibits in every department, as set forth in the 110 pages of the official catalogue.

Sweet Clover

Gaining in Favor as a Cultivated Crop

SWEET clover, which is so common along roadsides and in waste places in many parts of the country, is rapidly gaining favor as a cultivated crop. This is due to its value for soil improvement, for pastures, and for hay. There are three species of sweet clover commonly found in the United States. The biennial yellow-flowered species (*Melilotus officinalis*) and the biennial white-flowered species (*Mililotus alba*) are valuable over a wide area, while the annual yellow-flowered species (*Mililotus indica*) is of little economic importance except in the extreme South and Southwest, where it is grown as a winter-cover and green-manure crop. With the exceptions of a few localities, white sweet clover is grown almost entirely. This is due to the fact that it yields more forage and produces larger roots than the other species. The white-flowered species is ordinarily referred to as sweet clover, while the other two species are called yellow sweet clover.

Sweet clover resembles alfalfa when young, but can be distinguished from it by its bitter taste, its smooth shiny leaves, and later, when in bloom, by the long, loose spike-like arrangement of white flowers in contrast to the close purple clusters of alfalfa flowers. One of the most notable features of sweet clover is its root system. During the first season of growth the roots often reach a diameter of one half inch at the crown of the plant. On account of the fleshy character of the roots, a large quantity of vegetable matter is added to the soil, even when the tops of the plants are removed for hay.

There are few plants which will put waste land or run-down farms into condition for producing crops as quickly as sweet clover. Its value for this purpose is recognized in Alabama and Mississippi, and also in parts of Kentucky and Ohio. On account of the root development of this plant, large quantities of vegetable matter are added to the soil when a field of sweet clover is plowed. The root system alone has been estimated to be about twenty tons of green weight per acre for a good growth of sweet clover. In some parts of the country it has been used in a small way as a green-manure crop, the second year's growth being plowed under. By turning under a crop of sweet clover, or only the stubble, marked gains are obtained in the following crop.

Sweet clover is a very good winter-cover crop in that it prevents the soils from gullying and washing. It also takes up large quantities of available fertilizers which would probably leach out of the soil during the winter. On account of the large taproots of sweet clover plants, potassium and phosphorus may be taken up in the subsoil and deposited, at least in part, in the surface soil when the roots decay.

Since sweet clover is a biennial, like red clover, it is readily adapted to similar rotations. Sweet clover will undoubtedly prove to be a valuable crop as a substitute for red clover in the ordinary farm rotations where red clover will no longer grow. It may be seeded in the spring on grain as red clover is sown. When seeded in this manner some pasturage will be produced that fall in the North and pasturage or a hay crop in the South. The following season it produces two crops in the North and three crops in the South. It may be handled in a manner similar to red clover.

Sweet-clover hay is rapidly coming into favor as a feed for all classes of live stock, especially in places where more desirable types of hay will not grow successfully. Ordinarily some trouble is experienced in getting stock to eat sweet clover at first, on account of its bitter taste, but after they have been accustomed to eating it no trouble is experienced. A high percentage of digestible protein is contained in the hay.

Sweet clover makes excellent pasturage for horses, sheep, cattle, and hogs. Probably the easiest way to create an appetite for this plant is to commence pasturing stock on it very early in the spring of the second year, before other green feed has started. A sufficient number of animals should be kept in a sweet clover pasture to keep it grazed rather closely. This will prevent the stems from becoming large and woody and will also induce an abundant growth of young shoots. Stock when pastured upon sweet clover make gains which compare very favorably with those obtained from either alfalfa or red clover.

There is very little danger of bloating when stock are pastured on sweet clover, but it is safest to avoid turning the stock into a sweet clover pasture when it is wet with dew or rain or when stock are unusually hungry. Sweet clover will also thrive well during midsummer droughts and produce much early and late pasturage.

Sweet clover has the ability to thrive on poor clay soils as well as on poor sandy soils, but it will make a better growth on fertile soil. It prefers soils of limestone origin. Clay soils which are acid should be limed before sweet clover is sown. Sweet clover is also very resistant to alkali, and plants may be found in the West growing on soils so alkaline that little else than salt grass is able to survive.

The primary requisite for obtaining a stand of sweet clover is to have a firm, thoroughly compacted seed bed with just enough loose soil on top to enable the seed to be covered. The lack of a firm seed bed is probably the chief reason why sweet clover so often fails when seeded under cultivation. However if it is seeded with spring-sown grain the seed bed should be rolled after seeding. Better results are usually obtained where sweet clover is seeded alone in the late winter or spring on ground which has been plowed and thoroughly worked the previous fall.

The time for sowing sweet clover varies considerably in different sections of the United States. In the eastern part, in the latitude of Washington, D. C., a good stand may be obtained by seeding either early in the spring or about August 15th. One disadvantage with early fall seeding is that the plants mature and die the following year and only a small growth of roots is obtained. If seeded in spring in a nurse crop sweet clover will develop an extensive root system the first year and produce a small amount of pasture. For this reason it is recommended that so far as possible it be seeded in the late winter or spring. In the Southern States, as far north as the Ohio River, the practice is to seed quite early in the spring, during February or the early part of March. In the States farther north the date is correspondingly later, until in Wisconsin it is usually seeded in the latter part of April or first of May. When the rainfall is sufficient, a stand can be obtained by seeding in small grain, such as fall wheat or spring-sown crops like oats and barley, but in seeding with grain one runs some risk of having the sweet-clover plants killed out by drought during the summer. Owing to the rather slow germination of the seed it is usually best to seed at the rate of fifteen to twenty pounds of hulled seed and twenty-five pounds of unhulled seed to the acre.

On poor soils in localities where sweet clover is not common, it is quite important that the soil be inoculated at seeding time to insure good results. Even in localities where sweet clover is plentiful the early growth has been made much more vigorous by thoroughly inoculating the soil. Inoculation can be accomplished by mixing soil from a field where sweet clover, bur clover, yellow trefoil (black medic), or alfalfa grows abundantly, pound for pound, with sweet clover seed. This mixture should be sown after sunset or on a cloudy day and immediately harrowed in, since daylight greatly injures the inoculating germs. Inoculation is also accomplished in the South by using unhulled seed. Pure cultures of the inoculating bacteria may be obtained free of charge from the department.

When hay is desired, sweet clover should be cut just before it begins to bloom. At this time the leaves are most abundant, and the stems have not yet become woody. Sweet clover hay should be tedded while in the swath, and just before the leaves become dry enough to shatter it should be raked into windrows. After lying in the windrow for a day it may be put into shocks and cured. When sweet clover is seeded in the spring with a nurse crop, only a small amount of pasture is produced that autumn, but where it is seeded alone in the spring a cutting of hay may be made in the autumn. The following year a hay crop and a seed crop, or two cuttings of hay if seed is not desired, are usually obtained. In the South, where seeded alone, two cuttings may be obtained the first year, and either two cuttings of hay and a seed crop or three cuttings of hay the second year. Where seeded alone in the North there is no danger of the hay becoming woody the first year, and for that reason it does not need to be cut until it has attained its largest growth in the fall.

In harvesting the seed it is important that the plants be cut before the seed is fully matured. One must watch the seed crop carefully, and as soon as the lower racemes or spike-like arrangements of flowers are dry and mature it is best to cut the crop. Even where it is mown and the seed flailed out, probably not more than three-fourths of the racemes should be allowed to become fully mature. Sweet clover seed can be thrashed most easily by the ordinary thrashing machine, but if it is to be hulled a regular clover huller with special rasps is used. In semi-arid and irrigated sections the hulls are so dry that an ordinary grain thrasher will remove most of them. Since the seed shatters very easily, sweet clover should be cut when it is wet with dew. If the first growth be cut for hay when it is two and a half feet tall, leaving a six-inch stubble, the seed crop will come on much more evenly. Care should be taken to cut the stubble of the preceding hay crops as high as possible, so that there will be sufficient stems remaining to resume growth, as this plant, unlike alfalfa, does not form new crown shoots. Seed yields vary from two to eight bushels to the acre.

The failure of the farmers throughout the United States to make use of this valuable legume has largely been on account of the fear that it could not be eradicated from their farms if once started. The biennial nature of the plant makes the problem of eradication very easy. It will not persist when continually mowed so that it cannot produce seed, nor is it troublesome in clean cultivated or intertilled crops.—*Weekly News Letter of the Department of Agriculture.*

A New Glass for Culinary Ware

IN THE *Journal of Industrial and Engineering Chemistry*, Messrs. Sullivan and Taylor describe a new borosilicate glass that is peculiarly suitable for culinary ware, as it has a low reflectivity for radiant heat and resists fracture by a blow better than crockery or enameled earthenware. It is free from the heavy metals, and from metals of the Mg-Ca-Zn group, and combines low thermal expansion with great resistance to attack by reagents.

Insects That Perplex Naturalists

Many Strange Features That Have Defied Explanation

By Harold Bastin

SINCE the days when Darwin and Wallace formulated their great theory of evolution through the agency of natural selection, there has been a strong tendency among ill-informed writers to assume that all mystery has been swept aside—at least in so far as the structure and habits of living things are concerned. Yet such an assumption is manifestly fallacious, for we are still faced with numberless problems that have so far baffled all attempts at solution. This is notably the case where insects are concerned. There are literally hundreds of species that perplex naturalists. Take, for instance, the so-called lantern-flies, each with its enormous, hollow process projecting forward from the head. This beak or rostrum was formerly believe to emit a phosphorescent glow after sundown. But careful observers are nowadays agreed that these lantern-flies are not luminous—the real "fire-flies" being beetles of various kinds. What purpose is served by the huge rostrum—if, indeed, it serves a purpose at all—remains a mystery.

The curiously fashioned "horns" with which many male beetles are equipped are scarcely less perplexing. True, in a few instances, these appendages are known to be used as weapons, or as grasping organs by means of which the female may be conveyed to a safe retreat. But in the majority of cases their extravagant shape, and the positions which they occupy on the head and thorax, seem at once to impugn any theory of practical utility.

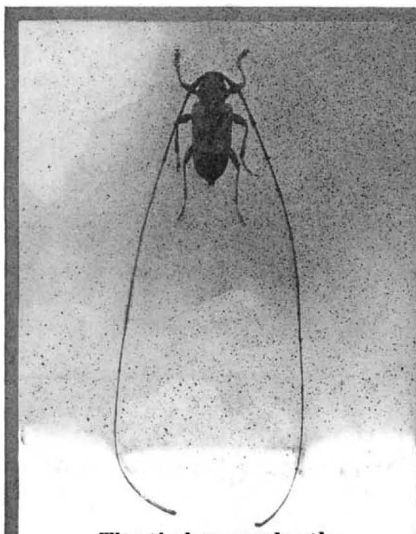
Among the quaintest insects known to naturalists are certain tropical beetles, called Brenthids. The head and thorax (especially in the male sex) are often extremely long and narrow, and the creature presents a most weird appearance. Dr. David Sharp mentions that "the males of some species fight; they do not, however, wound their opponent, but merely frighten him away." This statement is not difficult to credit, since the typical male Brenthid is undoubtedly an awe-inspiring monster. Yet are we to believe that herein lies the sole significance of the insect's amazing form? So far as the writer is aware, no other explanation has been proffered.

The feelers, or antennæ, of many insects are very perplexing. There is, for example, a fine Mexican chafer whose male is furnished with antennæ like great fans, the slats or laminæ of which can be opened or closed at the discretion of the owner. The chief function of these organs is probably olfactory. But why this particular insect should possess antennæ so disproportionate to its size is very puzzling. Appendages planned on such a gigantic scale would seem, *ipso facto*, to be very inconvenient; and science fails to suggest a plausible excuse for their existence.

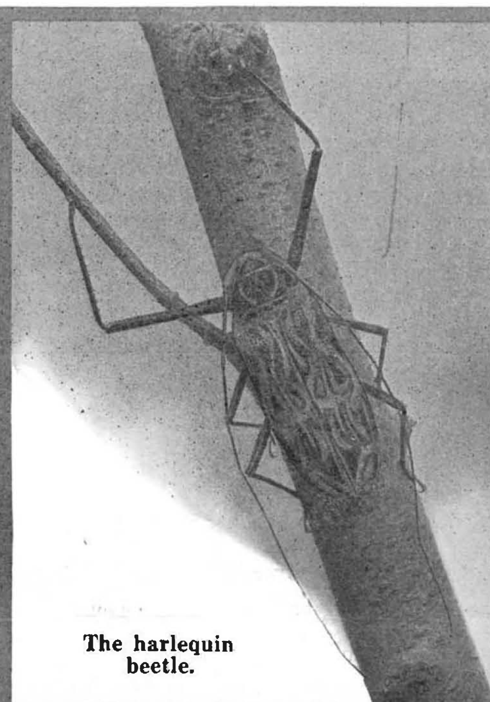
Again, there are the long-horned beetles, or Longicornia. A particularly striking example is the comparatively small species, known as "the timberman," which is common in Lapland and Sweden. In the male, the antennæ are several times longer than the rest of the body; and the reason for this—if reason there be—has never been elucidated. Another remarkable species of the same family is the so-called "harlequin beetle" of tropical America. Not only its antennæ, but also its fore-legs, are disproportionately long. Why this should be, nobody appears to know, although the insect is admittedly a good climber among the branches of the trees which it frequents. This piece of information, however, does not serve to clear up the mystery, since many beetles with short legs frequent trees and climb well.

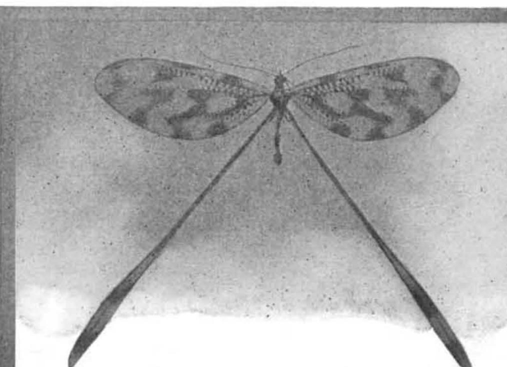
Numerous examples of insects with abnormal eyes might be cited, but for our present purpose one instance must suffice, viz., the stalk-eyed flies of tropical Asia and Africa. These curiosities have the sides of the head produced into long stalks, or horns, at the extremities of which are placed the eyes and antenna. Little is known concerning the life-histories of these insects, and men of science are quite unable to account for their strangely placed visual organs.

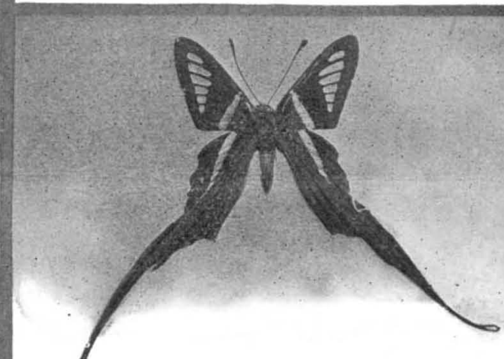
In a general way it may be said that the modifications of the insect's mouth-parts accord with the food that is eaten, and the manner in which it is obtained. Nevertheless, this explanation is not always admissible. For example, there is the interesting genus *Corydalis*, which is represented both in the Indian region and the American continent. It comprises some gigantic species of alder-fly whose males have enormously developed mandibles which project like horns from the front of the head. Despite their formidable aspect, these huge jaws are never used for tearing or biting,

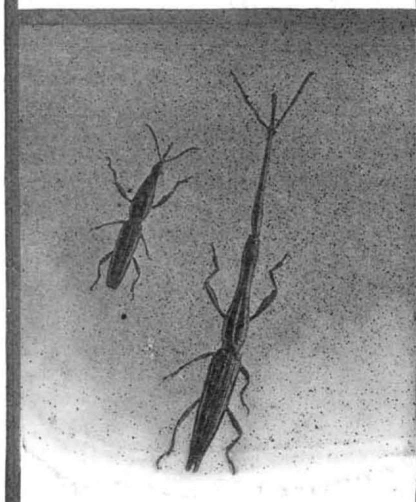

The timberman beetle.

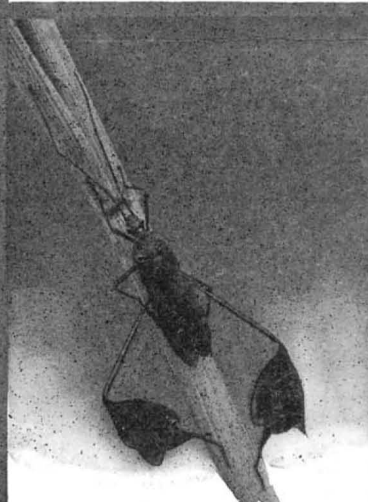

A Mexican chafer beetle, allied to our own cockchafer.

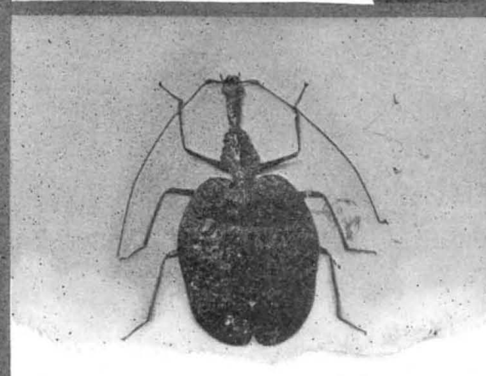

The harlequin beetle.

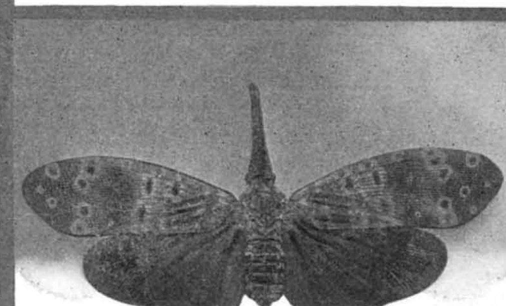

A beautiful Neuropterous insect from Southern Europe.

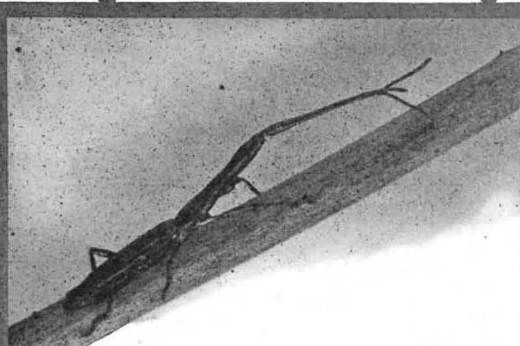

A quaint Indian butterfly.

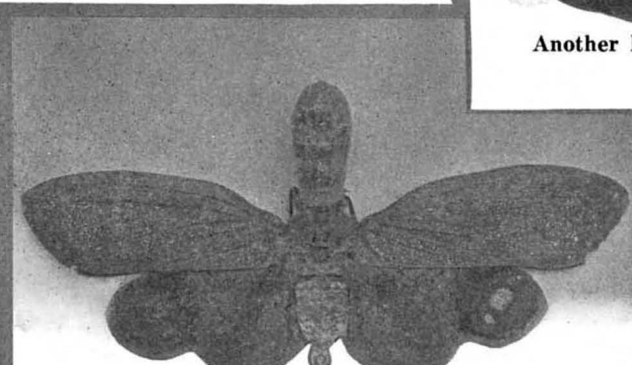

A male Brenthid beetle compared with its female.

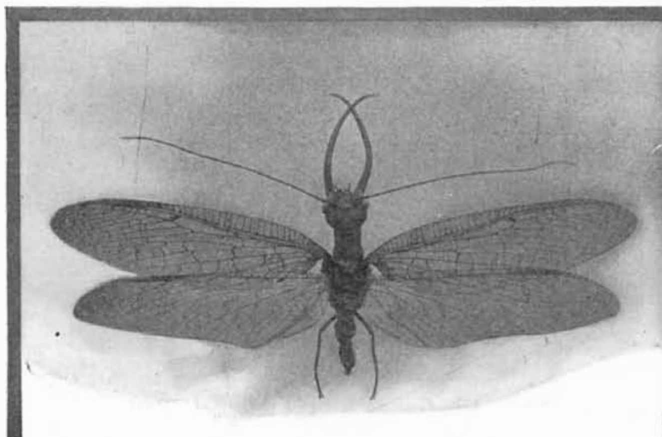

South American plant bug with flag-like expansions on its shins.


A beetle from Java, sometimes called the "fiddler" on account of its shape.

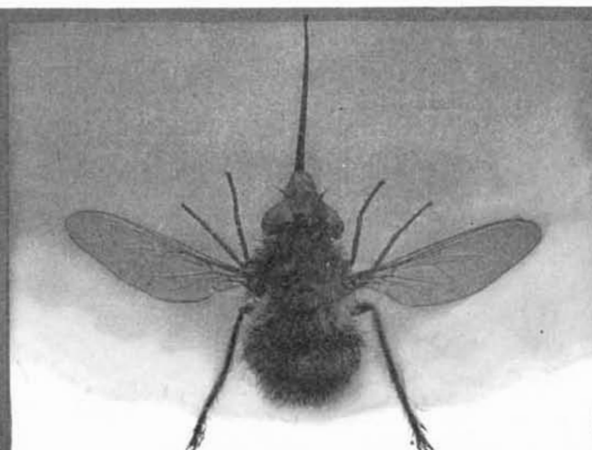

Another kind of lantern-fly, from India.


A male Brenthid beetle, from South America.

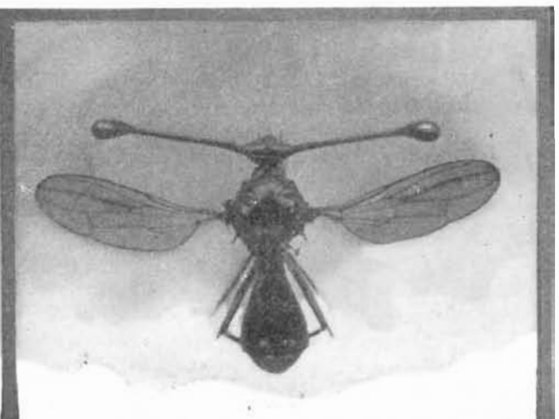

Great Brazilian lantern-fly. Its beak was at one time supposed to be luminous at night.



One of the giant alder-flies from Central America. Enormous mandibles are quite useless for feeding.



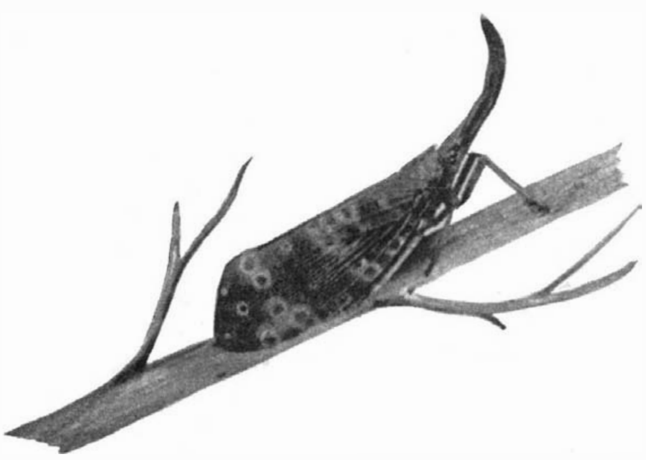
A "Seroot" fly, a blood-sucking species of Nubia.



One of the "stalk-eyed" flies of tropical Africa. Its eyes and feelers are carried at the ends of long horns.

and their *raison d'être* is difficult to conjecture. We may note, too, the case of the so-called "seroot" flies—insects that render parts of Nubia uninhabitable for three months each year on account of their blood-sucking proclivities. Why the trunks, or proboscides, of these particular gad-flies should be immensely long, while those of their near relatives (no less blood-thirsty and annoying) are short, remains an unsolved mystery.

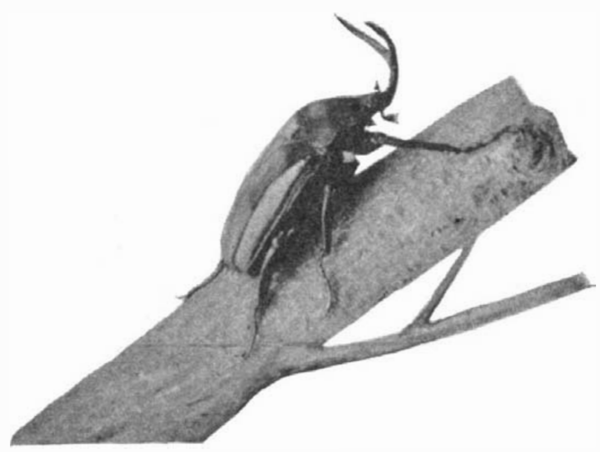
To the foregoing instances of perplexing insects must be added a Javanese beetle, sometimes called "the fiddler" because of its shape. It is perfectly flat, looks like the confection called "brandy snaps" or "jumbles," and lives under the bark of decaying trees. The creature, whose scientific name is *Mormolyce*, is a veritable walking enigma. No explanation of its curious form has been offered, although its large, flat wing-covers are known to be used as planes for gliding when the insect flies.



Lantern-fly from India, in resting position. No use is known for the amazing "beak."

The tropical American plant-bugs of the genus *Diactor* present an extremely remarkable appearance because the tibia, or shin, of each hind-leg is flattened and expanded in a manner suggestive of a leaf. These expansions are invariably prettily colored. Is it possible that they serve to confuse creatures that prey upon the bugs? This explanation has been advanced to account for the long wing-tails of certain butterflies and moths, and of the Neuropterous insects which make up the family *Nemopteridæ*. The idea is that a bird, when chasing one of these insects, might seize and break off the trailing wing-tail. If this should happen, the bird might be temporarily disconcerted, with the result that the insect would gain time to effect its escape. It must be admitted, however, that the theory is not entirely convincing—especially in so far as the *Diactor* bugs are concerned.

On the whole, the most satisfactory solution of the problem suggested by the remarkable insects mentioned in this article seems to lie with the modern doctrine of "momentum in organic development." Let it be granted that natural selection tends to establish useful variations, and to eliminate those that are harmful. There still remains the possibility that variations of a neutral character, i. e., neither useful nor harmful, may persist, and that as generation succeeds generation they may attain considerable dimensions. Much indirect evidence exists to support this view. In the end, of course, a variation that was originally neutral in character may become harmful, and lead to the extinction of the race; but before this happens an immense alteration in the form of the species may have been effected. It seems at least possible that some, if not all, of the insects described in the preceding paragraphs may be products of "momentum in organic development."



An East African beetle whose great forked antler is a puzzle to naturalists.

The Loom and Spindle

The subject of weaving is discussed historically and practically in an instructive manner in a publication of the Smithsonian Institution written by Mr. Luther Hooper, who says that the spindle and the loom, the one for twisting the fiber into thread, and the other for weaving the thread into cloth, are prehistoric and almost universal tools. These tools, and the methods of using them, have never been subjected to much variation, whether invented by prehistoric man, skillful weavers of the ancient world, or ingenious craftsmen of the primitive tribes of to-day. It is not only in elementary forms of weaving that this similarity is found; the essential principles of the most modern spinning and weaving machinery are identical with those used in the most ancient times, and the complicated textile machinery of to-day is a natural development from that used by primitive weavers of all time.

Mr. Hooper demonstrates the principles of the primitive loom and spindle, and traces their gradual evolution into the wonderful, but still far from perfect, mechanism of the modern machines actuated by steam power. He also indicates the lines along which textile machinery of the future is likely to be improved. Prehistoric examples of the weaver's art are extremely rare owing to the perishable nature of the materials of which they are composed, but these merest shreds of textile fabrics show unmistakably that the art of the loom, as well as that of the spindle and needle, was understood and successfully practised in what has been called "the night of time."

It was among the remains of one of the earlest of the lake dwellings of Switzerland, discovered in the bed of the lake at Robenhausen, that bundles of raw flax fiber fine and coarse linen threads, twisted string of various sizes, and thick ropes, as well as netted and knitted fabrics, and fragments of loom-woven linen cloth were found. There were also spinning whorls and loom weights of stone and earthenware, and one or two fragments of wooden wheels and frames, which were possibly the remains of thread-twisting machines and simple looms, all of which very clearly demonstrate that the people of the stone age in Europe cultivated, spun, and wove flax and hemp in the simplest manner.

With an oblong board, two sticks, and a piece of string, the author describes the construction of a simple loom, typical of all looms. The string is wound about the board, over the ends, making a series of vertical cords lightly separated, and the two sticks are inserted between alternate cords at one end. The threads or cords which cross between the two sticks are separated into a well-ordered warp which is easily kept free from entanglement, and through the alternate spaces of which the shuttle with its thread or string forms the woof or weft in an over-and-under weave.

Mr. Hooper goes on to describe spinning by hand with a distaff and spindle, used previous to 500 B. C., the flier, bobbin, and the spindle of Leonardo da Vinci, 1519, which were parts of the spinning wheels of later dates, down to the machines of extraordinary capacity and exactness which supply quantities of yarn of all kinds required in textile industries to-day.

In discussing the development of the modern loom from the hand loom of early date, the writer states that the first indication of the coming change in the broad-weaving trade was in 1687, when Joseph Mason patented a machine which he described as "an engine by the help of which a weaver may performe the whole work of weaving such stuffe as the greate weaving trade of Norwich doth now depend on, without the help of a draugh-boy, which engine hath been tryed and found out to be of greate use to said weaving trade."

A machine invented by Joseph Marie Jacquard, and known in England as the "Jackard" machine, which substituted for the weaver's tie-up a band of perforated paper, was first applied to the draw loom in 1725, and in 1728 a chain of cards was substituted and a perforated cylinder added. Its most striking advantage is the fact that it makes possible a frequent change of design, it being only necessary to take down one set of cards and substitute another to change the pattern. At first employed alone for weaving elaborate designs in the silk trade, it has since come to be universally used in all kinds of plain and ornamental textiles whether woven on hand or power looms. Its truly wonderful mechanism can be made to govern all the operations of the loom except throwing the shuttle, and operating its own actuating lever.

In the course of describing many loom operations, the author mentions a new loom which he thinks is likely to revolutionize the construction of machines for weaving by power. It weaves cloth in the form of an enormous tube, the tube being cut between selvages after weaving, so that a broad flat piece of cloth results. There is no shuttle in this loom, but there is a cop which remains stationary while the loom revolves and weaves a spiral thread around and through the cylindrical warp. In addition, its operation is all but noiseless, and very little power is required to run it.

In reviewing the future promise of development in weaving, the author says that the hand shuttle, for work not too wide for it, and the perforated comber board will be retained, that some arrangement similar to that in the circular loom will be effected, and that the Jacquard machine will be superseded by an electro-magnetic arrangement. With these retentions and improvements, he feels that the master weaver of the future will not only produce webs as exquisite as those of the best weavers of the past, but will carry the art forward to a higher degree of perfection.

The National Museum possesses many models and important textile machines arranged in a series from the earliest spinning and weaving appliances to the modern loom, which supplements the article well, and itself teaches a lesson in the development of the textile industry.

Corrosion Resisting Steel and Iron

From an abstract of a research report by D. M. Buck and J. O. Handy, prepared for the American Chemical Society, and published in the *Iron Age*, it appears that sheet iron or steel containing an addition of copper to the amount of 0.25 per cent has the property of resisting corrosion when exposed to the atmosphere to a considable extent. Larger amounts of copper gave little or no improvement in results; and some previous work done by one of the investigators seemed to indicate that 0.15 per cent of copper is in most cases equally as efficient as the 0.25 per cent plates.

Telegraph Codes of the World*

Various Systems of Signs Used for the Electrical Transmission of Thoughts

FROM the beginning the mind of man has ever been concerned with the problem of devising symbols or signs which could be used in conveying thoughts and ideas to the minds of other men. History tells us that in all ages and in all lands the people of the period had their own peculiar methods of communication—in the less civilized countries by means of signs manifested by gesticulation of the hands and arms, and among more highly developed peoples by means of inscribed marks or symbols.

In the writings of Homer "the lambent flame which shone 'round the head of Achilles" is compared to the signals made in besieged cities by clouds of smoke in the daytime, and by bright fires at night—signals which were employed in calling for assistance and in notifying friendly cities of the imminence of hostile attack.

Signaling-systems employing alternately obscured and exposed lighted torches were used by Polybius in the Punic war, B. C. 264. Flag and semaphore signaling-systems were employed by Washington's army in the war of the Revolution; and before and immediately after that time many ingenious signaling-systems were proposed which consisted mainly of symbols representing certain prearranged groups of words.

The necessity for a universal signaling-alphabet having a symbol for each of the letters that form the elements of written language had been recognized from very early times.

The Francis Bacon alphabet of 1605 A. D. is the first successful attempt of which there is record having as its basis "dimension" and "duration" of the elements of the signal. It was a far cry, however, from this early alphabet to the scientific arrangement adopted by Morse in the year 1884.

It would task the comprehension of a seer to grasp the wealth of significance contained in those three simple words, "the Morse Alphabet." To-day the language of the wire, the language of the rail, the universal language of the sea are made up of the mystic symbols which comprise the telegraph alphabet.

In the minds of many the idea prevails that the first telegraph code was devised by Prof. S. F. B. Morse, the inventor of the electromagnetic telegraph, with the aid of his assistant, Alfred Vail. It is true that both Morse and Vail performed a vast amount of painstaking labor in devising a satisfactory signaling-code for the Morse telegraph system introduced in the year 1844; but it has since been learned that had Morse known of the work along the same lines done by prior scientists he would have found ready at hand an alphabet answering his requirements better than the first code arrangement which he employed.

The present article, which has been especially prepared for the readers of the *Railroad Man's Magazine*, gives for the first time a complete account of the various steps taken in the development and application of the telegraph alphabet.

In the year 1605 Francis Bacon, in his "Advancement of Learning," discussing cryptography, submits a form of biliteral alphabet which may be made up of all things which are capable of two differences.

Employing dots and dashes in the composition of this alphabet, the letters were designated as follows:

BACON'S ALPHABET OF 1605.

A	.....	I	. – . . .	R	– . . . .
B	.... –	K	. – ... –	S	– ... –
C	... – .	L	. – . – .	T	– .. – .
D	... – –	M	. – . – –	V	– .. – –
E	.. – ..	N	. – – ..	W	– . – ..
F	.. – . –	O	. – – . –	X	– . – . –
G	.. – – .	P	. – – – .	Y	– . – – .
H	.. – – –	Q	. – – – –	Z	– . – – –

The omission of the letters J and U is due to the fact that these letters of the English alphabet had not at that date been differentiated from I and V.

REES'S ALPHABET.

In a cyclopedia published by Dr. Abraham Rees in 1809 there appears an alphabet in which the first nine letters are represented identically with Bacon's code. In the Rees alphabet the inclusion of the letters J and U necessitated a shift forward of the signs. With the exception of the letters X, Y, and Z, this alphabet is the same as that of Bacon.

SWAIM'S ALPHABET.

James Swaim of Philadelphia, in the year 1829, described an "acoustic" alphabet which could be employed in telegraphing along or through a wall. As shown herewith this alphabet is represented in conventional dots and dashes; but as originally devised the dots were represented by a letter T (meaning "tap"), while the dashes were represented by a letter S (meaning "scratch").

A	.	J	. .. –	S	. . –
B	..	K	. .	T	.. .. –
C	...	L	. ..	U	.. .
D	....	M	. ...	V	.. ..
E	–	N	. ....	W	.. ...
F	– –	O	. –	X	.. ....
G	– – –	P	. – –	Y	.. –
H	– – – –	Q	. – – –	Z	.. – –
I	. –	R	. – – – –		

It is evident that this alphabet was not carefully designed, as with four signs only a sufficient number of combinations could have been made to represent thirty letters or characters. The employment of spaces between the elements of two thirds of the total number of letters makes this alphabet somewhat cumbersome and difficult to memorize.

LOST ALPHABETS.

The alphabet employed by Lomond in France in the operation of his pith-ball telegraph in the year 1787 has evidently been lost to telegraphic history, as also is that used by Harrison Gray Dyar in the United States in the operation of his electrochemical telegraph in the year 1828.

SCHILLING'S ALPHABET.

The alphabet employed by Baron Schilling, whose telegraph was constructed in St. Petersburg, Russia, in the latter part of 1832, consisted of elements indicative of the position—to the left or to the right—of a vertical pointer whose movements were controlled electrically from a distant station.

As usually shown this alphabet consists of combinations of the letters R and L, meaning "right" and "left." For example, in transmitting the letter N the sending lever is moved to the left once and to the right once. At the receiving station the indicating needle would swing first to the left and then to the right; this would be translated as the letter N.

The Schilling alphabet as shown herewith is made up of dots and dashes so that the various letter-combinations may be compared with later alphabets made up of similar elements. A dot represents a swing of the needle to the right, and a dash a swing to the left.

A	. –	J	.. – –	S	– –
B	...	K	... –	T	–
C	. – –	L	– ...	U	– – .
D	.. –	M	– . –	V	– – –
E	.	N	– .	W	. – . –
F	....	O	. – .	X	– . – .
G	– – – –	P	– – ..	Y	. – – .
H	. – – –	Q	– – – .	Z	. – ..
I	..	R	– ..		

GAUSS AND WEBER'S ALPHABET.

In 1883 Gauss and Weber, of Germany, introduced a telegraph system employing a galvanometer with a reflecting mirror, the movements of the mirror to the left or to the right being observed by means of a telescope. The alphabet used is shown herewith, a dot representing a movement of the mirror to the right and a dash a movement to the left:

A	.	H	– – –	P	....
B	– –	I	..	R	... –
C	...	K	...	S	.. – .
D	.. –	L	– – .	T	. – ..
E	–	M	– . –	U	– .
F	. – .	N	. – –	V	. – .
G	– ..	O	. –	W	– ...
				Z	.. – –

In this alphabet C and K have the same symbol, as also have F and V.

STEINHILL'S ALPHABET.

The alphabet employed by Steinhill in Germany in 1836 was as follows:

A	– . –	I	.	R	– –
B	– .. –	J	.	S	– – ..
C	– – .	K	– – .	T	– .
D	. –	L	. – –	U	. – .
E	–	M	...	V	. – .
F	– ..	N	..	W	. – . –
G	.. –	O	– – –	Z	.. – –
H	. ..	P	. – – .		

It will be noted that I and J have the same symbol, also U and V, and that the letters Q, X, and Y were dispensed with.

DEVELOPMENT OF MORSE ALPHABET.

Prof. Morse's first idea of a telegraphic alphabet was that a dictionary of words could be made up, giving to each word a numerical reference, thus: Alabama, 123; Arkansas, 321, *et cetera*. The dot-and-dash code used to represent each figure was as follows:

1	.	6	. –
2	..	7	.. –
3	...	8	... –
4	....	9	.... –
5	.....	0	..... –

It is apparent that a very long list of words may be arranged with these ten figures in different relations; but the time required, first to compose the words of the message to be transmitted into groups of figures, and then to translate these groups into written words at the receiving station, caused delay which resulted in the early abandonment of this method of telegraphing.

The first complete alphabet devised by Prof. Morse in which each letter was given a dot-and-dash symbol was that used in the year 1838.

MORSE'S 1838 ALPHABET.

A	...	J	.. .	S	. – .
B	.. ..	K	– . –	T	– – .
C	. ..	L	—	U	. – –
D	... .	M	– ..	V	– – –
E	.	N	– .	W	.. –
F	. ...	O	..	X	– –
G	.. .	P	.....	Y	. –
H	....	Q	.. – .	Z	. – .
I	. –	R	. .		

It will be noted that the same symbol has been given to G and J, to I and W, and to S and Z. The Morse alphabet used in the year 1844—which is still in use unchanged in the United States and in Canada—consisted of a rearrangement of the symbols, avoiding duplication.

MORSE'S 1844 ALPHABET.

A	. –	J	– . – .	S	...
B	– ...	K	– . –	T	–
C	.. .	L	—	U	.. –
D	– ..	M	– –	V	... –
E	.	N	– .	W	. – –
F	. – .	O	. .	X	. – ..
G	– – .	P	.....	Y	.. ..
H	....	Q	.. – .	Z	... .
I	..	R	. ..	&	. ...

1	. – – .	6	......
2	.. – ..	7	– – ..
3	... – .	8	– ....
4	.... –	9	– .. –
5	– – –	0	—

. Period .. – – ..	; Semi-colon . – . – .
: Colon – . – . .	, Comma . – . –
¶ Paragraph – – – –	? Interrogation – .. – .
- Fraction line .	() Parenthesis . – . . –
! Exclamation – – – .	

A person might well be pardoned for not at first sight observing that the Morse alphabet is a scientific arrangement of dots and dashes composed with the object of providing short signals for those letters which occur most frequently in English words, and also with the object of arranging letter-signs sufficiently dissimilar to prevent or at least lessen the likelihood of confusion.

The symbols are arranged from three elements—the dot, the dash, and the space—having the following relative values:

The dot	1 unit
The space between the elements of a letter	1 unit
The space employed in the "spaced" letters	2 units
The space between letters	3 units
The space between words	6 units
The short dash	3 units
The long dash	6 units

THE BAIN ALPHABET.

Edward Davy in England in 1839, and Alexander Bain of Scotland in 1846, employed the alphabet shown herewith:

A	. –	J	... –	S	– ..
B	. – .	K	. – – .	T	– ...
C	...	L	....	U	– .
D	.. –	M	. – . –	V	– – – .
E	.	N	.. – –	W	– – ..
F	. – – –	O	–	X	– .. –
G	. ...	P	– . –	Y	– –
H	. – –	Q	– . – .	Z	– – –
I	..	R	– – .	&	– – – –

In the years 1849 and 1850 Bain electrochemical telegraph lines were in operation between New York and Boston, New York and Washington, and New York and Buffalo.

The numerals used with the Bain alphabet were:

1	. – – – –	6	– – – – .
2	. . – – –	7	– – – . .
3	. . . – –	8	– – . . .
4	. . . . –	9	– . . . .
5	. . . . .	0	– – . – –

AUSTRO-GERMANIC ALPHABET OF 1854.

The alphabet and system of notating numerals and punctuation, as employed in European countries, is given herewith:

A	. –	J	. – – –	S	...
A	. – . –	K	– . –	T	–
B	– ...	L	. – ..	U	.. –
C	– . – .	M	– –	U	.. – –
D	– ..	N	– .	V	... –
E	.	O	– – –	W	. – –
F	.. – .	O	– – – .	X	– .. –
G	– – .	P	. – – .	Y	– . – –
H	....	Q	– – . –	Z	– – ..
I	..	R	. – .	CH	– – – –

* By Donald McNicol, Engineering Department of Postal Telegraph Company, in *The Railroad Man's Magazine*.

1 . – – – –	6 – . . . .
2 . . – – –	7 – – . . .
3 . . . – –	8 – – – . .
4 . . . . –	9 – – – – .
5	0 – – – – –
Period	? Question mark . . – – . .
, Comma . – . – . –	! Exclamation – – . . – –
: Colon – – – . . .	; Semi-colon – . – . – .
' Apostrophe . – – – – .	- Fraction mark – – – – – –

THE CONTINENTAL ALPHABET.

The Austro-Germanic alphabet was first compiled at the telegraph conference held in Berlin, Germany, in 1851. This alphabet is still in use and is known variously as the Continental, international, or universal code. It is employed on European Morse lines, and is used almost universally in radiotelegraphic service as well as in submarine cable service throughout the world.

CONTINENTAL CODE'S SIGNALS.

In addition to the symbols shown as constituting the Austro-Germanic code, the Continental alphabet of the present day includes the following signals:

- Fraction line – –	" " " " Quotation . – . . – .
- Hyphen – . . . . –	End of quotation . – . . – .
/ Shilling . . .	% Per Cent – – – . . . – – –
. Decimal point . – – .	Italics or underline . . – – . –
¶ Paragraph – – – – – – . – – . –	
() Parenthesis . – . – – . – . – – .	É (French) . . – . .
Ñ (Spanish) – – . – –	
Å (Spanish-Scandinavian) . – – . –	

The Continental alphabet as made up in 1851 was supposed to embody the best features of all then existing telegraph alphabets. As an indication of how the various alphabets were picked over to form the international code it may be seen that the symbols for E, H, O, and P were taken from Steinhill's alphabet; the letter X and the numerals 1, 2, 3, 4, and 5 from the Bain alphabet, while the numerals 6, 7, 8, and 9 also were taken from the Bain alphabet, but were rearranged in reverse order. The letters C, F, L, and R were taken from an obsolete pamphlet used in Germany and known as Gerke's, while twelve of the remaining letters were taken from the American Morse alphabet of 1844.

Operators in submarine cable service use abbreviated symbols for the numerals of the Continental code, as shown in the subjoined table:

1 . –	6 – . . . .
2 . . –	7 – – . . .
3 . . . – –	8 – .
4 . . . . –	9 – .
5 .	0 – –

UNITED STATES NAVY ALPHABET.

Until a few years ago when the Continental code was adopted as standard in the radio service of the United States army and navy, the navy had a code of its own, as follows:

A – –	J . . – –	S – . –
B – . . –	K – . – .	T –
C – . .	L – – .	U . . –
D – – –	M . – – .	V . – – –
E . –	N . .	W . . – .
F – – – .	O – .	X – . – –
G – – . .	P . – . –	Y . . .
H . – –	Q – . . .	Z – – – –
I .	R – . .	
1		6 – – . .
2 – – – –		7 . – – –
3 . . . –		8 – . . .
4 – – – .		9 – – – .
5 . . – –		0 – . . –

PHILLIPS'S CODE PUNCTUATIONS.

As before stated the Morse alphabet of 1844 is at present the standard telegraph code used on the land lines, both commercial and railroad, in the United States and Canada. The punctuation marks and special symbols employed, however, are those composed by Walter P. Phillips in the year 1876. They are shown herewith:

. Period . . – – . .	: Colon – . – . .
, Comma . – . –	— Dash . . – . . – . .
- Hyphen . . . . – . .	/ Shilling . . – –
d Pence – . .	$ Dollars . . . – . .
¢ Cents . . .	% Per Cent . . . .
"" Quotation . . – . – .	[] Brackets . . . – . . . .
:—Colon Dash – . – . – . .	' Apostrophe . . – . . – . .
End of Quotation within Quotation . . – . . – . .	
Italics or Underline . . – . – .	
Capitalized Letter . . – . – .	
End of Quotation . . – . – . – .	
Quotation within a Quotation . . – . . – . .	
() Parenthesis . . . . – .	
:" Colon Followed by Quotation – . – . – .	
? Interrogation – . . – .	
– Fraction Line .	
; Semi-colon . . .	
£ Pound Sterling . . . . – . .	
. Decimal Point – – . . – –	
¶ Paragraph – – – –	
! Exclamation – – – .	

THE JAPANESE TELEGRAPH CODE.

The Morse symbols employed in transmitting telegrams which are written in regulation Japanese characters are fifty in number, in addition to those used to represent figures and punctuation marks.

Approximately 3.6 Japanese letters are equal to one English word of 4.67 Morse letters.

The fifty symbols making up the alphabet have been taken from the American Morse and Continental alphabets, to which additional combinations of dots and dashes have been added to represent the extra twenty-four letters of the Japanese alphabet.

TURKISH TELEGRAPH ALPHABET.

In the Turkish Empire two telegraph codes are in use. One of these, the Continental code previously shown, is employed in communicating with foreign telegraph administrations, and when necessary in internal communication. The other alphabet used is known as the Turkish government private code, being used chiefly for official business. It is shown herewith:

A . –	ZE . – – –	K – . –
B – . . .	S . . .	Q – – . . –
P . – – .	SH – . . . –	L . – . .
T –	X – . . . –	M – –
C – . – .	DAT . – –	N – .
DJ – . . . . – – –	TI . . –	V . . . –
H	ZI – . . . . –	E . . – . .
D – . .	AIN . – . . –	LA . – . . . –
ZELL – – . .	CAIN – . . .	I . .
R . – .	F . . – .	O – – –

Since the adoption of the Continental alphabet on European land lines in 1851 there has been an almost continual, although unofficial, agitation in the United States, having for its object the substitution of the Continental alphabet in place of the Morse alphabet on American lines. On March 20th, 1873, a votewas taken in the main operating room of the Western Union Telegraph Company at 145 Broadway, New York, to determine whether or not American telegraphers favored a change to the Continental alphabet. The result of the ballot indicated a pronounced sentiment in favor of retaining the Morse code.

On various occasions in the past fifty years the controversy has resulted in the production of a mass of testimony and opinion for and against the adoption of the Continental alphabet as a universal code. Sifted down, the chief arguments favoring the retention of the Morse alphabet seem to be based on sentiment and upon the slightly superior speed possibilities of the Morse alphabet. while those advocating the adoption of the Continental code base their opinions upon greater accuracy of transmission and upon the desirability of having but one alphabet in use on telegraph lines, cables, and in radio service throughout the world.

The American Morse alphabet—26 letters—has a total of 77 elements, or 2.9615 average signals per letter and 14.807 average signals per word of five letters—an average English word. The Continental alphabet—26 letters—has a total of 82 elements, or 3.1538 average signals per letter and 15.769 average signals per word of five letters.

Including spaces, the average five-letter word—American Morse—contains 36.59 dot elements, or practically 5 per cent less than a five-letter word composed of Continental signs. A sending speed of 25 words per minute means 394.22 signals per minute in the case of the European alphabet, and 370.17 signals per minute in the case of the American Morse, exclusive of space elements between words.

Regardless of the fact that a considerable amount of the opinion favoring the change to the Continental alphabet comes from highly intelligent and progressive sources, nothing has so far been done in an official way to bring about the change. Indeed the deadlock is such at present that compromise alphabets are being proposed.

In August, 1914, Mr. W. P. Phillips proposed the following code as a substitute for the American Morse, believing that its adoption in America would not violate the prevailing sentiment attached to the Morse alphabet and that its make-up successfully disposes of the objections to the spaced dot letters of the Morse code—C, O, R, Y, and Z.

PHILLIPS'S PROPOSED ALPHABET.

A . –	J – . – .	S . . .
B – . . .	K – . –	T –
C . . . – .	L . . . . –	U . . –
D – . .	M – –	V . . . –
E .	N – .	W . – –
F . – .	O – – –	X . – . .
G – – .	P	Y – . . . .
H	Q . . – .	Z – . . –
I . .	R – – . .	& And
1 . – – .	4 fr	7 sv
2 . . – . .	5 fv	8 ait
3 tre	6	9 nin

PRINTING-TELEGRAPH ALPHABET.

Most modern printing-telegraph systems employ a code having symbols made up of five elements or current impulses, each letter, figure, and punctuation mark requiring the same amount of line-time for transmission. It is not intended that these signals shall be intelligible on a Morse sounder, as the alternate positive and negative impulses transmitted from the sending end are required only to operate type-printing mechanism at the receiving end.

In the three following alphabets the letter P represents a positive impulse and the letter N a negative impulse, each impulse having unit duration:

THE BAUDOT ALPHABET.

A pnnnn	J pnnpn	S nnpnp
B nnppn	K pnnpp	T pnpnp
C pnppn	L ppnpp	U pnpnn
D ppppn	M npnpp	V pppnp
E npnnn	N npppp	W nppnp
F npppn	O pppnn	X npnnp
G npnpn	P ppppp	Y nnpnn
H ppnpn	Q pnppp	Z ppnnp
I nppnn	R nnppp	

Figure space—nnnpn Letter space—nnnnp

Figures and punctuation marks have symbols which are duplicates of some of the above letters and are taken care of by an "upper-case" shift.

THE MORKRUM ALPHABET.

A ppnnn	L npnnn	W ppnnp
B nnpnp	M nnnpn	X pnpnp
C nnppp	N pnnpn	Y nnnnp
D pppnn	O nnnnn	Z nppnp
E pnppn	P nnppp	, nnnnn
F npnpp	Q pnnpp	Space pppnp
G ppnpp	R nnppn	Figure npppp
H pnnnn	S npnpn	Release ppppp
I pnpnn	T ppnpn	Back ppppn
J pnnnp	U nnpnn	Line npppn
K npnnp	V pnppp	

THE WESTERN UNION MULTIPLEX CODE.

A ppnnn	L npnnp	W ppnnp
B pnnpp	M nnppp	X pnppp
C npppn	N nnppn	Y pnpnp
D pnnpn	O onnpp	Z pnnnp
E pnnnn	P nppnp	Car. ret nnnpn
F pnppn	Q pppnp	Line feed npnnn
G npnpp	R npnpn	Let. shift ppppp
H nnpnp	S pnpnn	Fig. shift ppnpp
I nppnn	T nnnnp	Space nnpnn
J ppnpn	U pppnn	
K ppppn	V npppp	

In both the Morkrum and Western Union multiplex alphabets the figures and punctuations are made by means of an upper-case shift, employing symbols which are duplicates of those used in forming some of the letters.

THE BUCKINGHAM OR BARCLAY ALPHABET.

A – . .	J . – –	S – – .
B . – .	K – – –	T . . .
C – . –	L . . –	U . . .
D – . –	M – – .	V – –
E . – .	N . – .	W – . –
F – . .	O . . .	X . –
G . . –	P . – –	Y – . .
H . – –	Q – – –	Z – . –
I . . –	R . – .	Space . . .
Type shift – . –		Paper feed – – –
	Car. ret . – –	

As in the case of the other printer alphabets, punctuations, figures, and special characters are made by means of the type-shift key. By this means the same symbol serves for C and colon, Q and 1, R and 4, T and 5, *et cetera*.

The symbols shown above are those composing the Barclay arrangement of the Buckingham alphabet. In the original Buckingham alphabet the symbol for V was – – . and for X . . –

TELEPOST ALPHABET.

The alphabet used in the operation of Delaney's chemical automatic system of telegraphy is the American Morse, or that hereinbefore described as the Morse alphabet of 1844.

Peanut Oil

THE oil of the peanut belongs commercially in the same class as cotton-seed and olive oils. Peanut oil is of a higher grade than cotton-seed oil and of somewhat lower value than first-class olive oil. Peanut oil is sometimes used for mixing with olive oil for the production of an oil that can be sold at a lower price than pure olive oil. On the other hand, peanut oil is frequently mixed with cotton-seed oil in order to improve the quality of the cotton-seed oil for certain purposes.

The quantity of oil that may be obtained from the peanut will depend upon the variety, the maturity of the peas, and the apparatus with which the extraction is made. The Spanish meats when shelled and thoroughly cleaned, frequently contain as high as 45 per cent of oil, as shown by chemical analysis, although not more than 34 per cent can be expressed by the best present methods and perhaps about 28 per cent by ordinary machinery. It is generally conceded that in order to make the manufacture of oil profitable good peanuts must be obtained at prices not exceeding 75 cents per bushel. A bushel of first-class Spanish peanuts, weighing 30 pounds, will produce about 1 gallon of oil worth 75 cents, and 20 pounds of oil cake and hulls, which when ground and mixed together will be worth approximately 25 cents, or $25 a ton as stock feed.

The greater portion of the peanut oil of commerce is manufactured at Marseilles, France, from peanuts that are bought very cheaply along the coast regions of Africa and transported as return cargo. The African grown peanuts are very rich in oil, often containing as high as 50 per cent.—*Farmers' Bulletin.*

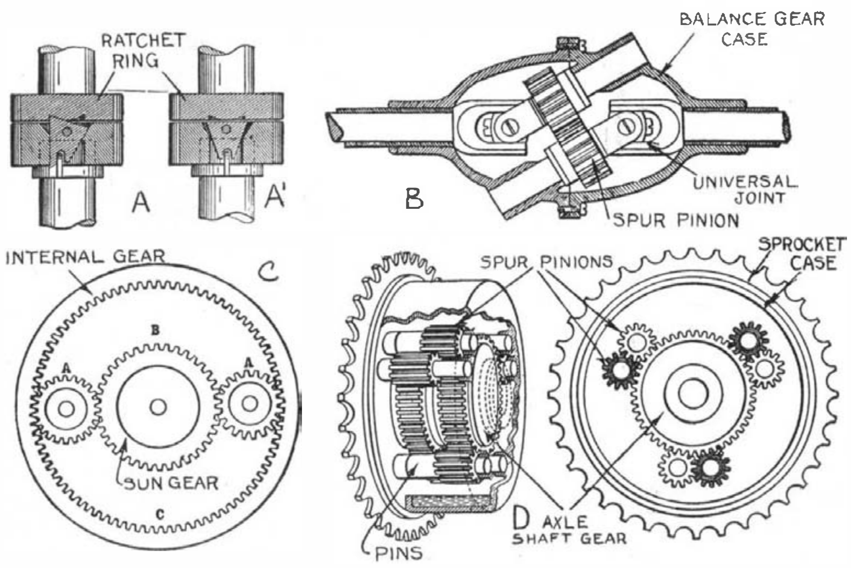


Fig. 1.

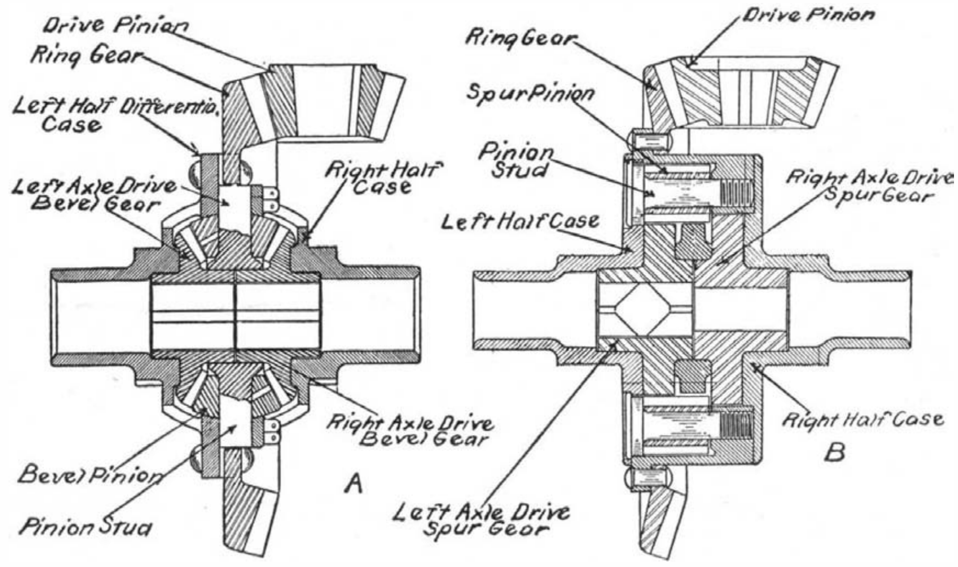


Fig. 2.

The Development of the Automobile Differential

Mechanisms for Controlling the Operation of the Driving Wheels of Motor Vehicles

By Victor W. Pagé, M. S. A. E.

One of the most important, and at the same time inconspicuous, of the parts of the modern automobile is the differential or balance gear, and its discovery and practical application did much to make the motor vehicle a successful commercial proposition. The three great mechanical inventions that made the motor vehicle, or road locomotive, practical for use on ordinary highways, and made steel rails unnecessary, were the compensating gear, the Ackerman pivoted front axle and the rubber tire. The differential is the most important of these three because four-wheeled automobiles have been made using steel tired wheels and a dirigible one-piece front axle mounted on a fifth-wheel just as in horse-drawn vehicle practice. Wherever the propulsive energy must be applied to more than one driving wheel from a single source of power, the differential gear is essential.

The first attempts to make motor vehicles without differential gearing were failures. If the power was applied to only one wheel of a four-wheeled vehicle, the steering was erratic and traction was poor on unfavorable roads. The three-wheeled vehicle, with power applied to the one rear wheel, was a workable proposition as far as power application was concerned, but it was not suitable for our rutted country roads because the driving wheel did not track with the directive members at the front. Electric trucks with a motor driving each wheel do not need differential gearing.

A group of differential mechanisms of early design is shown at Fig. 1. Before explaining their action, it will be well to discuss briefly the reasons why such gearing is needed. When any four-wheeled vehicle is turning a corner, it will be apparent that the inside wheels are describing a smaller circle than the outside ones, the difference in the radii being the tread of the vehicle. The inside wheels, therefore, must turn slower than those that are covering more ground. On a horse-drawn vehicle, or on the automobile front axle, this condition is easily met because the wheels are mounted independently on free running bearings, and thus can easily accommodate their speed of rotation to the circle they describe. On an automobile driving axle, however, the conditions are not so easily met, and some mechanism is needed to permit the wheels to revolve at different speeds and yet deliver some proportion of the power to each of them whenever a straight course is deviated from.

The mechanism shown at *A*, Fig. 1, has a ratchet ring made fast to each driving wheel hub. The ratchet block is pivoted in the lower ring, which is loose on the shaft, having a limited oscillating motion, stopped by keys. The small collar and key are fixed to the axle and on a straight run both pawl blocks bear in the forward teeth of the ring attached to the hub ring. When rounding a curve the outer wheel gains on the inner one, throwing the ratchet block into the position shown at *A*¹. This clutch works in the same way when the vehicle is in reverse. This is known as the Stewart ratchet clutch, and was evolved over a decade ago. It is the basis on which several devices marketed at the present time operate. It allows the outer wheel to be a free wheel, the drive going to the inner one.

The form shown at Fig. 1, *B*, was invented in France, and was first used on a light tricycle. It is a combination universal joint and spur gear type of simple design. The sprocket or spur gear that did the driving, i. e., that received the drive from the engine, was attached to the gear case. As long as the direction of movement was straight ahead, neither pinion rotated, but as soon as the vehicle deviated from a straight path, the pinions rotated around on their pins; this allowed one wheel to turn faster than the other and provided the proper compensation. This form did not become popular because of the rapid depreciation of the universal joints.

Another early form is shown at Fig. 1, *C*. In this, spur pinions *AA* are mounted on studs set in spokes of the sprocket. One of the wheel-driving axles is attached to the sun gear *B*, the other wheel is driven by the internal gear *C*. As long as the vehicle is going straight ahead, under which conditions the resistance against each wheel turning is the same, the pinions act as keying members and drive both internal gear *C* and spur gear *B* at the same speed. As soon as a corner is turned, however, the pinions *AA* revolve on their studs and permit a differential action between the wheels.

The balance gear shown at *D* is an all-spur type, and is a modification of that shown at *C*. In this the internal gear is replaced by a spur-gear, and both gears driving the wheel axles are the same size and pattern. While this is a more complicated type than that shown at *C*, it is an easier one to manufacture because there are only two sizes of gears used, whereas the simpler form has three sizes of gears. In the form outlined at *D*, the pinions revolve on studs carried by the differential case, one set of three pinions meshing with one of the axle driving gears, while the other set engages the remaining central spur gear. The pinions are also in mesh with each other, as indicated. The principle of compensation is the same as with the simple form at *C*, as the pinions do not revolve and act as keying members only as long as the automobile travels in a straight line. As soon as a corner is turned the pinions revolve on their studs, and as those of one set are meshing with the others, one wheel is permitted to turn faster than the other, yet the positive driving connection between the source of power and the differential casing is not interrupted and each wheel receives some of the engine power.

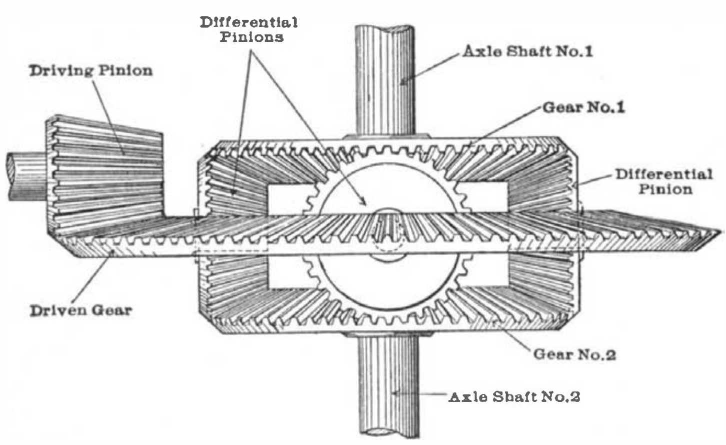


Fig. 3.

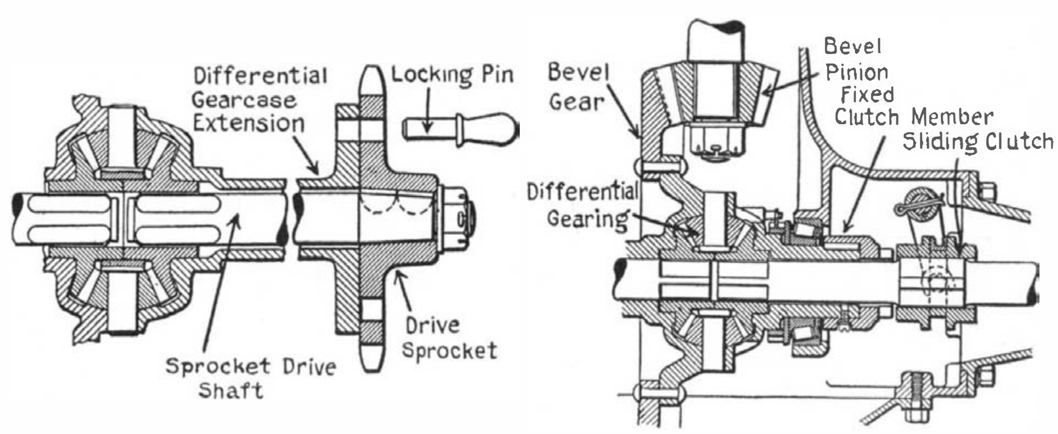


Fig. 4.

By far the most popular form of automobile differential is the bevel pinion form shown at *A*, Fig. 2. This can be easily compared to the all spur gear type shown at *B*, Fig. 2, as both are shown in section. As is evident from the simplified diagram, Fig. 3, bevel pinions and gears replace the spur members of the other form. The reason for the popularity of the bevel pinion type is that the device can be made more compact and at the same time stronger tooth forms used than in the all-spur form of equal capacity. Considerable trouble was experienced in the early days with the all-spur form if the small pinions were not made of proper stock and well heat treated. Exceptional care was needed in manufacturing as the teeth were relatively weak, and sudden application of power would shear the teeth of the pinions where they meshed together if they were the least bit brittle. Bevel gears were much more substantial, as there was considerably more metal between the tooth bottom and the pinion supporting stud. The bevel pinion form, however, imposed more of a strain on the differential case and its supporting bearings because there was an end thrust present that tended to spread the pinions and gears apart whenever the differential was in use. This internal end thrust does not exist with spur gearing.

The action of the bevel gear differential can be easily

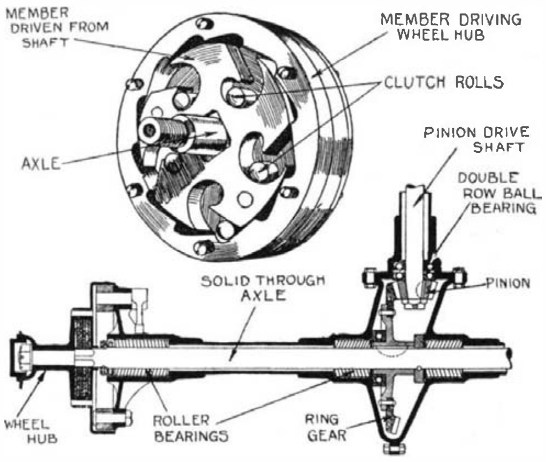


Fig. 5.

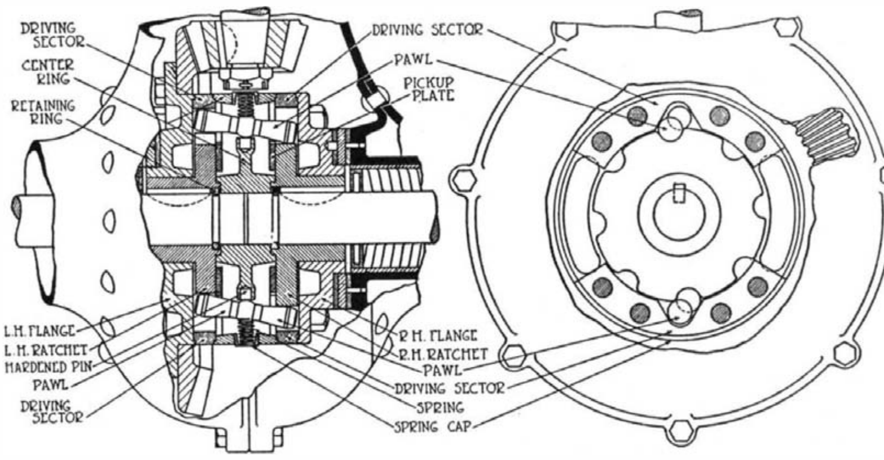


Fig. 6.

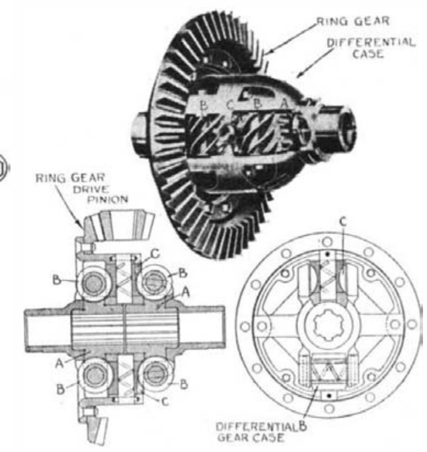


Fig. 7.

understood by referring to the simplified diagram, Fig. 3. As long as the vehicle moves in a straight line the differential pinions cannot turn on their supporting studs, which are attached to the differential casing and become keying members. Assume that the resistance becomes greatest on axle shaft No. 2, on account of the wheel to which the shaft is fastened becoming the pivot wheel in turning a corner. Bevel gear No. 2 of the differential mechanism must run at the same speed as the axle shaft to which it is keyed. The small pinions now revolve on their studs and run over the face of gear No. 2, which is slowed down. At the same time they carry bevel gear No. 1 along, and also the axle shaft to which it is fastened. Obviously the gear attached to the wheel that has the least resistance is always the driven one in either a spur or bevel gear differential.

There are times when this becomes a serious disadvantage, as in operating a car over muddy or slippery roads the differential gear will always deliver the power to the wheel that has the least resistance. Thus, if one wheel is in a mudhole and the other is on firm ground, the wheel that has the least traction will spin around whereas the other just remains stationary. To prevent this, some designers of motor trucks have provided some form of differential lock by which the balance gear can be put out of commission temporarily, and both wheels receive equal shares of the power. This is done by either of the two methods shown at Fig. 4. In that shown at the left, a locking pin may be used to fasten the drive sprocket at one end of the jackshaft to a flange projecting from a sleeve or differential gearcase extension. When the pin is in place no differential action is possible, and both driving sprockets are forced to turn at the same speed regardless of direction of vehicle travel. The differential lock at the right is a form that can be applied either to a jackshaft or live rear axle. This also operates by locking one of the driving shafts to the differential gearcase extension. This is accomplished by shifting a positive jaw sliding clutch so the wheel drive shaft cannot turn independently of the differential casing, as is necessary to obtain a balance gear action. These locks should only be used under conditions where traction is poor and when the vehicle is operated at low speeds. As soon as conditions become normal the lock should be released, otherwise there will be a serious strain on the mechanism and tires when turning corners.

In an endeavor to eliminate this serious disadvantage of the conventional differential mechanism, without introducing the added complication of a differential lock, several forms of balance gears have been evolved in which the power is directed to the wheel having the most traction instead of to that having the least. One of these has worm gears instead of spur or bevel members.

Several makes of light cars have been fitted with the gearless differential of the form shown at Fig. 5. In this construction one differential member is carried in each rear wheel, and the member driven from the axle transmits its motion to the member driving the wheel hub by means of roller clutches. These allow one wheel to turn faster than the other for rounding corners, but a positive drive is given to each wheel according to the traction; that having the most, and therefore turning the slowest, receives the power, while the wheel having the least, and tending to run fastest, overruns the central driving member. The shaft driven members have peculiarly formed roller guides so the differential action will be obtained if the car is run backward or forward.

A form of gearless differential intended to replace the conventional type in light car rear axles is shown at Fig. 6. This consists of a left-hand differential flange to which the ring gear is bolted, the right-hand flange, a center ring and, at the right and left, driving sectors, two at the top and two at the bottom. These are all bolted together. The ratchets, one right, the other left, are keyed to the axle shafts and are independent and able to move relative to each other inside of the housing. Two walking beams or pawls are provided, these being cross members having rounded ends and an enlarged bearing at the center. These are the interlocking members between the driving sectors and the ratchets. The illustration shows the end of the top pawl in the tooth of the right-hand ratchet and being driven by the contact face of the driving sector. This transmits a forward motion to the ratchet through the center of the end of the pawl. The left ratchet is driven in a similar manner by the lower pawl, which is engaged at its left end. Both wheels are driven forward in a positive manner. To drive backward the differential housing pushes the end of the pawl out of the ratchet and throws the opposite end of the pawl down into the tooth space of the opposite ratchet. The contact face of the reverse driving sector engages and drives the wheel backward. The lower walking beam acts in the same manner.

In turning a corner, assume the car is turning to the left and is driven forward. The right wheel starts to rotate faster than the left one, and thus causes the right-hand ratchet to move faster than the differential housing. This can only move as fast as the inner or slowly moving wheel. The ratchet pushes the end of the pawl out of the space it occupies, thus allowing the ratchet to move freely forward. As soon as the corner is made, and both wheels are revolving at equal velocities, the spring at the center of the pawl pushes the end back in engagement with the ratchet, and the drive is again taken by the two wheels. If the wheels propel the drive shaft, as in coasting or by using a drive shaft brake, both ratchets turn faster than the housing and push the engaged ends of the pawls out of engagement, and the opposite ends into the correct driving position in the opposite tooth spaces, this causing the ratchets to propel the drive shafts.

In the differential shown at Fig. 7, the gears have spiral teeth cut on a 45-degree angle, a spiral gear *A* being fitted to each wheel drive shaft. These mesh with other spiral gears *B* placed diametrically opposite each other. Gears *B* are meshed with vertically supported spiral gears *C*, the axes of these being at right angles to those of gears *B*. There are eight spirally cut gears located as follows: One on each drive shaft end and six in the housing, which is driven in the conventional manner by the ring gear riveted to it.

It is claimed that this construction transmits the engine power to the wheel having the most resistance, and that when turning a corner both wheels aid in driving instead of one acting as a pivot wheel. The division of power is in proportion to the distance traveled by each. The action has been explained as follows:

The two axle gears each have rotative powers through tractive distance of either wheel, when the car is turning or one wheel has to travel a longer distance than the other, thereby causing the six gears, namely, the four gears *B* and B^1 and two gears *C*, which are anchored in the gear housing, to rotate on their axes, permitting one wheel to advance proportionately to the retard of the slow wheel. These gears always present the same pulling face when power is applied to the master or ring gear *G* regardless of differentiation, consequently equalizing power on the turn.

On the other hand, the conventional type of differential is governed slowly by the tractive effort and distance of travel of the wheels.

This differential is automatic, the same as the conventional bevel or spur type, and operates forward or backward. The engine can be used as a brake upon the wheel with better results than it can be used on the bevel or spur types.

Other forms of differential gears have been devised besides those described. Some have incorporated multiple disk frictions, some have simple ratchet mechanism similar to those used on mowing machines. Ingenious devices composed of bell cranks and levers or eccentrics and cams have been invented, but these have not offered advantages commensurate with their mechanical complication. The simple all-bevel gear type of differential gear has withstood the test of time, and as constructed to-day it is one part of the modern automobile that gives no trouble except that resulting from normal depreciation. The average motorist might run automobiles a lifetime and never know he had differential gearing in the rear construction of the cars he operated, provided he obtained his knowledge of its existence from any trouble caused by this indispensable automobile component.

Profits From Drug Plants

A recent bulletin of the United States Department of Agriculture entitled "Drug Plants Under Cultivation" has the following to say in regard to the possibilities of making money by growing drugs:

"Very few, if any, drug plants are used in quantities sufficient to make them a promising crop for general cultivation. Many of the commoner ones which can be grown and prepared for market with little difficulty bring but a few cents a pound, and their cultivation offers little prospect of profit. A number of the high-priced drug plants must be given care for two or more years before a crop can be harvested, and since expensive equipment is usually required for their successful culture, the production of such crops offers little encouragement to inexperienced growers who are looking for quick returns and large profits from a small investment. The production of drugs of high quality requires skillful management, experience in special methods of plant culture, acquaintance with trade requirements, and a knowledge of the influence of time of collection and manner of preparation on the constituents of the drug which determine its value. Small quantities of drugs produced without regard to these conditions are apt to be poor in quality, and so unattractive to dealers and manufacturers that the products will not be salable at a price sufficient to make their production profitable. In general the conditions in this country seem far more favorable to the growing of drug plants as a special industry for well-equipped cultivators than as a side crop for general farmers or those whose chief interest lies in the production of other crops. Although a number of plants which yield products used as crude drugs are common farm weeds, they usually occur in such scattered situations and in such small quantities that their collection would scarcely be profitable to the farmer. Even when relatively abundant it is a matter for careful consideration whether the time and labor necessary for their collection might not be otherwise employed to better advantage. Moreover, it is not always easy to distinguish medicinal plants from others of similar appearance, and collectors not infrequently find that they have spent their time in gathering plants practically worthless as crude drugs. In proportion to the labor required in the collection, relatively low prices are paid for most crude drugs obtained from wild plants, and the farmer who turns to drug collecting as a source of additional revenue will probably meet with disappointment."

The Hardness of Drills

It is not generally known, even among mechanics, that a very hard tempered drill is frequently not the best for fast work. When a very hard metal is to be drilled a tool of this kind will work well, if considerable care is exercised; but when fast work on softer materials is required, the extremely hard drill will usually be found so brittle as to be practically useless. For such work a drill that can be readily filed will be found to do the best work.

A hand drill is brittle when cold, and nothing will crack a high-speed drill quicker than to turn a stream of cold lubricant onto it after it has become heated by drilling. It is equally bad to cool it in water after the point has become heated by grinding.

Early History of the Anglo-Egyptian Soudan*

From the Point of View of the Ethnologist

By Prof. Charles G. Seligman, M. D.

In my address I shall endeavor to outline the early history of the Anglo-Egyptian Sudan from the point of view of the ethnologist, and thus indicate some of the lines upon which future research may most usefully proceed.

Surprisingly little is yet known of the prehistory of this great area. No implement of river-drift type appears to have been found, and while admitting that this may be due to incomplete exploration, the fact seems of some significance considering the abundance of specimens of this type which have been found on the surface in Egypt, southern Tunisia, and South Africa. With regard to implements of Le Moustier type, I may allude to certain specimens which I have myself collected from two sites, namely, from Beraeis in northwest Kordofan, and from Jebel Gule in Dar Fung. At the former site I found a number of roughly worked unpolished stones. The majority are moderately thin broad flakes, showing a well-marked bulb of percussion, and little or no secondary working; other specimens are shorter and stouter. One surface is flat and unworked, the opposite curved surface shows a number of facets separated by rather prominent crests, all except the central facets sloping more or less steeply to the working edge. In some specimens the crests are sufficiently prominent to give a somewhat fluted aspect to the slope and a crenelated edge, one portion of which often shows signs of having been worn down and retouched. These implements, which I had suspected might have been Aurignacian, were considered by M. Breuil to belong to the Moustierian period, and he referred to the same period and industry some thick, fluted, and engrailed scrapers from Jebel Gule, which I have described as resembling the Palæolithic disks from Suffolk and other localities, as well as some implements of other forms which presented a Palæolithic facies. Besides the disk and Moustierian points, there is one implement which M. Breuil regards as a true, but much worn, *coup-de-poing* of Moustierian age. Whether all these really date from the Moustierian period or not, certain of the specimens from Jebel Gule show a surprising resemblance to South African specimens figured and described by Dr. L. Peringuey as of Aurignacian type, or, in other words, of the Capsien type of Tunisia.

Evidence concerning the later Stone age is furnished by a number of finds made on widely scattered sites; but though no explanation can be offered it should be noted that no stone implement of any kind has been recorded from the Red Sea Province, although it is one of the best known parts of the Sudan, and has been the scene of considerable engineering efforts. This is the more remarkable in view of the geographical features of the country; the absence of forest, the weathered plateaux, the valleys filled with deposits through which innumerable wadis have been cut, all suggest that if stone implements existed some at least should have come to light. Much interest attaches to the distribution of ground-stone axes in the Nile valley. While there is probably no museum with any pretense to an Egyptian collection which has not a number of these, and though they can be bought in almost every curio shop in Cairo, I have been unable to find any record of their discovery in a tomb group or undisturbed burial in Egypt; so that considering the number of prehistoric burials that have been examined, it can be said that they were scarcely if at all known in predynastic Egypt. On the other hand, they are common in Nubia, where a number have been found in predynastic and early dynastic tombs. Many examples have come from Meroë, and I believe that specimens occur on every site of Neolithic date in the Sudan. Moreover, the rock faces on which they were ground have been found both at Jebel Gule and Jebel Geili. We may therefore attribute a southern source to the ground-stone axes of the Nile valley, and in the light of our present knowledge regard them as of Negro origin. This view is supported by the results of recent work on the prehistory of the Sahara. Gautier, who has devoted much time to the ethnography of the French Sudan, points out that while at the end of the Neolithic period the northern Sahara had a stone industry characterized by unpolished implements of Egyptian affinities, in the central and southern Sahara the typical implement was the polished axe, and that this was of Sudanese Negro origin. That the boundary of the two provinces, i. e., the Berber-Negro frontier, was then some 1000 kilometers farther north than it is at present, is in no way opposed to this view. Besides the types already alluded to, Jebel Gule yielded a large number of pygmy implements of quartz, carnelian, and hornstone. These are similar to those found in South Africa and attributed to Bushmen, and there is reason to believe that this industry also existed at Faragab, where the innumerable disk beads of ostrich eggshell were probably bored with more or less worked-up slivers of quartz.

Some mention must be made of the existence of stone monuments of megalithic type in the Sudan, although their number is small and their origin obscure. There is a monolith about two meters high on the plateau overlooking the Khor el Arab near the Sinkat-Erkowit road, to which tradition says Mohammed tied his horse. Another monolith of much the same dimensions has been described and figured by Croefoot from Isa Derheib, inland from Akik. At present there seems no reason to attribute any great antiquity to these stones; presumably they are connected with the upright stones and "stelai" of Axum. Probably other rude stone monuments will be found in the Red Sea province; indeed, I have heard of such, though the information was never very precise. It is, however, worth noting that typical dolmens do occur in the Madi country in the southern Sudan.

The only rock pictures as yet found in the Sudan are in northern Kordofan. For the most part they are outlined in red or blackish pigment, but a few examples occur chipped on lumps of granite, on the hillside at Jebel Kurkayla in the Jebel Haraza *massif*. These figures are very rough, and the examples reproduced by H. A. MacMichael all represent camels. Drawings with pigmented outlines are found on Jebel Haraza and Jebel Afarit, and from the artistic point of view seem to form two groups. To the first belong rough but spirited sketches of men on horseback, camels, and giraffes. The workmanship of the second group is rougher and much less vigorous; it includes representations of camels, men on horseback, and men marching or dancing, carrying the small round Hamitic shield. This, together with their general resemblance to the "Libyo-Berber" rock pictures of the southern Sahara, indicates a comparatively recent date for these drawings. Moreover, MacMichael notes that the work is faint and indeterminate, and that there is no trace of graving; in other words, the Neolithic tradition has not persisted.

One of the most difficult questions arising in connection with the Sudan is that of ancient Egyptian influence. Its existence may be readily granted, but what of its extent and duration? For while it is a platitude to say that a great and powerful State with a uniform tradition lasting for thousands of years cannot but have influenced the countries on every side, it must be confessed that where history fails the evidence is often extremely difficult to interpret. Every custom which at first sight seems to betoken Egyptian influence must be closely examined, and the evidence carefully sifted, to determine whether it may not have had its origin in the older and more generalized Hamitic culture of northern and eastern Africa. In discussing the value of the data upon which ideas and customs are to be traced back to an Egyptian origin, it is important to remember that general resemblances, either in widely distributed forms of social organization and belief (e. g. matrilineal descent, cult of the dead, etc.), or in widely diffused technical devices (e. g. bow and arrow), cannot be admitted as good evidence. Whatever the future may bring, I do not think that in the present state of anthropological science even extreme and unusual beliefs and devices (which at first sight seem so strikingly convincing) should be considered as proof of common influence; otherwise it would be necessary to admit, immediately and without consideration, a cultural relationship between Papua and Central Brazil on the evidence of the phleme-bow, and between England and the Malay States on that of the fire-piston. It is only when there is a considerable consensus of agreement in underlying ideas and (or) in highly specialized customs or devices, that we are justified in considering an Egyptian origin, and even then it is necessary to bear in mind the possibilities of common ethnic origin and of "convergence." It is obvious that under these conditions facts will be differently interpreted, and opinions will vary within wide limits, while new discoveries may at any moment disturb views hitherto regarded as well founded.

Although I propose generally to confine myself to the area included in the Anglo-Egyptian Sudan, yet in considering the question of Egyptian influence in Negro Africa I shall overstep these limits. The records from the Belgian Congo, for example, are more numerous, while recent work in the northwest of Africa has provided material of much value from this comparatively new point of view.

With regard to the mode in which Egyptian influence was exerted on the Sudan there are three main routes along which we might expect to find its traces. The first is southward along the Nile, the other two are to the west; one route at first following the Mediterranean coast but broadening westward as conditions become more favorable, the other running southwest through the oases and so communicating with Darfur and the Chad basin. Yet another route has been suggested by Sir Harry Johnston, namely, through Abyssinia and Somaliland, presumably reaching them *via* the Red Sea. Perhaps it was by this route that the sistrum, still used in the church festivals, reached Abyssinia.

The extension of Egyptian rule up the Nile valley can be traced from the earliest times to the XVIII. dynasty. But although after this Egyptian domination becomes less marked, Egyptian influence had become so firmly established that the culture of the states in the Nile valley had a predominantly Egyptian tinge[1]; first Napata, then Meroë, and then farther south the States which we know later as the Christian kingdoms of Dongola and 'Alwah.

On *a priori* grounds the Nile route might be expected to be the most worn and the easiest to trace. For thousands of years Egyptian and Negro were in contact on the middle reaches of the great river, so that at least one great negroid kingdom arose; and though to this day a Negro dialect is spoken as far north as Aswan, yet at the present time there does not seem to be a single object or cultural characteristic which unequivocally can be said to have reached the zone of luxuriant tropical vegetation by way of the Nile valley. The evidence for the earliest spread of Egyptian influence is set forth in the Reports of the Archæological Survey of Nubia. In the reports, Prof. Elliot Smith shows that beyond Aswan, as far south as exploration has proceeded, the basis of the ancient population from the earliest times to the end of the Middle Empire was essentially of proto-Egyptian type, and that this type became progressively modified by dynastic Egyptian influence from the north, and Negro and Negroid influence from the south. As a result, the Nubians contemporary with the New Empire present such pronounced Negroid characteristics as to form a group (the C group) which stands apart from its Nubian and Egyptian predecessors. The recent discoveries made by Prof. Reisner at Kerma in Dongola province show that here was a fort or trading post certainly occupied during the Hyksos period, and probably as far back as the VI. dynasty. It is the remains of the Hyksos period that are especially interesting. Reisner describes a people who razed the buildings of their predecessors, and buried their dead in the debris, who battered the statues of Egyptian kings of the XII. dynasty, and whose funerary customs were entirely un-Egyptian. Each burial pit contains a number of graves in every one of which several bodies had been interred. The chief personage lies on a carved bed; "under his head is a wooden pillow; between his legs a sword or dagger; beside his feet cowhide sandals and an ostrich-feather fan. At his feet is buried a ram, often with ivory knobs on the tips of the horns to prevent goring. Around the bed lie a varying number of bodies, male and female, all contracted on the right side, head east. Among them are the pots and pans, the cosmetic jars, the stools, and other objects. Over the whole burial is spread a great ox-hide." Reisner could not observe any marks of violence, but, judging from the contorted positions of some of the bodies, thought that they had been buried alive. The remains from these burials have been examined by Elliot Smith, who states that the skeletons surrounding the bedstead are those of folk of proto-Egyptian and Middle Nubian (C group) types, while those on the beds belonged to typical New Empire Egyptians, such as lived in the Thebaid at this time.

The first historical capital of the Sudan was Napata, the mediæval Merowe or Merawi, near Jebel Barkal, between the 19th and 20th parallels of latitude, a few miles south of the Fourth Cataract. Napata was certainly an important place in the XVIII. dynasty, but how much earlier is uncertain. In the XX. dynasty the high priest of Ammon assumed the viceregency of Nubia, and there is evidence that during the two succeeding dynasties the priestly families of Thebes set up at Napata a kingdom which, in theory at least, reproduced the theocracy of Ammon at Thebes. The first recorded lord of this new

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[1] The early Ethiopian kings used the Egyptian language and writing for the r records; it was only toward the end of the Meroitic period after the downfall of Egypt, that the Meroitic language was written. A special hieroglyphic alphabet founded on the Egyptian may date back to the third century B. C., but the actual Meroitic script is later than this. Crowfoot, indeed, argues for so late and short a range as from the middle of the second to the fourth century A. D. (Griffith, "The Meroitic Inscriptions of Shablul and Karanog," chap. ii.)

kingdom was Kashta, whose son Piankhi succeeded him about 741 B. C., and by 721 B. C. had conquered and garrisoned Egypt almost as far north as the Fayum. His brother Shabaka founded the XXV. (Nubian) dynasty, which lasted at least fifty years. Thus Napata was Egyptianized, and being a great trading center cannot but have influenced profoundly the country to the south, so that when Meroë was founded in the eighth century B. C. the ruling influence must have been Egyptian. The mission sent by Nero to explore the Nile reported that Meroë was ruled by a Queen Candace, whose predecessors had borne that name for many generations. Yet, since the monuments show that a king was generally the head of the State, Pliny's assertion requires qualification; moreover, there is the perfectly definite reference to King Ergamenes slaughtering the priests who, as was the custom, had determined his death. In both statements I cannot but see examples of Egyptian theocratic influence. Nor are they mutually destructive if it be remembered that the throne might, and often did, pass in the female line, and that this practice was known to be in full force during the XVIII. and later dynasties. It would be entirely consonant with the policy of the priests of Ammon to take advantage of the spirit of the *sed* festival, the rite of ceremonial Osirification practised by the Egyptian kings, in order to obtain for themselves absolute political control. This would be the easier if among the barbaric tribes in southern Nubia the king was ceremonially killed as he recently was in Fazogli, and as he still is among the Nilotes. Strabo's description makes clear how relatively narrow was the stream of northern civilization which penetrated Black Africa by way of the Nile valley. But even this civilization did not come with a steady flow; when Egypt prospered under the early Ptolemies Meroë prospered; as Egypt decayed Meroë fell into the wretched condition recorded by Nero's officers; and even before this Candace could assert that neither the name nor condition of Cæsar was known to her. As northern influence lessened, and the power of Meroë decayed, the black element would preponderate more and more, so that the travelers quoted by Pliny who had actually visited Ethiopia told a story of barbarism and utter stagnation. But even in the earlier and better days when a king exerted real authority at Meroë it would be entirely consonant with African politics and African customs for vassal "kingdoms" to arise at the extremes of the State. So, when it is recorded on the authority of Eratosthenes that in the third century B. C. the Sembritæ who occupied an island south of Meroë were ruled by a "queen" but recognized the suzerainty of Meroë, we may think of the petty chieftains of the eighteenth century who were the true rulers of the country from Dongola to Sennar, though every sultan of Sennar claimed sovereign rights. There may have been many such "states" ruled by women, just as at the present day in the Nuba hills the highest authority passes in the female line, and may be exerted by a woman.

Meroë seems to have been destroyed before the introduction of Christianity. Nevertheless, two if not three culture phases can be traced in its history. There was first a period of Egyptian influence under King Aspelut and his successors, then came an influx of Greek ideas, a phase which Prof. Garstang would date from about the third century B. C. This is the period to which most of the monuments now visible belong, and it was succeeded by the period of Roman dominance. At Soba, on the Blue Nile a few miles above Khartum, Lepsius collected the cartouches of a number of kings and queens of Meroë; this site, the capital of the Christian kingdom of 'Alwah, was certainly inhabited through mediæval times, and may not have been fully deserted till three or four hundred years ago.

No doubt the territory over which the rulers of 'Alwah exerted authority extended south of their capital, yet beyond Soba, in the archæologically unexplored country south of the confluence of the two rivers, traces of northern influence quickly become fewer and less distinct. Nevertheless, at the present day among the hills between the White and Blue Niles the name Soba is still known, being recognized as that of a series of great queens who ruled over a mighty empire of the same name. The Fung or Hameg of Jebel Gule say that the great Queen Soba whom they worship was their ancestress, but they also apply her name to certain rocks which they regard as sacred. A prayer given me by a woman at one of these rocks ran somewhat as follows: "Grandmother Soba . . . permit us to go on our journey and return in safety." There was obviously the utmost confusion in this woman's mind between Soba the goddess, who may be asked to relieve sickness, and Soba the stone, on which she had just placed a handful of sand. Few will doubt that in the Soba of the Hameg belief there is preserved the memory of such queens as Candace the ruler of the Sembritæ, grafted on the recollection of the great city, which to the Negroids of the Gezira no doubt appeared to dominate the north. Nor do these traces of ancient tradition stand alone; at Jebel Moya near the Blue Nile some 150 miles south of Khartum there is actual archæological evidence of northern influence. Here, besides stone implements, were found beads and amulets, a number of scarabs, and small plaques bearing Ethiopian and Egyptian cartouches ranging from about 700 B. C., or perhaps going back to an even earlier date. I may also note that on the as yet unexplored site of Faragab in northern Kordofan, besides potsherds, stone implements and ivory objects, I have found a carnelian bead, identified by Prof. Petrie as of XVIII. dynasty make, as well as dolomite and scolecite beads which are certainly not of Negro workmanship or character.

These sites seem to mark the southern limit of Egyptian influence as far as the actual transmission of objects derived from the north is concerned. Of the racial affinities of the inhabitants of Faragab nothing is known, but we are better informed concerning the old residents of Jebel Moya. The cemeteries of this site have yielded the remains of a tall coarsely built Negro or Negroid race with extraordinarily massive skulls and jaws. In a general way they appear to resemble the coarser type of Nuba living in South Kordofan at the present day, and it is significant that the cranial indices of the men of Jebel Moya and the Nuba hills agree closely. Thus there is the clearest evidence that Egyptian influence reached south of Khartum, and since it has persisted to the present day in oral tradition among the tribes of the little known country between the Blue and White Niles, traces might equally be expected among the Nilotes of the White Nile. But, strangely enough, nothing of the sort has been found, although the Shilluk and Dinka are better known than any other of the Sudan tribes. On the other hand, the tribes of the Congo basin have a number of customs which do suggest Egyptian influence, and the same may be said perhaps of Uganda, so that it seems reasonable to believe that Egyptian influence spread up the White Nile and passed westward across the Nile-Congo watershed. An alternate route would be along the Blue Nile and its tributaries, the Dinder and the Rahad, to the Abyssinian hills, southward through the highlands to about 5 deg. N., and thence westward to the head waters of the Congo.

To return to the Shilluk and Dinka, the most northern of the Negro tribes of the White Nile. The fact that no cultural elements which can be connected with Egypt are found on the White Nile, where they might have been expected, suggests either that the tribes now occupying the district were not there when Egyptian influence spread south, or that the country presented such difficulties that the foreign stream left it on one side, as would have been the case had it followed the route *via* the Blue Nile and the highlands of Abyssinia. In other words, either the Shilluk and Dinka reached their present territory in comparatively recent times, or else led a wandering and precarious life in swamps as formidable as the Sudd of the present day. There is, I think, a good deal in favor of the latter view. The existence in the depths of the Sudd of Nuer communities, of which we know little except through rumor, shows that such a life is possible; while among the Dinka the Moin Tain, or "marshmen," who possess no cattle and scarcely cultivate, but live by hunting and fishing, exist under almost as unfavorable conditions. Moreover, there is abundant evidence that northwest Africa is drier now than it was a few thousands years ago, and if those authors are right who state that there was a general melting of glaciers in Eur-Asia some 5000 years B. C., giving rise to widespread floods (the origin of the Biblical deluge), the increased precipitation may well have given rise to a considerable northern extension of the Nile swamps. In support of this argument, it may be noted that in numerous XVIII. dynasty paintings Negroes are represented with bows and arrows and throwing sticks (boomerangs), i. e. their weapons are not those of the northern Negroes of the present day, the Shilluk and Dinka, who are not bowmen and do not use the throwing stick. Shilluk traditions state that they came from the south, and a language identical with theirs is spoken by the Acholi of the Uganda Protectorate.

Evidence pointing in the same direction exists on the physical side; the results of the archæological survey of Nubia show that even in late dynastic times the tall Negroids (E group) whose skeletons have been found near Shellal were mesaticephals, with a cephalic index higher by three or four units than those of the Dinka and Shilluk respectively. On the other hand, a people with a cephalic index nearer that of the northern Nilotes had reached Nubia by the Byzantine-Pagan period (200-600 A. D.). Elliot Smith and Derry speak of these people (the X group) as prognathous and flat-nosed Negroids who suddenly made their way north into Nubia. Sixteen X group skulls (eleven male and five female) in the College of Surgeons give a cephalic index of 70-8, and, comparing them with the series of about the same number of Dinka skulls in the collection, my impression is that as a group they show as many Negroid characters.

The numerous records of Negro incursions from the Middle Kingdom onward suggest that the Negroes were driven north in a succession of waves by some force from which this direction offered the only chance of escape. Such can only have been applied by other Negroes behind them. It may well be that there was more or less continual ferment on the southern border of Egypt in the early part of the first millennium B. C., and that the northern Nilotes were beginning to make their reputation as fighting men. Indeed, the passage in Isaiah can scarcely bear any other meaning than that this people was working north with sufficient energy for their peculiarities and those of their land to have become known to the Mediterranean world. "Ah, the land of the rustling of wings, which is beyond the rivers of Ethiopia: that sendeth ambassadors by the sea, even in vessels of papyrus upon the waters, saying, Go, ye swift messengers, to a nation tall and smooth, to a people terrible from their beginning onward; a nation that meteth out and treadeth down, whose land the rivers divide!" (Isa. xviii. 1, 2, Revised Version). But while the tall Negroes seem to have been the first to reach Nubia in organized groups, stray examples of short brachycephalic Negroes (usually female) have been found as far back as protodynastic times. I am indebted to Prof. Elliot Smith for the information that the four Negresses found in cemetery No. 79 at Gerf Hussein were short in stature with relatively broad oval crania, while at Dabod in a Middle-Kingdom cemetery there was found a skeleton of a man measuring 1.61 meters (about 5 feet 3 inches), with definite prognathism, typical Negro hair, and a cephalic index of 80. Presumably these were representatives of the group of short mesaticephalic Negroes who are at the present time found on both sides of the Nile-Congo divide, but predominantly west of it, a group represented by the Bongo, Azande, and cognate tribes. We thus reach the position that the Nubians, who were proto-Egyptians, were, in the earlier part of their history, in contact with just that class of Negroes among whom customs and ideas apparently of Egyptian origin are found at the present day. It must not, however, be assumed that it was this contact that led to the dissemination of Egyptian ideas; indeed, our present information suggests that it can scarcely have been sufficiently intense.

The following table, giving the measurements and indices available for the comparison of the E group Negroids with the tall Negroes of the present day, shows that the former belonged to the mesaticephalic group, which includes the Burun, the Bari, and the Nuba. As regards head length, head breadth, cephalic index, and stature, the E group stands closer to the Nuba than to the other tribes, while even in head breadth it is as near the Nuba as the Dinka.

	H.L.	H.B.	C.I.	Stature
Shilluk	195	139	71.3	1776
Dinka	194	141	72.7	1786
E group	190[3]	143[3]	75.68[2]	1723
Nuba	190	145	76.6	1722
Barun	190	150	79.16	1759
Bari	190	149	78	1741

[2] The H.L. and H.B. of the E group skulls have been increased by 7 millimeters and 8.5 millimeters respectively in order to make these measurements comparable with those on the living. For the same reason the C.I. has been increased by 2 units.

At the present day the mesaticephalic group includes the Hameg and the Berta of the hills between the White and Blue Niles. The excavations at Jebel Moya—also between these two rivers—have enabled Dr. Derry to show that in Ptolemaic times this hill stronghold was inhabited by tall mesaticephali with a cephalic index almost identical with that of the Nuba, so that we are led to conclude that all these tribes, including the E group Negroids, belong to one and the same stock.

A number of similarities between ancient Egypt and modern Africa have been set out recently by Prof. Petrie. He does not discuss the routes by which Egyptian influence may have reached Negroland, but simply marshals the evidence of similarity under sixty-one headings. A good many of these are so widely spread outside Africa as to be of little evidential value; others, and this applies specially to material products, include such simple or obvious devices that they can scarcely be regarded as carrying weight; but there are a number of instances which are highly suggestive, and when to these are added yet other habits and customs common to ancient Egypt and Negro Africa, a mass of evidence is presented which seems decisively indicative of Egyptian influence. This view does not imply that all the features common to ancient Egypt and present-day Negroes are instances of borrowing; on the contrary, I hold that many common customs are but expressions of the wide diffusion of old Hamitic blood and ideas. To this ancient stratum I would attribute those customs which I have discussed in a previous paper, including burial by the Nilotes in the crouched position, the use of the throwing-stick (boomerang) by the Beja, and the killing of the divine king (or rainmaker).

The ideas and customs reported from tropical Africa which may be due to Egyptian influence may be classified provisionally in the following groups, though the space at my disposal here permits only a brief reference to the third group:

(i) Beliefs connected with the soul.

(ii) Beliefs and customs connected with the king or the royal office.

(iii) Death customs.

In Egypt the body was prepared for the grave by an elaborate process of mummification; it was then inclosed in a coffin, often of anthropoid shape. In tropical Africa numerous instances of attempts to preserve the body are recorded. In Uganda the body of the king was opened, the bowels removed, emptied, washed in beer, dried, and then replaced, while among the Banyoro and the Makaraka other methods were adopted. It seems a far cry from the mummies of Egypt to the smoke-dried corpses of Equatoria, and it is not difficult to see that ancestor worship might easily give rise to attempts to preserve the body when everyday experience would suggest desiccation or smoking, but there are certain Congo tribes whose practices do suggest an actual link with Egypt. Among the Wambunda of Stanley Pool the body is placed in the squatting posture, the limbs are tightly flexed on the body and tied in that position, the whole being packed with a large quantity of spongy moss which is kept *in situ* by bandages. A gentle fire is kept up round the body for two or three months, after which it is rolled in native cloths and buried. The latter part of this ceremony hints that the attempts to preserve the corpse may have been imposed on an older habit of speedy burial; such an imposition could only have come from without.

Among the Wangata an important person of either sex is buried in a massive coffin with a lid carved to represent the deceased. It is difficult not to believe that here is an echo of the Egyptian mummy case. If this be so, may not the practice of a tribe near Lake Leopold II., who, after a rough preparation of the body, roll it in native cloth and place it in a canoe-shaped coffin, be regarded as connected with the funerary boats of Egyptian burial ceremony? Since the anthropoid coffin was unknown before the XI. dynasty, it follows that the northern influence must have been exerted after this period. Egypt's first great expansion (after the pyramid builders) dates from the XII. dynasty, when Egyptian and Negro were in intimate contact at the Second Cataract, as shown by the celebrated decree of Senusert III. Further, about this time special importance seems to have been attributed to the funerary voyage on the Nile, indeed, almost all the models of funerary boats in our collections are of this period.

If these facts be accepted as evidence of the date at which Egyptian ideas influenced equatorial Africa, there are other customs which seem to indicate that this was not the only period of such cultural drift. The coffins of the III. and IV. dynasties were often large rectangular boxes designed and painted to represent houses. Now the Mayumbe roll the body of a dead chief in layers of cloth and place it in an enormous wooden coffin of rectangular shape, the top of which is carved to present a homestead. Again, the funeral ceremonial of the Ndolo seems reminiscent of this period. Immediately after death the Ndolo prepare the body, painting it red, touching up the eyebrows with charcoal, and propping it up with open eyes and mouth on a high seat in the very posture of the *ka* statues of the pyramid-builders, i. e., seated with the forearms and hands upon the thighs, a position which I venture to say no Negro would adopt. The body remains here for a day, while more or less continued drumming and dancing go on, and is then buried.

The form of an Egyptian mastaba tomb was to a very great extent the expression of the Egyptian belief that the soul, or souls, of the deceased visited the body in the tomb chamber, coming in and out by the shaft of the pit, and indeed the XVIII. dynasty papyrus of the priest Nebqed represents the human-headed *ba*-soul descending the shaft to visit the mummy. These beliefs also led to the burial of supernumerary stone heads to which the soul might attach itself should the body perish. Recently eight life-size portrait heads of a princess and the courtiers of the court of Chephren have been found in the mastabas at Gizeh constituting the royal cemetery of the fourth dynasty. The cartonnage busts, presumably of the deceased, represented as carried in funeral processions of the Middle Empire, are probably a development of the same idea. Similar expressions of belief—perhaps most obvious in tomb construction—occur in Negro Africa, the examples being too numerous and the resemblances too exact for this to be due to any other cause than actual borrowing.

To sum up: concerning the early prehistory of the Anglo-Egyptian Sudan we have no more than indications. In the Neolithic stage, which appears to have persisted until a comparatively recent date, Negro influence, if not predominant over the whole area, was at least powerfully felt even in the north, as is shown by the distribution of polished axe-heads. But against this northward pressure must be set the continual extension of Egyptian culture, the evidence for which may best be found in the eschatological ideas and burial customs ("mummification" and anthropoid coffins) of the peoples of Equatoria. This influence, which seems to have persisted until mediæval times, may have reached tropical Negroland as early as the Middle or even the Old Kingdom. Nor was the Nile route the only one by which Egyptian influence was spread. Another and later drift extended westward, as shown by the coinage of the north African States, which enables us to fix its date within fairly precise limits. We do not know how far south this drift traveled, but it seems certain that it reached at least as far as the Senegal River and the great bend of the Niger.

The Manufacture of Synthetic Perfumes

The subject of synthetic perfumes is arousing much interest in the industrial world at present. An excellent *résumé* of it was given last year at a meeting of the *Société d'Encouragement pour l'Industrie Nationale* of France by Mr. Justin Dupont, professor in the School of Industrial Physics and Chemistry of the city of Paris. Mr. Dupont began with general considerations as follows:

"For forty years we have known how to reproduce artificially the essence of bitter almonds (benzoic aldehyde) and the essence of wintergreen (salicylate of methyl) . . . There were prepared also some ethers of the aromas of fruits. To-day not only have numerous natural perfumes been reproduced and prepared industrially by synthesis, but other chemical compounds have been discovered which have enabled the perfumer to reproduce with 'an extraordinary intensity and fidelity' perfumes such as those of the heliotrope, the lily of the valley, the cyclamen, which no process of extraction has hitherto enabled us to derive from the flower. Above all, during the last few years, certain admirable discoveries, made either (exceptionally) in purely scientific laboratories, or more often in the laboratories of factories, have rendered this industry one of the most attractive and prosperous branches of industrial chemistry.

"An error current among the general public is the belief that synthetic perfumes are crude products belonging in the category of so-called 'German trash.' . . . If some of them in the pure state have a too-powerful odor, there are many others of extreme delicacy . . . and we must not forget, moreover, that synthetic perfumes are never employed pure, but are sent by the manufacturer to the perfumer, whose art consists in graduating skillfully the quantity to be put into the blends offered the public. *Apropos* of pure products a word on vanilla may be said. This now has a larger market in various alimentary industries, such as the making of chocolate, of crackers and biscuit, etc., replacing the higher-priced natural vanilla, and the difference between it and the latter is hardly perceptible except to the most expert connoisseurs. . . .

"Synthetic perfumes are extracted from two entirely distinct classes of substances:

"1. The sub-products of distillation of coal, comprising derivatives of benzine, toluene, metaxylene, nahpthalene, and the cresols. Among the best known perfumes derived from this class and produced industrially are vanilline, coumarine, the artificial musks, benzoic aldehyde, acetate of benzyle, anisic aldehyde.

"2. The essential oils of vegetable origin. From these are derived the principal perfumes indicated in the following list:

"Principles derived from essential oils of plants:

Essence of turpentine (Landes)	artificial camphor; terpineol; ethers of terpineol
Essence of lemon grass (India, Tonkin)	citral; ionone; methylionone
Essence of citronelle (Ceylon)	geraniol → ethers of geraniol
Essence of citronelle (Java)	citronellal; geraniol
Essence of geranium (Algeria, Bourbon)	rhodinol
Essence of palma rosa (India)	geraniol → ethers of geraniol
Essence of camphor (Japan)	safrol → isosafrol → heliotropine
Essence of aniseed (China, Tonkin)	anisole
Essence of clove (Zanzibar)	eugenol → isoeugenol → vanilline
Essence of rosewood (Cayenne); Essence of linaloe (Mexico); Essence of shiu (Japan)	linalol → ethers of linalol
Essence of styrax (Isle of Rhodes)	cinnamic alcohol

"All these perfumes are produced in France, except benzoic aldehyde and benzyl acetate, which come to us from Germany.

"Benzoic aldehyde is, in fact, a primary substance of the manufacture of dyes. As for benzyl acetate it is prepared by the action of benzyl chloride on the alkaline acetates. But chlorine and acetic acid are obtained, for certain reasons, . . . cheaper in Germany than in France, and hence competition is impossible.

"Let us not forget, therefore, that the industries of organic chemistry form a closely related whole. Thus we must endeavor to develop the manufacture of primary substances such as chlorine, soda, magnesium, which are at the base of all these industries (explosives, dyes, perfumes, pharmaceutical substances, etc.) and for which we were dangerously tributary to our enemies."—*Génie Civil.*

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