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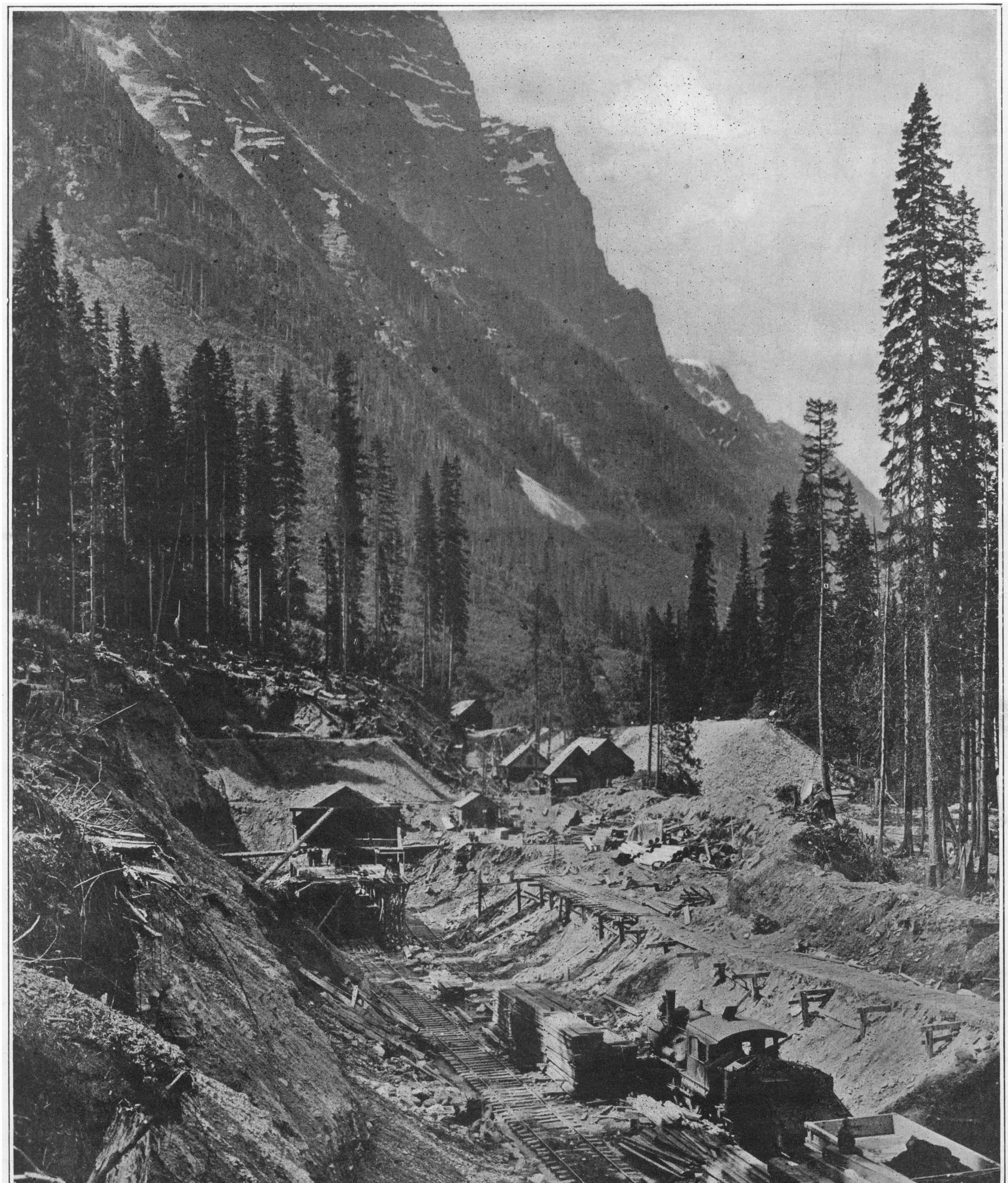


Western portal of the Rogers Pass tunnel, showing entrance to the pioneer bore.

THE LONGEST RAILWAY TUNNEL IN AMERICA.—[See page 152.]

The Importance of Geographical Research—I*

And a Plea for More Accurate Methods

By Major H. G. Lyons, D.Sc.

In order that we may see what advance has been made in the scientific study of geography in this country during the last quarter of a century, we must turn to the results that have been attained by the activity of geographical investigators who have devoted themselves to the serious study of various phenomena, and the detailed investigation of particular regions. If we do so I think we must admit that the number of original investigators in scientific geography who are extending its scope in this way is not so large as it might be, nor are we yet utilizing sufficiently all the material which is available to us. Anyone who will examine the geographical material which has been published in any period which he may select for review will find that purely descriptive treatment still far outweighs the analytical treatment which alone can lead to definite advances in scientific geography. If pleasing descriptions of this or that locality are sought for, they are, for the most part, to be found readily in the very large amount of such material that has been and is being published each year by residents, travelers, and explorers; but if information is desired in the prosecution of a piece of geographical research, we are checked by the lack of precise details. Few descriptions of this class are sufficiently definite to enable the necessary comparisons to be made between one locality and others which are similarly situated; thoroughly quantitative treatment is for the most part lacking, and while a pleasing picture is drawn which is probably true in character, it is usually inadequately furnished with those definite facts which the geographer requires.

The opportunity to undertake long journeys through distant lands comes to few of us, but this is not the only direction in which research can be profitably undertaken, for there is no part of these islands where a geographer cannot find within his reach some geographical problem which is well worth working out, and which, if well and thoroughly done, will be a valuable contribution to his science. Even for such as cannot undertake such field work the library will provide a host of subjects which have not received nearly the amount of attention and of careful study that they deserve. The one thing essential is that the study should be as thorough as possible, so that all the contributory lines of evidence shall be brought together and compared, and so that the result may prove to be a real addition to geographical science on which other workers may in their turn build.

The ease with which a tract of country or a route can be described by the traveler, and the attractiveness of such a description of a little-known region, results in the provision of a vast quantity of geographical information, the greatest part of which has probably been collected by those who have no adequate training in the subject. But anyone who has had occasion to make use of such material in a serious investigation is only too well aware how little precise and definite information he will be able to extract from the greater part of this wealth of material, and in most cases this is due to the traveler's lack of geographical knowledge. He probably does not know the phenomena which should be observed in the type of region which he is traversing, nor can he read the geographical evidence which lies patent to a trained observer at every point of the journey; much, therefore, of what he records may be of interest, but probably lacks data which are essential to the geographer if he is to understand the geographical character of the region, and utilize it properly.

Thus, it happens that although the amount of geographical material which is being garnered may be large, the proportion of it which is available for use in a scientific investigation of an area is smaller than is probably realized by those who have not made the experiment. And yet it is only by this scientific investigation of selected localities or of a single phenomenon and by working them out as thoroughly as possible that any real advance in geographical science can be made. There should now be an ever-increasing number of geographers trained to proceed in their investigations by the true scientific method, and there should be a very considerable amount of sound work in various branches of the subject which aims at thoroughly investigating some phenomenon, or group of phenomena, so as to present a grouping of data, carefully verified and critically discussed, in order to arrive at conclusions which may form a useful addition, however small, to the sum of our geographical knowledge.

So far as I am able to judge, the output of serious work of this character is not nearly as large as it should be, and I would indicate some fields in which there is a lack of individual work of this character. Until more of it is undertaken we shall lack in this country the material from which the foundations of scientific geography can be built up, and while our own islands and the various parts of the British Empire furnish unrivaled opportunities for such work, there are still far too many subjects where the most thorough investigations have been made in other countries.

Mathematical geography presents a field for research which has had comparatively little attention paid to it in this country. In many respects this part of the subject is peculiarly suitable for such treatment, since it admits of the employment of precise methods to an extent which is not always practicable in cases where so many of the factors can only be approximately defined. The determination of positions on the earth's surface is carried to great refinement in the national surveys of most civilized countries in order to furnish the necessary controls for the preparation of large-scale maps, but when we pass to the location of travelers' routes, where considerable allowance has to be made for the conditions under which the observations have to be taken, we find that very inadequate attention is usually paid to the discussion of the results. Usually a mean value for each latitude, longitude, or azimuth is obtained by the computer, and he remains satisfied with this, so that when the route of another traveler follows the same line or crosses it at one or more points, it is almost impossible for the cartographer to say which of the two determinations of any position is entitled to the greater confidence. In this class of work, whether the results are obtained from absolute observations at certain points or from the direction of march, and the distance traversed, it is quite practicable to determine the range of uncertainty within which the positions of different points are laid down, and it is eminently desirable that this should always be done in order that the results of various routes which may intersect in partially known regions may be adjusted in accordance with definite mathematical processes. Some important expeditions on which infinite labor and considerable sums have been expended have presented their results, in so far as they relate to the routes which have been followed and the positions of points which have been determined, in such a way that it is impossible to say with what precision such positions have been determined, and consequently any combination of these results with those of later expeditions has to be carried out empirically, since adequate data are no longer available for the employment of better and more scientific methods.

This crude and unsatisfactory way of treating observations, which in many cases have been obtained under conditions of the greatest difficulty and even hardship, is largely due to the lack of interest which geographers have shown in this part of their subject. Methods of observation and methods of computation are rarely discussed before any of our geographical societies or in any of our publications, and it is only by such discussions that the importance of properly working out the available material at a time when the observer can be consulted on points which are doubtful, or where further explanation is desirable, becomes generally appreciated.

No set of physical or astronomical observations is ever discussed or even presented without the degree of precision or trustworthiness being definitely stated; yet in geography this sound rule is too often neglected.

There are several regions where travelers' routes intersect which should provide ample material for the careful reduction and adjustment of the results. I fear, however, that there would be great difficulty in obtaining the original observations which are indispensable in such an investigation, and in the interest of research it is highly desirable that the original documents of all work of importance should be preserved and the place where they may be consulted should be recorded in the published account.

There is room in the geographical investigation of sea and land, even within the limits of the British Empire, for the employment of methods of observation and computation of the highest precision as well as of the simpler and more approximate kinds, but everyone who presents the results of his work should deem it his first duty to state explicitly the methods which he employed, and the accuracy to which he attained, in such a form that all who make use of them can judge for themselves of the degree of their trustworthiness.

In such work, while the instruments used are of great importance, too often the briefest description, such as "a 4-inch theodolite," is deemed sufficient. If the observer wishes his work to be treated seriously as a definite contribution to science we require to know more than this, and a clear account of the essentials of the instrument, a statement of its errors, and of the methods of observation adopted are the least that will suffice. The account of any expedition should treat so fully of the instruments, observations, and computations utilized to determine the positions of places visited that anyone can re-examine the evidence and form his opinion on the value of the results obtained. A mere tabular statement of accepted values, which frequently is all that is provided, is of small value from a scientific point of view. Probably one reason for this state of things is that too little attention is being paid by geographers to their instruments. Theodolites, levels, compasses, clinometers, tacheometers, plane-tables, pantographs, co-ordinatographs, planimeters, and the many other instruments which are used by the surveyor, the cartographer, the computer, have in no case arrived at a final state of perfection, but it is seldom that we find a critical description of an instrument in our journals. Descriptions there are from time to time, but these are for the most part weak and insufficient. Not only is a technical description required, which treats fully of both the optical and mechanical details, but we need an extended series of observations with the instrument which have been made under the ordinary conditions of practical work, and these must be mathematically analyzed, and the degree of the trustworthiness of the results clearly demonstrated. The description should be equally thorough and complete, including scale drawings showing the construction of the instrument as well as photographs of it. Nothing less than this is of any use to the scientific cartographer.

In this country the early advances of British instrument-makers of surveying instruments are far from being adequately represented in our national museum in a manner commensurate with their importance. The keen and enlightened zeal of geographers who are interested in this branch of the subject would doubtless quickly bring to light much still remaining that is of great interest, but which is yet unrecognized, while a closer attention to instrumental equipment would lead to improvements and advances in the types that are now employed. There is no modern work in this country on the development of such instruments, and references to their history are conspicuously rare in our journals, so that there is here an opportunity for those whose duties prevent them from undertaking travel or exploration of a more ambitious kind. In the same way, those whose opportunities of field work are few can find a promising field of study in the early methods and practice of surveying which have been discussed by many authors from classical times onward, and for which a considerable amount of material exists.

In geodesy and surveying of high precision there is ample scope for all who are attracted by the mathematical aspect of the subject; the critical discussion of the instruments and methods employed and results obtained, both in this country and in other lands, provides opportunity for much work of real value, while its bearing upon geology, seismology, etc., has not yet been adequately treated here. The detailed history of this part of our subject is to be found in papers which have been published in the technical and scientific journals of other countries for the most part; here, too little attention has been given to the subject, in spite of the large amount of geodetic work which has been executed in the British Empire, and which remains to be done in our Colonies and over-seas Dominions.

The final expression of the surveyor's detailed measurements is found in the map, and the adequate representation of any land surface on a map-sheet is both a science and an art. Here, we require additional work on all sides, for there is scarcely any branch of geography which offers so remunerative a field for activity as cartography. We need the co-operation of trained geographers to study requirements, and to make acquaintance with the limits of technical methods of reproduction, so that they may be in a position to deal with many questions which arise in the preparation of a map regarding the most suitable mode of presentation of data, a matter which is purely geographical, but which at the present time is too often left to the skilled draughtsman. Neither the compilation nor the reduction of maps is a merely mechanical process. The first requires great skill and care as well as technical knowledge and a sound method of treatment if the various pieces of work, which are brought together to make up the map of any considerable area, are to be utilized according to their true worth. This demands a competent knowledge of the work which has been previously done on the region, a first-hand acquaintance with the data

* President's address before the Geographic Section of the British Association. Slightly abridged by the author in *Nature*.

collected by the earlier workers, and the critical examination of them in order that due weight may be given to the better material in the final result. This is not a task to be handed over to the draughtsman, who will mechanically incorporate the material as though it were all of equal accuracy, or will adjust discrepancies arbitrarily and not on any definite plan. Such preliminary preparation of cartographical material is a scientific operation which should be carried out by scientific methods and should be completed before the work reaches the draughtsman, who will then have but to introduce detail into a network of controls which has been prepared for him and of which the accuracy at all points has been definitely ascertained. Similarly in the second case the elimination of detail which must of necessity be omitted is an operation needing the greatest skill, a full understanding of the material available, and an adequate appreciation of the result which is being aimed at, such as is only to be found in a competent geographer who has made himself intimately acquainted with all the material which is available and has his critical faculty fully developed.

All these problems are well within the reach of the geographer to whom the opportunity of travel in other regions does not come, and in them he will find ready to his hand a field of research which is well worth working and which will amply repay any labor that is spent upon it. The same precise methods of investigation which are employed in the discussion of observations should be applied to all cartographic material in order to ascertain the exact standard of its trustworthiness, in which is included not only the correctness of distance and direction, but also the accuracy of the information which has been incorporated in it; and these may be brought to bear also on those early maps of which so many are preserved in our libraries in this country. In this field of study several investigators have already achieved results of great interest and value, but I think they will be ready to admit that there is here a wide and profitable field of activity for many more workers who will study closely these early maps and, not being contented with verbal descriptions, will use quantitative methods wherever these are possible.

In the study of map projections some activity has been visible in recent years, and we may hope that those who have worked in this branch of the subject will see that British geography is provided with a comprehensive manual of this subject which will be worthy of the vast importance of cartography to the Empire. The selection of suitable projections is receiving much more attention than was formerly accorded to it, but the numbers of communications on this subject which reach geographical journals are few and far between. The subject is not one which can appeal strongly to the amateur geographer, but its importance renders it imperative that the scientific geographer who realizes its intimate bearing upon all his work should so arrange that the matter does not fall into the background on this account.

But it may be suggested that the lack of activity in mathematical geography is due to the somewhat specialized nature of the subject, and to the fact that the number of those who have received an adequate mathematical training and are prepared to devote themselves to geography is few. When we turn to physical geography in its treatment of the land we do find a field which has been more actively worked, for this is just the one to which the traveler's and explorer's observations should contribute most largely, and where therefore their material should be utilized with the best results. Even here there is room for much more work of the detailed and critical type, which is not merely general and descriptive, but starts from the careful collection of data, proceeds to the critical discussion of them, and continues by a comparison of the results with those obtained in similar observations in other regions.

To take a single branch of physical geography, the study of rivers, the amount of accurate material which has been adequately discussed is small. In our own country the rainfall of various river basins is well known through the efforts of a meteorological association, but the proportion of it which is removed by evaporation, and of that which passes into the soil, has only been very partially studied. Passing to the run-off, which is more easy to determine satisfactorily, the carefully measured discharges of streams and rivers are not nearly so numerous as they should be if the hydrography of the rivers is to be adequately discussed; for, although the more important rivers have been gaged by the authorities responsible for them in many cases, the results have usually been filed, and the information which has been published is usually a final value, but without either the original data from which it has been deduced, or a full account given of the methods of measurement which have been employed. For the requirements of the authority concerned such a record is, no doubt, adequate, but the geographer requires the more detailed information if he is to co-ordinate satisfactorily the volume discharged with local rainfall, with changes in the rates of erosion or deposition, and the many other phenomena which make up the life-history of a river. Here, too, it is usually only the main stream which has been investigated; the tributaries still await a similar and even fuller study.

In the same way we still know too little of the amounts of the dissolved and suspended matter which is carried down by our streams at various seasons of the year, and in the different parts of their course.

In this one branch of the subject there is ample scope for workers of all interests in the measurement of discharges, in the determination of level, and of the movement of flood waves, in determining the amount of matter transported both in suspension and in solution, in tracing out the changes of the river channel, in following out the variation of the water-table which feeds the stream, in ascertaining the loss of water by seepage in various parts of its course, and generally in studying the hundred other phenomena which are well worth investigating, and which give ample scope for workers of all kinds and of all opportunities. There is work not only in the field, but also in the laboratory and in the library which needs doing, for the full account of even a single stream can only be prepared when data of all classes have been collected and discussed.

On the Scottish lakes much valuable scientific work has been done, and also on some of the English lakes, so that excellent examples of how such work should be done are available as a guide to anyone who will devote his spare time for a year or two in making a thorough acquaintance with the characteristics and phenomena of any lake to which he has access.

Coast-lines provide another class of geographical control which repays detailed study, and presents numberless opportunities for systematic investigation and material for many profitable studies in geography. The shores of these islands include almost every variety of type, and furnish exceptional opportunities for research of a profitable character, especially as lying on the border line between the domain of the oceanographer on one hand and the physiographer on the other. The precise methods of representation which are possible on the land have to give way to a more generalized treatment over the sea, and the shore line is liable to be handed over to the latter sphere, so that there is much interesting and useful work open to anyone who will make an accurate and detailed study of a selected piece of coast line, coordinating it with the phenomena of the land and sea respectively.

(To be concluded.)

Our Modern Engineering Education.*

A NEW expenditure of unprecedented magnitude is being inaugurated here to-day to provide opportunities for the study of the problems of the clay and allied industries and for the training of young men to enter these industries on a professional or engineering basis. The ceramic school of university grade is a distinctly American institution. The change in the educational ideas disclosed between ceramic training of twenty-five years ago and that being given here and elsewhere in America to-day is a startling one. And now, at the beginning of still greater and more ambitious preparations, it seems wise and appropriate to cross-examine ourselves and make sure that we are on the right track and that we can give a reason for the faith that is in us.

Among the friends of technical education there are some, perhaps many, possibly even a majority, who think they perceive in the present increasing subdivision of technical education, in the growing number of courses, with the implied narrowing of the field occupied by any one course, a real and serious danger. The complaint of the users of engineering graduates is most commonly directed to their lack of grasp and power to use their fundamentals—their mechanics, their physics, their mathematics, their English. They say that the young engineer has been over so many subjects that he hasn't had time to go through any. We are accused of forgetting that the capacity of any group of healthy, vigorous young men to absorb knowledge and to acquire power to use knowledge in novel fields is about the same from year to year. To borrow a homely illustration from the kitchen, our technical professors are accused of trying to can more fruit than their cans will hold.

Not a few eminent engineers and large employers of engineering labor have urged the technical schools to give over trying to do the impossible and to return to the simpler, less differentiated courses, with more time on each subject and more practice in the application of each subject taught. They take the ground that in the nature of the case the industries themselves must act as the final schools for the young engineers who are being brought in for the maintenance and extension of these industries. These appeals from the industry have, if anything, grown in volume and insistence in the last decade. But the technical schools have, so far as I can discern, not yielded much if anything to them. In my judgment the discussion of this educational policy must continue and increase until it brings action. I think technical schools must settle down to a much better defined and less pretentious schedule. The four-year technical course of the future will, in my opinion, prepare young men to enter their profession as beginners, with the very clear understanding that expert knowledge of any field must come through the specialized schools, maintained in and by the various industries themselves or through the graduate research and experiment stations at the universities or through both.

The bearing of this discussion of engineering or technical education on the case in hand here to-day may not at first be clear. We are gathered together to lay the cornerstone of a new structure whose purpose is to teach one of these very subdivisions of knowledge which has been described and in a way frowned upon. Is it justifiable educationally and industrially to make such splendid provision to carry out a plan whose foundation principles are still under debate? In answer to this I say that we must distinguish between subdividing a field of knowledge and cramming a course of instruction.

Subdivision of the field of knowledge in technical schools is not, *per se*, a danger or a weakness. It becomes a weakness whenever the training becomes superficial—whenever the mass of detail is allowed to obscure or replace the foundation. In fact, subdivision of our courses of study is not only not inconsistent with sound educational processes, but may be regarded as a step toward strengthening them. The subdivision of civil engineering, for instance, into railroad engineering, sanitary engineering, municipal engineering, structural engineering, hydraulic or irrigation engineering, to a large extent relieves the tendency to try to crowd a little of each of these subjects into one undivided or unspecialized civil-engineering course.

On the other hand, subdivision in itself is no safeguard against cramming; the temptation to cram is still there and must be resisted alike by school authorities, students and the industries. The views of undergraduates are almost always crude and materialistic in such matters, and they nearly always tend to overestimate the importance of special knowledge over general principles.

The thing which made the old course of two generations ago strong was the thoroughness of the drill in the foundation subjects. With a curriculum meagerly representing engineering, these early schools produced engineers who became famous. Why? Because they hammered their physics and mathematics and English in until the student could use them.

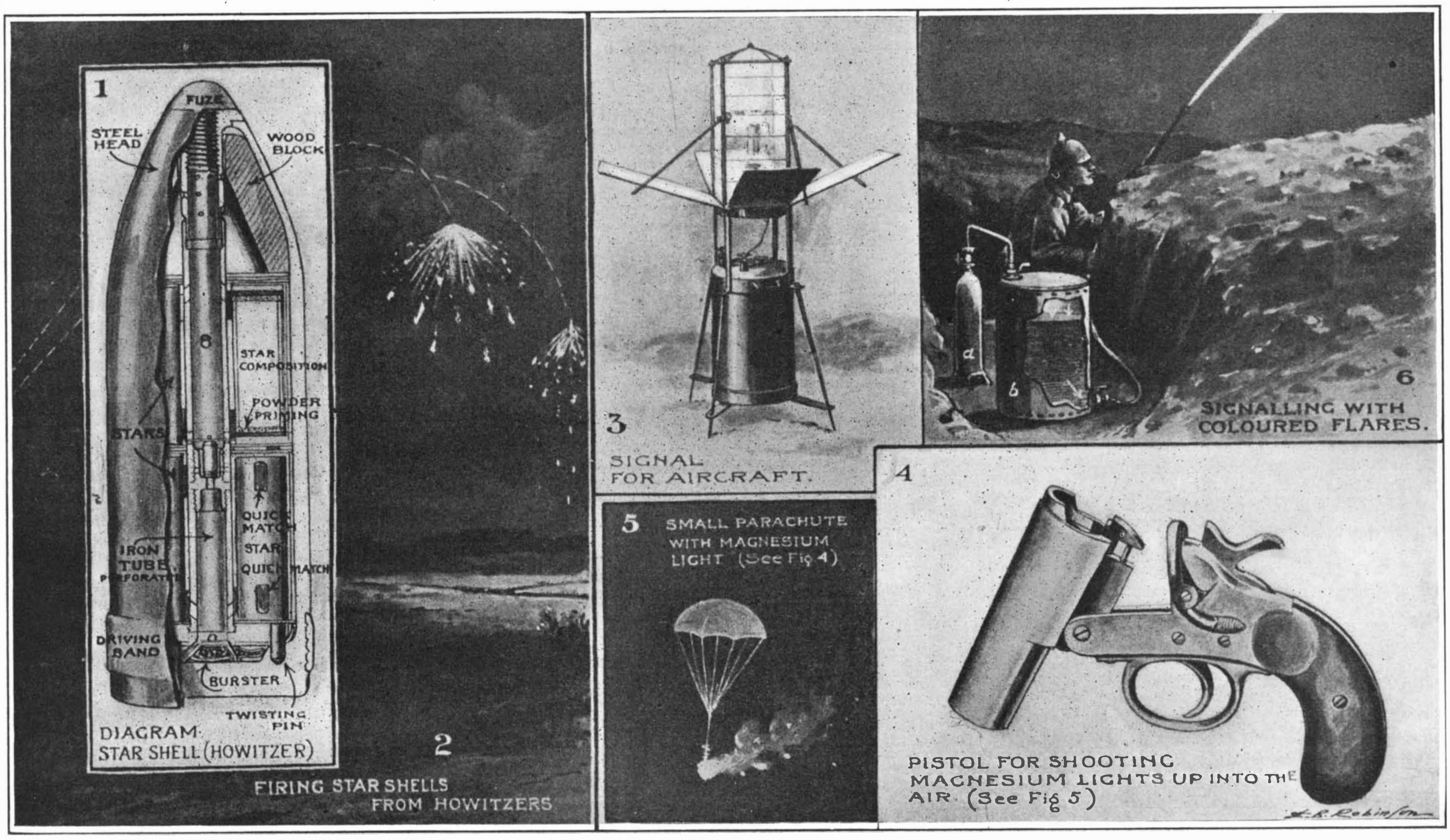
It s no longer possible or desirable for our schools to try to obtain the esults of two or three generations ago by return to the methods of that time. The old-fashioned all-around scholar, who was a cultured gentleman first and always, and who knew something in every field, was the product of a social system which has gone. But the principles which made the education of that day sound and productive and fertile are still the same! All that is necessary is to preserve the principle of thoroughness in all that is done—to direct the educational process toward producing power to think.

Any good engineering course must, in the nature of the case, contain the same foundation. The foundation subjects, developed as far as is needed for securing the working power previously described, will require from 50 to 60 per cent of the time of the engineering student in his four years. In the first year they take practically all of his time. As he goes further, descriptive and specialized courses founded upon or utilizing the foundation courses come in, together with some few of a more general cultural value. Toward the last, these specialized courses may comprise a large part of the work.

The acquirement of the power of constructive thought, which is the object of al technical education, can be had through one set of descriptive subjects as well as through another. I hold that it is immaterial whether the illustrative matter in a course of education is chosen from civil engineering or mechanical engineering or chemical engineering. I hold that it matters not whether it be ceramic engineering or electro-chemistry or aeronautics.

It is perfectly true, therefore, that in our modern specialized and subdivided technical education we may be weakening our product and discrediting the engineering profession, or we may be creating strong, virile thinkers and apt workers who will be the leaders in their field, according as we disobey old and tried principles or obey them. A specialized education is not *per se* either a good one or a bad one; it is not necessarily either strong or weak. It is as easy to train the human mind, using illustrations and problems from one industrial field or scientific field as from another. The whole value of the process and the strength of the character produced will depend not upon the technical content of a course o instruction, but upon the thoroughness with which the foundation is laid and the persistence with which the principles are applied as the work progresses.

*From an address delivered by Prof. Edward Orton, Jr., Dean of College of Engineering, Ohio State University, at the laying of the corner-stone of the Ceramic Engineering Building, University of Illinois.



Courtesy of the *Illustrated War News*

War Illuminations*

Various Methods That Have Proved Their Value

In order that operations in war may be carried on by night as well as by day, artificial light in many forms has to be resorted to. One of these forms, known as the star-shell (Fig. 1), is a projectile fired from a field-gun, its fuse being arranged so as to burst the shell over the area to be illuminated (Fig. 2), or, alternatively, on impact with the enemy's earthworks. This particular device is very useful for detecting troops attempting a surprise attack.

The star-shell fired from the 3-inch quick-fire gun is fixed into a cartridge-case the base of which contains the propelling charge; every round fired, therefore, takes the form of fixed ammunition. The corresponding shell used in the 6-inch howitzer and its propelling charge are, on the other hand, separate units. The star-shell itself is constructed on similar lines in each case. The body of the shell is an iron cylinder having a copper driving band round it near the base. A steel nose is attached to the body and screwed in at the forward end to take a fuse, either time or percussion, or a combination of both. The percussion-fuse carries a striking needle supported on a thin copper diaphragm. The diaphragm collapses when the fuse receives a smart blow on its nose, and the needle is driven against a percussion cap, in that way igniting the "quick-match," which passes down the tube shown in the center of the shell and communicates with the bursting charge in the base.

The shell has a wooden lining, and carries between this and the central tube a number of cylinders, each containing a composition which ignites from the quick-match in the central tube (see Fig. 1). These cylinders are scattered as the shell bursts, and burn for a considerable time, giving out a brilliant light (Fig. 4). When used for "ranging," star-shell should be burst at such a height from the ground that the "stars" are all burnt out before they reach the ground. Otherwise, the herbage may be set alight and the smoke so produced obscure the target.

Small illuminating shells holding "Véry lights" are fired from a Webley and Scott pistol (Fig. 4). They are used for signaling purposes. The weapon has a range of about 500 feet, and the shell is attached to a parachute, which descends slowly during the 45 seconds that the composition remains alight (Fig. 5). The latest pattern of pistol has a detachable stock for alternative firing from the shoulder, as the "kick" is rather heavy for a pistol.

Aircraft can assist artillery operations at night by dropping fire-bombs fastened to parachutes. The slowly descending mass of burning composition gives sufficient light to enable gunners to pick up the range readily.

* The *Illustrated War News.*

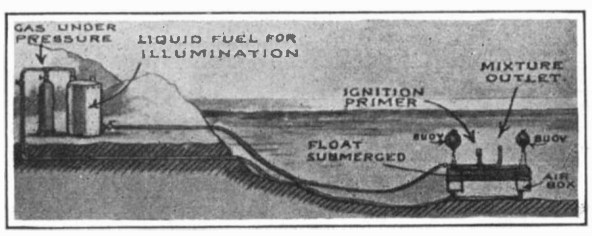


Fig. 7.—Apparatus for sea-surface illumination.

By means of gas, buoys and floats the apparatus is kept below the surface at any required depth.

Fig. 8.—Apparatus in action lighting up the surface.

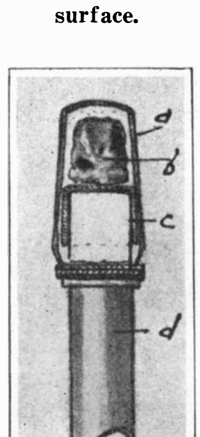


Fig. 9.—Submerged ignition primer detail.

a, cap; *b*, lump of potassium or sodium; *c*, weak india-rubber diaphragm closing top of tube; *d*, tube of liquid fuel illuminant. Pressure from liquid fuel reservoir ashore bursts the diaphragm and cap, setting the potassium alight from the water and igniting the liquid fuel.

In one type of star-shell the "stars" take the form of cylinders, in one end of which the illuminating composition is inset. The other end contains a folded parachute, which is forced out of the cylinder by a coiled spring after the "star" is liberated from the parent shell. The composition is ignited by the bursting charge of the shell itself, which contains twelve or more of these parachute-stars. Many kinds of flare-lights are in use for illumination in digging trenches at night, etc.

An acetylene flare, to which are attached four mirrors radiating from the source of light (Fig. 3), is used as a signal to aircraft.

The angular positions of the mirrors enable the airmen to "pick up" the light from several different directions. Fig. 6 shows a German device for the production of colored flares for transmitting signals. The particular color desired may be obtained by adding suitable chemicals to the combustible liquid with which the reservoir (*b*) is charged. Chloride of strontium produces a red flame; copper salt a green flame; and so on. A long or short flame may be produced by admitting more or less gas pressure to the reservoir (*b*) from the gas cylinder (*a*) alongside. The same apparatus is used for distributing asphyxiating gas, and in a portable form for projecting liquid fire. For modifications of this device for illumination on the surface of water, and the apparatus, see Figs. 7, 8 and 9.

Boiler Explosion in Germany

In the entire Empire of Germany, not including those used in the military and naval service, there were, in 1914, only eight explosions of steam boilers. One of these was built in 1873, one in 1874, one in 1880, one in 1881, one in 1892, one in 1902 and two in 1906. The dates are mentioned as showing that all the boilers were well along in years; the most were of the last century. Low water is given as a probable cause in five out of the eight cases. In three of the explosions no personal injuries were caused. The other five killed two, seriously injured two and slightly injured seven persons.

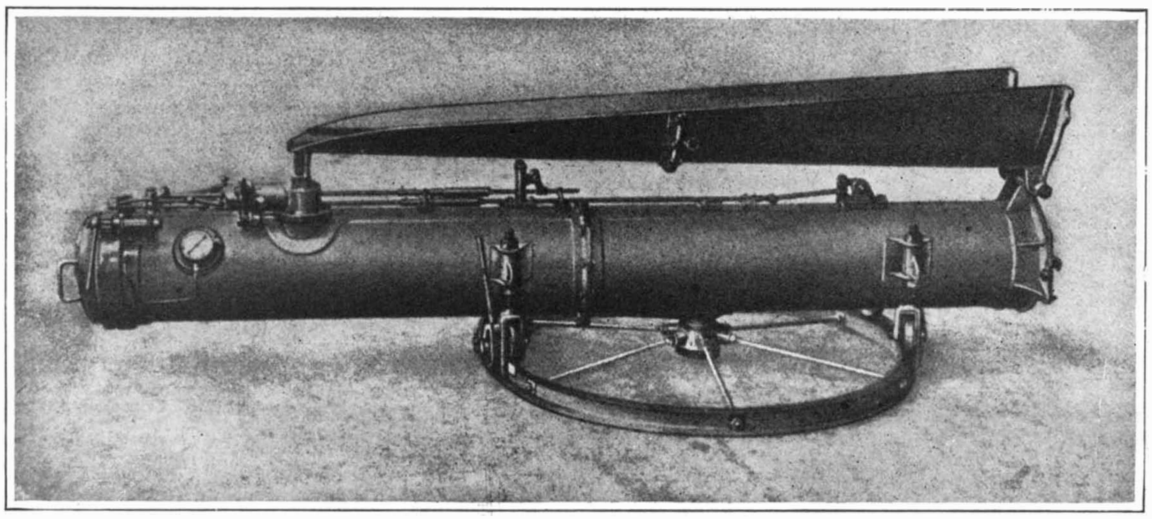
In the same period there occurred in the United States 575 accidents to boilers, by which 300 persons were killed and 476 more or less seriously injured; and yet there are those who protest with all of the outraged righteousness of American citizenship imposed upon against any governmental control or supervision of the design and operation of boilers, or of the competency of the men that run them.—*Power.*

Torpedo Tubes*

The Mechanisms Used Above and Below the Surface

PRACTICALLY speaking, modern torpedoes are launched by means of an impulse tube, usually known as a "torpedo tube." These tubes are of two different general types, the above-water or deck pattern, and the submerged or under-water pattern. In both types the mode of expelling the torpedo is the same, that is, by means of a charge of highly compressed air, introduced at the inboard end of the tube, and expelling or blowing out the torpedo, or alternatively by means of a charge of powder or explosive. In some foreign navies other methods are used, such as outboard clips or dogs, which can be operated as desired, thus releasing the torpedo and starting it upon its course. The impulse system has this great advantage, that the actual torpedo is started upon its course with considerable initial velocity, thus economizing the internal charge of compressed air in the torpedo itself.

The above-water or deck tubes, which may be either single or in pairs, are used chiefly on destroyers and light fast craft, as this pattern is lighter and more simple than the under-water type. Moreover, the deck tubes can be trained in any direction relative to the center line of ship, whereas the direction of the submerged tubes cannot, of course, be altered, otherwise than by altering the course of the ship. Consequently, under-water craft, such as submarines, can only fire their torpedo in certain directions relative to their center line.



Torpedo-launching tube—above-water pattern.

The actual tube itself is composed largely of steel and consists mainly of a strong circular carrying platform or racer, built on to the deck; on this platform the actual carriage which supports the tube is arranged to turn, a center bearing and outer carrying wheels or runners being provided for this purpose. The tube is strongly ribbed on the exterior, and is provided with a removable end plate or cover, which is secured in place by means of suitable screw-down clips. Through this end door the torpedo is inserted. In some patterns the door, or breach, has a hinged door, with a movable collar or locking ring on its circumference. This movable collar has an interrupted screw thread cut upon it, somewhat after the style of the breech block of a modern gun, and so arranged that it can be tightened up by means of a pinion crank, cog wheel and rack.

The torpedo slides on guides in the interior of the tube, and when it has been placed in the tube the breach is closed, the air pressure pipes connected, and the safety devices having all been unlocked, the weapon is ready for firing, which is effected by electrical means, thus opening the stop valve, admitting the highly compressed air to the back of the torpedo, and thus impelling it forward and out of the tube.

When the torpedo is fired by a charge of powder or explosive, a similar sequence of events takes place, but before the charge can be fired, the locking bolt and safety devices have all to be clear, which can only be obtained when the door is properly closed and everything in order. Means for ensuring the accuracy of direction, or aim, are provided, and in this respect the tube is somewhat akin to a gun.

Submerged tubes call for different construction, as not only are larger diameter torpedoes used, but there are the added difficulties of ensuring a water-tight joint between the tube and the hull side, and in addition means must be provided to keep the sea from entering the ship whenever the tube is opened. In addition, means must be provided to mechanically guide the torpedo until it is actually clear of the ship's side, otherwise the wash of the water may deflect the torpedo from its course, or cause it to jam in the opening of the tube. Moreover, as the modern torpedo is some 21 feet in length, it is impractical in most cases to load the tube from the end, and therefore the torpedo must be inserted from the side. To accomplish this, suitable lifting and handling gear is provided to enable the torpedo to be readily conveyed to the side of the tube, but before the tube can be opened the outer end must be closed to prevent ingress of sea water. This is effected by means of a sluice valve housed in a strong bronze casting, which serves to fill the space between the hull sides and the tube proper. An electrically interlocked system is adopted to prevent the side of the tube being opened until the sluice valve is closed. This having been done, the torpedo tube can be opened; for which purpose it is divided longitudinally into two halves, with a strong hinged joint at the bottom; and a series of hydraulic rams at the top to close up the joint absolutely air and watertight. Hydraulic power is also provided to open and close the side of the tube.

The tube side having been opened, the torpedo is then placed into an inner cage or guide free to slide in the tube proper, for which purpose guides and runners are provided. This inner cage also has suitable guides to carry the torpedo and ensure its correct direction. The tube side is then closed, the various firing and safety devices set in order, the sluice valve opened and the torpedo fired.

As the torpedo is set in motion by the air pressure behind it, the inner cage is also set in motion in the tube, and thus, as the torpedo travels in the cage, the cage itself also travels forward in the tube and thus is able to guide the torpedo as it emerges from the ship's side, and to protect it from the otherwise unbalanced side pressure of water due to the motion of the ship. No special check or recoil device is needed to return the cage into the tube, as the external water pressure is ample to do this. The cage having resumed its normal internal position, the water in the tube is blown out and the sluice valve closed, when the tube is again ready for use.

In both cases the actual firing of the torpedo is controlled by the officer in charge, who is usually stationed in the conning tower, where a number of instruments are employed to judge the position of the enemy ship. The range and direction as observed by the officer is then transmitted by suitable electrical means to the officer in charge of the torpedo crew, who has a suitable direction indicator enabling him to make necessary adjustments. At the appropriate moment the officer in charge in the conning tower presses the firing key and the torpedo is launched.

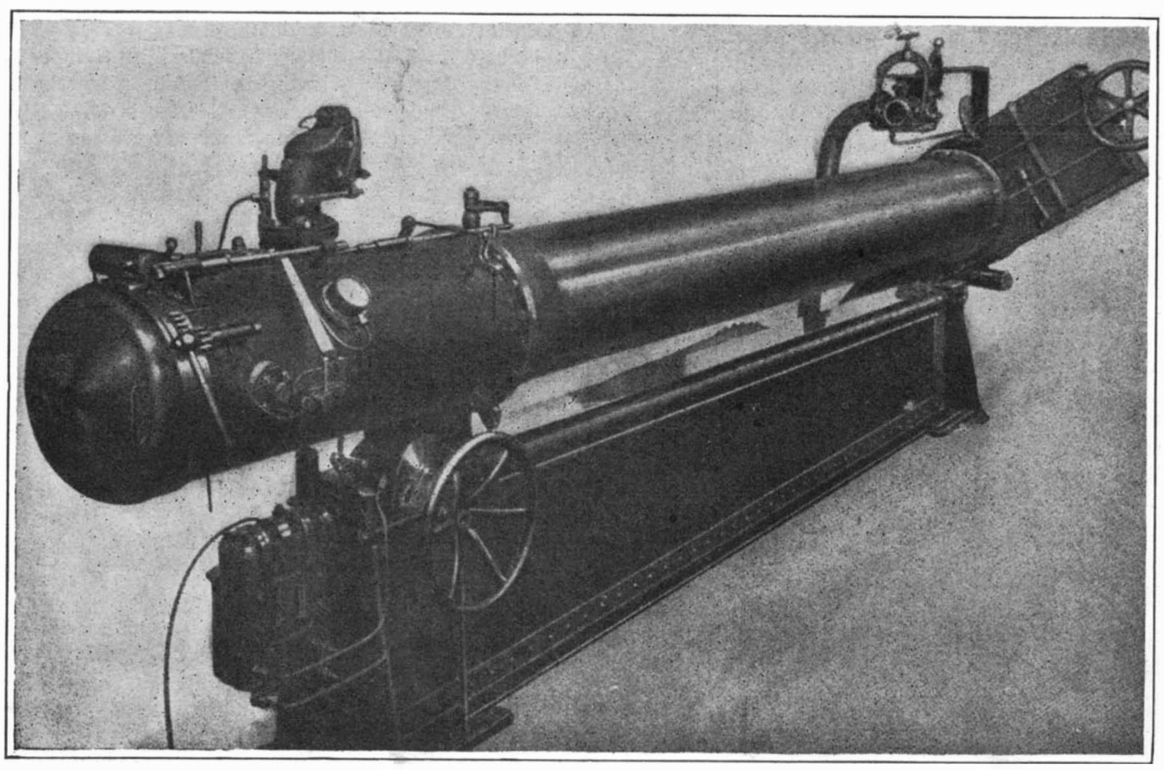
In both above-water and submerged tubes a locking bolt is provided to retain the torpedo in its place in the tube, and prevent its shifting about when the boat rolls. The tripper gear for automatically starting the engines in the torpedo as it leaves the tube is situate on the upper part of the tube as may be seen in one of the illustrations.

The general disposition of the various parts of these tubes is clearly shown in the accompanying illustrations, but numerous details are necessarily omitted at the present time in the national interest, but we have endeavored to indicate the general lines on which these deadly modern weapons are used, as some acquaintance with the subject may be helpful to shipmasters and other sea-goers.

* *The Marine Engineer and Naval Architect.*

Oxford India Paper

THE beautifully thin paper known as Oxford India paper was for many years made only in England, but is now made in several other countries. Its characteristics are that it must be very thin, weighing under 30 grammes per square meter, non-transparent and impenetrable to ink, says *Papierfabrikant.* It is made principally from linen rags, a standard receipt being 80 per cent of best bleached white linen, 10 per cent of best white bleached cotton, 5 per cent of bleached straw pulp, 2 per cent of finest white loading (e. g., talc), 3 per cent of waste. The rags are boiled with 1 to 2 per cent of soda for 3 hours at 3 atmospheres pressure, washed carefully and bleached with 1 to 2 per cent of chlorine until snow white. Ultramarine is used for coloring and indanthrene blue, R.S., for tinting. Beating is carried on for 20 to 34 hours in engines of up to 100 kilometers capacity, with sharp blades so as to obtain a short, non-transparent whole stuff. Cone engines have proved very suitable; sand traps must be used on pulping and beating machines. Paper machines of 150 to 170 centimeters width are most satisfactory, running at not more than 40 meters per minute; wire about No. 90. The strainers should be first a rotary strainer, followed by a flat one, having slots 0.4 millimeter wide and fitted with an automatic cleaning device. Shaking should be severe and short. Suction should be weak and couchers and presses lightly loaded so that the paper may have a thick handle. Stone rollers should be employed for the wet-press. The paper must be lightly calendered; moist calendering is not used.



Torpedo-launching tube—under-water pattern.

Industrial Militarism*

Government Training to Develope the Individual

By John Lee Mahin

None of us who believe in the objects of the Navy League can understand the viewpoint of many of our fellow citizens who are opposed to doing anything in the way of preparing to meet armed aggression which might come from an ambitious military power.

Yet, as practical men we must take cognizance of the fact that there are many very good people who sincerely are opposed to military preparedness.

We certainly can gain nothing by ridicule or condemnation of their motives. We need and are entitled to their co-operation, and I honestly believe I have a plan which will secure it. From the beginning of time human beings acting collectively have always been influenced by two very distinct and easily discernible factors:

First, a big, broad, fundamental idea that appeals strongly to their emotions.

Second, confident, aggressive, persistent, dominant and unswerving leadership.

The men who cause other people to act always appeal to their emotions.

You cannot show me a successful propaganda based on anything else than an emotional idea. Arguments and philosophical discussions divide instead of concentrating group consciousness. Confident affirmation persistently repeated invariably precedes action by the masses.

So, if we are to secure preparedness for the United States we must never forget that we are governed with the consent of the governed. A popular vote makes or destroys a political leader. Hence, we must have a plan that will appeal to the masses and an able leader capable of selling that plan to them in such a way that they will promptly respond.

If there is any question in the mind of any of you that this plan must be strong in its emotional appeal, let me call your attention to the religions of the world. All of them that have endured the test of time, all of them that have large groups of people advocating them, are ready constantly to minister to every human being, rich or poor, great or small, on the three occasions when every one is most susceptible to emotional suggestion.

The most cherished ceremonials of all who propagate the great religions are associated with birth, marriage and death. This thought deserves careful consideration. The plan that will enable the Navy League to accomplish what we all earnestly desire must have its emotional appeal.

The plan I present to you, to-day, for the want of a better name I call "Industrial Militarism."

It contemplates no radical changes in men or conditions. It does not mean destroying anything that men have worked for centuries to bring about. The plan is thoroughly comprehensive—it is big enough and broad enough to be presented to everyone as including all of his pet theories.

Briefly, it means purging the Navy and Army from any thought of aggressive militarism, focusing strongly on the idea of initiating, developing, fostering and protecting industry.

The prime object of the Army and Navy should be to discover, promote and execute the most efficient methods of training men to accomplish the best they are capable of doing in ordinary, everyday business life.

At least two hours a day should be given to the study of everything that can be learned about the military plans and equipment of every other nation in the world. We should be ready with munitions and plans to successfully oppose any offensive action by any nation. We should command the absolute protection and respect for an American citizen, anywhere he may be. None of us believe any nation has thought of taking any liberties with German citizens during the past twenty-five years. Citizenship of the United States should be as desirable as any.

We have many instances proving that the present military training at West Point develops the highest type of business capacity.

With the building of the Panama Canal came the changing of living conditions in the tropics, where formerly yellow fever was rampant, to those that are ideal from a health standpoint. This is certainly the greatest achievement of American military genius.

Men with whom I have talked and who know what they are talking about tell me that the training of the German soldier, although it is compulsory, has great economic value in making him a more efficient workman.

Careful students of economic conditions say the cost of the German army and navy is not a tax in any sense of the word, when the increased industrial efficiency of the German common soldier as a citizen is considered.

No one of those who oppose military preparedness in the United States objects to our public school system or is opposed to education.

To them we can show that industrial militarism means taking our young men from 18 to 22 years of age—when they are most susceptible—and making them the most efficient men on the face of the globe from an industrial and physical standpoint.

Industrial militarism should include the employment by the Navy and the Army of efficiency engineers who will teach men how to breathe, walk, eat, work, think and plan and do the ordinary everyday things of life as they should be done.

It should also embrace the employment of men competent to advise the young soldier the occupation he is temperamentally best suited to follow after he leaves the Army.

A certificate of a Naval or Army efficiency engineer given a young man on mustering out should enable him to secure a good job for which he has been specifically trained by men most competent to do so.

The man who voluntarily puts himself in the hands of competent instructors to learn how to do things as they ought to be done multiplies his efficiency many times. This fact alone would command the endorsement of all who now oppose a large Army and Navy on economic grounds, and I am sure will do so when properly presented.

If there is any doubt of the enormous waste incident to our present industrial system, all that is necessary for us to do is to consider conditions for a few minutes.

Simply ask yourselves how many young men of your acquaintance of from 18 to 25 years of age have found themselves and know what they can best do in life and have been convinced that persistent application to that particular thing is best for them.

Note the changes in the names on a large pay-roll in twelve months' time. The tremendous loss of energy and efficiency due to men constantly changing their jobs and not being thoroughly instructed in fundamentals is an appalling waste. Go into a grocery store and you will note that it is the exception to find a man who knows how to arrange his stock conveniently, or who uses his hands and feet in a manner that will accomplish the most with the minimum of physical effort.

In how many restaurants do you see men who know how to wait on a table, to say nothing of finding food properly cooked before serving?

The young American can learn to be a better groceryman, a better restaurant man, a better carpenter as well as acquiring a knowledge of electricity and machinery. All these talents are now developed to the highest state of efficiency in modern military establishments. It needs only the particular instruction of experts to the enlisted men on how this knowledge can be utilized in later life to make our plan of industrial militarism complete.

Industry in the good old times paid highly for military protection.

In feudal times, the farmer was protected by soldiers who were too proud to work. It is only in line with military traditions that the Navy and Army should develop industry to its highest efficiency.

If you will agree with me, as I sincerely hope you do, that industrial militarism is a big, broad, fundamental, comprehensive idea that can best solve our present problems, I will then ask your most serious consideration of the question of the leadership by which this idea shall be actually sold to the American people.

We should profit by the knowledge and the experience of our larger manufacturers who use modern merchandising methods to build up and maintain national demand for their products.

None of them depend on the intrinsic merit alone of the goods they produce.

The fact that the goods have merit must be constantly, persistently, confidently reiterated to the consuming groups.

Hence, it is necessary that the idea of industrial militarism have able, competent leadership if the American people are to have the benefit of it.

In 1896, when William J. Bryan was convincing a large portion of the American people that the free coinage of silver would eliminate the evils and preserve the good things that all of us are striving to obtain, I contributed an article to the Chicago *Record* entitled, "The Free Coinage of Labor."

In it, I said that the one thing that every human being had to give in exchange for the necessities of life—food, shelter and raiment—was his own labor, and he should always be in position to dispose of the same.

It is only the miners that have gold and certainly the increased interest that Mr. Bryan developed in silver was a good thing at that time for the owners of silver mines. Mr. Bryan possessed all the qualities of a successful leader. He has needed only ideas that would stand the test of time to make his leadership realize his ambitions.

It would be difficult for me to select a better man to sell the idea of industrial militarism to the American people than Mr. Bryan. The idea is so big itself that the people would forget any personal prejudice they might hold against the salesman of the idea. I can say the same of Mr. Roosevelt, Justice Hughes, Mr. Root, or even President Wilson, himself.

With an idea so big, so broad, so fundamental, so far-reaching as industrial militarism, any one of these men could render a public service which would insure their pre-eminence when future historians recorded the incidents of the present time.

While I have never voted anything but the straight Republican ticket, I am sure I would vote for the man who sincerely espoused the idea of industrial militarism, no matter what ticket he be on. It is my hope that the Navy League may be able to give such endorsement and support to this idea that the best man to sell it to the American people will espouse it and make it the dominant issue of the next campaign.

The only question in my mind is whether the service in the Army and the Navy should be made compulsory on the part of every young man.

Personally, I believe that modern advertising methods have proven that the Government could make service in the Army and Navy so attractive in its presentation that more young men would offer themselves than would be required.

It is certainly better to get men who will voluntarily put themselves under discipline with an intelligent appreciation of its advantages to them than to resort to conscription.

I cannot escape the conviction that plenty of men would enlist if the Government made a straight out-and-out proposition to the young men of America that in exchange for the promise to serve the country in the Navy and Army when needed, they would be given a three years' training in industrial efficiency. The offers should emphasize the fact that a young man's latent capacities would be fully developed and he would be shown by experts what line of work he was best suited to follow when he left the Navy or Army.

Certainly a young man could accept his education from the Government in exchange for a promise to serve when required, as the proposition would appeal both to his self-respect and patriotism in the strongest way.

Surely, under such a plan we would have a "trained citizenry" capable of meeting any emergency.

Some of you who know the power of advertising may ask what could the Navy and Army do with so many young men as would offer themselves under a well advertised plan of industrial militarism?

There are swamps to be drained, there are roads to be built, there are plants and minerals in all parts of the world to be analyzed, tested, and their usefulness to mankind determined.

When I was in Italy I rode in an automobile on a road that was built over 2,000 years ago. The foundation was laid so well that only a top dressing is needed to-day to keep it in the very finest condition.

We must not forget that our young men from 18 to 22 years of age are going to be fed, clothed and sheltered whether they have efficiency training or not.

Society will not get the benefit of their labor unless they are given work to do.

Somebody will support them if they do not do so themselves. There can be no question that it is an advantage to society as a whole, which we certainly mean when we speak of the Government, to see that these young men from 18 to 22 years of age are employed in a manner that insures their best industrial development.

* An address by John Lee Mahin before the Chicago Section Navy League of the United States, January 11, 1916.

Mr. Arthur Brisbane has said that the Navy and Army ought to be made self-supporting. I fully concur with him that this is a possibility.

When we realize that this could be done and the young men come out of the Army and Navy better citizens in every sense of the word, capable of producing much more for themselves and for the people as a whole than would be possible without this training, we are justified in advocating "Industrial Militarism" for industrial advantages alone.

We need it though for an entirely different reason. Certainly, no thoughtful American citizen can look across the Atlantic or Pacific without feeling way down deep in his heart that it would be well to be prepared to meet, resist and overcome every form of military aggression.

When we can equip ourselves with men who offer themselves as volunteers and have these men thoroughly trained and under legal obligation to give their services when needed and at the same time raise the standard of our physical and industrial manhood higher than we could possibly do without it, there seems to be absolutely no reason why we should not have industrial militarism and insist on doing so at once.

Do you not agree with me that the statesman who would make industrial militarism his dominant plan, and who has the capacity to sell the idea to the American people, could at this time serve this country better and make his place in history more secure by doing so than by anything else?

Evolution in Shipbuilding—II*

The Wonderful Progress of the Past Century

By A. C. Holzapfel, M.I.N.A.

Concluded from Scientific American Supplement No. 2095, Page 131, February 26, 1916

Since the beginning of this century several very rapid steps in the advance of the size of ships have been made. The first, by the building of the "Lusitania" and "Mauretania" for the Cunard Company, which marked a striking advance in size and speed; and the next, in the building of the "Olympic," which went forward at one bound to the extent of a further 10,000 tons; and subsequently of the "Imperator," "Aquitania," and "Vaterland," the latter being some 14,000 tons larger than the "Olympic." The speed also of these vessels was considerably increased, and the comfort and elegance of passengers' quarters reached a development which has aroused the admiration of the traveling public. Whether these huge vessels will prove to be a good investment at the end of the present war is a serious problem, no doubt occupying the owners at this time.

A remarkable development which took place in the United States is that of the navigation of the Great Lakes. Few people realize what an enormous traffic takes place here and to what wonderful perfection and economy of time and money it has been developed. The size of the vessels almost rivals the large ocean liners, and they are in every way adapted to their work of economically transporting large quantities of grain, coal, iron ore, and other goods.

In construction these vessels are mainly built on the lines of sea-going vessels, except that their scantlings are slightly reduced owing to the lesser stress of the seas on the Lakes. But the arrangements for their rapid loading and discharge are unique, and excel in speed and economy those in any other part of the world.

On a recent journey to Green Bay, a friend showed me his arrangements for discharging coal from Lake steamers, and I found the cost of discharging per ton is about one tenth of the cost which the shipowner has to pay for discharging coal in London. In the latter case, the receiver of the goods who undertakes the discharge probably makes a profit, but the actual amount of labor expended in the operation on the Lakes is infinitely less than in any other part of the world, and the dispatch is three to ten times better. The cost of transport from Buffalo to Green Bay, 35 cents per ton, would produce severe hysteria among European shipowners.

Warships also began to develop rapidly in size, the first step in that direction being the "Dreadnought," of 17,200 tons, which has since culminated in a vessel of 32,500 tons, built for the Brazilian navy, and since acquired by the British government. At the International Congress of Naval Architects in Paris in 1900, I submitted a paper in conjunction with Mr. Frank C. Goodall, surveyor of shipping to Trinity House, London, under the name of "The Battleship of the Future," in which we proposed battleships of 30,000 tons having a complete steel armor belt of 20 inches in thickness, our intention being to make these ships invulnerable to gun-fire, either from other warships or from shore batteries. We did not propose the increase of speed which has since been realized in the "Dreadnought" type, but we aimed in our paper at one thing only, that is, complete protection from gun-fire. The vessel we proposed had a length of 600 feet and a beam of 100 feet, and a speed of 17 knots, at that time the usual speed of battleships in Europe. Our paper was unfavorably criticised at the time by Mr. Martell of Lloyd's Register, Lord Brassey, and other gentlemen, but a similar proposal was again made two years ago in a paper by Gen. Cuniberti, late chief constructor of the Italian navy and the reputed father of the "Dreadnought" type.

Gen. Cuniberti proposed, under the name of the "Invulnerable," a battleship of 27,000 tons with an armor belt of 16 inches, which he considered practically proof against the heaviest modern artillery, but I think in this he did not err on the safe side, and in view of the 15-inch guns since constructed, I would still suggest an 18-inch or 20-inch belt. Last June, Prof. Biles, at Newcastle-on-Tyne, proposed to armor-plate the bottom of ships with armor to be proof against torpedoes from submarines and other craft, and against submarine mines. The thickness of armor which he proposed was 4 inches, but I consider this would be hardly enough to secure immunity from the high-power explosives of a submarine torpedo striking 10 to 20 feet below the water surface. I then came to the conclusion that it is possible to build battleships which shall carry a 12-foot belt of 20-inch armor from stem to stern, giving them immunity from gun-fire above water as high as the armor belt reaches, having turrets or gun shields of the same thickness, and below the 20-inch belt of armor 5-inch armor plating reaching down to the bilges. Such a vessel need not necessarily have a high rate of speed, but she would probably be proof against gun-fire, submarines and mines, and could enter a fortified port with comparative impunity. The only danger to which she would be exposed would be large shells from howitzer batteries, but it is very problematical whether the aim of such batteries would be accurate in regard to rapidly-moving objects like a war vessel. If the battleship is to survive at all after this war, I expect it will have to assume this sort of shape, as the present type of battleship seems to be doomed.

I find that a vessel of 600 feet in length, 110 feet beam, and drawing 25 feet of water could be built, which would displace 31,500 tons on a coefficient of 0.68. To give her a 12-foot armor belt 20 inches thick to reach 4 feet underneath water and 8 feet above water, and to give her 5-inch armor plating from the bottom of the belt to the bilges, would take a weight of about 12,000 tons of armor plating, leaving about 19,500 tons of displacement available for the rest of the hull and superstructures, machinery, turrets, guns, coal, etc. My suggestion is that such a vessel might be built with moderate speed of 17 or 18 knots, and she could destroy anything that came within range of her guns, and would be indestructible and invulnerable, except possibly by the ram of a very heavy vessel. She could also invade fortified ports regardless of submarines, mines and torpedoes, and destroy the shipping in such ports and give the crew a sense of security which does not exist at present on our modern warships. It has been shown that the young officers commanding submarines are governed by such indomitable pluck that they readily risk their lives to attack large vessels whenever an opportunity offers. There can be no doubt but that, in view of recent developments, the building of submarines will increase to such an extent that the battleship and large cruiser of the present type, unless made proof against mines and torpedoes, will be practically doomed.

I think it would not be out of place to also refer to the wonderful results as to speed obtained from torpedo boats and destroyers. These small vessels had attained remarkable progress even twenty-five years ago, when Yarrow, Thornycroft and Schichau evolved this type in the form of torpedo boats. In attack on large vessels torpedo boats have so far been singularly unsuccessful, while their employment as scouts, particularly with the aid of wireless, has been of much greater importance.

The question of evolving a hydroplane or glider suitable for naval scouting has occupied many minds. This has, in the meantime, taken the shape of the hydro-aeroplane. At the same time I believe, in fact I know from experiments which I have made myself, that it is not impossible to construct ship-shaped craft with very high engine power which will rise on the surface of the water and glide over it at a very great speed. Such craft could be used even now on many rivers, lakes, and estuaries where the sea is comparatively calm, and I think they would also be capable of considerable further evolution. This may be driven by water propellers or by air propellers, and offer a suitable field for further experimentation to the naval architect. I think it will be conceded that the evolution from the sailing ship of a hundred years ago to the present type of cargo, passenger and war vessels, and the advance in speed, size and comfort are absolutely unique in the history of this world, and testify to the wonderful ingenuity possessed and the large amount of strenuous work accomplished by naval architects and engineers.

* From the *Shipping World*.

Copper Refining in 1914

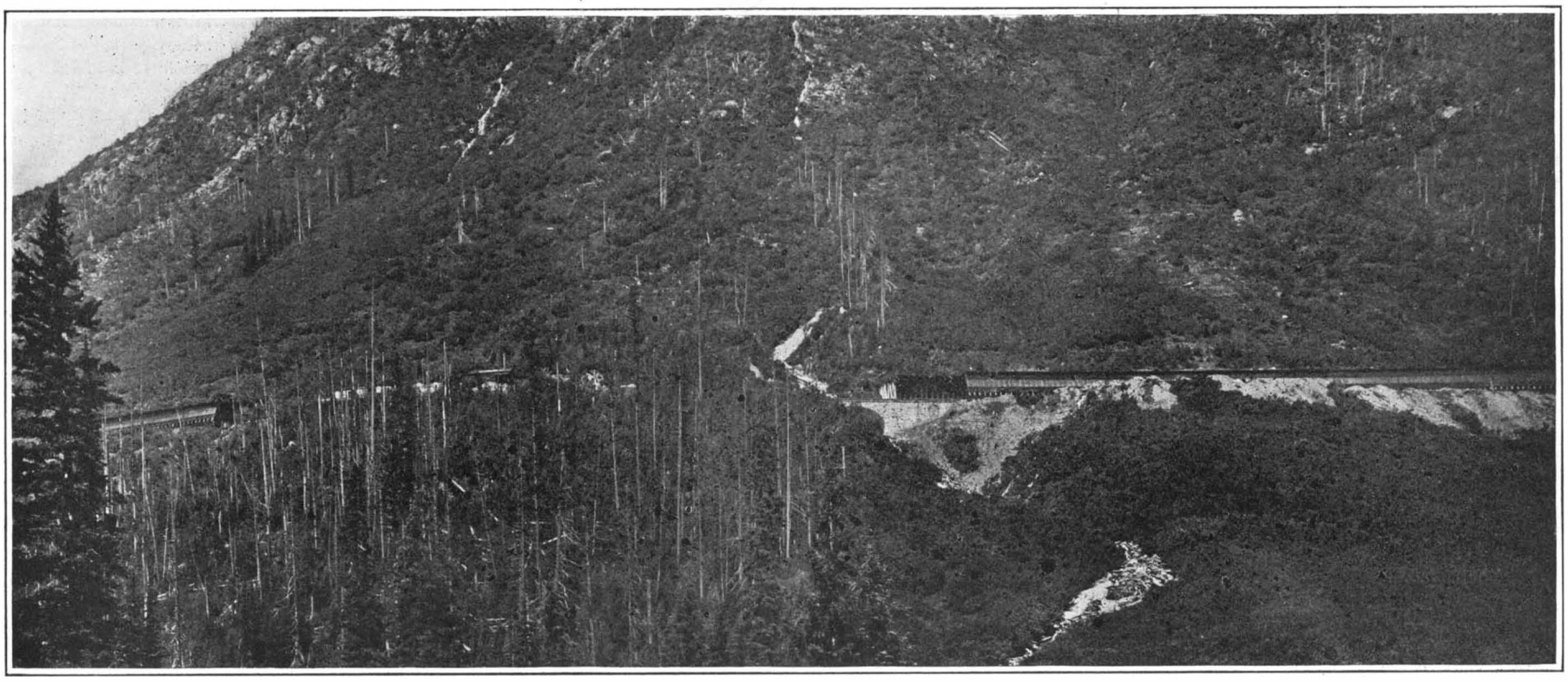
As for some years past, much attention was given during 1914 to improvement in metallurgical practice. Within the last few years many of the smelting plants of the country have been remodeled or entirely new plants have been built. A notable feature of this reconstruction has been the increase in reverberatory furnace capacity, with corresponding decrease in blast-furnace capacity. Perhaps the most important metallurgical change introduced in 1914 was the installation of flotation plants in concentrating mills. These plants have been most successfully employed, both in the cleaning of concentrates produced by the usual wet methods, and in the treatment of certain of the mill products, in which products the losses by the methods previously in use were heavy. The use of the flotation process in the treatment of copper ores will probably be largely increased in the next few years. The development of leaching processes, which has received much attention for some time, was actively carried on during the year by several companies, and plants are now in process of construction that will employ this method both for the treatment of low-grade oxidized ores hitherto unavailable and for the recovery of additional copper from the material treated by other processes that has hitherto been discarded as tailings.

Both domestic consumption and export of copper showed a marked decrease, and in spite of the decreased output there was a considerable increase in the stock of refined copper at the close of 1914, as compared with 1913.

The outlook for the immediate future in the industry is so closely dependent on conditions that cannot be foreseen, that any prediction is of little value. Important new producers will enter the field in 1915, notably the Inspiration Consolidated Company, of Arizona, and the White Pines Company, of the Lake district. Many of the older producers are prepared to make larger production than ever before, and if there is demand for the metal the output can be largely increased. During the first half of 1915 there was a steady improvement in market conditions and in production, and by the close of the half-year period production was probably about normal.

At the outbreak of the war the copper producers, with promptness and keen foresight, curtailed production to meet changed conditions, and it is reasonable to expect that the future production will be largely controlled by demands for the metal.

In July, 1914, the Copper Producers' Association discontinued the publication of monthly statistics of production, domestic deliveries, export, and stocks of marketable copper, and later the association disorganized. This association was formed in 1909, and since that time had published monthly statistics. It is hoped that some new organization may be formed, by which not only the condition of the producing but also that of the consuming end of the industry shall be reported at frequent intervals, so that there shall be no undue advantage, but rather a mutual helpfulness in regulating the industry to the best advantage of all concerned. —*Mineral Resources of the U. S.*—Part I (Dec., 1915).



Some of the long stretches of snowsheds that will be eliminated by the new tunnel.

The Longest Railway Tunnel in America

The Roger's Pass Bore Through the Selkirk Mountains in British Columbia

On October 21st, 1880, the Canadian Pacific Railway Company signed a contract with the government of the Dominion of Canada to build a railway across the prairies and through the Rocky Mountains to the Pacific Coast. The contract called for completion in ten years' time. This was deemed by many an out-and-out impossibility, owing to the topography of certain sections of the country and the inaccessible nature of the right-of-way for the supply of construction materials. By many, also, the project was pronounced a useless enterprise, to go down in history as one of the greatest blunders of the new Dominion. The country through which much of the railway would pass was believed by many to be a land "where nothing—not even a blade of corn—will ripen."

To the surmise regarding the engineering impossibility of the project within the time limit, it is a remarkable and equally creditable fact that trains passed from tide-water to tide-water in November, 1885, and that during the year fixed for the completion of the contract, the line earned $20,000,000 for the builders. This latter accomplishment answers in a measure the traditional rumors of foolhardiness and blunder, as have likewise the annually increasing earnings of the company. During the past five years the gross earnings have amounted in round numbers to $10,500 per mile. The mileage of the line, as it stands at the present day, including branch services, amounts to 12,917 miles.

The speedy construction of the line in the early eighties necessitated a considerable amount of temporary work. The judgment of this has been fully warranted, first in the matter of early operation and later by realization of a large saving in first cost and interest and a correspondingly large sum in ultimate cost.

It was to have been expected, therefore, that increasing trade, with its resultant changes to rolling stock and right-of-way, would see in the past thirty years many millions spent in grade reductions, in the erection of permanent structures and in the development of better terminal facilities. It is doubtful if there is in America a better illustration of what may be done in the way of grade reduction in mountainous regions than the improvement of the line in British Columbia. It has involved the construction, some six years ago, of one of the most interesting systems of tunnels in existence, and also the construction, now under way, of the longest tunnel on the continent. We refer in the former instance to the spiral tunnels in the valley of the Kicking Horse River, and in the latter to the Roger's Pass tunnel that is being driven through Mount Macdonald in the Selkirk Range.

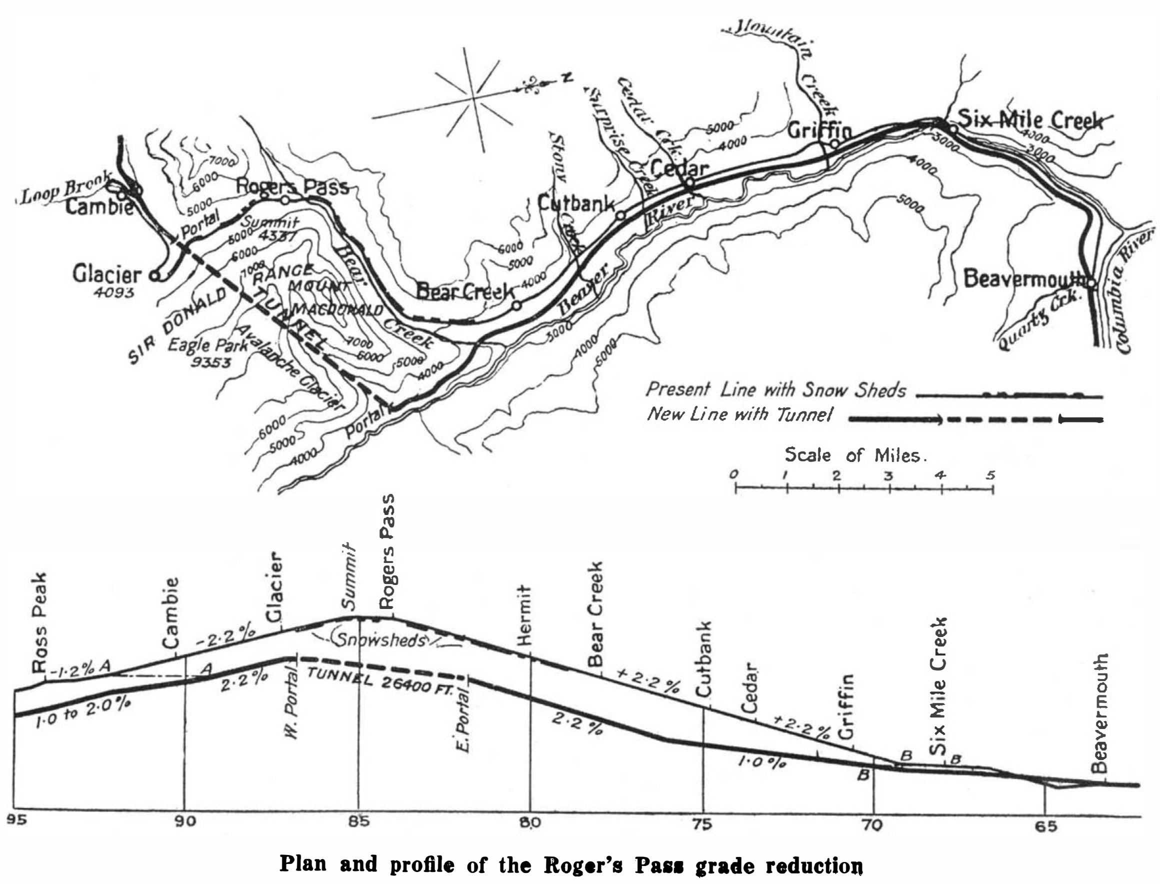
Prior to 1908 Hector and Field, B. C., were separated by such extreme grades that four 154-ton consolidation (2-8-0) locomotives were required to haul a trainload of 710 tons of freight over this section of the main line. For about three miles a grade of 4.5 per cent prevailed, decreasing to 4 and 3.5 per cent for the remainder of the distance. These grades involved the use of spring switches at different points along the line for the purpose of safety. Unless the engine driver of a descending train signaled to the switchman that his train was under control, the normal setting of one of these switches would divert the train to a catch siding.

Increase in the density and extent of traffic made grade reduction practically a necessity. The main line now traverses the valley of the Kicking Horse River between these two stations with an increased length of 8.2 miles and a maximum grade of 2.2 per cent (compensated).

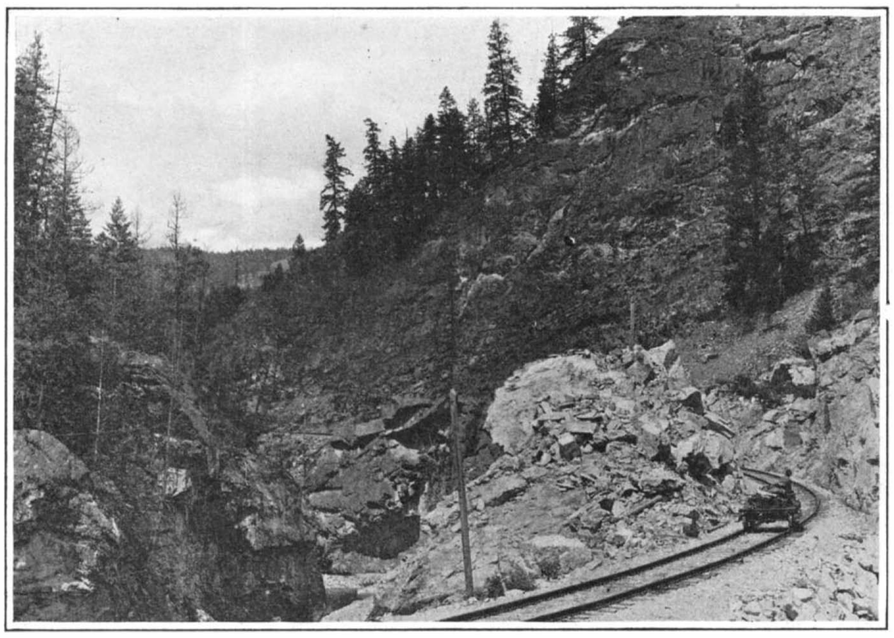
This development of length was rendered a difficult problem, owing to the steep mountain sides on either bank of the river. The only solution lay in tunneling a loop on each side and in the construction of bridges. The driving of these spiral tunnels has been regarded by many engineers as one of the most interesting engineering features of the whole Canadian Pacific Railway improvement. Tunnel No. 1 is 3,206 feet in length, turning an angle under Mount Stephen of about 234 degrees on a 573-foot radius with a grade, as reduced by compensation, of 1.6 per cent, producing a difference of level at the portals of 48 feet. Tunnel No. 2 has a similar radius of curvature through an angle of 232 degrees. It is 2,890 feet long and the grade produces a difference in elevation of about 45 feet at the two portals. Thus the road now traverses the valley by three lines at different elevations. It crosses and recrosses the river by four bridges. The improvement further necessitated the driving of a 170-foot tunnel, this one on a tangent, before connecting with the old line near Field. With the gradients improved to this extent, two engines of the same class as the four previously used can haul 980 tons of freight up the valley.

The spiral tunnels were driven through crystallized limestone of a widely distorted nature. In places, the stratification would vary from nearly horizontal to almost vertical, and in others from normal to almost parallel with the direction of the center line. The hardness and brittleness of the rock varied every few feet, rendering drilling operations difficult. Water seepage through the rock crevices hampered progress on the down-grade ends of each tunnel, while the high altitude (about 5,000 feet) and severe winter weather added to the adverse conditions under which the task was so successfully accomplished.

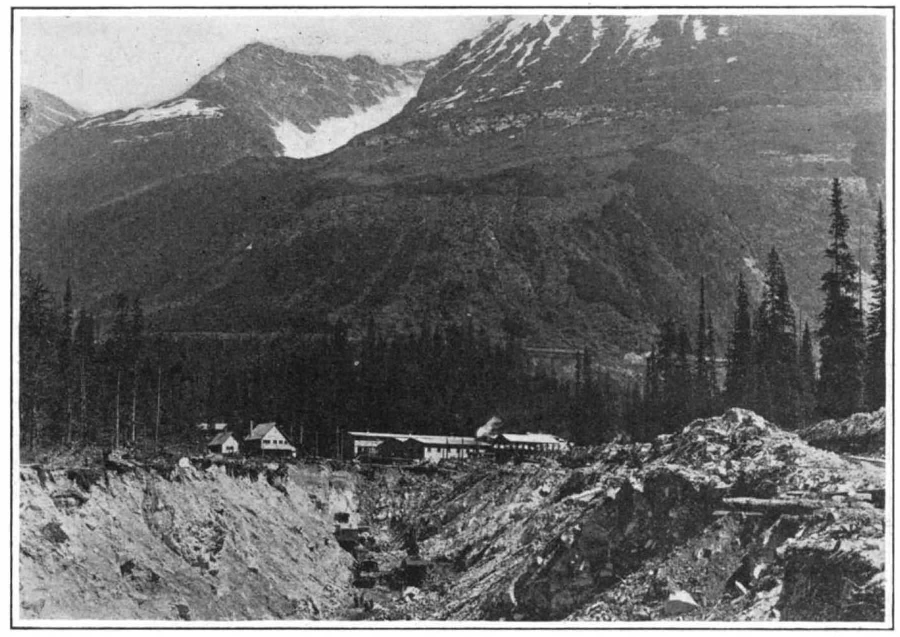
About 85 miles west of Field, there is at present under construction a double-track tunnel through the Selkirk Range of mountains in British Columbia. The driving of this tunnel is making itself a prominent place in the annals of notable engineering achievements. From portal to portal its center line will measure 26,400 feet, thereby exceeding by three fourths of a mile the longest existing tunnel in America. The method



Plan and profile of the Roger's Pass grade reduction



Temporary track on approach to the tunnel.



Eastern approach to the tunnel, present line in distance.

by which it is being driven involves the tunneling of a "pioneer bore" paralleling the center line of the main tunnel. This feature is new and the interest of tunnel engineers has naturally been aroused the world over. Its adoption arose from the keen desire to have the undertaking finished before the close of 1916. There is now no doubt that this aim will be achieved. The world's tunneling records have been repeatedly broken, and the progress made has certainly vindicated the adoption of the pioneer heading method.

The estimated $12,000,000 expenditure connected with this undertaking is another indication of the efforts that are being made to eliminate grades and snow troubles that have for years gone hand in hand with Western railway operation. The tunnel will bring down the summit elevation of the Selkirk portion of the line from 4,330 feet to 3,791 feet. It will reduce the length of maximum grade from 22.15 miles as at present to 6.61 miles, the maximum grade, 2.2 per cent, remaining the same. It will dispense with about four miles of snow sheds in a length of thirteen miles of main line. It will incidentally reduce the length of the line by about four and a half miles. The total curvature will be considerably reduced and several loops eliminated. Thus, while the maximum trainload will remain the same, the operating conditions will be much more favorable in consequence of the lower elevation, the shortening of the grades, and the reduction of expense and delay in the season of snow. In short, one of the most costly sections, from an operating point of view, of the whole system will be entirely eliminated. The large force of pusher engines, snow ploughs and equipment shops, that have necessarily carried on a busy existence at Roger's Pass, in service on both sides of the Selkirk Range, will have to seek ranges anew.

The tunnel, with a bearing under Mount Macdonald of south 38 degrees 11 minutes west, is being constructed on a tangent throughout its entire length of five miles. The maximum depth of rock above it is 5,690 feet. For about 1,100 feet at each end the material encountered is clay and boulders, the balance being solid rock, mica, schist and quartzite. Throughout the softer materials the tunnel is being lined with concrete. The finished section will be 24 feet high by 29 feet in width.

The pioneer heading is for the greater part of its length about 45 feet from the center line of the main tunnel, with its grade, for the most part, 10 feet above the subgrade of the latter, although the western portal is 135 feet and the eastern portal 53 feet above grade. Its headings are 7 feet by 8 feet, and each extends from its portal along the right side of the center line of the tunnel except in the central portion where the pioneer headings, about a mile apart, are carried over to the center line and are continued as the center heading. Cross cuts from these headings to the line of the main tunnel are being made every 1,500 feet or so, and drifts from each cross cut are being driven in both directions. The driving of the main tunnel is thus being accomplished at a large number of headings simultaneously. In addition, the main tunnel work was advanced from each portal. The initial heading is being made as an 8 feet by 11 feet center heading and the enlargement operations follow closely.

The main object sought by the contractor through the construction of this pioneer drift was the securing of increased speed in the tunnel excavation and a decrease in the expense, through ability to attack the excavation at several points at the same time and permit of the continuous operation of the shovels without danger of breaks in the air lines, or serious interruptions from other causes. The saving of time in this construction is considered very important by the railroad, as well as by the contractors; and a value has been placed by the railroad for each day saved. The contractor anticipates that this method of construction will result in such a saving of costs in the tunnel excavation that the saving, when combined with the time bonus received, will exceed the cost of the pioneer drift.

Early in August of 1914 the pioneer headings were completed to the points where they were carried over to the center line, and on August 15th they only were 4,920 feet apart. About 2.95 miles of the center heading has been driven and 1.69 miles of the enlargement completed. Concrete lining of the earth sections will be finished before the end of the year.

Besides necessitating about eighteen miles of new track, the tunnel project involved, in its preliminary stages, a 900,000-cubic yard fill in the center of the Illecillewaet River valley, extending westward for a distance of one and one half miles. Between this hill and the west portal there is a 300,000-cubic yard cut, the entrance being at a level of about 80 feet below the ground surface. In the east end there is another approach cut of about 100,000 cubic yards.

The work, commenced in June, 1914, will probably be completed in September, 1916, several months before the time stipulated. It is being carried out under the direction of Mr. J. G. Sullivan, chief engineer of Western Lines for the Canadian Pacific Railway. Mr. H. G. Barber is the engineer-in-charge.

Notes on the History of Coal in the United States

The earliest mention of coal in the territory which afterward became the United States is recorded in the journal of Father Louis Hennepin, a French missionary, who in 1679 recorded the site of a "cole" mine on Illinois River, near the present city of Ottawa, Hennepin having passed through that region ten years before. The next mention of bituminous coal in the United States territory is in the writings of Col. William Boyd, who in a report made to the Virginia Assembly in 1701, mentioned the discovery of coal in what is now known as the Richmond Basin, near Richmond, Va. The first actual mining of coal was from this Virginia locality. Authorities differ as to the date the first coal was mined, but it was some time between 1720 and 1750. During the revolutionary war the mining of coal in the Richmond Basin was a comparatively important industry. Ohio probably ranks second in priority of production, as coal was discovered there in 1755, but the records of production date back only to 1838. The earliest record of coal mining in the bituminous regions of Pennsylvania is for the year 1760, five years after the discovery of coal in Ohio, when Capt. Thomas Hutchins visited Fort Pitt (now Pittsburgh) and found a coal mine on the opposite side of Monongahela River, the product being used by the resident garrison. In 1768 the Penn Proprietaries purchased from the Six Nations the whole of the bituminous coal field of Pennsylvania except that portion which lies northward of Kittanning, which was purchased sixteen years later. The mining of anthracite began in the last half of the eighteenth century. Its earliest discovery was in 1762 when settlers from Connecticut found "stone" coal in the Wyoming Valley. The first use of it, so far as known, was made in 1768. It was first used in a forge in 1769. Mining may be said to have begun near Pittston in 1775, and in 1776 to 1780 anthracite was mined on the banks of Susquehanna River near Wilkes-Barre and shipped by barges to Carlisle and Columbia. Anthracite was used in making nails in 1788, all of these instances occurring in the Wyoming region, the discovery of coal in that region having antedated the discovery in the Schuylkill region by twenty-eight years. In 1807 a shipment of 55 long tons of anthracite was made by Abijah Smith & Co., from Plymouth to Columbia, and it is estimated that from 1807 to 1820, when the first shipments were made from the Lehigh region, about 12,000 tons had already been shipped from the Wyoming Valley. Coal was discovered in the Lehigh region in 1791, and the first anthracite company, the Lehigh Coal Mining Company (now the Lehigh Coal and Navigation Company), was organized in 1792. In 1820 the shipments from the Lehigh region began, thirteen years after the first shipments were made from the Wyoming region. In 1814, six years before the Lehigh region was opened, some coal was mined at Carbondale and shipped *via* Lackawaxen and Delaware rivers to Philadelphia. The records of the bureau of anthracite statistics began in 1820, when the first rail shipments were made from Lehigh region, one long ton for each day of the year. In addition to having the credit for priority of discovery and mining of anthracite, the Wyoming region, although the latest of the three large regions to report regular shipments of coal, has contributed considerably more than one half of the total quantity of coal sent out of the anthracite fields of Pennsylvania.—*From a Report of the United States Geological Survey.*

Spots Before the Eyes

The prevalence of this condition has given rise to a great many curious ideas. Almost everyone either sees fixed or floating spots at times, or hears some friend complain of these conditions, so that it is not strange that many popular misconceptions have arisen. The commonest form of floating spots are those which are known by the name of muscae volitantes, an old name which indicates how long the condition has been observed. These are tiny transparent chains, or strings, which are seen especially on a white or brightly illuminated field. They persistently float in the line of vision, and though a shake of the head may carry them out of the way, they at once float back again. These spots are probably caused by the remains in the fluid part of the eye of certain cells which should have been completely absorbed in the development of the eye. They never lead to impairment of vision, and, as before stated, are perfectly transparent. Other floating spots are due to cobweb-like masses of inflammatory material which are thrown out into the fluid of the eye by some low-grade inflammation. These spots usually obscure the vision, which is their great point of difference from the former ones. It is, of course, very important to find out in any case whether the spots are due to inflammation or not, and this can only be done by a skilled observer. It is a prevalent idea that the wearing of a dotted veil may leave permanent spots in the field of a vision. While the dotted veil may be a source of strain by causing the wearer to pull on the eye muscles in order to avoid the obstruction of vision, it certainly is not the case that the dots, or any other object seen, can be permanently photographed on the nerve tissues of the eye. There is only one exception to this statement. Many people who have carelessly looked too much at the sun, generally in observing the eclipse, have actually produced a slight inflammatory change in the retina, so that there is always a blurry spot wherever they look. But it is doubtful if any light less brilliant than the sun can produce a permanent spot, and certainly a dark object can not do so.—*Journal of the American Medical Association.*

Signaling Among the Ancients*

Various Methods That Were Employed on Land and Sea

By Commander Hon. Henry N. Shore, R.N.

Considering the amount of thought and attention bestowed on the art of war by the ancients, it is strange that so little information regarding the methods of transmitting orders among their armies and fleets should have filtered down to modern times. For, as the Greek historian, Polybius, who lived in the second century, B. C., very justly observed, "opportunity is of great advantage in all things, but especially in war; and among the several things which have been invented to enable men to seize it, nothing can be more conducive to that end than signals."

The earliest recorded means of conveying intelligence rapidly over great distances was by the human voice. Thus, when the King of Persia invaded Greece (480 B. C.) he is stated to have posted sentinels at suitable distances apart, the whole way from Susa to Athens, by which means news could be transmitted at the rate of 450 miles in forty-eight hours.

According to Cæsar, the same method was in use among the Gauls, who, he tells us, when desirous of transmitting important intelligence, or in need of help, shouted the news from place to place; and that thus, the massacre of the Romans in Orleans, at sunrise, was known at Auvergne, 120 miles away, between eight and nine o'clock the same evening.

Obviously, such a method would be liable to interruption by weather. But, as human life was little accounted among the ancients, the normal line of shouters would, doubtless, be supplemented when need arose.

A proposal is said to have been made to Alexander the Great (356–323 B. C.) by a native of Sidon, for establishing an "infallible method" of communication between Greece and his remotest conquests in India within the space of five days. The king, however, regarding the proposer as an impostor, declined even to consider it—the fate of many a valuable suggestion in our own times.

Another method, which originated in the mists of antiquity, was by means of pigeons. It is related by Pliny, that when the city of Modena was besieged by Anthony, he sought to prevent all communication with the outside world by drawing lines round it, and stretching nets across the river. Decimus Brutus (d. 43 B. C.), who was in charge of the defense, was able to laugh at these precautions, by using pigeons, to whose feet letters were fastened, which duly reached their destinations. "Of what use were Anthony's entrenchments and sentinels, and of what service were all the nets he spread," asked Pliny, "when the new courier took his route through the air?"

The Chinese, as is well known, have utilized the service of pigeons from remote times, for transmitting the names of successful candidates at the great Provincial Competitive Examinations, to their native places, using a small whistle of bamboo, attached to the bird, for the purpose of frightening off hawks and other enemies *en route.* Pigeons were also used by the merchants of the Levant, as recorded by Chaplain Teonge, in his quaint diary, for announcing the arrival of ships, to their agents inland. The British Navy, in fact, was the last to make use of the "pigeon-post," previous to the introduction of "wireless."

By far the most popular—because the most reliable—method of transmitting intelligence among the ancients was, however, by fire signals, the earliest recorded use of which is attributed to the Greeks; which shows, to quote from a very old writer, "to how great a perfection they had carried all the parts of the noble art of war, the judicious reflections they had formed in all things relative to it, and the astounding progress thay had made."

This method has even been traced back to fabulous times. Thus, when the fifty daughters of Danaus—the mythical founder of Argos—murdered all their husbands in one night—except one; the solitary survivor, having fled to a place of safety, communicated with his wife, who had also fled, by means of fire-signals. Agamemnon, also, on setting out for the Siege of Troy, promised to announce its fall by fire-signals, which he duly accomplished—one of the lady sentinels, appointed to watch for the signal, complaining of having passed several tedious nights on the look-out.

For details concerning this system of signaling, we are indebted to the Greek historian, Polybius, whose somewhat discursive treatise on the subject was first placed before the modern world by the distinguished French writer, M. Rollin (1661–1741).

The earliest method of using fire-signals was confined to the transmission of a very limited number of prearranged messages, which, as pointed out by Polybius, "was of very little advantage, because of its too great simplicity."

Æneas, a contemporary of Aristotle, in a treatise on the art of war (about 360 B. C.), described an improved method by which a greater variety of signals might be made. The device was as follows:

Two earthenware pots of cylindrical form, about four and a half feet deep and a foot and a half in diameter, were filled with water, on top of which floated in each vessel a piece of cork of a diameter rather less than that of the cylinder, so that it could travel up and down, as the height of the water varied. Into each cork was fixed an upright stick, divided into three-inch spaces, in each of which was written "such events as generally happen in war"—such as the movements of troops, ships, etc. A tap was provided at the bottom of each cylinder, for the purpose of running off the contents. And, finally, the two complete apparatus were tested, the one against the other, to ensure an exact correspondence, both in respect to the markings on the sticks and in the still more important matter of the rate at which the water flowed when the taps were simultaneously opened; so that, at any moment, the markings on the sticks exactly agreed.

The vessels having been taken to the appointed places and all being in readiness, the operator at the transmitting station displayed a torch, or light, until answered in like manner by the distant signalman, to signify his readiness to receive the message; whereupon the transmitter lowered his torch, and the taps were opened in each apparatus, simultaneously. As the water escaped, the sticks descended in the cylinders, until the space whereon the desired message was written had reached the top of the cylinder. The tap was then closed by the transmitter, who, at the same time displayed a light, as a signal for the receiver to close his tap and read off the message.

This method, though an improvement on the earlier one, was still far too circumscribed to meet the varied requirements of war. Accordingly, as time went on, another method was devised, which met with the approval of Polybius, who is described by his modern interpreter as a "great soldier." As the system he advocated was employed in mountainous countries, we may suppose that it represented the "last word" in signaling among the ancient Greeks.

Briefly the system was alphabetical, thus enabling any message to be transmitted, and was worked as follows: The letters of the alphabet were set out, in regular sequence, in five columns on a board, lights being displayed from behind screens to denote, first, the column in which the first letter of the word was to be found; and, secondly, the position of the letter in the column. The method of working the lights was somewhat complicated, requiring the assistance of four men, disposed behind two screens—two men to each, set up several feet apart. Thus, supposing the first word of the message was "AM": the men behind the left-hand screen, whence the column in which the letter occurred was first transmitted, held up one light, to denote the first column. This being answered by the distant station, the position of the letter in the column was denoted by a single light displayed from the right-hand screen; and on this being answered, the men on the left showed three lights, to denote the column in which M was to be found, and so on, until the entire message had been spelt out.

The better to enable the signalers at each station to discriminate between right and left screen, in default of telescopes, they were provided with what Polybius calls "a geometrical instrument with two tubes," which is thus interpreted by M. Rollin, with the aid of M. Chevalier, mathematical professor in the Royal College at Paris:

An upright post is driven into the ground and provided at the top with a pin, on which a cross-bar works, as on a pivot horizontally. At each end of the cross-bar a small metal tube, a few feet in length, is fixed horizontally at right angles to the bar; each tube being exactly parallel to the other, and in the same plane. When the signal station has been prepared, the "geometrical instrument with two tubes" is set up, in such a position that the right and left tube align directly on the right and left screen of the distant station. An observer is stationed at each tube, and by carefully watching the opposing screens reads off the signal lights. Needless to add, each signal station is provided with one of these instruments.

For the more accurate working of this instrument, M. Chevalier tacks on several rather intricate adjustments, which if one may hazard the opinion had no place in the original. t was a cumbersome system, at best.

Here, then, in a signaling appliance in use among the Greek armies more than two thousand years ago, we have the undoubted prototype of the Morse alphabet, combined with Colomb's Flashing Lights. And the question at once suggests itself—why were not flags used for day signaling? Neither Polybius, nor his modern interpreter, even mentions such things.

A curious and, it is believed, authentic instance of the practical application of the torch system of signaling to war, early in the seventeenth century, is described in the life of a certain Capt. John Smith.

According to Smith's own statement, the Turks were besieging the town of Olumpagh—wherever that may be—so straitly as to cut it off from all intelligence and hope of succor. At this juncture Capt. Smith arrived on the scene, and informed Baron Kisell, who was desirous of communicating with the governor of the beleaguered town, that he had taught the latter "such a rule, that he would undertake to make him know anything he intended, and have his answer." All Capt. Smith requested was that they "would bring him to some place where he might make the flame of a torch seen to the town. Kisell, inflamed with this strange invention, forthwith gave him guides, who in the dark night brought him to a mountain, where he showed three torches equidistant from each other, which plainly appearing to the town, the Governor presently apprehended, and answered again with three other fires in like manner; each knowing the other's being and intent." The Captain goes on to state that, though distant seven miles, he signified to the Governor these words: "On Thursday at night I will charge on the east, at the alarum, sally you." To which the Governor replied he would.

The captain then proceeds to explain the method of transmitting the signals, which seems to have been in accordance with the system already described.

The following stratagem, by means of which the relief of the garrison was effected in the face of a much superior investing force, due to the inventive genius of the English captain, is so curious as to merit notice.

Baron Kisell, the relieving general, being doubtful of his ability—with but half the number of the enemy's force—to effect his object, Capt. Smith pointed out that "two or three thousand pieces of match fastened to divers small lines of an hundred fathom in length, being armed with powder, might all be fired and stretched at an instant before the alarum, upon the plain of Hysnaburgh, supported by two staves, at each line's end, in that manner, would seem like so many musketeers."

The proposal was carried out, and the Turks "prepared to encounter these false fires, thinking there had been some great army, while Kisell with his 10,000 men entered the Turks' quarters, who ran up and down as men amazed, it was not long ere the Governor of the town was pell-mell with them in their trenches; in which distracted confusion a third part of the Turks were slain, many of the rest drowned, but all fled."

One is glad to know that the Englishman, at whose suggestion this very successful *ruse de guerre* was adopted, received a substantial reward, as well as "preferment to be captain of 250 horsemen, under the Earl of Meldritch."[1]

Of the origin of that particular method of signaling known as the semaphore, nothing very definite seems to be known, beyond the fact of its great antiquity. Its use is stated to have been "revived" by the French at the time of the Revolution.[2] Learned men tell us, moreover, that the name by which the system is known in this country was conferred on it by Admiral Sir Home Popham, and they further ease their consciences by disclosing the fact that it is derived from two Greek words, signifying, respectively, a *signal,* and *to carry, or bear.* The British Admiralty adopted the system from the French, thus superseding the cumbersome method hitherto in use, consisting of an enormous frame containing six movable shutters.

And what of marine signaling? The ancients must have had some means of transmitting messages afloat.

*The *United Service Magazine.*

[1] "The True Travels, Adventures and Observations of Capt. John Smith, into Europe, Asia, Africe and America, from Anno Dom. 1593 to 1629."

[2] As an instance of the absurd claims that are put forward on behalf of inventors, it may be mentioned that, in a biographical notice of Commander James Spratt, R.N., it is stated that he was presented with the Silver Medal of the Society of Arts, May 30, 1809, for his invention of a "Homograph or mode of communicating at a distance by particular positions of a handkerchief," which contrivance, it is further stated, "formed the groundwork of the semaphore afterwards adopted throughout England and France." In the "Century Dictionary" homographic is defined as "so related, as two figures, that to any point in one, only one point in the other corresponds, and vice versa." Homography, as "the relation between homographic figures."

It would have been impossible to maneuver the vast armadas they were wont to assemb e for war purposes, without some ready method of conveying orders—especially in battle. Pigeons would have been useless, and while "shouting-signals" might sometimes have answered, in the close order obtaining among the fleets of ancient days, the human voice would have been useless amid the din of battle, or in storm. History, however, is reticent on the subject.

In considering the means of transmitting messages in ancient times, whether ashore or afloat, the question of visual power must not be ignored. There is every reason to believe, indeed, that the visual sense, in former times, was much superior to what we find among the highly civilized nations of the present day. Few people, moreover, outside the ranks of experts, seem to realize how widely the power of vision differs among individuals, and the extent to which this sense is governed by conditions of life. It is easy to understand, however, that people whose lives are passed in wide, open tracts of country and clear atmosphere, where long-distance vision is in constant demand, would develop powers of sight which must appear a'most miraculous to town-bred folk whose visual organs are seldom taxed beyond the recognition of a friend across the street.

In the course of our South African wars, for example, many instances have come under notice of quite abnormal powers of sight among natives—both white and colored. Apropos of which may be cited the case of a young negro, mentioned by Dr. Lindsay Johnson at the Institute of Ophthalmic Opticians, some years ago, who was found, on examination, to possess four times the normal sight. This astonishing youth could see three of Jupiter's moons with the naked eye, and could read a leading article in the *Times* at a distance of ten feet.

If serious writers are to be trusted, this particular power has, sometimes, developed into what might very well be termed a new sense, which has been endowed with the somewhat uncouth name of "Nauscopy," thus cautiously defined in the Century Dictionary as ' the art, or pretended art, of sighting ships or land at great distances."

For some curious examples of nauscopy we are indebted to the narrative of the voyage of H.M.S. "Nissus," 32 guns, Capt. Philip Beaver, in 1810, compiled by Mr. James Prior, surgeon. Referring to certain stories, "related as facts," current in the island of Mauritius, concerning the great distance at which ships had been sighted from the hills, Mr. Prior writes: "This faculty of far-seeing, or rather divination, is confined to a few, and appears something like the second sight of Scotland."

It seems that one of the persons thus gifted reported having distinctly observed from the island the shipwreck of a vessel in one of the ports of Madagascar, at a distance of 400 miles. Though laughed at, he persisted in his story, mentioned the day, the hour, and the precise scene of the mishap, all of which being duly noted, turned out afterward to be correct. On another occasion, the same person discovered a man on board a vessel, three days' sail from the island, who, he stated, was at the time engaged in washing his clothes—all of which likewise proved true.

"Without attending to improbable tales," continues our authority, "I am told by credible persons that vessels have been distinguished as far as ninety miles distant, as was a terward ascertained by comparing dates with their subsequent run toward the land; which may perhaps be accounted for by the clearness of the atmosphere, reflecting objects from the surface of a smooth sea to the sky, whence they become visible to those who possess acute visual organs."

The obvious comment of an old-time sailor-man on such a story as this would have been, "You may tell that to the marines!" And were it not for confirmation of these strange happenings coming from a most unexpected quarter, we should be inclined to class "nauscopy" and the quoted instances of "far-seeing, or divination," as "travelers' tales."

In a work entitled "Mémoire sur la Nauscopie," by M. Bottineau, published toward the close of the eighteenth century, we are given the results of the author's own experiments, conducted with the sanction and under the close observation of French government officials. The circumstances under which the "Mémoire" came to be compiled were as follows:

M. Bottineau, a native of the island of Bourbon, having shown that he possessed powers of nauscopy, proceeded to France, where he reported the circumstances to M. Castries, a minister of the government, who ordered him back to the isalnd, where he was instructed to continue his experiments under supervision of the authorities. M. Bottineau guaranteed that not a single vessel should approach the island without his having discovered and reported it several days previously.

During the experiments, an exact register of M. Bottineau's reports was kept in the secretary's office, in order to compare them with the ship ' logs on arrival, and every means was adopted to prevent deception, his reports not only being registered in the government office, but made known throughout the island.

During the eight months over which the observations extended, M. Bottineau announced the approach f one hundred and fifty ships, none of which was visible to watchmen stationed on the hills at the time of their report. It was shown, moreover, from the register of his reports, that he was wonderfully accurate. The government officials, indeed, who—it may be remarked—were anything but favorable to him, had to bear testimony to the reality of his extraordinary powers, in making their report to the French minister, and this report is embodied in the aforementioned "Mémoire."

It would take us too far afield to discuss the various explanations of M. Bottineau's uncanny powers which have been advanced. Suffice to state that, while one writer accounts for the phenomena by asserting that, when one ship approaches another, or land, there appears in the air a meteor of a particular nature, which with a little attention is visible to any person; another would persuade us that the decay of innumerable animals at the bottom of the ocean produces certain volatile vapors which, rising to the surface, form an atmosphere round a vessel—"a kind of sheet projecting forward to a considerable distance, which is suddenly seen to acquire consistency and color, until at last the ship makes its appearance." It must be confessed that these so-called explanations do not take us very far. They would scarcely carry conviction to the straightest sect of scientists.

We do not hear very much of nauscopy nowadays, and it is curious that the two most famous nauscopists should have sprung from adjacent islands in the Indian Ocean.

Specialization being at present the vogue in scientific circles, it might repay some one—with a thirst for notoriety—to found a society for the study of nauscopy; many a less promising cult is on the market just now. Who knows what it might lead to? The ability to discover enemy's ships while yet a great way off would render the presence of an expert nauscopist a most useful addition to the staff of an admiral—even in these days of "wireless."

Only fools laugh at what they cannot explain. For as Shakespeare does well to remind us, "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy." Nauscopy, like astronomy and wirele s, may yet have its representatives at the Admiralty. Who knows?

The Limitations and Possibilities of Radio Telephony

By Theodore N. Vail

To make wireless communication understandable, and to make plain both its possibilities and limitations, the governing conditions and principles, which to the layman are somewhat abstruse, must be explained.

There exists, through all space, some "ether" or other medium through which can be transmitted light, heat, and electrical waves or vibrations, or some such movement or activity as has all the manifestations of waves or vibrations.

Broadly speaking, the science of electricity is still undeveloped and unrevealed, but from its manifestations, laws or rules of action have been deduced, and its action and effect are calculable.

The wireless telephone and telegraph, or operating radiograph, is the "generation" and "control" of electrical vibrations of great intensity thrown out into space, which seem to proceed in every direction, seem to conform to the curvature of the earth, and seem to penetrate most material substances. They spread and fill space as do the waves of sound. Their intensity rapidly diminishes as do sound vibrations, probably in the ratio of the increase of the space filled by them as they pass out and onward, and like any sound, are intense or loud at the source, but fade away into silence as distance increases, so that at the distant receiving station they are of slight tenuity.

There is, as yet, no practical method of deflecting or reflecting these waves, as is done with light or sound, and probably because of their great length there never will be.

The existence of these waves has long been known, but until Hertz discovered or invented a practical "detector" it was impossible to convert them into any tangible form. Since then many methods have been discovered, some one or more of which is utilized in the various wireless telegraph systems.

These waves are of different lengths, frequency and intensity; can be controlled so far as impulses or variability are concerned; and can be used for telephonic or telegraphic or signaling purposes.

The wave length and frequency can be availed of to get a certain range of selection; but selection is not secrecy, as any receiver can be adjusted to all lengths and frequencies.

The intensity of these radiations is so great that any large number of sending stations erected near each other would seriously interfere with and confuse each other's outgoing transmission, and even a small number would absolutely destroy the tenuous incoming vibrations, and all could be destroyed by extremely high tension and high frequency radiation in close proximity.

The nearest thing that can be compared to such a situation is a steam engine blowing off steam at high pressure when someone nearby is trying to converse. Under such conditions conversation is impossible.

The most interesting and most useful characteristics of the radio vibrations—those which make possible distant telephonic communication—are that these vibrations, unlike the electrical speaking vibrations over the wire, retain their peculiar and essential speaking form even to the very faintest activity at the point of actual disappearance or loss to detection, and therefore, when magnified by the telephonic appliances used by the Bell system, the speech is distinct whether it be in distant Honolulu or Hong Kong or Paris or Petrograd.

The great obstacles to dependable usefulness with commercial possibilities—the causes which confine this great achievement to particular undependable uses—are natural conditions as yet and probably forever uncontrollable.

In space, or through the "ether," and the earth, there seem to be continuous electrical "storms," activities or manifestations, which for the sake of clearness may be called natural disturbances. These natural disturbances are sometimes mild and not very serious, while at other times they are of such intensity and activity as to absolutely nullify and destroy the artificial vibrations of the wireless stations.

For long periods these natural disturbances will continue of sufficient intensity to make it impossible to send the artificial radiographs, or at least to receive or detect them. In the midst of these storms there will be lulls or moments of quiet or comparative quiet, and it is at these times that it is possible to use the wireless or radio for telegraphic or telephonic communication. In the quiet moments it is possible to communicate without much effort. In the less quiet moments, by repetition and continuous effort, messages and conversation can be got through. In the moments of great activity all effort is useless.

The coming and going of these natural disturbances are known only by their effect upon the artificial vibrations with which they come in conflict; no clouds or prevailing winds, barometer or thermometer, indicate their coming or enable a forecast to be made. They fill, or seem to fill, all space, and even if their origin and course were determined, would probably be as uncontrollable as is the water in the midst of a great ocean when in its wildest moments; you might float upon it, but not with confidence.

Wireless telephony can be compared to an attempt to carry on all telephone exchange business over one great conductor connecting everyone, and over which all telegraph, all artificial electrical disturbance caused by transmission or power lines, and all the natural electrical disturbances were in full play at the same time. These are the conditions that govern radiograph activity and limit its possibilities.

There are only two ways of carrying on wireless telephony; one, by getting far away from all artificial disturbing causes and having only natural disturbances to contend with; or by the use of one of the limit selectives which have only the interference of the natural disturbances.

There are, however, uses, many and important, probably as many and as important as can attach to any absolutely undependable thing. Distant communication will be possible some of the time. Short-distance communication will be possible sufficiently for communication with isolated places or things not otherwise to be reached.—*Telephone Engineer.*

Petroleum Production in Galicia Decreasing

Production in Galicia has been declining continuously since 1909 at the rate of about 2,000,000 barrels a year. In 1913, however, the decline was less than 1,000,000 barrels or from 8,535,174 barrels of 42 gallons each in 1912 to 7,818,130 barrels in 1913. The decline came altogether from Tustanowice, the dominating field of Galicia. In the other districts, Boryslaw and West Galicia, an increase was shown. There was a considerable decline in the amount of oil exported from Austria-Hungary and a large increase in the imports.

The Austrian railways have partly abandoned the use of oil on their northwestern lines and have reintroduced coal as fuel.

Oil production from hand-dug wells has entirely ceased in Galicia, the number of such hand-dug wells having been reduced to 15, and on these no work was done during the year. Forty-three producing wells were worked by hand pumps, 914 by steam, 620 by gas motors, and 18 were flowing wells. There are also 861 wells which were not productive. Of the wells in the Boryslaw-Tustanowice area 252 exceeded 4,000 feet, the deepest having reached 5,400 feet, or over one mile.—*Mineral Researches of the United States, 1913, Part II.*

Wood Older Than the Hills

Interesting Specimens Found in Glacial Deposits

By Arthur Koehler, Forest Products Laboratory, Madison, Wis.

SPECIMENS of wood which are veritably older than some hills have recently been unearthed in a railroad cut at Woodville, in St. Croix County, Wisconsin. The wood, somewhat mixed with black soil, was found in a layer 4 to 12 inches thick, in the base of a hill fully 50

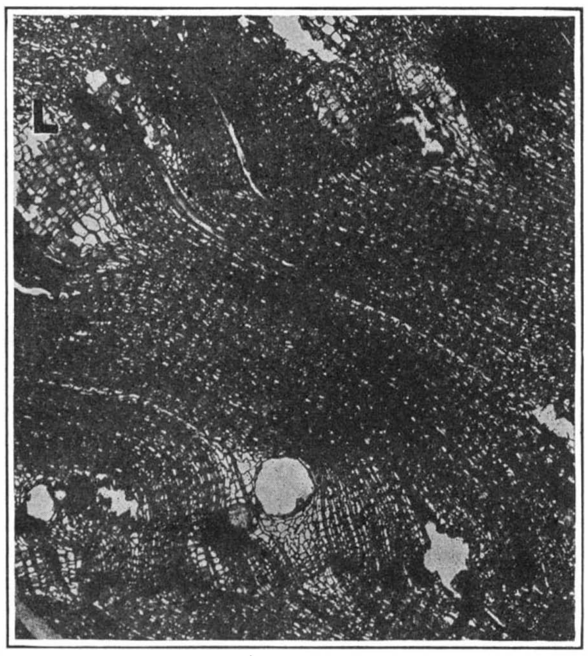


Fig. 2.—Photomicrograph of spruce wood found in a glacial drift, magnified 50 diameters, across the grain.

feet high. Fig. 1 is a diagrammatic sketch illustrating the location of the wood-containing layer with respect to the immediate topography.

Some fragments of the wood were sent by Mr. S. Weidman of the Wisconsin Geological Survey to the Forest Products Laboratory, Madison, Wis., for identification. The wood was very brittle and much distorted, most of the cells being flattened. However, by cutting thin sections of the wood and viewing them through a microscope the characteristic structure of the cells could be made out. The wood proved to be spruce. Fig. 2 is a photomicrograph of a cross-section of the wood magnified 50 diameters, and Fig. 3 is a cross-section of normal spruce for comparison. It will be seen that most of the cell walls are wrinkled, although a few cells which were infiltrated with limestone (*L.* Fig. 2) retained their normal shape.

Geologists explain the occurrence of the wood so far under ground something like this: Ages ago a thick sheet of ice (glacier) covered the greater part of the State of Wisconsin and neighboring States, and moved slowly southward. Heavy masses of ice will "flow" in the same manner in which a brittle piece of molasses candy will gradually spread out on a plate. At the end of the glacier where the ice melted it deposited a great amount of soil which had become mixed with the ice in its journey southward.

This lower deposit at Woodville is designated as the pro-Kansas drift. The time came when the lower end of the glacier melted faster than it could move, and consequently the terminal margin receded northward, allowing vegetation and even trees to encroach upon the deposit. The fact that the wood which was found is spruce, however, indicates that a moderately cool climate prevailed, for even now this species is confined chiefly to the northern latitudes and high altitudes.

Later, probably some 500,000 years ago, the climate again became cooler, allowing another glacier to come down. The forest was destroyed and buried under a mass of ice and gravel. Again the glacier was melted and deposited a deep layer of soil, forming the Kansan drift, on top of the remains of the forest. Long after the Kansan drift was deposited on the forest bed a third glacier descended and later receded, depositing the Illinoian drift.

These theories may seem "far-fetched" to those who have not studied the formation of our land areas, but to the geologist they offer the only logical explanation of present conditions. At the present time in Alaska some glaciers are slowly pushing their huge ice masses along to the utter destruction of all forests and other plant life in their paths. Other glaciers are being melted

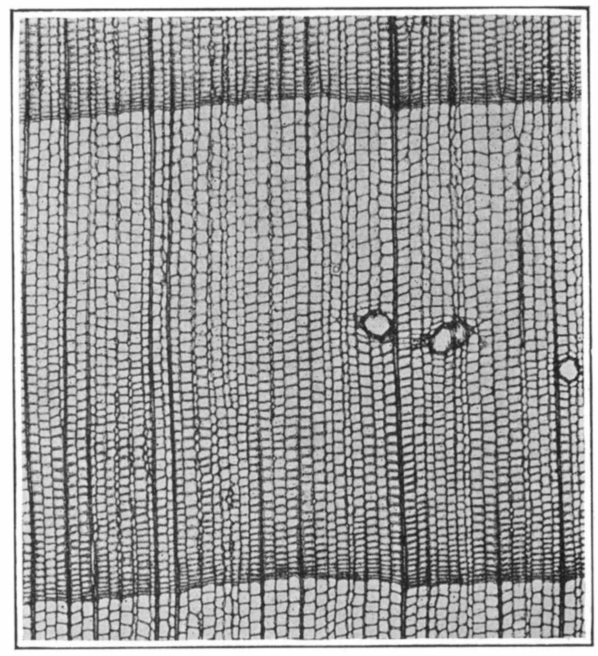
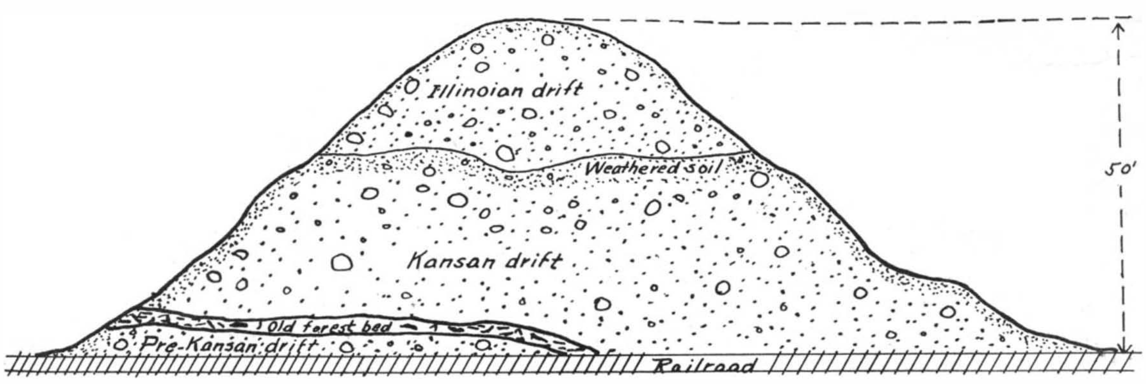


Fig. 3.—Photomicrograph of normal spruce, magnified 50 diameters, across the grain.

faster than they can advance and, consequently, their terminals are receding and depositing large masses of earth and stones. A detailed account of Alaskan glaciers, together with pictures of forests that are being overturned by glaciers, illustrating the above described conditions, may be found in the January number of the *National Geographic Magazine* for 1910.



How Bacteria Were First Seen

IT IS well known that the Dutch naturalist, Leeuwenhoeck, described micro-organisms which he had detected in water, vegetable infusions, the intestinal canals of various animals, and in the saliva and dental tartar. Some of these were plainly such as can be observed any day with moderate magnifications; but, on the other hand, it is hardly possible to doubt, after examining his descriptions and figures (which he communicated to the Royal Society from 1673 onward) that he did really see bacteria (bacilli) and spirochaetes. It is stated that he used the simple microscope only. A description of his lens-holder will be found in Carpenter and Dallinger (Volume I, page 132, of the eighth edition). The subject of bacteriology seems to have remained where Leeuwenhoeck left it till about a century later, when the compound microscope was sufficiently improved to be of some service for the purpose. The organisms in question can be detected—hardly more—with a microscope of the Adams type, such as that shown in Dallinger's Fig. 111 (*op. cit.*). I have used such an instrument many times, with the special object of finding out what could be seen in the pre-achromatic period. But I have always had a great difficulty in understanding how Leeuwenhoeck saw what he describes with a simple lens. I now suggest the following explanation. We are now accustomed to use the simple microscope as a direct accessory to the optical system of the eye: we hold it close to the eye, just as we hold the eye close to the ocular of the compound microscope. In the first case our "object" is the object itself; in the second, it is an aerial image of the object formed by the objective of the compound microscope. But we can, if we like, examine an object with the simple lens held at a considerable distance—say eighteen inches—from the eye. Doing this we get a normal, non-inverted image. It is of no service microscopically, because we could see just as much by looking at the object from a shorter distance, supposing that we have the requisite power of accommodation. But if, while we are still looking at the object through the lens from a distance of eighteen inches or so, we carefully withdraw the lens from the object in the direction of the eye, we find another point at which the image is visible; it is now, however, inverted and considerably magnified. What has happened is that we have extemporized a compound microscope: we are unconsciously looking at some point between the eye and the lens, and at this point we have produced an aerial image of the object. Normal loss of accommodation (Leeuwenhoeck was forty-eight when he published his "Arcana"), together with myopia, will greatly facilitate this experiment. Normal-sighted people can imitate it, or short-sighted people can increase their myopia, by wearing a convex glass for the purpose. In this case it is evident that the convex glass is functioning as the ocular of a compound microscope. Spectacles with biconvex glasses were commonly used in the seventeenth century by engravers and watchmakers, and doubtless also by minute anatomists. Leeuwenhoeck may have been accustomed to use them, or he may have been markedly myopic, or both myopic and (for the occasion) convex-spectacled. Though it has nothing to do with the formation of the aerial image, it contributes to the success of the experiment to have the direct light screened off round the lens which is acting as objective, as is done by the tube in the compound microscope. This would seem to be the reason for the flattened plate in the middle of which Leeuwenhoeck mounted his lenses. Another way of increasing the efficiency of the device is to darken the room, and work in the light admitted by a hole in a shutter, with a spherical flask in front of the hole to concentrate or "condense" the light. This, I am told, was quite a familiar device among the old etchers, so it is improbable that our author should have been unaware of it. I have found by experiment that a lens, mounted in a screen such as he used, gives remarkably good effects—rather better, on the whole, than those I obtained with my old Adams microscope mentioned above. Further, it would seem that in the case of liquid preparations Leeuwenhoeck used a nearly globular lens, and applied the liquid to the front surface of the lens itself. By this method one can undoubtedly see living bacteria. If these surmises with respect to his method of working are correct, Leeuwenhoeck anticipated the modern bacteriological microscope in all its essential features.—E. W. Bowell in *Knowledge.*

Clean Linen for Steamships

IMMACULATE napkins and sheets are such a matter of course on the big trans-Atlantic passenger steamships that little thought is given as to how the supply is maintained. On some ships laundries are maintained, but in the big vessels that have been built of late the requirements are too great, and space for other purposes is too valuable to admit of any laundry work being done on board; consequently great stocks must be carried to meet the necessities of a voyage, and as the laundry work is usually done only at the home port, enough must be carried for a round trip. On a ship having accommodations for 4,500 passengers, it is estimated that in the neighborhood of 33 tons of wash accumulates on a double passage across the Atlantic.

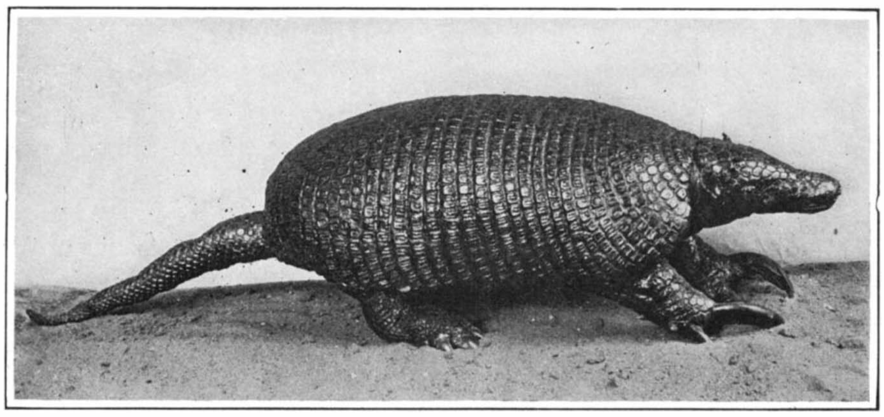


Fig. 1.—The giant armadillo of South America.

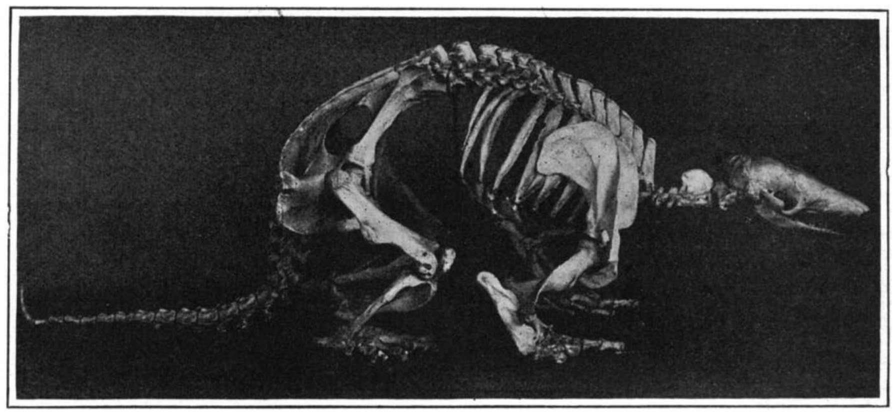


Fig. 2.—The heavy, bony structure provided for supporting the armor.

Some Remarkable Armadillos

Interesting Armored Mammals of South America

By Dr. Bergner

Moving along in their armor-plate, the heavy creatures called armadillos seem like forms from pre-historic ages. And, in fact, they are the dwarfed successors of those Glyptodons or giant armadillos which have died out only since the coming of man, and whose remains, more massive than the bony structure of the elephant, are still to be found in great numbers in the pampas clay of Brazil and Argentina.

With their rigid back-shields, almost four yards in length, these creatures resembled giant land tortoises. The armor plate of the present race of armadillos, however, arranged in bands and attached to the soft skin, affords to the armadillo comparatively great freedom of motion. The head and neck; the legs, at least in front, and in almost all species, the tail, are likewise protected by horny plates which have the firmness of the thin sole of a shoe. Breast and belly are covered merely with a firm skin and scattering bristles, which grow between the shoulders and loosely connected band.

To the heavy armor plate there corresponds a similar bony structure (see Fig. 2). The width of the ribs increases in certain species so that their edges touch or overlap. The vertebræ of the neck are even partially grown together, and those of the back show strong appendages of great carrying power. The well-developed extensions of the leg bones serve as attachments for strong muscles, helping not only in the movement of the heavy body, but also in the burrowing activities of which they are masters.

The almost barren sand plains and fields and the edges of forests in South and Central America are their homes. They live a solitary life, remaining days at a time in their caves, the entrance to which is two yards long with a width equal to the diameter of their bodies. Beyond this entrance, however, the burrow widens out inside, extending horizontally or bending to one side and ending in a kettle-shaped hollow or bed. Only when night approaches do they leave this burrow to go on the scent of food. This consists of everything which their weak teeth can master. They have neither tusks nor incisors and the other teeth are only weak crowns with a covering of enamel which are not adapted to hard chewing. Because of the inadequacy of such teeth armadillos belong rightly to the class Edentata, although the number of teeth varying within the class may with the giant armadillo even reach one hundred. Only soft substances, worms, snails, and especially insects and their larvæ, serve as food. Therefore, the armadillo digs his burrow preferably at the foot of great ant hills. With its sticky tongue covered with horny papillæ it gathers up the ants after it has undermined the hill. As soon as the resources of one dwelling are exhausted the armadillo seeks another. In this way it leads a truly vagabond existence. Moreover, its solitary wanderings bring it often so far from its burrow that it never returns to it, but digs another wherever the daylight happens to find it. By this burrowing process the ground often becomes undermined and many accidents are caused in those lands where even the beggars ride horseback. For that reason the armadillos are pursued with great bitterness and even poisoned with strychnine. In other respects, however, and on account of their flesh they are hunted by dogs especially trained for the purpose. The flesh is tender, white as a chicken, and similar in taste to roast pork. The fat, generally to be found in great quantities, is similar to that in veal kidney. The only unpleasant thing about the meat is the smell of musk.

Europeans eat the flesh of two kinds only which are less permeated with this odor and which are regarded as delicacies and serve as such in first-class South American hotels. The gauchos, as the half-savage shepherds are called, and still more, the negroes, eat all kinds and lay snares even for the defenseless armadillos. The track left by the dragging tail betrays at once the inhabited burrows. Armed with a stout stick the hunter seeks to surprise the creature as it prowls indolently about in the moonlight and to bring it to bay with dogs. The latter can often finish the animal alone by turning it over on its back with their noses, and tearing it to pieces in the unprotected part of the body. If they do not succeed in doing this they hold their prey fast till the hunter comes up and kills the beast by a vigorous blow on the head. It never makes any fight against man or dog. It can be lifted into the air by its tail without defending itself with its powerful claws. The only protection the awkward creature has is its armor plate and the incredible speed wtih which it can burrow into the ground. Moreover, the sense of smell is so developed that it discovers its enemy at a distance and escapes quickly into its hole or digs a new one. Before one can get hold of it the armadillo is half out of sight. If the hunter seizes it by the tail it bends its back so that the edges of the armor plates are braced against the walls of the entrance while the claws hook so firmly into the ground that it is impossible to drag the creature out. Even its method of defense fails however in the presence of the hunter provided with knife, ax or spade. Therefore the armadillo has almost died out in places in spite of the fact that the mother bears four, six or even nine young ones at one time. These creatures are often offered for sale in animal markets and often at comparatively low price. With proper care they live for years in captivity and multiply, but they bring their owners little joy because of their stupidity.

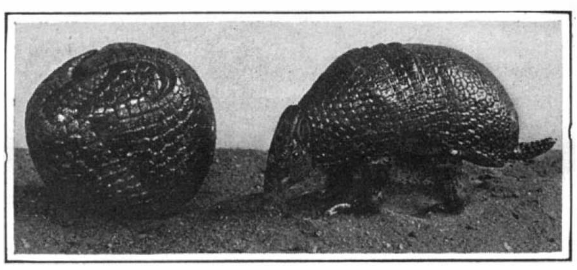


Fig. 3.—The little Dasypsus triciactus.

Taking from the many species three especially remarkable types we find the giant armadillo (Fig. 1) not only the largest, but one of the rarest. It inhabits the vast forests from Guiana to Paraguay, but its deserted burrows under the roots of old trees are more often to be found than the animal itself. The length of its body is about one yard exclusive of the tail, which is from twelve to twenty inches long and covered with a spirally arranged armor plate. From it the Batocudos of Brazil make their trumpets while shoulder and pelvis armor plates are used for baskets or made into violin or guitar bodies. They weigh about one hundred pounds and twelve or thirteen bands give the necessary flexibility. The structure of the front foot is remarkable with its short immovable toes provided with strong claws for digging, the middle one of which is abnormally developed. The hind legs have broad, almost hoof-shaped nails, as if intended for shoveling away the loosened earth. It is even said that buried bodies are disinterred and torn to pieces by the giant armadillo so that the graves of those who have lost their lives in the forests are covered with heavy tree trunks to protect them from the ravages of this dark brown monster.

Much smaller, but more interesting is the apar or matico, which is about fifteen inches long and which inhabits the grassy plains of Argentine. Although it has only three bands, it can roll itself into a ball as is shown in Fig. 3. The unarmored limbs disappear into the ball and the head-plate closes the ends of the body thus brought together. The position of the animal is always a bent one and straightening out is an impossibility. To this peculiarity is added the singular tripping gait upon the tips of the two toes with the longer claws. The effect is so comical that people often keep a matico for a pet for children. They play with it by rolling it about on the floor and letting it run on a board in order to enjoy its curious gait. The harmless creature gets quite tame and eats dainty bits from the hand.

The matico cannot endure northern climates, and so is rarely found even in the Zoo. It uses its ability to roll up like a hedgehog only when surprised by its enemies; otherwise it seeks safety like other armadillos by burrowing into the ground. It is true that its weak feet and claws do not give the impression of being particularly fitted for this, but the loose swampy soil of the South American fields makes the burrowing easy. Dogs cannot get at the creature, for the smooth gray or brownish ball offers no point of attack to their teeth. The native herdsman kills the little animal by hurling it violently to the ground or even by roasting it alive in its shell!

The rarest armadillo and at the same time the most remarkable creature of the whole animal world is the *Chlamyphorus truncatus*, living on the sandy plateau of Mendozza and San Luis in Western Argentine. With their subterranean existence and their habit of appearing above ground only in the night, these creatures remained unknown to the inhabitants of that sunny country until the zoologist, Harlan of Philadelphia, discovered them in 1825 and made them the object of study. Nevertheless, for a long time there were only two specimens, those in the museums of Philadelphia and London. In the course of time others were secured, but these having been taken in a water trap by the natives, who knew nothing of skinning, they were preserved only as imperfect, dried specimens. Only in recent years have living Chlamyphori been captured and one was kept alive in the Zoological Garden in Buenos Ayres. Well preserved specimens still command good price as curiosities.

In form and mode of living the little armadillo reminds one of the mole, but it is much more skillful in burrowing and digging. A marked characteristic of this creature, which is from four to five inches long, is its leather-like armor plate of a reddish hue which wraps it about like a cloak and which has given it the scientific name Chlamyphorus or "cloak-bearer."

Twenty-four diagonal, movable plates form the armor, which begins at the forehead and attached only along the spine ends in a truncated shield which has grown into the pelvic bone. The armor plates can be lifted at the sides, showing the yellowish-white skin covered with silky hair. The above-mentioned pelvic shield serves as a sort of rammer to push back the dirt dug up and to press it down for a sort of bar to the horizontal passage. Out of a slit in this issues the stiff tail which with the front legs supports the body, while the rapidly moving hind feet make the dirt fly. Still more noteworthy than the outer form is the remarkably strong skeleton of Chlamyphorus, which with its flat and stout arm and thigh bones and other peculiarities corresponds most nearly to that of the armadillo giants of antiquity.

The Screw Propeller*

A Discussion of Slip, Cavitation and Other Operating Factors

By Sir Archibald Denny

THE first screw propeller was probably a complete helix, but it was found that a complete helix was disadvantageous, and that a small portion of it was all that was necessary. A two-bladed propeller is derived from a double helix, a three blader from a treble helix, and so on.

The important particulars of the screw propeller are usually stated as follows: D is the diameter, P is the pitch (that is, the distance which would be traveled by the screw without slip in one revolution, or the length of the generating helix), and the ratio of projected area of all the blades to the disk area is very important and is usually written $\frac{\text{proj.}}{\text{disk}}$ The ratio of P to D, the pitch ratio, has an important bearing upon efficiency.

Suppose for the moment that the screw is working a long way astern of the ship and that v is the speed of the ship; now to drive the ship forward the propeller must drive a column of water aft. Let the speed of water in the propeller race be V, then $(V\text{-}v)$ is the speed imparted to the water by the screw, or is the speed of the slip. You must have slip in order to move the vessel. How is it then that engineers find that sometimes they get negative slip? That is what I propose to explain. I may, however, say at once that real slip, such as you might get under the conditions aforementioned, is a very different thing from the apparent slip, which is what the engineer gets on trial trip or at sea; because in actual practice the propeller is fitted fairly close to the stern of the vessel and then other conditions arise.

A vessel moving through the water experiences resistance due in part to the frictional resistance of the water on the immersed surface, which causes the water to be dragged in a forward direction, and hence at the stern there is usually a following wake; in other words, the water is not moving toward the screw with speed v, but with some smaller speed. The wake effect is not, however, solely due to frictional resistance, but there is, at anything but very low speeds, the orbital motion of the particles of water due to wave-making, and there is also the effect of stream line motion.

Let v_1 be the speed of the following wake with reference to still water, then the speed of advance of the screw through this water is not v but $(v\text{-}v_1)$. Now the usual way of stating slip-ratio is $\frac{V-v}{V}$ where V is equal to $P \times R$. P being the pitch and R the revolutions per minute. But the speed of water flowing toward the screw is now $(v\text{-}v_1)$ instead of v and hence the real slip is greater than the apparent slip of a screw working near the stern of a ship. When stating the speed of the screw as $P \times R$ it is assumed that the pitch of the driving face of the screw is the real pitch, but this is not necessarily so, in fact it is seldom so.

Our experimental tank was opened in 1883. At first we dealt only with ship models, but as soon as possible we also began experiments with model screw propellers, both behind models and without models in front of them. We observed curious differences between real and apparent slip and we thought that some light might be thrown on this by experiments with a series of screws and a corresponding series of disks and sectors of the same diameters.

Early in 1898 we tackled the work seriously and Diagram 1 shows one set of screw propeller results. These screws were all of the same diameter, number of blades, projected to disk area, thickness at the root and general outline, but while the pitch of the driving face of each screw was uniform, the pitches of the different screws varied from 0.5 of a foot to 2 feet. These were driven along the tank without any model in front of them—driven in the open, as we call it—and were driven at different rates of speed of advance and at progressive r.p.m. (revolutions per minute) for each speed. In Diagram 1 the speed along the tank was 500 feet per minute. The diagram is plotted on a base of slip ratio (assuming the pitch of the propeller to be the pitch of the driving face) and thrust, revolutions and efficiency are the ordinates.

Now with a slip ratio of zero—that is to say, when $P \times R = 500$ feet—there should be no thrust. This is far from being the case for a screw with 0.5 of a foot pitch; the thrust, instead of being zero, is 8 pounds, and the efficiency is nearly a maximum, while the efficiency curve does not strike the base line until the slip ratio is nearly minus 20—that is to say, instead of the real pitch being 0.5 foot it is 0.588 foot at zero thrust. Similarly, the screw with 1 foot pitch had a thrust at zero slip ratio of nearly 1 pound, and the efficiency is very considerable. In the 1.5 foot screw, on the other hand, the real pitch is slightly finer than the pitch of the driving face, also in the case of the 2 feet pitch screw.

I do not know whether this was generally known by marine engineers at that time, at any rate it did not seem to have been so. In a recent publication, the discrepancy between the real pitch and that of the driving face has been recognized and referred to, but it is there assumed that the real pitch exceeds that of the driving face by a constant percentage. We have found that this is not so, and that the difference varies with a number of factors. Generally, however, it may be stated that if the blade sections be symmetrical, a coarse-pitched propeller has a slightly finer real pitch than the pitch of the driving face, and a fine-pitched propeller has a considerably greater real pitch than that of the driving face. When the pitch ratio of the driving face is about 1½, the pitch of the driving face is then identical with the real pitch. The discrepancy between the real pitch and that of the driving face varies, however, with speed of advance, with the width and shape of the blade and with its thickness, and, if the section of the blade be not symmetrical about its center, the real pitch may vary greatly from the face pitch. I am also of opinion it is not correct to take the real pitch at any particular speed of advance as being that pitch at which you get no thrust.

The question, therefore, becomes exceedingly complicated, and the results of our experiments with screw propellers suggested a series of experiments to ascertain the effect of revolutions alone. It was thought that light might be thrown on the kind of variation of pitch due to thrust by experiments on flat sectors without pitch, and also that such experiments might help the study of the effect of revolutions on the amount of water acted upon by screw propeller blades of certain widths and varying revolutions as compared with the complete disk—that is to say, it was desired to study the effect of revolutions *per se* upon the efficiency of screws. We therefore tried, in 1898 and 1899, complete disks of different diameters, and sectors of the same disks of varying proportionate areas—a sixth, a fifth, a fourth and a third.

Diagram No. 2 shows the result of a series of tests of such a disk and of such sectors, all of the same diameter as one of the previous sets of screws, made as thin as possible, and advancing at 500 feet per minute. In order to eliminate the effect of eddies round the periphery of the disks and sectors which might be caused by the two square edges of the plate, the edges were rounded as shown, but the sectors of course had still no real pitch. This diagram shows the resistance of the complete disk and sectors when advancing at 500 feet, but driven at different revolutions. The lower series of curves show the turning moments, the upper series of curves show the resistances. The diagram is of extreme interest, and it will be observed that for the complete disk the resistance increases with increase of revolutions per minute. When the sectors are not revolved the resistances in proportion to that of the whole disk are practically in proportion to their respective areas, showing that eddy-making had either the same proportional effect, or practically no effect.

When the whole disk was revolved the resistance increased, and doubtless the effect was as if the disk had been increased in diameter, due to centrifugal action throwing the water out beyond the edge of the disk, while the turning moment was roughly in proportion to the square of the speed, as one would expect, because it can only be due to surface friction. Quite another effect, however, is got with the sectors. The resistance at first increases very rapidly with increase of speed of rotation, but the turning moment, after a slightly more rapid increase than that of the complete disk, falls off, passes through zero and becomes negative over a considerable range of revolutions per minute, and the smaller the sector the greater is this range. I do not propose to study this diagram exhaustively, but it seems to show that while the sectors had no apparent pitch they had a very real pitch when rotating. The shape of the resistance curve is interesting in this regard, as it would otherwise probably not have had the dip down as shown between 400 and 600 revolutions per minute in the different sectors, alteration in shape begins where the turning moment curve crosses zero, and the curve is re-established where the turning moment curve re-crosses the zero line. The general shape of this curve would also seem to show

Results of Model Screw Propeller experiments in open water—speed 500 ft. per min. Tips immersed half the radius.

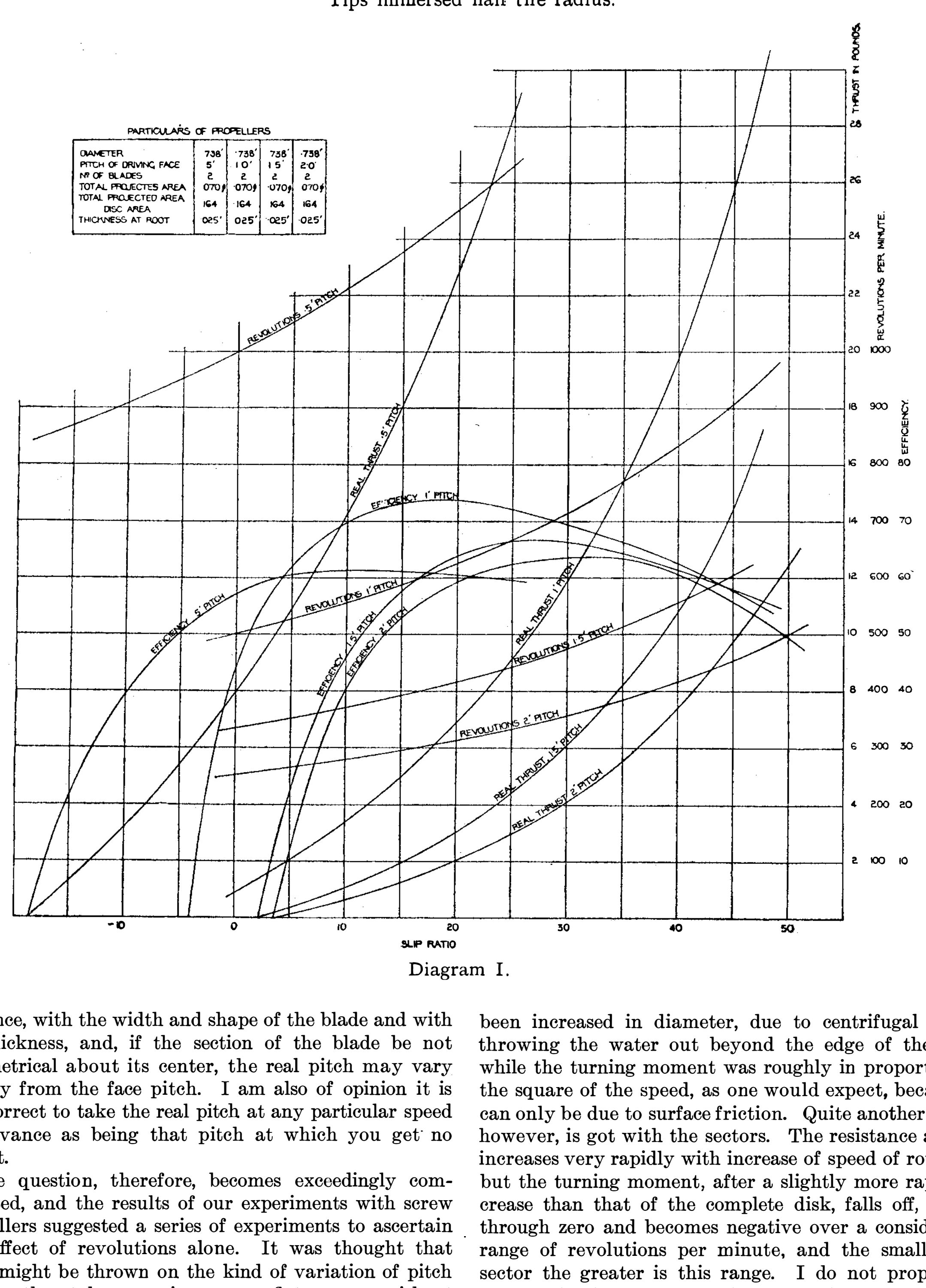


Diagram I.

* Presidential address before the Institute of Marine Engineers, England.

Curves of Resistance in Pounds, and Turning Moment in Foot Pounds, of a Disc and Sectors in terms of revolutions per minute at a constant speed of advance in fresh water.
Diameter of Disc and Sectors = ·738 feet.
Thickness ,, ,, = ·012 feet.
Speed of advance = 500 feet per min.
The Sectors have no pitch of either face, and the edges are sharpened.

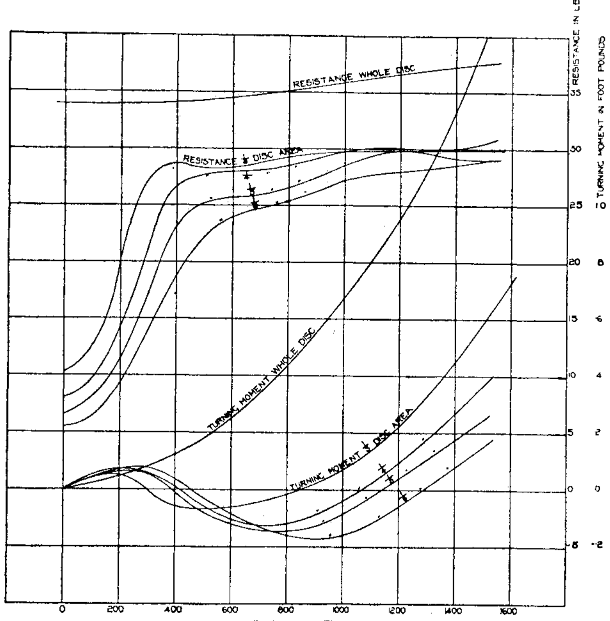


Diagram II.

that a flat sector, driven at an infinite number of revolutions, would probably have the time resistance as the complete disk, and that revolutions *per se* are an important element in screw propellers.

In making these experiments we found, if the sector was started on the run down the tank, free, but not revolving, that it then remained non-revolving, and we simply got the resistance of the sector at no revolutions. But, if we started the sector on its runs with an initial spin, but free from the cord which gave the turning moment, then the revolutions increased during the run until they arrived at the point where the turning moment curve re-crossed the zero line of turning force—that is to say, the sector really became a screw with a certain pitch, and was rotated at a definite speed by being dragged through the water. It was found that this was true in whatever direction the flat sector was started to revolve. This is perhaps the best proof that the flat pitchless sector has a real pitch. This experiment can be repeated with a similar sector in an air current produced, say, by a blowing fan.

The effect of revolving any of the sectors in water was to rapidly increase their virtual area, and the same virtual increase of area no doubt takes place in an ordinary screw propeller. It is for this reason that excellent efficiencies are got with slow-turning large propellers, whose projected area to disk is low, say in the region of 0.25, and this diagram also explains why increase of projected area to disk at higher revolutions of screw propellers has not the same proportionate effect as at lower revolutions per minute. These facts, I think, should be helpful in the study of cavitation.

An explanation of why the turning moment curves of the sector rise more rapidly at first than that of the whole disk, although the sectors have only a small proportion of the area of the whole disk, is that the sector has a real pitch very much less than that required to give no thrust or resistance, and thus drives the water forward relatively more than the disk does, and hence increases the relative resistance. This real pitch varies as the revolutions increase, until it drives water forward at a reduced rate with increase of revolutions per minute, thus the increased revolutions per minute over a certain range requires reduced turning moment, and causes a corresponding reduction of resistance of the sector. That is why I have given it as my opinion that real pitch does not remain the same throughout all revolutions and thrusts in the actual propeller.

Another way of stating this is as follows: It will be seen from the diagram No. 3 that the turning moment of the sector thereon dealt with, and which has an area equal to one third of that of the disk, has a negative turning moment over a considerable range of revolutions per minute, and if we deduct the turning moment due to surface friction (which may be assumed to be about one third of the turning moment for the complete disk) we find that the turning moment due to the hydrodynamic pressure on the sector blades is very considerably negative between, say, 300 and 1400 revolutions per minute, as shown by the curve. On the same diagram a curve of pitch for no thrust or resistance is given (pitch in feet equals $\frac{500}{\text{r.p.m.}}$). Now the apparent pitch of the sector is a constant; in fact, it has no pitch whatever the revolutions per minute may be, but the real pitch varies with revolutions per minute, and therefore it differs in varying degree from the apparent zero pitch with varying revolutions per minute, and it appears from the curve of resistance of the sector that the difference between the real pitch of the sector and that required for no thrust or resistance is a variable, which at low revolutions is a very rapid variable. The difference becomes much less as the revolutions per minute increase, but the change of curvature in the resistance and turning moment curves for the sector shows that the real pitch of the sector changes at probably an irregular rate with varying revolutions per minute. If it really remained a constant, or if it changed at the same rate as the pitch for no thrust, then we should always find resistance of sector increasing with increase of revolutions per minute, instead of sometimes being reduced.

The remarks I have made as to the following wake might be taken to mean that for any particular ship at any particular speed this following wake has a definite speed for all arrangements of propellers. This is not so.

In the case of a single-screw vessel, the wake is probably symmetrical on each side of the stern post, and what we get as following wake would be the same whether the propeller revolved right-handed or left-handed, but in the case of twin screws the wake percentage is different, depending upon which way the propellers revolve. Usually, propellers of twin-screw ships revolve either both inward, or both outward, at the top, but if the wake is taken from the model with inward revolving screws, and then taken again with the same screws revolving outward, that is to say, reversing the screws from starboard to port, a different percentage would be obtained. It is for this reason that different hull efficiencies, different gross efficiencies, and different speeds for the same power by revolving the screws outward or inward on the same ship are obtained. This is rarely tried on a ship, but in our own experience we had one notable case, a large yacht, in which the engine guides were so arranged that the screws could either revolve outward or inward, when steaming ahead. The owner's preference was for inward revolving screws. We tested this in the tank, and our preconceived idea that it would not be so good as revolving the same screws outward was confirmed, and the owner consented to a double trial with the screws reversed. As we had predicted from our tank trials the difference in speed for the same power was fully half a knot. The following wake with the inward revolving screws was 11 per cent of the ship's speed, and with the outward revolving screws 17 per cent.

The hull efficiency with the outward screws 1.03.
" " " " " inward " 0.95.

In the ordinary type of cargo-carrying vessels the wake percentage is fairly large, but in certain other types of vessels (usually of high speed) we have found a very small wake or none at all, and in several cases we have actually found a negative wake with twin screws turning outward on the top.

It will thus be seen what an extremely complicated question this interference between hull and screw is, and how essential it is that each screw should be suited to the hull which it is to drive. It is this fact which gives the screw inventor his opportunity and he is occasionally fortunate in producing by his patent screw a better result than that of an ordinary but badly proportioned screw, which improvement could have been produced by altering the proportions of the screw of ordinary design.

If any one would like to study the variation in the factors that affect hull efficiency, I would refer them to Mr. Luke's Institution of Naval Architects paper of March, 1910, where the matter is dealt with at greater length.

Referring now to "cavitation" in screw propellers, a comparatively new disease, which did not affect the old sea-going engineer, and indeed does not affect the majority of marine engineers even now, it appears in an aggravated form in high-speed vessels with small screws and hence direct-driven turbine steamers are more likely to suffer from it than those fitted with reciprocating engines or geared turbines. I think it was first recognized as a special disease capable of curative treatment by Mr. Sydney Barnaby in the "Daring," and he cured it in that case by increasing the area of his screw blades. He was hence led to express the condition under which "cavitation" is likely to occur in terms of pressure per square inch of projected blade area (11¼ pounds as a matter of fact). Since then with screws of modern design and higher revolutions as against speed, and also turbine driven, he has found that this figure may be increased to 13 pounds. We, in our experience, have found that we have got no serious cavitation in a certain vessel with pressures up to 18 pounds. For details see Mr. Barnaby's paper read at the Institution of Naval Architects in July, 1911, and my remarks upon his paper.

In an experimental tank such as ours, we do not reproduce "cavitation" at corresponding speeds, but the great value of such experiments is that when the results are compared with those obtained from trials on the measured mile, we can see at what point "cavitation" begins to be serious and at what point there is an absolute breakdown of the ship's propellers compared with those of the model. "Cavitation" does not begin suddenly, although its worst effect (a complete breakdown) does take place somewhat suddenly.

Disc and Sector of ⅓ disc area, having no pitch.
Diameter, ·738 feet.
Speed of advance, 500 feet per minute.

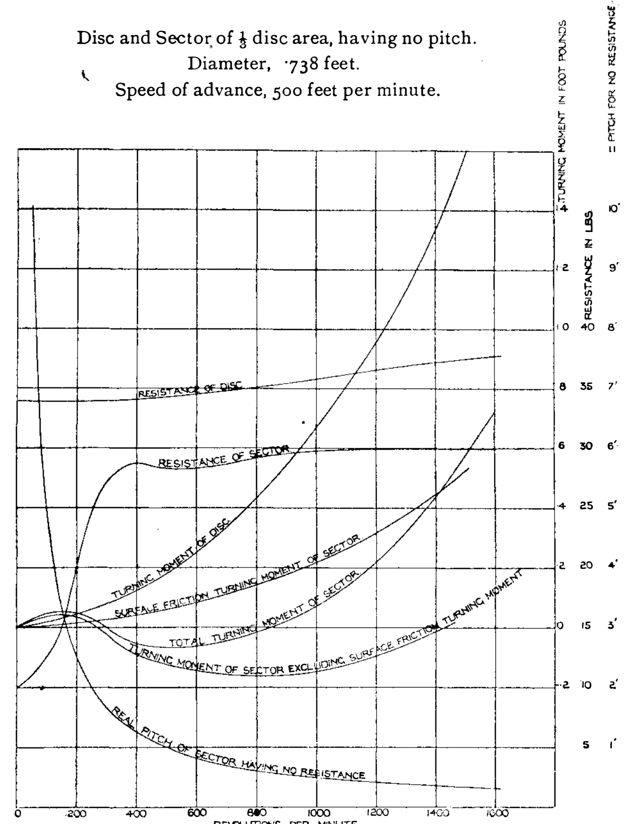


Diagram III.

When a screw is working in water it produces in front of it a reduced pressure. The reduced pressure causes the water to flow toward the screw. This flow is caused by the pressure of the atmosphere and water above the screw. Of course, I am not referring to the rearward flow of water toward the screw caused by the speed of advance of the ship; I am referring to the extra speed imparted to the water by the action of the screw.

Now as the atmospheric pressure is roughly equivalent to 33 feet of water, this is a more important factor than immersion of screw. This is specially so in shallow draught vessels, to which there has been a very large application of turbine propulsion. In such a shallow draught vessel, the total head may be equivalent to 36 feet of water to the center of the screw, then the highest velocity at which the water can reach the screw is (from the formula $V^2 = 2gh$) 48 feet per second or 2,880 per minute. Therefore one would say that until the real slip was equal to 2,880 feet per minute the water should follow up the screw, and there should be no cavitation. Our experiments and experience with actual screws show that this is not nearly the truth, and that something below half this figure is quite dangerous. I do not pretend that I can give a complete explanation for this, but water is not a perfect fluid, and sea water is saturated with air and other gases, which tend to come off and form a gas-filled cavity when the pressure in front of the screws is reduced somewhat below that of the atmosphere. Those who desire to study more fully this question screw efficiency—real pitch and cavitation—I would refer them to the excellent published papers of Mr. R. E. Froude and Sir Charles Parsons, and to the books and papers published by Mr. Barnaby.

I now want to refer to some erroneous notions on screw propeller action. In the case of the disk it will be remembered I referred to the water thrown out to the periphery by centrifugal action, but in the case of an ordinary screw working under ordinary conditions there is no such action, and all the inventions which have for their object the prevention of centrifugal action are quite useless. Anyone who takes the trouble to make a model screw revolve in a glass-sided tank filled with water and charged with flocculent material can easily prove the truth of this statement. Further, by fitting a spider behind the screw to which long threads are attached, as these follow the streams of water, it will be seen that they twist and that they show a contracted area behind the screw, just as illustrated by Mr. Froude in his Institution of Naval Architect papers of 1889 and 1911. Centrifugal action, however, can be produced by an abnormal condition. If a plate is brought up nearly touching the back of the screw, the screw changes from a propulsive instrument to a centrifugal pump, drawing the water from the driving face of the screw and throwing it out at the periphery. I have been told that in abnormal cases, in which a screw has been very near to a blunt-ended barge, when the engine was started ahead the vessel actually went astern instead of ahead.

Just one final word of warning; we have been obliged to make many model screws at the instance of friends who had been approached by propeller inventors. It is really sad to see so much wasted energy, but it is still sadder to think that this waste will go on as before. I

cannot remember a single case where we succeeded in convincing an inventor that he was wrong. He either thought that we were prejudiced, that we were not conducting the experiments properly, or that he had made some slight error which he could easily put right, and he would again approach us with some new abortion. After years of tank experiments and progressive trials on actual vessels I should like to express my opinion that the ordinary uniformly pitched propeller of the usual shape and section of blade made of suitable pitch, diameter and ratio of projected to disk cannot generally be beaten by any fancy propeller. I hope that friends in future will neither waste their time, nor ours, in bringing influence to bear upon us to try still-born inventions.

I am greatly indebted to Mr. Mumford, the chief of our experimental tank, who was really responsible for the inception and carrying out of the experiments illustrated on the diagrams, and who has also prepared the experiments showing the flat sector revolving in air, also the model propeller working in water, demonstrating the shape of the propeller race and the absence of centrifugal action.[1]

In conclusion, I should like to say this to engineers, that the only trial which is really useful for the future study of propellers is the progressive trial with clean bottom surface of ship carried out on a series of runs on a proper measured mile with sufficient depth of water, and, if they are in charge of the construction of any vessel, and have the power to dictate what kind of trial shall be made, I beg of them to insist upon such progressives. The tremendous loss of valuable data which takes place every year through the lack of these important trials is very saddening; it means slow progress toward the full comprehension of that most interesting tool—the screw propeller.

[1] The experiments referred to were shown during the evening by means of motors and a glass tank filled with water.

The Action of Gases on Iron and Steel.

By a curious coincidence, three out of the eight papers presented at the recent autumn meeting of the Iron and Steel Institute deal with the effects of a gas or its compounds when present in iron or steel. The gases dealt with are oxygen, by Mr. Wesley Austin; nitrogen, by Prof. N. Tschischewski, of Tomsk; and blast-furnace gases, by Mr. T. H. Byrom. The prominence thus given to the question of the action of gases reflects the increasing attention which this subject demands in practice. During most ordinary manufacturing processes our metals are exposed—often for prolonged periods—to the action of gases, and a knowledge of their action is thus of great importance. The subject is, however, beset with difficulties, since in many cases it is not at all easy to prepare alloys containing a given gaseous element in any desired proportion, while even the analytical determination of the nitrogen or oxygen contents of steel is by no means free from doubt and difficulty.

These difficulties are evident in the two papers named above, which deal with oxygen and nitrogen. Mr. Austin's specially prepared "oxygen alloys" contain relatively very large amounts of oxygen, and this makes it difficult to bridge the gap between his laboratory series and even the most highly oxygenated steels met with in practice. The same difficulty occurs in regard to Prof. Tschischewski's paper, which does not, therefore, set at rest the vexed question whether the very minute quantities of nitrogen which are found in industrial steels, and particularly in those made by the Bessemer process, are really responsible for the injurious effects which are sometimes ascribed to them. It was therefore satisfactory to hear that the whole question of the influence of nitrogen was to be placed on a more satisfactory basis by systematic research under the auspices of Dr. J. E. Stead. Meanwhile, the results of the Russian investigator furnish the best available data in regard to nitrogen in steel. In order to introduce nitrogen into steel, Prof. Tschischewski found it necessary to expose the heated metal to ammonia vapors, since free nitrogen apparently does not combine with iron except, possibly, at very high temperatures. Incidentally, this result is of importance from the point of view of experiments on iron and its alloys at moderately high temperatures, since it indicates that an atmosphere of pure nitrogen would be without action on the material.

Interesting from what is at first sight an entirely different point of view, are the results obtained by Mr. Byrom in his observations of the carburizing action of blast-furnace gases at temperatures not exceeding 500 deg. Cent. Hitherto it has been generally held that the carburization of iron does not take place until the temperature of Ac_1—about 700 deg. C.—is exceeded. The explanation given has been that since iron carbide is not soluble in alpha iron, which can alone exist at such lower temperatures, carburization would not occur, or, if it did, must remain strictly confined to the surface. Mr. Byrom, however, with the co-operation of Dr. Stead, has shown that in the stream of gases which come from a blast-furnace, iron becomes rapidly carburized, and is, in fact, converted into a carbide of iron so rich in carbon that the presence of a carbide, Fe_2C, in addition to the well-known Fe_3C, is suspected. There is, however, a simultaneous increase in the sulphur-content of the material.

The contradiction between these observations and the previously accepted views is not so great as at first sight appears. An examination of the iron after partial carburization by these gases at once shows that there really is no diffusion of the carbides through the iron, but that the carbide is formed *in situ* by the interaction of gas, which has diffused through the iron as such, and the iron immediately in contact with it. It is, further, very doubtful indeed, if it has not actually been disproved, whether any such carburizing action would occur if the blast-furnace gases were replaced by pure carbon monoxide; it is almost certain that some of the other gases present in the blast-furnace, such as the carbon oxy-sulphide which Mr. Byrom suggests, plays an important part in the reaction as "catalytic agents."

This consideration also affects a theoretical bearing to which attention was directed by Prof. Carpenter in the discussion on Mr. Byrom's paper. The point in question is that of the supposed "meta-stable" character of iron carbide. This conception of the nature of the carbide, and its tendency to dissociate into free carbon and iron, lies at the base of the widely accepted equilibrium diagram of the iron-carbon system. If, however, it could be shown that iron and carbon could unite to form iron carbide at these moderate temperatures, then the idea that the carbide is meta-stable at these temperatures would have to be abandoned. As was pointed out by Dr. Rosenhain, however, the results obtained by Mr. Byrom do not at all establish such a fact; all that they do establish is that in the complex system consisting or iron, carbon monoxide, and a number of other gases, iron carbide can be formed at temperatures in the neighborhood of 500 deg. Cent. But it is quite possible, and even probable, that the equilibrium ranges of such a substance as iron carbide may be very considerably altered in the presence of three or more components. The fact that the presence of another component does frequently alter or depress the lines or surfaces of equilibrium in a thermal diagram is well known, and it may be that what is frequently termed "catalytic action" is simply due to such an effect. Therefore, although interesting and important in themselves, Mr. Byrom's results appear to leave the question of the stability or otherwise of iron carbide much where it was before.

The two papers on the nitrogenization and the carburization of iron brought out one common feature of great interest. In both it was shown that the gases penetrated along the boundaries of the crystals of the metal and from these spread into the masses of the crystals along the cleavage planes. Both the carbide and the nitride of iron exhibit the distribution typical of such action most clearly—so much so that attack by means of gases would seem to offer possibilities for the study of the crystallographic data of the material by rendering visible certain cleavage planes.

The phenomenon is, however, interesting in itself, and demands explanation. Such an explanation was offered in the discussion, on the basis of the "amorphous cement" hypothesis of Dr. Rosenhain. If the crystals are held together by thin layers of amorphous metal, then these layers would naturally serve as channels for the diffusion of gases. Liquid metals are well known to possess greater powers of dissolving gases than the solid material, and the "amorphous" condition is at all events closely akin to the liquid phase, even if it is not entirely identical with it. Even iron carbide would be soluble in the amorphous layers, and its distribution along the crystal boundaries would thus be readily explained. On the cleavages, also, traces of amorphous metal might well be left as residues of the amorphous metal which would—according to the views of Beilby and Rosenhain—be formed on those planes whenever the metal was "wrought." It will be seen that these results of experiments on the action of gases throw an unexpected sidelight on a theory which is still the subject of controversy; they even suggest the possibility of employing gases as "reagents" for the detection and location of any amorphous metal which may be present in a specimen.

Finally, it should perhaps be stated—although it is obvious enough—that the results contained in these papers are of some considerable practical importance, but in this place they have been regarded rather from the point of view of scientific interest.—*Nature.*

Drying Films for the Movies

The drying of photographic films by the ordinary method is a slow process and is the cause of much delay in the manufacture of the long strips required for moving pictures. To reduce the time of production one of the big film companies has introduced an electrical apparatus that greatly facilitates the process. The wet films are wound spirally on large drums 27 feet in diameter, which are introduced into a casing that has a 3,000-watt air heater set in the back. The current is turned on, and the drum is steadily revolved by a small electric motor, with the result that the film is now thoroughly dried in about one fourth the time previously required, which varied from 4 to 10 hours according to the humidity of the atmosphere.

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Table of Contents